

# Agricultural Land Monitoring of Land Subsidence Area Using Spatio-Temporal Approach in East Java Indonesia 2018-2022

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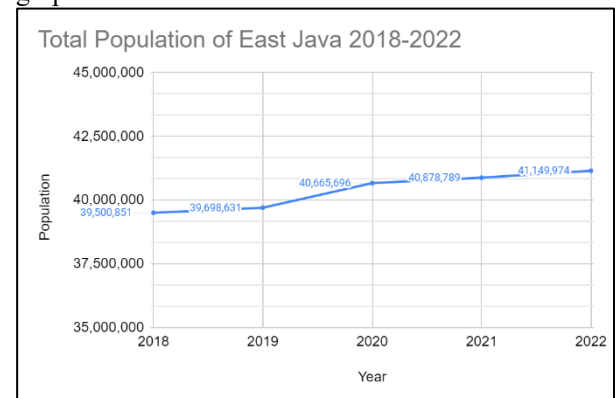
**Abstract.** Java Island is the center of economy and government so that infrastructure and economic development are evenly distributed and the accessibility is high, including in East Java. As a result, East Java has become a migration destination which causes its population to continue to increase from 2018 to 2022 as it increases the chances of land conversion. As a province with high rice production, this is a challenge for East Java to maintain its rice production. A calculation was carried out to determine the carrying capacity class of East Java agricultural land in 2018-2022 using a combined method of Odum, Christaller, Howard, and Issard. The analytical method used in this study is quantitative descriptive analysis with a spatio-temporal approach. The results showed that the carrying capacity class of East Java's agricultural land from 2018 to 2022 continued to decline. Since 2021 there are no more areas in class I of the agricultural land carrying capacity. The lowest carrying capacity of agricultural land is in Surabaya Municipality, while the highest is Ngawi Regencies. East Java experienced a decrease in the carrying capacity of agricultural land from class II in 2018 to class III from 2019 to 2022.

## 1 Introduction

Referring to the results of the 2020 population census, Indonesia is the country with the fourth largest population in the world with a population of 270.20 million people [1]. It is stated that 56.10% of Indonesia's total population was concentrated on the island of Java. In fact, the area of Java Island is only 7% of the total area in Indonesia [2]. Java Island is the center of government and economic in Indonesia. It has high economic activities and has the largest contribution value to GDP in Indonesia [3]. As the center of government and economy, this causes Java Island to have a relatively large population. Equal infrastructure development, equitable distribution of economic centers, and ease of accessibility of service centers used by the community are strong pull factors for residents outside Java Island to urbanize [2]. The concentration of population in Java Island according to [4] Java Island almost has everything needed by the community, so it becomes an attractive gem for residents outside the island to try their luck there.

Java Island is administratively divided into several provinces, one of them is East Java. As the center of economic activity, East Java has the highest GDP of Constant Prices in Indonesia from 2012-2016. [5] stated that the GDP growth rate of East Java Constant Prices was higher than Special Capital Regencies (DKI) of Jakarta as the center of the capital of Indonesia.

The population of East Java is increasing from 2018-2022. This trend is visualized in the following graph.



**Fig. 1.** Total Population of East Java 2018-2022

A fixed land area accompanied by greater population growth has implications for the threat of narrower agricultural land. [6] argues that increasing population will demand development activities that cause agricultural land conversion. According to [7], the increasing population, the area of agricultural land that continues to decrease, and the reduction of land area to live properly are factors that affect the carrying capacity of agricultural land.

The most critical problem related to environmental carrying capacity is population pressure on land, especially agricultural land [8]. Population pressure is inversely proportional to environmental carrying capacity. The higher the population density, the lower

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the carrying capacity [9]. Agricultural land carrying capacity is the ability of a gricultural land to support the lives of people in an area, especially related to meeting food needs [10]. [11] argues that the high population pressure on a gricultural land causes the threat of a land to be able to meet food needs.

