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Analysis of Changes in the Carrying Capacity of Food Agriculture in Kulon Progo Regency, Yogyakarta

Irwansyah Sukri[1*], **Rika Harini**[2], **Sudrajat**[3]
[123] Faculty of Geography, Universitas Gadjah Mada
Jl. Kaliurang, Sekip Utara, Bulaksumur, Yogyakarta, Indonesia 55281
*Corresponding Author: geoirwansyah@mail.ugm.ac.id

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Abstract: The increase in the population impacts the increasing demand for food and non-food. Hence, to fulfill non-food needs, agricultural food land is converted into non-agricultural. It affected the carrying capacity of food agriculture. This paper aimed to analyze changes in the carrying capacity of food agriculture and the factors that influence the carrying capacity of food agriculture in the Kulon Progo Regency. This study used a descriptive-quantitative approach with spatial-temporal analysis techniques on secondary data, including population, rice field area, and rice field productivity for 2011, 2015, and 2019. The results showed that in 2011 Kulon Progo Regency could not be self-sufficient in food. However, in 2015, the research area had a great carrying capacity for food agriculture and continues to increase. This increase was influenced by the addition of rice fields and increased productivity. On the other hand, the reduction of rice fields decreased the productivity of rice fields, and the increase in the population led to a decrease in the carrying capacity of food agriculture in the Nanggulan, Kalibawang, and Samigaluh Districts. The rice field area and the productivity of rice fields affect food availability, while the population affects food needs. This paper showed that land-use changes in agri-food land (rice field area and productivity of rice fields) and the number of populations resulted in changes in the carrying capacity of food agriculture.

Keywords: Carrying capacity, land use change, food self-sufficiency, rice field, population growth

INTRODUCTION

A direct consequence of the increase in population is an increase in food and non-food requests globally. Increasing consumption puts pressure on existing natural resources, causing tremendous challenges for humankind, namely responding to the demands of a growing society without releasing environmental sustainability (Lopes et al., 2020).

The Population Explosion Theory proposed by Malthus, presented by Brezis & Young (2017), briefly stated that if the population is not inhibited, it will increase more than food production, which will be a problem. When a country's population reaches its limit of food production possibilities, there are only two ways to maintain the balance: actions that reduce the birth rate and/or actions that increase the death rate. However, Ester Boserup's Theory of Agricultural Intensification, restated by Kaldor (2010), stated that population growth is considered an independent variable which in turn is the main factor that determines agricultural development. Population growth should be considered a

dependent variable, especially on agricultural productivity, which can be summarized as population trends causing agricultural development.

The number of people in Indonesia is growing every year. Data from the Central Bureau of Statistics (BPS) shows that from 2010-2020, there was an increase in the population in Indonesia, as much as 32.56 million people, or 3.26 million/year, with a population growth rate of 1.25 percent every year. In 2010 the total population of Indonesia was 237.63 million, while in 2020, the total population of Indonesia was 270.20 million (Badan Pusat Statistik, 2021). From 2011-2018, the rice fields area in Indonesia decreased by around 1 million hectares, then in 2019, there was an increase in the rice fields area by around 3 thousand hectares. Based on data from the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN), in 2011, the national rice fields area was around 8.1 million Ha. In 2018 it was around 7.1 million Ha, while in 2019, it was around 7.4 million hectares (Central Bureau of Statistics, 2021).

Kulon Progo Regency is one of the regencies on the island of Java, precisely in the Province of Yogyakarta Special Region (D.I). This district has undergone a massive transportation infrastructure development. Some of the development projects in this district include the construction of Yogyakarta International Airport (YIA), which began in 2017, and the South Crossing Road Line (JJLS) project, which began in 2018. Transportation infrastructure development is a catalyst for accelerating urbanization, changing society's social economy, and reducing agricultural land (Novenanto, 2018). The construction of the YIA airport project requires 600 hectares of land, most of which comes from the conversion of rice fields. It causes a reduction in the rice field area in Kulon Progo Regency, especially in Temon District.

