Population Pressure on Agricultural Land due to Land Conversion in the Suburbs of Yogyakarta

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Abstract. The agricultural sector is one of the sectors that has a multiplier effect on others in which ultimately affects the regional economy. The uncontrolled development of urban areas will threaten the existence of the agricultural sector due to the conversion of agricultural land into built-up areas and trigger an acceleration of migration which results in high population growth rates. The increasing rate of population growth will also increase the need for land for settlements, industry or services which leads to population pressure on agricultural land so that it affects the carrying capacity of the land. This study aimed to determine the level of population pressure on agricultural land and the level of carrying capacity of agricultural land on the suburbs of Yogyakarta City. The method used in this research was descriptive quantitative with the research location was on the suburbs of Yogyakarta and the main data source was secondary data. Population pressure on agricultural land was analyzed using the Otto Soemarwoto Model I formula which is presented in the form of tables and maps. The results of the analysis showed that population pressure on agricultural land on the suburbs of Yogyakarta exceeded the threshold (TP>1). Meanwhile, the carrying capacity of the land was very low in which the area was no longer able to carry out food self-sufficiency to meet the food needs of the population (α<1). Efforts that can be done to increase the carrying capacity of agricultural land are conservation, prevention and rehabilitation of agricultural resources.

1. Introduction
The increase in population is caused by natural factors such as births and deaths. In addition to natural factors, it is also influenced by migration factors [1]. Based on data from the Central Statistics Agency of Bantul and Sleman Regencies from 2011 to 2020, the general population on the suburbs of Yogyakarta increased by 4.06% from 457,975 people in 2011 to 477,375 people in 2020 with a population growth rate of 0.42%. The increasing population causes the need for land to increase and the conversion of agricultural land to residential land is inevitable. Conversion of agricultural land will be more widespread if it is not controlled, which in turn will also affect agricultural production. In fact, the protection of agricultural land has been carried out by the government through Law No. 10 of 2011 concerning the Protection of Sustainable Agricultural Land and the Sleman Regency Spatial Plan where it states that development carried out on rice fields must obtain a conversion permit and soil drainage systems. However, in fact, many people do not comply with these regulations. Law No. 10 of 2011 is expected to reduce the conversion of agricultural land into built-up land that cause high population pressure on agricultural land [2]. In the regulation, the value of population pressure can be used to determine the carrying capacity of an area. If the value of population pressure is less than one, the area's carrying capacity is still in normal capacity, while if the...
value of population pressure is more than one, the environmental carrying capacity of an area has been exceeded. High population pressure can cause environmental damage [3] since high population pressure can cause excessive carrying capacity of an area so that the environment is unable to recover and will continue to be damaged [2]. Population pressure can also lead to higher potential for environmental degradation [4] as well as causing widespread damage to agricultural land [5].

The increase in population is not only in line with the need for land for settlements and socio-economic activities, but also in line with the need for agricultural land to increase production so that the food needs of the population can be achieved. To determine the ability of an environment to be able to support life, it is necessary to analyse the carrying capacity of the land which depends on the percentage of land that can be used for agriculture and other industrial activities. Java's rice fields are generally less than 0.5 hectares per household [6]. With the increase in population, areas controlled by farmers tend to become increasingly narrow. Even more and more farmers now lose arable land. This situation causes increased population pressure on agricultural land. However, due to the limited area of agricultural land, the ability of an area to support life or what is often referred to as the carrying capacity of land is also becoming increasingly limited. The larger the agricultural land, the greater the carrying capacity of the land [7] and vice versa. Meanwhile, the higher the population or population pressure on agricultural land, the lower the carrying capacity [8].

There is an assumption that the population's needs will increase along with the increase in population and changes in lifestyle. As a result, resources tend to decrease and the concept of environmental carrying capacity was then coined [2]. Therefore, limited resources require a development plan that pays attention to proportional use so that optimal and sustainable environmental quality can be realised [9], [10].

2. Methodology

The research was conducted on the suburbs of Yogyakarta consisting of Sleman Regency and Bantul Regency. The suburbs of Yogyakarta in Sleman consist of three sub-districts, namely Gamping, Mlati and Depok Districts which include nine villages with four villages in Gamping District, three villages in Depok District and two villages in Mlati District. The suburbs of Yogyakarta in Bantul also consist
of three sub-districts, namely Banguntapan, Sewon and Kasihan sub-districts which include nine villages with five villages in Banguntapan sub-district, two villages in Sewon sub-district and two villages in Kasihan sub-district. For more details, the research location is presented in Figure 1.

The research method used was descriptive quantitative. Descriptive quantitative is a method of research aiming to measure or explain carefully certain phenomena and symptoms intended to prove the truth in the field [11]. The type of data used in this study was secondary data obtained from literature studies and related agencies, namely the Central Bureau of Statistics.