Land subsidence caused by fluid extraction (groundwater, oil, and gas) can reach 10 cm per year, the faster the fluid is extracted the faster the land subsidence. This land subsidence has a spatial pattem varying from patchy to regional. Land conversion such as reclamation, construction, and a griculture activities can cause subsidence by the same mechanism as subsidence land caused by natural phenomena. The study of the analysis of the carrying capacity of a gricultural land needs to be carried out as material in development planning because it can provide an overview of the relationship between population, land use, and the environment [12, 13]. The calculation of the carrying capacity of a gricultural land for East Java Province in 2018-2022 was carried out to determine the trend of changing carrying capacity classes according to the combined method of Odum, Christaller, Howard, and Issard which is based on production, harvested area, and average rice production per hectare [9], and its implications for a gricultural activities in East Java Province.

## 2 Methodology

The analytical method in this study is quantitative descriptive analysis with spatial and temporal approaches.

### 2.1 East Java

East Java is located in Java Island, between 111.0'—114.4' East Longitude and 7.12"—8.48" South Latitude. East Java Province is directly adjacent to Central Java Province, Java Sea, and Bali Strait. The plains of East Java are divided into highlands (>100 meter above sea level), medium (45-100 masl), and low (<45 masl). In addition, East Java is also watered by two main rivers, namely the Brantas River and Bengawan Solo River. The tropical wet climate makes East Java have less rainfall than western Java. East Java has 29 regencies and 9 municipalities with Surabaya as the provincial capital. With an area of 47,803.49 km<sup>2</sup>, East Java has a population of 39,500,851 people in 2018 and has increased to 41,149,974 people in 2022. BPS recorded an increase in East Java's population density from 2020 to 2021, from 851 to 857.

### 2.2 Data

This research requires data such as total population of each regencies/municipality, paddy harvested area (Ha), average rice production per hectare (kg/Ha), and KFM or Minimum Physical Needs

(kg/capita/year). All data used are data from 2018 to 2022 because the trend of carrying capacity class of a gricultural land in East Java Province is being studied. All data is obtained from the Central Bureau of Statistics (BPS) Indonesia.

### 2.3 Agricultural Land Carrying Capacity

Agricultural Land carrying Capacity is the ability of a gricultural land to support the lives of people in an area, especially related to meeting food needs [14]. The analysis serves to calculate the availability of paddy a gricultural land in supporting population needs [11]. Land carrying capacity atatus will be carried out by comparing land availability (SL) with land demand (DL). The following is an interpretation of the results of the analysis, namely: If  $SL > DL$  means the carrying capacity of surplus land. If  $SL < DL$ , it means that the carrying capacity of the land is deficit or exceeded.

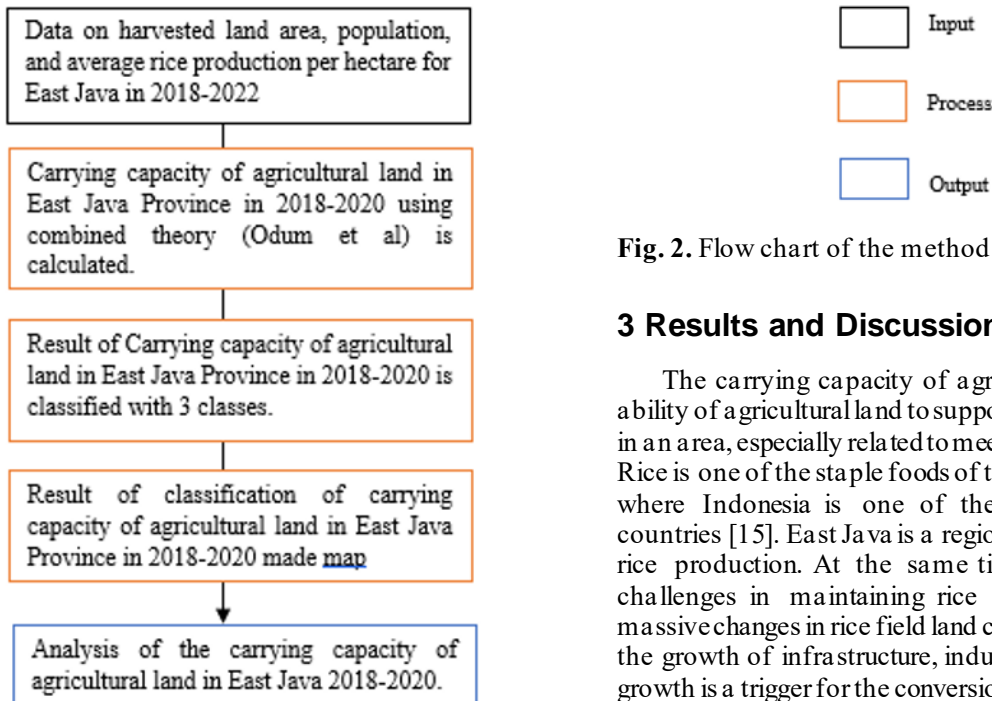
The following formula can be used to calculate a gricultural land carrying capacity.

