Analysis of the Carrying Capacity Agricultural Land of Jawa Tengah Province in 2022 using the Soemarwoto Method

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Abstract. Jawa Tengah is one of the provinces in Indonesia which has high agricultural productivity. That way, it is necessary to carry out an analysis of the carrying capacity of agricultural land in Jawa Tengah Province in 2022. The method used to calculate population pressure and the carrying capacity of agricultural land is the Soemarwoto method which is suitable for local conditions and can assess the factors that affect the level of carrying capacity of land in an area. Jawa Tengah Province has a carrying capacity of agricultural land of 1.43. The value of population pressure in Jawa Tengah Province with a dominance of less than 1 indicates that districts/cities in Jawa Tengah Province are dominated by the carrying capacity of high agricultural land. The high rate of population growth and not accompanied by an area of land capable of supporting the needs of the population can be a threat to the availability of sustainable agricultural land.

Keyword: *Agricultural, Capacity, Carrying, Method, Soemarwoto*

1 Introduction

An agrarian country is a country where most of the people work in the agricultural sector. Indonesia is an agricultural country because around 38 million Indonesians work in the agricultural sector [1]. That way, the need for adequate carrying capacity of agricultural land for the sustainability of the agricultural sector. The carrying capacity of agricultural land can be affected by population pressure and high population pressure can reduce the carrying capacity of agricultural land.

The need to know the role of the carrying capacity of agricultural land to analyse land capability. Land capability can be interpreted as land quality that can be assessed inclusively and differently between uses [2,3,4]. In analysing it is also necessary to use the theories that have been used before. There are many theories to analyse the level of carrying capacity of agricultural land such as the Combined Theory and Soemarwoto Theory.

Jawa Tengah is one of the provinces in Indonesia which has high agricultural productivity. One example is the rice plant. The productivity of rice plants in Jawa Tengah Province in 2022 will reach 55.41 ku/ha and production will reach 9 million tonnes [5]. That way, it is necessary to carry out an analysis of the carrying capacity of agricultural land in Jawa Tengah Province in 2022.

2 Methodology

Population pressure is a symptom of overpopulation in an area, given the availability of available resources for the needs of the population, in accordance with the desired standard of living in the area concerned [6]. An increase in population that continues continuously with the availability of land that remains in an area can cause population pressure on land to increase. Increasing population pressure on land can accelerate this occurrence, influenced by population growth factors, and shifts in livelihoods in the dynamics of urban growth [7]. There are 3 calculation models to calculate population pressure on agricultural land. The first model assumes that people only depend on the land they cultivate themselves. The second model assumes that the higher the income from the non-agricultural sector, the less population pressure. The third calculation model assumes that the greater the land productivity, the lower the population pressure [8]. Population pressure The Soemarwoto method is classified as supportive (if the population pressure value is >1), present (if the

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population pressure value is 1), and unsupported if the population pressure value is <1).

For this analysis using Model 2, the following formula [8]:

$$Tp = Z\ (1-\alpha\ ) \frac{fPo\ (1+r)t}{L}$$

information:
TP : Population pressure on agricultural land
Z : Minimum land area for decent living (ha/person/year)
F : Percentage of farmers in the population (%)
Po : Total population in the first year (people)
r : Average annual population growth rate (% year)
t : Calculation time period
α : Percentage of non-agricultural income
L : Agricultural land area (ha)
Pt : Number of population at the end of the year (people) or Po(1+r)

The carrying capacity of agricultural land is closely related to the balance of supply and demand. Supply is generally limited, while demand is unlimited [9]. The supply of agricultural land is very limited due to the continuous demand for land for residential needs. Population pressure is inversely proportional to carrying capacity. The higher the population pressure, the lower the carrying capacity [10]. The carrying capacity of agricultural land can be classified as high (if the carrying capacity of agricultural land is> 1), optimal (if the carrying capacity of agricultural land is 1), and low (if the carrying capacity of agricultural land is <1) [11]. The following is the formula for knowing and analyzing the carrying capacity of agricultural land using the Soemarwoto method:

$$iDDL = \frac{1}{TP}$$

information:

iDDL: Carrying Capacity Land Agricultural Index

TP: Population Pressure

The reason for using the Soemarwoto method in calculating population pressure and the carrying capacity of agricultural land is because the method is in accordance with local conditions. The Soemarwoto method was developed based on studies and observations made in Indonesia, making it suitable for this analysis. The Soemarwoto method can also assess the factors that affect the level of land carrying capacity in an area. This theory is approached by the carrying capacity of the land which is the ratio between the available land and the number of farmers. The use of this analysis is based on land area standards with the availability of land according to its designation [12].

