Agriculture Carrying Capacity Evaluation of Land Subsidence Area in Yogyakarta Special Province

Alfindy Juliansari Alam, *Azizah* Nurkhalifah, *Muhammad* Zayyin Asrofi, *Muhammad* Raidan Azani and *Ratih* Fitria Putri*

Department of Environmental Geography, Faculty of Geography, Universitas Gadjah Mada, Indonesia

Abstract. The Special Region of Yogyakarta Province is one of the regions where the agricultural sector serves as a significant source of income. Due to the development of the region in the Special Region of Yogyakarta Province, several districts have experienced a decline in agricultural land due to land conversion for residential purposes. The ability of an area to achieve food self-sufficiency or meet its own food needs can be assessed through Land Carrying Capacity (DDL) and food availability. This analysis of Land Carrying Capacity for Agriculture and Food Availability employs a quantitative descriptive method. The land carrying capacity in the Special Region of Yogyakarta Province in 2022 indicates that all districts/cities have a DDL value of <1. This implies that the districts/cities in the Special Region of Yogyakarta Province cannot achieve food self-sufficiency and cannot adequately meet the population's food needs.

1. Introduction

Indonesia, as an agrarian country with fertile agricultural land, has led to most of its population working in the agricultural sector. The favorable agricultural conditions in Indonesia are influenced by its geographical location, resulting in a tropical climate conducive to significant rock weathering processes. The pivotal role of the Agricultural Sector in Indonesia's economy includes engaging a substantial portion of the population and contributing significantly to domestic food production. In other words, the agricultural sector also plays a role in enhancing the well-being of society. Furthermore, this sector can contribute to sustainable development through environmentally friendly farming practices and sustainable agricultural development.

As time progresses, population pressures have increased, leading to a decline in agricultural land. The growing population has led to increased development activities, resulting in the conversion of agricultural land into residential, industrial, and office areas, among others. Land conversion from agriculture has been experienced in various regions across Indonesia due to the expansion of built-up land for other sectors [1]. There are areas in the Special Region of Yogyakarta Province that have experienced a reduction in agricultural land due to conversion for residential use.

The Special Region of Yogyakarta Province is one of the regions where the agricultural sector is a significant source of income. [12] asserts that development orientation has favored urban areas. This is evident from the decrease in agricultural land area in recent years in various parts of the Special Region of Yogyakarta Province. The stagnant agricultural land area is not commensurate with the growing population. An increase in population translates to an increased demand for food, necessitating the enhancement of agricultural land resources in a region. To prevent a decline in food crop productivity and establish equilibrium, an analysis to enhance the carrying capacity of agricultural land is essential.

The problem of subsidence in agricultural land get serious attention along with the growing intensity of the issue of climate change and global warming. Therefore, it is necessary to revitalize agricultural lands that have been damaged due to over drying. Drainage canals must be immediately blocked or even (if possible) completely hoarded, so as not to cause increasingly serious damage to agricultural land environment. To support this, then regulate the ground water level with building blocks and forestry efforts back to reduce the rate of land subsidence the farm. The carrying capacity of agricultural land illustrates the ability of such land to support the food needs of the population [9]. The analysis of agricultural land carrying capacity serves as a valuable tool for sustainable development planning, especially within the agricultural sector [7], [14]. Determining agricultural land carrying capacity involves various parameters, including population size, harvest area, food requirements, and food productivity.

2. Methodology

2.1 Location Determination

The Carrying Capacity of Agricultural Land research was conducted in the Special Region of Yogyakarta Province. Considerations for determining locations in Special Region of Yogyakarta Province

*Corresponding author: ratihfitria.putri@ugm.ac.id

include the area of paddy fields which tends to increase year by year during the period 2015-2019 (Table 1). With the potential availability of these lands, it is hoped that the Special Region of Yogyakarta Province can not only be self-sufficient in food but also properly meet the community's food needs.