$$\ell = \frac{Lp/Pd}{KFM/Pr} \quad (1)$$

- $\ell$  = agricultural land carrying capacity
- $Lp$  = harvested area (ha)
- $Pd$  = people population
- KFM = Minimum Physical Needs (kg/capita/year)  
265 kg/capita/year
- $Pr$  = average rice production per hectare (kg/ha)

Based on the results of the a gricultural land carrying capacity calculations, a classification is obtained into three classes, namely:

- Class III ( $\ell < 1$ ) means that the region is unable to implement food self-sufficiency, or the population exceeds the optimal population.
- Class II ( $1 \leq \ell \leq 2,46$ ) means that the region has an optimal carrying capacity.
- Class I ( $\ell > 2,46$ ) means that the region is able to carry out food self-sufficiency or the population is below the optimal population.



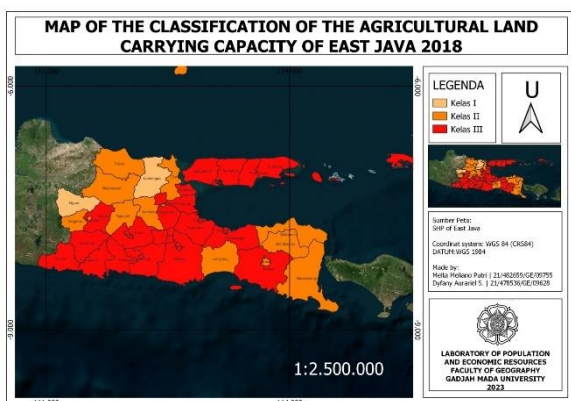
**Fig. 2.** Flow chart of the method used in this paper

### 3 Results and Discussion

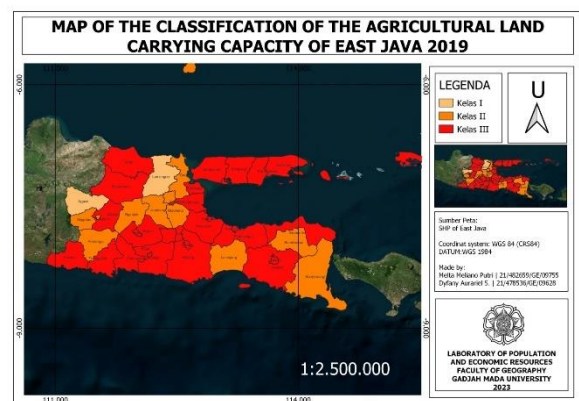
The carrying capacity of agricultural land is the ability of agricultural land to support the lives of people in an area, especially related to meeting food needs [14]. Rice is one of the staple foods of the world community where Indonesia is one of the largest producing countries [15]. East Java is a region that has very high rice production. At the same time, East Java has challenges in maintaining rice production due to massive changes in rice field land cover. [16] argues that the growth of infrastructure, industry, and population growth is a trigger for the conversion of agricultural land into developed land that will threaten rice production.