3 Discussion

Table 1. Population Pressure Value of Jawa Tengah Province in 2022 using Soemarwoto Method

Regrency/City	Population Pressure
Cilacap	0,56
Banyumas	0,70
Purbalingga	0,64
Banjarnegara	0,49
Kebumen	0,85
Purworejo	0,45
Wonosobo	0,65
Magelang	0,95
Boyolali	0,67
Klaten	0,80
Sukoharjo	0,60
Wonogiri	0,37
Karanganyar	0,76
Sragen	0,85
Grobogan	1,08
Blora	1,03
Rembang	0,44
Pati	0,72
Kudus	0,44
Jepara	0,51
Demak	0,68
Semarang	0,59
Temanggung	0,85
Kendal	0,60
Batang	0,47
Pekalongan	0,80
Pemalang	0,97
Tegal	0,90
Brebes	1,16
Magelang	1,65
Surakarta	3,08
Salatiga	0,23
Semarang	0,21
Pekalongan	0,54
Tegal	4,44
JAWA TENGAH	0,70

Table 2. The value of the carrying capacity of agricultural land in Jawa Tengah province in 2022 using Soemarwoto Method

Regrency/City	Carrying capacity
Cilacap	1,77
Banyumas	1,43
Purbalingga	1,56
Banjarnegara	2,06
Kebumen	1,18
Purworejo	2,23
Wonosobo	1,55
Magelang	1,06
Boyolali	1,50
Klaten	1,25
Sukoharjo	1,68
Wonogiri	2,68
Karanganyar	1,32
Sragen	1,17
Grobogan	0,93
Blora	0,97
Rembang	2,27
Pati	1,39
Kudus	2,28
Jepara	1,98
Demak	1,47
Semarang	1,68
Temanggung	1,18
Kendal	1,66
Batang	2,11
Pekalongan	1,26
Pemalang	1,03
Tegal	1,11
Brebes	0,86
Magelang	0,60
Surakarta	0,32
Salatiga	4,33
Semarang	4,69
Pekalongan	1,85
Tegal	0,23
JAWA TENGAH	1,43

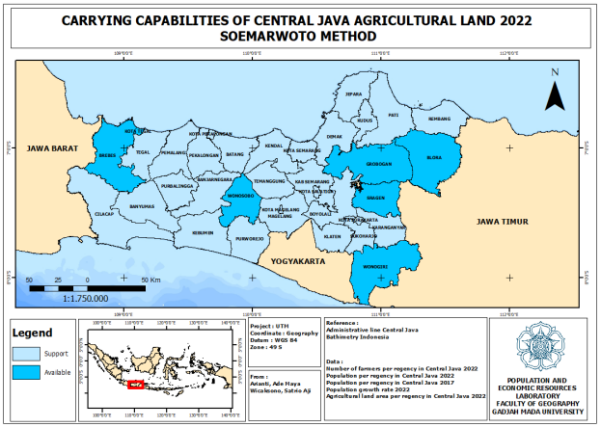

Fig 1. Map of Population Pressure on Agricultural Land in Jawa Tengah Province in 2022

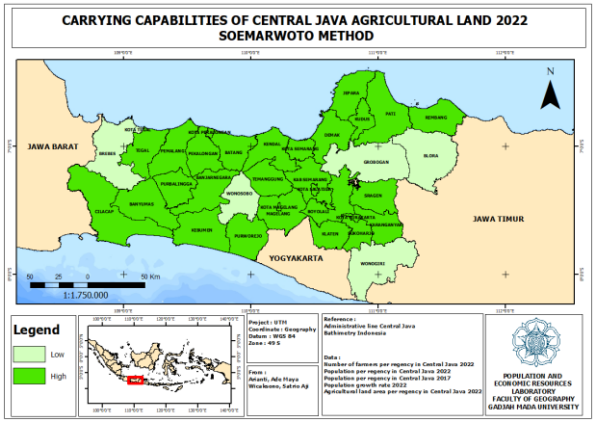

Fig 2. Map of the The carrying capacity of agricultural land of Jawa Tengah Province Soemarwoto Method in 2022

Administratively, Jawa Tengah Province consists of 35 regencies/cities. Regencies/cities in Jawa Tengah Province have various population pressures on agricultural land, this population pressure will affect the carrying capacity of agricultural land. Jawa Tengah Province has population pressure in the model 2 ITP calculation of 0.7, the ITP value is less than 1, indicating that there has not been population pressure on the land. A low ITP value indicates that there are a large number of people working in non-agricultural fields, thereby contributing to reducing population pressure on land. The calculation results also show that Jawa Tengah Province is dominated by agricultural land which is still able to support the needs of the population. Overall, Jawa Tengah Province has a carrying capacity for agricultural land of 1.43. The value of population pressure in Jawa Tengah Province with a dominance of less than 1 indicates that districts/cities in Jawa Tengah Province are dominated by the carrying capacity of high agricultural land. Meanwhile, different conditions occurred in several areas of Jawa Tengah Province, namely there were 6 regencies/cities that experienced

high population pressure and low land carrying capacity, namely Grobogan Regency, Blora Regency, Brebes Regency, Magelang City, Surakarta City, and Tegal City.