The conversion of agricultural food land and population is a very interesting issue because food agriculture production has an important role in creating food security. However, agricultural land is reduced, resulting in decreased food production (Harini & Lestariningsih, 2014). Decreasing food production will reduce the carrying capacity of food in an area. If the depletion of agricultural land continues, it will cause food insecurity (Widiyantoro et al., 2020).

The concept of the land transfer function can be divided into two main streams of thought, dominant and recessive. Most literature on land use change has focused only on the land use amount and structure (the dominant form). Several other researchers have also studied recessive forms of land use, including land use quality, function, and agricultural productivity (Liang et al., 2020). However, studies that combine these two schools of thought are still limited. In this study, in addition to examining changes in the use of rice fields, the author also examines the productivity of rice fields to determine the carrying capacity of food agriculture in the Kulon Progo Regency. Agricultural land use changes can significantly affect food production (Wang et al., 2020). Although production values are

only considered key, maintaining agricultural production is necessary for sustainable food security (Šťastná & Vaishar, 2020).

This study aimed to measure the carrying capacity of food agriculture in Kulon Progo Regency and analyze the changes in the carrying capacity of food agriculture due to changes in population, rice field area, and productivity. The carrying capacity of food agriculture is the ability of a region to provide food to meet the food needs of its population in order to have a prosperous life. This concept has been formulated by Odum, Howard, and Issard to calculate the level of self-sufficiency of rice food in a region (Muta'ali, 2012). The carrying capacity of food agriculture contains two main components, which are the component of rice availability (supply) and the component of rice needs (demand). Rice availability is related to the area and productivity of rice fields, while rice needs are related to the population.

Changes in the carrying capacity of food agriculture were analyzed using spatial-temporal rice carrying capacity analysis. Spatial-temporal transformations in the interaction of social and ecological systems affect land use. It is the core of evaluating the carrying capacity of food agriculture because it reduces the carrying capacity at different scales in different areas (Lunyolo et al., 2020).

The land is a functional space that is intended to accommodate various uses. From this perspective, land accommodates regional developments driven by population growth (Edy, 2019). A growing population, followed by an increase in demand for food, will put pressure on the environment (Bengochea Paz et al., 2020). However, until now, it is still unknown how to balance population growth, land use, and sustainable food supply.

Studies on the impact of land-use change and population growth have been widely undertaken. The study by Saputro (2019) showed that the driving factor of land transfer in Temon District is increased population growth. It encouraged the conversion of rice fields into built-up land. Wang et al. (2020) researched to assess the impact of agricultural land changes on water and food in China in the 1990-2015 period. The results showed that the decrease in agricultural land area in China was about 0.80%, which resulted in a decrease in Nawangwulan et al. (2013) the average yield of food crops of about 0.37% per unit area and increased water consumption by about 1.97%. The results show that Pati Regency has a deficit in rice availability.

Meanwhile, a study from Prasada & Rosa (2018), which examined the impact of rice field conversion on food independence in Yogyakarta, used statistical analysis. The results showed that the conversion of rice fields reduced rice production by 18,359 tons from 2006 to 2015. However, the food availability of Yogyakarta residents is still maintained. Furthermore, Nurpita et al. (2018) have examined the impact of land conversion on the level of food security of farmers' households in Temon District, Kulon Progo Regency. The results showed no differences in food security before and after land transfer. However,

from the data of descriptive statistics, it can be seen that there is an increase in the number of food-prone farmer households after the conversion of land functions.

The results of existing studies show that the impact of the conversion of agricultural land on food security in each region is not always the same. The availability of food in an area is influenced by the use of agricultural food land (area and productivity of rice fields owned) and the number of inhabitants. Therefore, to measure the carrying capacity of a region's food agriculture, it is necessary to consider the rice field area, the productivity of rice fields, and the number of residents.

With this study, it is hoped that it can be seen whether the land use change and population growth impact the carrying capacity of food agriculture in Kulon Progo Regency. With the knowledge of the effects of land use change and population growth in this district, it is expected to provide direction and guidance in determining sustainable agriculture policy strategies.