**Table 1.** Agricultural Land Carrying Capacity Class of East Java 2018-2022

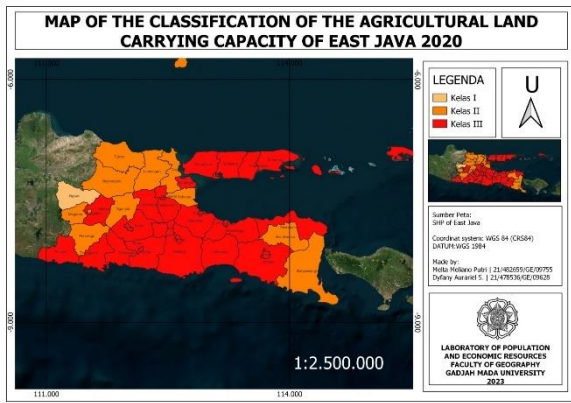
Year	Population	Harvested Area (Ha)	Productivity (Kg/Ha)	KFM	Carrying Capacity	Class
2018	39,500,851	1,828,700	5,763	265	1.01	II
2019	39,698,631	1,702,426	5,628		0.91	III
2020	40,665,696	1,754,380	5,713		0.93	III
2021	40,878,789	1,747,481	3,235		0.52	III
2022	41,149,974	1,693,210	3,303		0.51	III



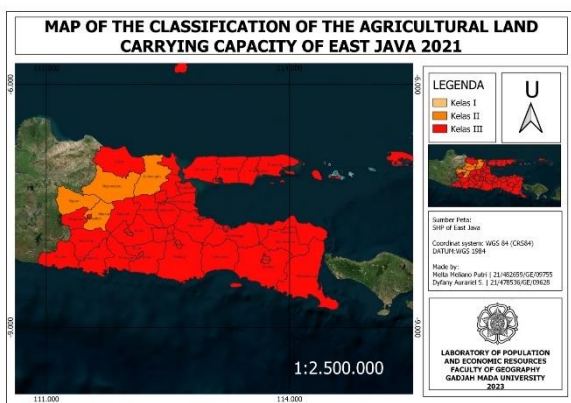
**Fig. 3.** Map of the classification of the agricultural land carrying capacity of East Java 2018



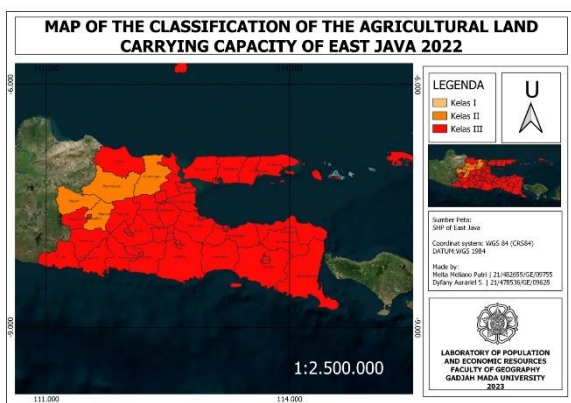
**Fig. 4.** Map of the classification of the agricultural land carrying capacity of East Java 2019



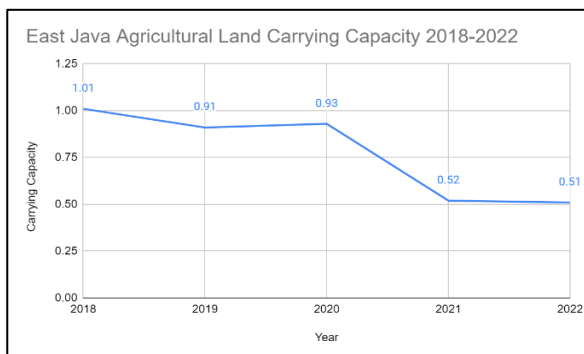
**Fig. 5.** Map of the classification of the agricultural land carrying capacity of East Java 2020