Administratively, Tegal City is part of Jawa Tengah Province. This city has the highest population pressure compared to other regions. Population pressure in Tegal City was analyzed using model 2 to get a value of 4.44. Agricultural land in this region has the third smallest area after Magelang City and Surakarta City, which is only 652 ha. However, this condition is not supported by a high population parameter compared to Magelang City so that population pressure on land is relatively high. Food sustainability can support community welfare which can be pursued through increasing the carrying capacity of agricultural land by increasing the area of agricultural land.

Model 2 population pressure is low in Semarang City, which is equal to 0.21. This condition can occur marked by a large population of farmers as a livelihood, namely 14,517 people and a declining population from 2017 to 2022, the pattern of population decline only occurs in several districts/cities in Jawa Tengah Province. The low population pressure value indicates the effect of population income in the non-agricultural sector being able to support the welfare of farmers. The condition of low population pressure on agricultural land is also influenced by the area of agricultural land (irrigated and dry rice fields) occupying an area of 0.57 of the total area of Jawa Tengah Province with a balanced number of farmers and residents. The distribution pattern of population density in Semarang City, which has a high optimal population level, is generally classified as a rural area where many rice fields are still found.

Semarang City is an area with the highest carrying capacity of agricultural land in Jawa Tengah Province, namely 4.69 and is classified into the class of carrying capacity of high agricultural land. This happens because the irrigation conditions in Semarang City are supported by the West River Flood Canal [13]. The soil conditions in this area are also dominated by alluvial soil types which are fertile and have high levels of nutrients. The existence of an agricultural development policy regarding the development of this area which is oriented towards maintaining food security in Semarang City is also the main cause of this area having a high carrying capacity of rice plants. This phenomenon is different from Tegal City which only has a small land area and a large population. As a result, the City of Tegal has a carrying capacity of 0.23 agricultural land which is classified as a carrying capacity of low agricultural land. This means that this district has not been able to carry out food self-sufficiency and has not been able to meet the food needs of the community properly. The decline in food crop production was due to the decreased productivity of agricultural land.

Semarang city is a metropolitan city with a high population accompanied by food needs in the city of Semarang which continues to increase which is also followed by the need for space to accommodate the activities of its population. So that there is a struggle for land between residents who want to live with agricultural areas where the availability of land in the city of Semarang is increasingly limited. To control land conversion, the Semarang City government regulates land use regulations listed in Semarang City Regional Regulation No. 14 of 2011. The city of Semarang has agricultural potential to be developed in several areas to be able to support efforts to achieve food security, namely Banyumanik, Genuk, Gunungpati, Mijen, Ngaliyan, Pedurungan, Tembalang, and Tugu Districts for the development of the agricultural sector by empowering communities and introducing methods and the latest technology. The city of Semarang also has a farming community and farmer women's groups of around 10,285 farmers who are members of 389 farmer groups.

The population in each district varies so that it experiences different population growth. The smallest percentage of population growth rates occurred in Magelang City and Surakarta City with a population growth rate of 0.07%, while the highest growth rate occurred in Cilacap Regency. Population growth causes land use problems to become more complex and competitive [14]. However, the population pressure that occurred in Cilacap Regency of 0.56 was classified as being able to support the population because the large population was accompanied by the number of farmers with a percentage of the population working in this sector of 0.11%. Therefore, the carrying capacity of agricultural land is also high at 1.77. This condition also occurs in Wonogiri Regency with the percentage of farmers of 0.11% with low population pressure of 0.37 and wide agricultural land available, so the carrying capacity of the land is classified as high at 2.68. Different conditions occurred in the City of Magelang, Surakarta City, Semarang City, and Pekalongan City with a low percentage of farmers to the population of 0.01%.

The population pressure figure reflects the ratio between population parameters (population size and population growth rate) and the area of agricultural land. Along with the increase in population, simultaneously the need for agricultural land is also increasing [15]. The high rate of population growth and not accompanied by

an area of land capable of supporting the needs of the population can be a threat to the availability of sustainable agricultural land. The population continues to increase and is not accompanied by a balanced distribution pattern causing the need for land to increase resulting in land conversion. Under the same conditions, food consumption also increases, while food production remains relatively constant or decreases. The population that continues to increase can lead to a number of food crop production that is not balanced with the needs of the population. This condition shows that the carrying capacity of agricultural land will be increasingly deficit. Indications in the field are known that the need for land is influenced by an increase in population, while the availability and area of land are fixed [16].