METHODS

This research uses a descriptive approach carried out quantitatively. The secondary data, including population, rice field area, and rice field productivity obtained from the Central Bureau of Statistics and the Agriculture Office of Kulon Progo Regency. Other data is from regional administrative maps obtained from the Indonesia Geoportal. The research area, namely Kulon Progo Regency, is part of the province of D.I Yogyakarta, Indonesia (Figure 1). Analysis of changes in the carrying capacity of food agriculture, specializing in rice field agriculture, using analysis of rice food carrying capacity. The analysis was carried out spatially in each district within the study area. It is done to see the spatial pattern of changes in the carrying capacity of food agriculture. Analysis was also carried out temporally in 2011, 2015, and 2019. An analysis of rice food carrying capacity can be done using a comparison between rice availability and rice needs (Muta'ali, 2012). It can be formulated as follows:

$$\mathbf{DDPb} = \frac{S}{D}$$

(1) Description

DDPb = Rice Food Carrying Capacity
S = Supply (Rice Availability)
D = Demand (Rice Needs)

Based on the formula, the provisions for the value of the carrying capacity of rice food land (DDPb) are as follows:

- If DDPb ≥ 2, the area has a very good rice food-carrying capacity.
- If DDPb ≥1 - <2, then the area has good rice food carrying capacity.
- If DDPb < 1, then the area has poor rice food carrying capacity.

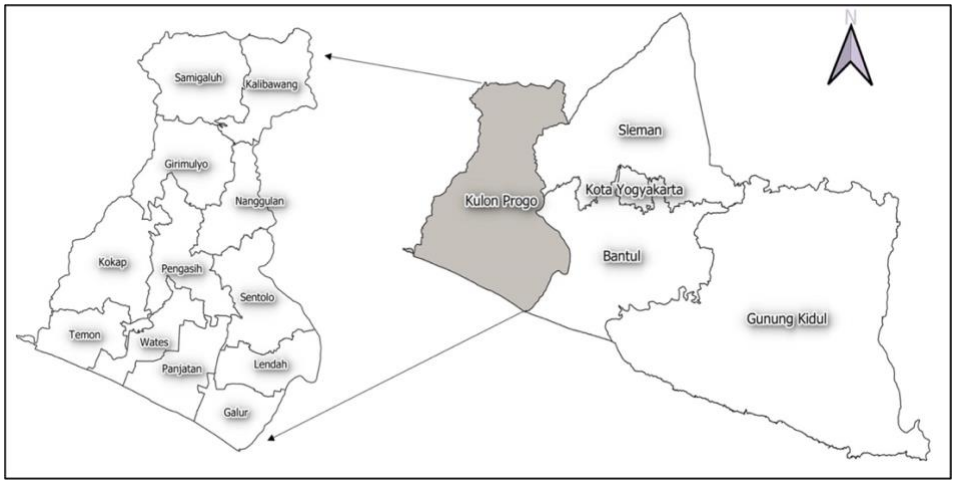

Figure 1. Research location in Kulon Progo Regency, D.I Yogyakarta, Indonesia.

Analysis of rice availability is obtained from the multiplication of rice field productivity with rice field area and multiplied by the conversion index. The analysis of food availability can be written as follows:

$$\mathbf{S} = (PrL \times LLtp) \times \alpha$$

(2)

Source: Muta'ali, 2015
Notes:
S = Rice Availability (Kg)
PrL = Land Productivity (rice planted) (Kg/ha)
LLtp = Rice Field Area (Ha)
s = Conversion Index from Paddy to Rice Grain

The conversion index from paddy to rice grain is the conversion number of grain drying from dry milled grain (GKG) to rice grain. The figure in the equation uses the conversion rate of GKG to rice for the DIY Province, based on the results of the 2018 grain-to-rice conversion (SKGB) survey, namely 63.06% (Central Bureau of Statistics, 2019). The availability of rice food is only calculated from within the research area and does not consider rice production outside the area.

Analysis of rice needs is obtained from the multiplication results of the number of people with rice needs standards. The equation can be written as follows:

$$\mathbf{D} = JP \times Stdb$$

(3)
Source: Muta'ali, 2015
Notes:
D = Rice Needs (Kg)
JP = Total Population (People)
Stdb = Rice Needs Standard (Kg)

The population data use data from the Central Bureau of Statistics of Kulon Progo Regency. Standard rice needs based on Central Bureau of Statistics data for 2011 and 2015 using Stdb in 2013 amounted to 113.48 Kg, while in 2019 amounted to 114 kg.