**Fig. 6.** Map of the classification of the agricultural land carrying capacity of East Java 2021



**Fig. 7.** Map of the classification of the agricultural land carrying capacity of East Java 2022



**Fig 8.** Graph of the agricultural land carrying capacity of East Java 2018-2022

The calculation results show that overall, the carrying capacity of East Java agricultural land in 2018 is in class II. However, from 2019 to 2022, the carrying capacity class of East Java agricultural land continues to decrease to class III. A drastic decrease occurred from 2020 to 2021, from 0.93 to 0.52. This happened because of a decrease in rice harvest area and considerable land productivity. In fact, the population of East Java itself has increased.

In general, the number of regencies or municipalities that have class I carrying capacity also continues to decrease. In 2018 and 2019, there are 2 regions with the carrying capacity of class I agricultural land which are Ngawi Regencies and Lamongan Regencies. Lamongan Regencies dropped to class II in 2020, then there are no more regencies or municipalities with the carrying capacity of class I agricultural land in 2021 and 2022. The same thing also happened to the carrying capacity of class II agricultural land, which was originally 13 in 2018, then became 12 in 2019, dropped to 11 in 2020, and finally only 4 regions in 2021 and 2022.

**Table 2.** Total Regencies/Municipalities in Each Carrying Capacity Class

Year	Carrying Capacity Class		
	I	II	III
2018	2	13	23
2019	2	12	24
2020	1	11	26
2021	0	4	34
2022	0	4	34

Over time, the carrying capacity of agricultural land in East Java Province is decreasing. This happens not only in general, but also in each regencies or municipality. The area that has the lowest carrying capacity of a agricultural land is Surabaya Municipality, while the highest is Ngawi Regencies. The development of Surabaya Municipality causes developed land in this region to tend to increase. Land use change in East Java was recorded in 2019 at 9,597 hectares. Agricultural land is converted into warehousing areas, industrial areas, to property areas [17]. This makes massive land shrinkage. In fact, Sidoarjo Regencies, which used to have characteristics or local wisdom from a agricultural products and ponds that are sufficient to meet independent food needs [18], has now gone through a rice deficit since 2018. One of the factors is because Sidoarjo Regencies became a supporting area for

Surabaya which later became the core area of development, resulting in land conversion.

Based on research conducted by [6] on the carrying capacity of agricultural land, it was found that the cause of the low carrying capacity of agricultural land of food crop agriculture in the Cibalung watershed area was caused by an increase in population from year to year, while the area of agricultural land tended to be static and even decreased with poor land quality drop. In addition, according to [6] the low quality of agricultural land is caused by land management that is not in accordance with conservation principles, which results in low food production and crop failure. This inappropriate management of agricultural land is caused by the low knowledge of the community regarding conservation and conservation techniques in general, farming communities manage agricultural land only based on hereditary knowledge obtained from their ancestors.

Low carrying capacity of agricultural land has implications for meeting low food needs as well. Low food needs according to [10] indicates that people's welfare in terms of food is low. Therefore, the carrying capacity of agricultural land of agriculture, especially food crops, must be maintained so that the fulfilment of food needs can be fulfilled. Efforts that can be made to improve the quality of agricultural land according to [10] are suppressing or reducing the population and improving the management of agricultural land so that the yields produced increase both in quality and quantity.

## 4 Conclusion

The trend of the carrying capacity of agricultural land in East Java changes every year. In 2018 and 2019 there are still 2 regencies/municipalities that fall into the class I classification. In 2020 there is still 1 regencies/municipality that falls into the class I classification. In 2021 and 2022 there are no regencies/municipality that fall into the in class I classification. The number of regencies/municipalities that fall into class III always increases from year to year. The cause of the lower carrying capacity of agricultural land in East Java, namely due to the increase in population each year and due to land management that is not in accordance with conservation principles. Efforts are needed to improve the quality of agricultural land by suppressing or reducing populations and improving agricultural land management so that the yields produced increase both in quality and quantity.

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