2.1. Data Analysis Technique

The analysis used in this study included analysis for Population Pressure and Land Carrying Capacity. The calculation of population pressure on agricultural land used model I proposed by Otto Soemarwoto, namely [12]:

\[ TP = \frac{Z f P_o (1+r)^t}{L} \]  

where:

- \( TP \) : Population Pressure
- \( Z \) : Minimum land area for decent living
- \( f \) : fraction (%) of farmers to total population
- \( P_o \) : Total population in the first year
- \( r \) : Population growth rate
- \( t \) : Time period
- \( L \) : Total agricultural land area

The value of Population Pressure (TP) is classified into three, namely:
- \( TP > 1 \), there is population pressure that exceeds the land capacity limit
- \( TP = 1 \), optimal use of agricultural land on land capability
- \( TP < 1 \), there has been no population pressure on the land or it can be said that the land is underutilized

The following formula is used to obtain the value of the minimum land area for decent living (Z) [7]:

\[ Z = \frac{0.25 L S I_2 + 0.50 L S I_1 + 0.50 L S T + (0.16 L L K)}{L S I_2 + L S I_1 + L S T + L L K} \]  

where:

- \( Z \) : minimum land area for decent living
- \( L S I_2 \) : area of harvested irrigated rice fields > 2x/year
- \( L S I_1 \) : area of irrigated rice fields harvested 1x/year
- \( L S T \) : area of rainfed rice field
- \( L L K \) : dry land area

The percentage of farmers in the population (f) is obtained by the following formula:

\[ f = \frac{\text{the number of farmers}}{\text{the number of population}} \times 100\% \]  

The population growth rate (r) is calculated using the following formula:

\[ r = \left( \frac{P_t}{P_o} \right)^\frac{1}{T} - 1 \]  

where:

- \( r \) : Population growth rate
- \( P_t \) : Total population in year t
- \( P_o \) : Total population in the first year
- \( T \) : time period

The calculation of the carrying capacity of the land is calculated using the following formula [13]:
\[ \alpha = \frac{X}{k} \]  

(5)

where

\( \alpha \): carrying capacity of land

\( X \): area of land available for cultivation of food crops/capita

\( K \): area of land required for self-sufficiency in food

The value of land area available for food crop cultivation per capita is obtained using the following formula:

\[ X = \frac{\text{rice field area}}{\text{the number of population}} \]  

(6)

The value of the land area required for food self-sufficiency is obtained using the following formula:

\[ k = \frac{\text{the minimum consumption per person}}{\text{average rice production/ha}} \]  

(7)

Minimum physical consumption is the average consumption of rice per person per year which this study used the value of 265 kg/capita/year or 2.65 kw/capita/year. As for the average rice production, the conversion value from paddy to rice is 68%.

The criteria for the carrying capacity of land are classified into:

- \( \alpha > 1 \), the area is capable of food self-sufficiency if the population is below the optimal population
- \( \alpha < 1 \), the area is not capable of food self-sufficiency if the population has exceeded the optimal population
- \( \alpha = 1 \), it means that the area has optimal carrying capacity

3. Results and Discussion

3.1. The Number of Population and Population Growth

The number of populations of Caturtunggal Village is much higher than that of other villages on the suburbs of Yogyakarta. In 2020, the population in Caturtunggal Village was 47,768 people. This is in contrast to Singosaren Village which has the lowest population among other villages. For more details, the number of populations is presented in Table 1.

| Districts | Sub-districts | Villages | Pt  | Po  | r    |
|-----------|---------------|----------|-----|-----|------|
| Bantul    | Banguntapan   | Wirokerten | 16465 | 13470 | 0.0203 |
|           |               | Singosaren | 4521  | 4478  | 0.0010 |
|           |               | Tamanan   | 14802 | 13258 | 0.0111 |
|           |               | Baturetno | 17771 | 16941 | 0.0048 |
|           |               | Banguntapan | 41528 | 49530 | -0.0175 |
| Bantul    | Sewon         | Panggungharjo | 32889 | 32989 | -0.0003 |
|           |               | Bangunharjo | 29152 | 28908 | 0.0008 |
| Bantul    | Kasihan       | Tirtonirmolo | 25249 | 24227 | 0.0041 |
|           |               | Tamantirto | 24767 | 26575 | -0.0070 |
|           |               | Ambarketawan | 23527 | 20775 | 0.0125 |
| Sleman    | Gamping       | Banyuraden | 18033 | 16090 | 0.0115 |
|           |               | Nogotirto | 19890  | 18270  | 0.0085 |
|           |               | Trihanggo | 19960  | 17349  | 0.0141 |
The highest population growth is in Maguwoharjo Village. For ten years, from 2011 to 2020, there was a population growth of 0.0274 per year. Meanwhile, the lowest population growth was in Catur Tunggal Village with a growth rate of -0.0254 per year.