RESULTS AND DISCUSSION

Rice Food Availability

Analysis of the carrying capacity of food agriculture in this study uses a comparison between the availability of rice (supply) and the need for rice (demand). Supply is calculated from rice production in each district in Kulon Progo Regency and does not count rice from outside the study area. Analysis of changes in the carrying capacity of rice food was carried out in 2011, 2015, and 2019.

The availability of rice in an area depends on the rice field area and its productivity. Data on the rice field area and productivity in each district in Kulon Progo Regency for 2011, 2015, and 2019 are presented in Table 1.

Table 1. Area conditions and productivity of rice fields per district in Kulon Progo Regency

No.	District	2011		2015		2019	
		Rice Field Area (Ha)	Productivity (Kg/Ha)	Rice Field Area (Ha)	Productivity (Kg/Ha)	Rice Field Area (Ha)	Productivity (Kg/Ha)
1	Temon	1,067	6,230.24	1,065	6,439.39	1,236	6,536.29
2	Wates	713	6,242.87	710	6,429.20	1,094	6,538.91
3	Panjatan	1,045	6,231.83	1,045	7,037.05	1,242	6,516.26
4	Galur	1,175	6,111.98	1,175	7,113.37	1,178	6,499.12
5	Lendah	658	6,099.66	658	7,013.03	735	6,498.78
6	Sentolo	1,155	6,257.93	1,166	6,510.46	1,318	6,537.50
7	Pengasih	634	6,121.59	646	6,443.61	750	6,535.89
8	Kokap	73	5,919.71	73	6,437.96	109	6,547.17
9	Girimulyo	536	6,566.06	536	6,734.20	560	6,534.82
10	Nanggulan	1,563	6,569.94	1,595	7,133.89	1,392	6,513.94
11	Kalibawang	947	6,108.22	947	7,022.55	789	6,478.62
12	Samigaluh	738	6,175.04	738	6,674.38	644	6,526.10
Regency		10,304	6,277.52	10,354	6,814.48	11,047	6,518.09

Source: Central Bureau of Statistics of Kulon Progo 2012; 2016; 2020.

Table 1 shows that Nanggulan District has the widest area of rice fields in the research location, followed by Galur District, Sentolo District, and Temon District. Unlike other districts, Kokap District has the least area of rice fields, which is less than 100 hectares. It happens because the morphology of this district is in the form of hills (Bukit Menoreh).

Meanwhile, in 2019 the area of rice fields in this district increased to 109 hectares. In addition, Table 1 also shows that there is a difference in the area of rice fields. The rice field area decreased in Nanggulan, Kalibawang, and Samigaluh Districts.

Meanwhile, other districts have increased the area of rice fields, especially in 2015 and 2019. The addition of rice fields is done by making new rice fields. In general, the area of rice fields in Kulon Progo Regency continues to increase despite the transfer of land functions. In 2011 there were 10,304 hectares of rice fields in Kulon Progo Regency, an additional 50 hectares in 2015, to 10,354 hectares; in 2019, it again increased to 11,047 hectares.

Based on Table 1, the highest average productivity of rice fields in Kulon Progo Regency occurred in 2015, and the lowest was in 2011. Rice field productivity in this regency has increased from 2011 to 2015. Then it decreased from 2015 to 2019. Although it decreased, the level of rice field productivity in 2019 was still better than in 2011. Nanggulan District had the highest productivity level in 2011, amounting to 6,569.94 Kg/Ha, and the lowest in Kokap District, amounting to 5,919.71 Kg/Ha. In 2015, the highest productivity level was in Nanggulan District, which was 7,133.89 Kg/Ha, and the lowest was in Wates District, amounting to 6,429.20 Kg/Ha. While in 2019, the highest productivity level was in Kokap District, which was 6,547.17 Kg/Ha, and the lowest was in Kalibawang District, amounting to 6,478.62 Kg/Ha.

Changes in the area and rice productivity will affect rice availability in the study location. The availability of rice in Kulon Progo Regency for 2011, 2015, and 2019 is presented in Figure 2.