Table 1. Area of Rice Fields by City in Special Region of Yogyakarta Province during the period 2015—2019 (Ha)

No	Regency/ City	Year (ha)				
		2015	2016	2017	2018	2019
1	Kulon Progo	9,806	10,164	10,038	11,053	11,008
2	Bantul	14,116	14,067	14,857	14,857	14,945
3	Gunungkidul	7,718	7,862	7,861	31,896	31,973
4	Sleman	21,856	21,834	19,083	18,129	18,295
5	Yogyakarta	57	58	58	55	51
Special Region of Yogyakarta Province		53,553	53,985	51,897	75,990	76,272

Source: Ministry of Agriculture, 2020 processed.

2.2 Carrying Capacity of Agricultural Land

The ability of a region to achieve food self-sufficiency can be determined by comparing the optimum population size with food production output [6]. The concept used to understand the critical threshold of carrying capacity involves a limited and sustainable population that does not degrade the natural environment, thereby maintaining the ecosystem [10]. The carrying capacity of a region for agriculture can be calculated using a formula based on a combination of theories by Odum, Christeiler, and Ebenezer Howard, as follows [9]:

$$DDL = \frac{\left({}^{Lp}/_{Pd}\right)}{\left({}^{KFM}/_{Pr}\right)}$$

Information:
DDL = Carrying capacity of agricultural land
Lp = Area harvested (ha)
Pd = Total population (people)
KFM = Minimum physical requirements (kg/inhabitant/year) = 2,65 kw/inhabitant/year
Pr = Land productivity (kg/ha)

A region capable of meeting the minimum physical needs of its population, equivalent to 1600 calories/person/day or 265 kilograms of rice/person/year (KFM 2.65 kg rice/person/year). Meanwhile, a region capable of adequately meeting the dietary needs of its population is equivalent to 650 kilograms of rice/person/year or 2.47 times KFM. Based on these values, the established classification is as follows:

1) Class I (DDL > 2,47)
   A region capable of food self-sufficiency and capable of offering a decent life to its inhabitants.
2) Class II (1 ≤ DDL ≤ 2,47)
   Regions capable of food self-sufficiency but which have not been able to ensure a decent life for their inhabitants.
3) Class III (DDL < 1)
   Regions that are not yet self-sufficient in food.

2.3 Food Security

Food security represents a condition where the food needs of a region are fulfilled, characterized by sufficient, safe, equitable, and accessible food supply (Government Regulation No. 68 of 2002 on Food Security). The concept used to assess food security involves the variables of Food Availability and Food Needs. Food availability and needs can be calculated using the following formulas:

Food availability = (Pr×Lp) × Paddy to rice conversion index

$$\text{Food demand} = Pd \times KFM$$

Information:
Pr = Land productivity (kg/ha)
Pd = Total population (people)
Lp = Area harvested (ha)
Paddy to rice conversion index = 64,02%
KFM = Minimum physical requirements (kg/inhabitant/year) = 2,65 kw/inhabitant/year

3. Results and Discussion

3.1 Carrying Capacity of Agricultural Land in Special Region of Yogyakarta Province

Table 2. Carrying Capacity of Agricultural Land in Special Region of Yogyakarta Province in 2022

No	Regency/ City	Harvested area of rice per capita	Area of land in food self-sufficiency	DDL Rate	Classification
1	Kulon Progo	0.043	0.044	0.97	Class III
2	Bantul	0.024	0.049	0.49	Class III
3	Gunungkidul	0.057	0.058	0.97	Class III
4	Sleman	0.021	0.054	0.38	Class III
5	Yogyakarta	0.000	0.049	0.00	Class III
Special Region of Yogyakarta Province		0.029	0.052	0.56	Class III

Source: Department of Agriculture and Food Security, 2023 processed.