Wonogiri Regency has the largest number of farmers and agricultural land compared to regencies/cities in Jawa Tengah Province. The total population with people working in the agricultural sector is 270,879 people. However, the area of this area with land use in the form of agricultural land is 107,163 ha. This condition causes the minimum area of land to be able to live properly at 0.23 ha/person/year. High population growth and a large part of the population living as farmers can increase population pressure on agricultural land. If this condition continues, it can reduce the ability of agricultural land both in quality and quantity [17]. Areas with a population density that works in the agricultural sector will experience greater population pressure than areas with a population density where the population works in the non-agricultural sector [18]. This value indicates that there is an inverse relationship between the area of agricultural land which tends to decrease, while the population working in the agricultural sector increases. This condition causes people who work as farmers to lose agricultural land. [19] stated that population pressure can occur if population growth causes a decrease in the ratio of land to population. This condition causes farmers to expand agricultural land or work outside the agricultural sector. Based on the fact, the area of paddy fields in Jawa Tengah Province has decreased every year, including being converted as built-up land. This land conversion has not been accompanied by efforts to open new agricultural land. Reduced agricultural land resulted in reduced productivity of agricultural crops. Vigilance against increasing population pressure is an urgency for the government of Jawa Tengah Province in implementing a strategic program for the development of the agricultural sector in the future.

The highest minimum land area for decent living is owned by the City of Magelang with an area of 0.5 ha/person/year. This value is supported by the number of farmers of 1,049 people against a population that occupies this region in 2022 of 121,675 people. Meanwhile, the total agricultural land area is 206 ha. So that this Regency is classified on the existence of population pressure on land. The high population pressure on land through the ITP parameter illustrates that agricultural products in Magelang City are unable to meet the food needs of the population so that there is population pressure on land. This condition is evidenced by the low availability of agricultural land and low land productivity. There are many land uses other than agriculture so that the conversion of existing land functions is relatively high [20]. The land in this area is less productive but can be utilized based on the appropriate land capability.

The stability of agricultural land so that further land conversion does not occur, it is necessary to optimize agricultural land management efforts and reduce land conversion and divert the livelihoods of the farming population to the non-agricultural sector in districts with high population pressure on agriculture. One of the solutions offered in reducing population pressure is to increase the benefits of land for sharecroppers. High population pressure on agricultural land can result in a decrease in land resources and damage to ecosystems. This reflects the imbalance between the population and its growth rate with the availability of agricultural land.

Agricultural land has the potential to support the food security of a region. However, it cannot be denied that agricultural land has limitations in its processing. Limited land use needs to be identified or analyzed for land suitability to determine land capability in agricultural activities, especially in processing sustainable crop production. Sustainable crop production can meet food needs in a region. The increased demand for food is due to an increase in population accompanied by an increase in the use of agricultural land.

4 Conclusion

Jawa Tengah Province has a carrying capacity of agricultural land of 1.43. The value of population pressure in Jawa Tengah Province with a dominance of less than 1 indicates that districts/cities in Jawa Tengah Province are dominated by the carrying capacity of high agricultural land. Meanwhile, different conditions occurred in several areas of Jawa Tengah Province, namely there were 6 regencies/cities that experienced high population pressure and low land carrying capacity, namely Grobogan Regency, Blora Regency, Brebes Regency, Magelang City, Surakarta City, and Tegal City. Semarang City is an area with the highest carrying capacity of agricultural land in Jawa Tengah Province

because the irrigation conditions in Semarang City are supported by the West Flood Canal River and the soil conditions of this area are also dominated by alluvial soil types which are fertile and have sufficient nutrients and regional policies regarding Food security makes Semarang City have a high carrying capacity of agricultural land.

The high rate of population growth and not accompanied by an area of land capable of supporting the needs of the population can be a threat to the availability of sustainable agricultural land. Areas with a population density that works in the agricultural sector will experience greater population pressure than areas with a population density where the population works in the non-agricultural sector. This value indicates that there is an inverse relationship between the area of agricultural land which tends to decrease, while the population working in the agricultural sector increases. This condition causes people who work as farmers to lose agricultural land. One of the solutions offered in reducing population pressure is to increase the benefits of land for sharecroppers. High population pressure on agricultural land can result in a decrease in land resources and damage to ecosystems.

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