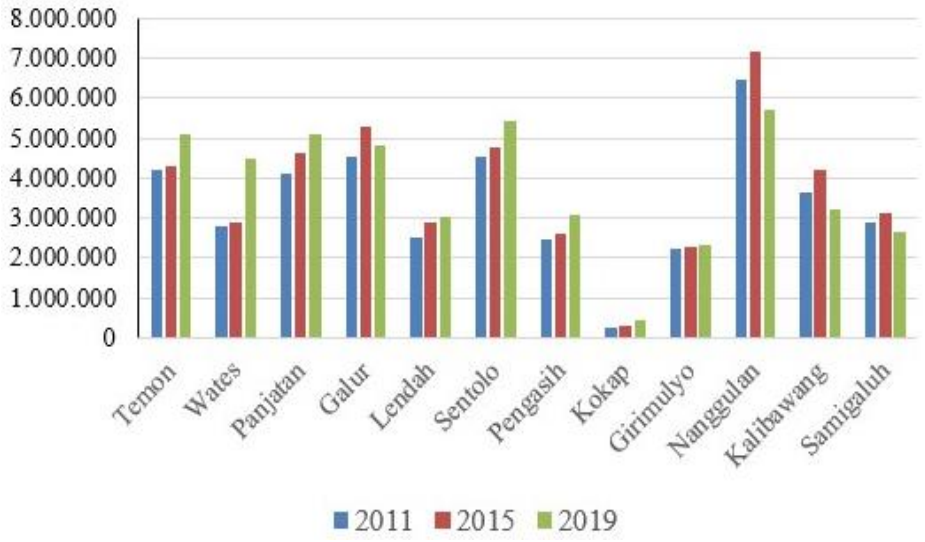

Figure 2. Supply of Rice in Kulon Progo Regency
Source: 2021 data processing.

Based on Figure 2, it can be seen that the highest supply of rice in Kulon Progo Regency from 2011-2019 was in Nanggulan District. It happens because this district has the widest area of rice fields and high productivity. However, the food availability in this district decreased drastically due to rice field conversion. It is reduced from 1,595 Ha (2015) to 1,392 Ha (2019) or reduced by 203 Ha in 2019. The district that has the second highest rice availability is Sentolo District. This district shows an ever-increasing rice availability caused by an increase in the area of rice fields, which is accompanied by an increase in productivity. At the same time, the district that has the lowest availability of rice is the Kokap District. It happens because this district's area of rice fields is minimal, and the productivity level is low.

Rice Food Demands

Rice is the staple food of the people of Kulon Progo Regency. The size of rice demands is closely related to the region's number of inhabitants (Aji & Rahayu, 2020). If the population increases, the demand for rice will also increase. Changes in the number of residents in the study area are presented in Table 2.

Table 2. Percentage increase in the population of Kulon Progo Regency The year of 2011-2019

Year	Total Population	Percentage of Increase in Population (%)
2010	388,869	-
2011	393,796	1.27
2012	397,639	0.98
2013	401,450	0.96
2014	405,222	0.94
2015	408,947	0.92
2016	412,611	0.90
2017	416,200	0.87
2018	425,758	2.30
2019	447,246	5.05

Source: Central Bureau of Statistics of Kulon Progo 2011-2020:

It can be seen in Table 2 that Kulon Progo Regency, from 2010 - 2019, experienced an increase in population between 0.87% - 5.05%. The percentage increase in population for 2011 was 1.27%. In 2015 it was 0.92%, and in 2019 it was 5.05%. In 2019, there was a very high increase in population compared to previous years. Along with the increasing population, the demand for food (rice) also increases. Information on food demands for 2011, 2015, and 2019 is presented in Figure 3.