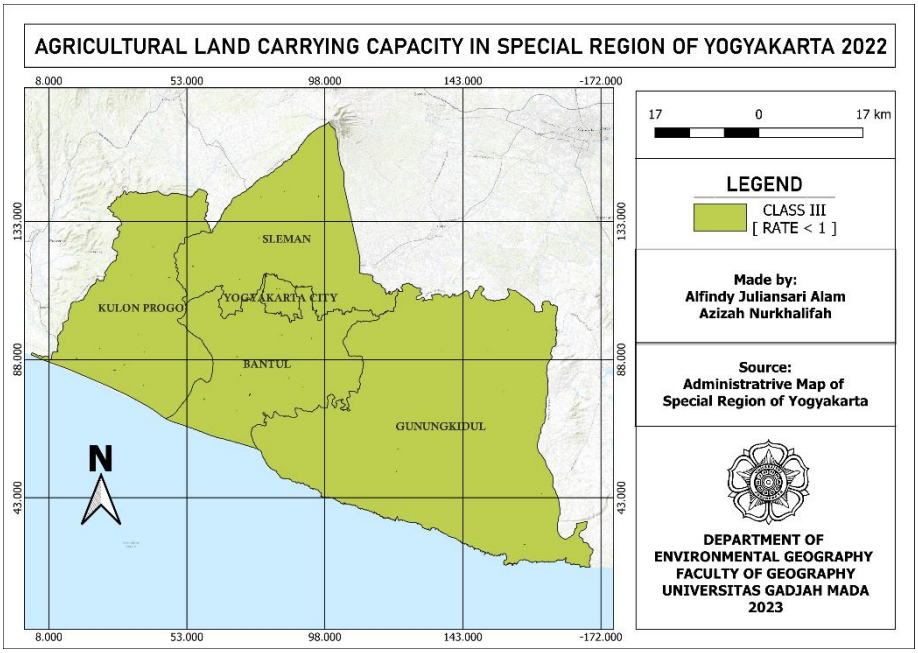

Fig. 1. Agricultural Lan-Carrying Capacity in Special Region of Yogyakarta 2022 Map

The analysis of land carrying capacity is linked to sustainable agricultural development, as understanding the land carrying capacity allows us to predict the future agricultural capabilities [4]. The results of the Land Carrying Capacity (DDL) calculation for Special Region of Yogyakarta Province in 2022 indicate that all districts/cities have DDL values < 1. The districts/cities in the Special Region of Yogyakarta Province cannot achieve food self-sufficiency and adequately meet the population's food needs.

A balanced land carrying capacity is determined when the agricultural land area in a region can meet the minimum physical needs of its population. The condition for achieving food self-sufficiency (DDL = 1) in Special Region of Yogyakarta Province occurs when the agricultural land productivity reaches 89.86 kw/ha. Apart from productivity, achieving food self-sufficiency in Special Region of Yogyakarta Province also requires a population size of 2.119.619 individuals. This population size indicates that the Special Region of Yogyakarta Province currently has a population above the optimum level, necessitating increased food production and maintaining agricultural land availability.

The districts of Kulon Progo and Gunungkidul are targeted by one of the programs of the Special Region of Yogyakarta Agriculture and Food Security Office, the "Lumbung Mataram" program. According to jogjaprov.go.id, the Special Region of Yogyakarta Regional Government states that this program aims to fulfill the food needs of the community. The program is rooted in traditional community farming practices and serves to educate farmers and encourage them to develop better farming practices. In addition to education, the funds allocated are used for equipment procurement, dry land cultivation, and various activities to enhance agricultural productivity. The program's development can support the population's food needs and contribute to enhancing the carrying capacity of existing agricultural land.

Bantul District is known as the rice granary of Special Region of Yogyakarta. However, in 2022, it shows a lower DDL value compared to Kulon Progo and Gunungkidul Districts. Bantul District has been experiencing population pressure on agricultural land (paddy fields) since 2015 [11]. This indicates that the available agricultural land can no longer support the food needs or livelihoods of the existing farmers. To address this issue, the farming population in Bantul needs to consider sectors outside of agriculture or expand their farming activities. This is consistent with the physical conditions of Bantul District, which has sub-districts with potential for Sustainable Food Crop Agricultural Land (LP2B) in wetland areas.

The agricultural land carrying capacity of Sleman District shows the lowest value after Yogyakarta City. Based on its physical condition, Sleman District, which spans slopes, foothills, and the base of Mount Merapi, should ideally have a high DDL value. However, the agricultural land carrying capacity of Sleman District decreased from 2016 to 2019. Land use change is driven by population density, social infrastructure, industrial activities, Gross Regional Domestic Product (PDRB), and productivity [13]. The decrease in agricultural conditions in Sleman District is due to development trends directed towards Sleman District, which shares a direct border with Yogyakarta City, a high-growth center in the region.