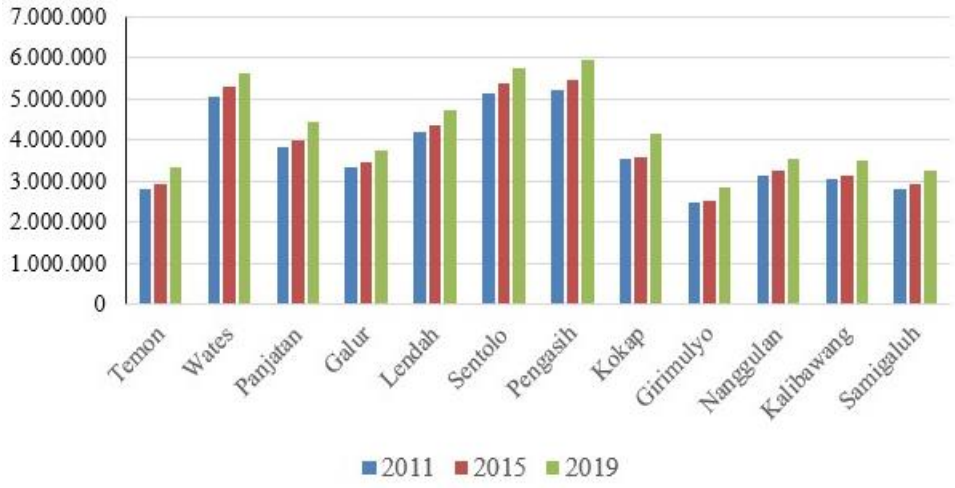

Figure 3. Demand of rice in Kulon Progo Regency.
(*Source: Results of data processing, 2021*).

Figure 3 shows it was influenced by the increase in population in the 2015-2019 period, which was greater than in the 2011-2015 period. A significant increase in population occurred in 2018 and 2019. We can also see from the figure that the greatest demand for rice is in the Districts of Pengasih, Sentolo, and Wates. Meanwhile, there is the least demand for rice in Girimulyo District. The status of rice food carrying capacity in Kulon Progo per district is shown in Table 3.

Table 3. Carrying capacity of rice food in Kulon Progo Regency

No.	District	Rice Food Carrying Capacity					
		The year of 2011	Classification	The year 2015	Classification	The year 2019	Classification
1	Nanggulan	2.07	Excellent	2.29	Excellent	1.82	Good
2	Temon	1.49	Good	1.53	Good	1.81	Good
3	Galur	1.35	Good	1.58	Good	1.44	Good
4	Kalibawang	1.19	Good	1.37	Good	1.05	Good
5	Sentolo	0.89	Less Good	0.93	Less Good	1.06	Good
6	Samigaluh	1.02	Good	1.10	Good	0.94	Less Good
7	Girimulyo	0.89	Less Good	0.91	Less Good	0.92	Less Good
8	Wates	0.55	Less Good	0.57	Less Good	0.89	Less Good
9	Panjatan	0.70	Less Good	0.79	Less Good	0.87	Less Good
10	Lendah	0.60	Less Good	0.69	Less Good	0.72	Less Good
11	Pengasih	0.47	Less Good	0.50	Less Good	0.59	Less Good
12	Kokap	0.08	Less Good	0.08	Less Good	0.13	Less Good
Kulon Progo		0.91	Less Good	1.00	Good	1.02	Good

Source: 2021 Processed Data.

Table 3 shows that Nanggulan District has the highest rice-carrying capacity value. It happens because this district has the largest rice field area and high rice availability, while the demand for rice is not too much. The lowest value of rice food carrying capacity is found in Kokap District. It is because the area of rice fields is the least, and the availability of rice is also very low, while the rice needs are quite high.

Spatio-temporal Changes in the Carrying Capacity of Food Agriculture

Spatio-temporal changes in the carrying capacity of food agriculture in the Kulon Progo Regency are shown in Figure 4.

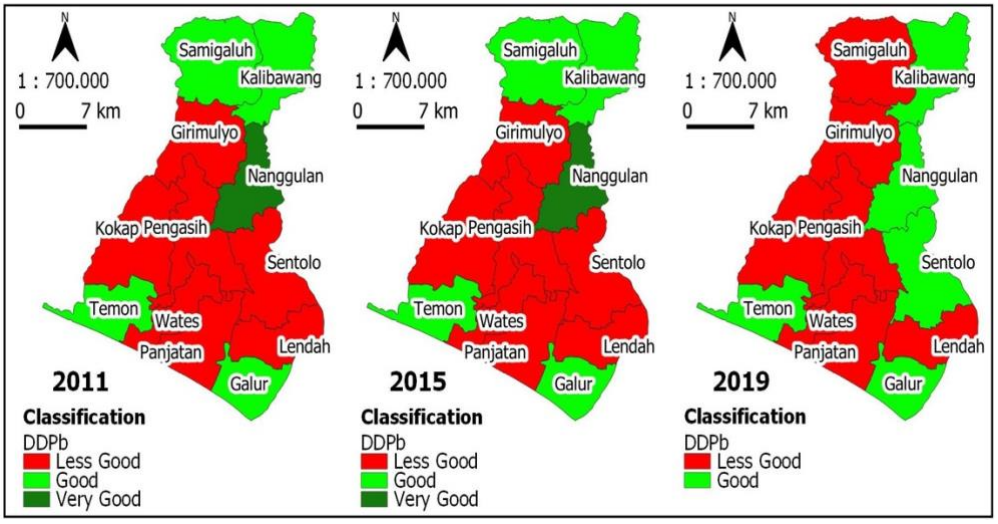

Figure 4. Analysis of Changes in the Carrying Capacity of Food Agriculture in Kulon Progo Regency, Yogyakarta
Source: Data Analysis 2021

Figure 4 shows the spatial pattern of changes in the carrying capacity of food agriculture in Kulon Progo Regency temporally in 2011, 2015, and 2019. The spatial pattern of rice food carrying capacity in this district for 2011 and 2015 has the same pattern. Regions with a very good rice food carrying capacity are in the eastern part, which is in the Nanggulan District. Regions with a good rice food carrying capacity are grouped in the northern part, namely Samigaluh and Kalibawang Districts, and scattered in the south, which are Temon and Galur Districts. Meanwhile, regions with less good rice food carrying capacity group in the central to southern parts, namely Girimulyo, Kokap, Pengasih, Sentolo, Lendah, Wates, and Panjatan Districts.

Rice food carrying capacity in the research area for 2019 has changed spatial patterns. Areas with good rice food carrying capacity are in the east, except in Lendah District, while the west has less rice food carrying capacity, except in Temon District. In 2019, no district had a very good rice food carrying capacity in the research area.

Increasing the Carrying Capacity of Food Agriculture

According to the land use system by Liu et al. (2020), agricultural land consists of three interrelated components: food production, economic development, and ecological stability. Food production systems, especially rice fields, provide agricultural products for human survival. The socio-economic development system offers economic benefits, social security, and livelihood services. Furthermore, improvements in the socio-economic sector can support agricultural production and environmental protection by providing funds, technology, and other resources. Land use control is important to achieve compatible, balanced, and optimal land use to achieve sustainable development (Muryono et al., 2018).

Based on research conducted by Muryono et al. (2018) related to land use discrepancies with regional spatial plans (Neighborhood Unit/Community Unit) in Yogyakarta for 2010-2017, it was found that Kulon Progo Regency has the highest discrepancy of 57.11%, which means that land use control activities in this regency are not optimal. Based on the research conducted on the use of agricultural food land, from the results of data analysis, Kulon Progo Regency experienced improvements, as seen in Table 3. The table shows that in 2011 this district had a value of rice food carrying capacity of <1, which means it was less good. Then, in 2015 and 2019, it became ≥1, which means good. It shows that this regency positively affects rice field agricultural land use despite having high land use discrepancies.

The carrying capacity of food agriculture in Kulon Progo Regency is getting better. It indicates that efforts to improve the rice field agriculture sector have been successful, despite a significant increase in population. It is in line with the Theory of Agricultural Intensification proposed by Ester Boserup that population growth is the main factor determining agricultural development.

Changes in rice field area, productivity, and population led to changes in the carrying capacity of food agriculture at the study site. The area of rice fields and the productivity of rice fields affect food availability, while the population affects food needs. The changes that occurred in Kulon Progo Regency were not similar. As what happened in Nanggulan District in 2011 and 2015, the carrying capacity of food is very good, but in 2019 the area of rice fields decreased and followed by a decrease in productivity, resulting in a change in the percentage of carrying capacity.