3.2 Availability of Food in the Special Region of Yogyakarta Province

Table 3. Food demand and availability in the Special Region of Yogyakarta Province in 2022

No.	Regency/ City	Total population (people)	KFM	Food demand	Rice Production (kw GKG)	Food availability (kw Beras)	Availability-Demand	Information
1	Kulon Progo	451.342	2,65	1.196.056	1.160.560	742.991	-453.066	Deficit
2	Bantul	1.013.170	2,65	2.684.901	1.303.390	834.430	-1.850.470	Deficit
3	Gunungkidul	770.883	2,65	2.042.840	1.983.100	1.269.581	-773.259	Deficit
4	Sleman	1.147.562	2,65	3.041.039	1.169.510	748.720	-2.292.319	Deficit
5	Yogyakarta	378.913	2,65	1.004.120	430	275	-1.003.844	Deficit
Special Region of Yogyakarta Province		**3.761.870**	**2,65**	**9.968.956**	**5.616.990**	**3.595.997**	**-6.372.959**	**Deficit**

Source: Badan Pusat Statistik, 2023 processed.

The food availability in Special Region of Yogyakarta Province is at 3.595.997 kw/year during 2022, while the food requirement reaches 9.968.956 kw/year. When the available food is lower than the required amount, a deficit condition occurs. All districts/cities in the Special Region of Yogyakarta Province show deficit conditions, with the highest figure reaching 2.292.319 kw of rice in Sleman District. According to the Special Region of Yogyakarta Agriculture and Food Security Office, rice consumption in 2022 is only 0,8 kw/capita/year. This has a significant difference from the Minimum Physical Requirement (KFM) used as the reference, which is 2,65 kw/capita/year. The larger the KFM value in the calculation, the greater the difference between Food Availability and Food Requirement becomes.

Districts with deficit analysis results between Food Availability and Food Requirement do not necessarily show complex food scarcity issues. The availability of rice can still be found in various markets at prices that are still affordable for the local population. However, the rice production in the Special Region of Yogyakarta Province is not yet capable of achieving food self-sufficiency for its population. Consequently, it can be concluded that the food needs of the Special Region of Yogyakarta Province population are met in areas outside the province.

3.3 The Relationship between Agricultural Land Carrying Capacity and Food Availability

Variables affecting the value of Agricultural Land Carrying Capacity (DDL) include population, harvested land area, farmland productivity and KFM. Meanwhile, variables affecting food security in quantity include population, KFM, agricultural production, and the rate of paddy-to-rice conversion. Agricultural Land Carrying Capacity is linked to the extent of land, both for harvest and decent living, so a decrease in DDL can be addressed through land conservation, agricultural intensification, and land conversion.

Population growth also affects market demand and needs, which in turn affect market selling prices. A region's ability to achieve food self-sufficiency or meet its own food needs can be assessed through Agricultural Land Carrying Capacity and Food Availability. Agricultural Land Carrying Capacity (DDL) analysis focuses on rice productivity and the land's ability to achieve optimal conditions. Meanwhile, food availability analysis focuses on the population's consumption and the conversion rate of paddy to rice, which can depict the quality of rice, whether it is for consumption (GKG) or as seed (GKP). Thus, the relationship between paddy agricultural land carrying capacity and rice food availability has a strong correlation, where higher paddy agricultural land

carrying capacity values correspond to better food security [4].

4. Conclusion

The agricultural land carrying capacity of Special Region of Yogyakarta Province in 2022 indicates that all districts/cities have DDL values < 1. The districts/cities in the Special Region of Yogyakarta Province cannot achieve food self-sufficiency and adequately meet the population's food needs. Furthermore, all districts/cities in the Special Region of Yogyakarta Province also exhibit deficit food availability conditions and still receive external food assistance to meet its food requirements. The relationship between paddy agricultural land carrying capacity and rice food availability reveals that as the value of paddy agricultural land carrying capacity decreases, food security worsens.

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