In 2011, 2015, and 2019, the carrying status of food agriculture in the Galur and Kalibawang Districts was always good, but fluctuations in carrying value occurred. In 2015, there was an increase, but it again decreased in 2019. In 2015, the carrying capacity value in the two districts was relatively high because the productivity of rice fields was higher, although the area of rice fields remained relatively constant. In 2019 there was a decrease due to decreased rice field productivity.

Sentolo District experienced a change from less good to good carrying capacity. It occurred due to adding rice fields and increased productivity, especially in 2019. Samigaluh District experienced the opposite, from good carrying capacity to less good. The change occurred due to this district's reduced area of rice fields. The reduction in rice fields occurs because rice fields are converted to non-agricultural land uses.

Temon District has a carrying capacity value that always increases with a good carrying capacity status. The higher productivity of rice fields influences this increase in carrying capacity value. Despite the conversion of rice fields in Temon District, as an impact of airport development, Temon District can still carry out food self-sufficiency. It is in line with the findings of Nurpita et al. (2018) that there is no difference in food security before and after land conversion due to construction of an airport in Temon District.

Girimulyo, Wates, Panjatan, Lendah, Pengasih, and Kokap Districts have less good food agriculture carrying capacity status, but in this region, there is an increase in the carrying capacity value of food agriculture. This increase is sought by adding rice fields by opening new ones. This rice field positively affects Wates, Pengasih, and Kokap Districts, increasing the rice fields' productivity level.

Districts that are food supporters so that Kulon Progo Regency can carry out food self-sufficiency are Nanggulan, Temon, Strain, Kalibawang, and Sentolo Districts. Nanggulan District has the highest rice carrying capacity value because Nanggulan District has the most extensive rice field area, and the availability of rice is very high, but the rice needs are not too much. The carrying capacity of food agriculture in Nanggulan District experienced fluctuations, which increased in 2015 to 2.29 (very good) and decreased to 1.82 (good) in 2019.

The Districts of Nanggulan, Kalibawang, and Samigaluh experienced a reduction in the area of rice fields in the 2015-2019 period, causing the productivity of rice fields to decrease. It is in line with the findings of Wang et al. (2020) in China that a decrease in the area of rice fields results in a decrease in food crop production. The increase in the number of residents in these three districts continues to impact the decrease in the carrying capacity value of food farming. According to Pujiriyani et al. (2019), the population will increase, but rice fields will decrease over time. It applies to the three districts in the study locations but is inconsistent with the other nine districts. Even though the population is increasing, the area of rice fields in nine districts has increased.

Food policy is a strategic policy, given that food is a basic human need. Policies to increase food production by increasing the productivity of rice fields play a role in agricultural development. In addition, existing rice fields need to be maintained to maintain the productivity of food agriculture. It aims to keep an area self-sufficient, despite the increase in population. If rice fields must be converted due to vital development such as transportation infrastructure, then the converted rice fields must be replaced by opening

new rice fields. This study is expected to provide information to development implementers related to areas with rice fields with high productivity and good food agriculture carrying capacity. It can be an input for planning regional development and determining sustainable agricultural land.

CONCLUSION

The carrying capacity of food agriculture in Kulon Progo Regency has changed in the last ten years. In 2011 this regency had a carrying capacity value of <1, which means that it is less good, meaning that this regency cannot meet the rice food needs of its residents. In 2015, the research area had a good food-carrying capacity and continued to increase. It indicates that the effort to increase the carrying capacity of food agriculture was successful despite a significant increase in population. These efforts include the making of new rice fields and increasing the productivity of rice fields. This rice field positively affects Wates, Pengasih, and Kokap Districts, increasing the rice fields' productivity level. The area of rice fields and the productivity of rice fields affect food availability, while the population affects food needs. Food availability higher than food needs in an area indicates that the region has a good carrying capacity for food agriculture to become self-sufficient in food.

RECOMMENDATION

Rice fields that are converted to non-agricultural must be replaced in other regions. New rice field making is directed to districts with high productivity levels. Furthermore, high-productivity rice fields should be maintained and avoided in development areas. Development can be directed to areas that have low rice field productivity.

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