3.2. Minimum Land Area for Decent Living

The area of land needed for a decent living can be known based on the area of paddy fields and dry land area. The area of land needed for a decent life is the area of land that can be used by residents to support their activities to work and meet their daily needs. The largest rice field area is in Tirtonirmolo Village with a land area of 150 Ha while the narrowest is in Singosaren Village with a land area of 12 Ha. The largest dry land area is in Maguwoharjo Village with an area of 143.96 Ha while the other seven villages do not own dry land including Wirokerten, Singosaren, Tamanan, Baturetno, Banguntapan, Sinduadi and Sendangadi villages.

| Table 2. Land Area for Decent Living (Z) |
|----------------------------------------|
| **Districts** | **Villages** | **Irrigation Rice Field** | **Dry Land** | **Z** |
| Banguntapan | Wirokerten | 132.32 | 0.250 |
| | Singosaren | 12.00 | 0.250 |
| | Tamanan | 132.89 | 0.250 |
| | Baturetno | 146.88 | 0.250 |
| | Banguntapan | 97.38 | 0.250 |
| Sewon | Panggungharjo | 168.00 | 8.00 | 0.246 |
| | Bangunharjo | 279.79 | 7.10 | 0.248 |
| Kasihan | Tirtonirmolo | 482.00 | 1.00 | 0.250 |
| | Tamanan | 150.00 | 1.50 | 0.249 |
| Gamping | Ambarketawang | 186.00 | 24.40 | 0.240 |
| | Banyuraden | 99.00 | 3.50 | 0.247 |
| | Nogotirto | 91.00 | 0.01 | 0.250 |
| | Trihanggo | 186.00 | 76.46 | 0.224 |
| Depok | Catur Tunggal | 33.00 | 109.70 | 0.181 |
| | Maguwoharjo | 254.05 | 143.96 | 0.217 |
| | Condongcatur | 62.95 | 49.34 | 0.210 |
| Mlati | Sinduadi | 70.00 | 0.250 |
| | Sendangadi | 137.00 | 0.250 |

Source: Analysis results, 2021

The index of land area needed to live decently on the suburbs of Yogyakarta is on average of 0.240. Nine villages such as Wirokerten, Singosaren, Tamanan, Baturetno, Banguntapan, Tirtonirmolo,
Nogotirto, Sendangadi and Sinduadi hold the highest index of land area with a value of 0.250. Meanwhile, Caturtunggal holds the lowest index value of the land area needed for a decent living with a value of 0.181.

3.3. Number of Farmers
The main livelihood of residents on the suburbs of Yogyakarta is not the agricultural sector. This is related to the decreasing area of existing agricultural land so that people who previously worked in the agricultural sector turned to work in the service sector and others. This is supported by the existence of many universities, both public and private, on the suburbs of Yogyakarta, which in turn will require a lot of service sectors such as food stalls, boarding houses, rented houses, laundry, photocopying and so on. The highest percentage of farmers to the total population is in Trihanggo Village with a value of 20.04% while the lowest is Catrurtunggal with a value of 0.31%. The more detailed information is presented in Figure 2.

3.4. Population Pressure on Agricultural Land
Population pressure on agricultural land on the suburbs of Yogyakarta in Bantul and Sleman Regencies occurred because population pressure exceeded the land capacity limit (TP>1). The highest value of population pressure occurs in Sinduadi Village, Mlati District and Sleman Regency with a TP value of 156.53. This is because in Sinduadi, there are several universities, both public and private, that become the pull factor for migration. While the lowest value of population pressure is in Tirtonirmolo Village, Kasihan District, Bantul Regency with a TP value of 13.61.

Things that need attention related to population pressure on agricultural land on the suburbs of Yogyakarta are population growth and land management that is able to provide optimal results with the area of productive agricultural land. During the ten-year period (2011-2020), population growth in the suburbs of Yogyakarta was 0.71% per year.
Another activity that can reduce population pressure on agricultural land is to open job vacancies other than agricultural sector so that exploitation of agricultural land will decrease for example is raising large livestock. It can be used to increase income and the feces can be used as manure to help increase land productivity. The current problems faced are related to the high population pressure on agricultural land, which is closely related to the dependence of the population on agricultural land, especially economic dependence. The link between population pressure, poverty and environmental damage is a vicious circle. Therefore, solving this problem must be done comprehensively [13].

### Table 3. Population Pressure on Agricultural Land in the Suburbs of Yogyakarta in 2020

| district | districts | village        | Z  | f  | Po     | r  | L    | TP  |
|----------|-----------|----------------|----|----|--------|----|------|-----|
| Bantul   | Wake up   | Wirokerten     | 0.25 | 2.55 | 16465  | 0.0203 | 132.32 | 38.03 |
|          |           | Singosaren     | 0.25 | 3.17 | 4521   | 0.0010 | 12.00  | 95.09 |
|          |           | garden         | 0.25 | 8.72 | 14802  | 0.0111 | 132.89 | 31.09 |
|          |           | Baturetno      | 0.25 | 0.40 | 17771  | 0.0048 | 146.88 | 31.73 |
|          |           | Wake up        | 0.25 | 3.80 | 41528  | -0.0175| 97.38  | 89.39 |
|          |           | Sewon          | 0.25 | 7.72 | 32889  | -0.0003| 176.00 | 45.81 |
|          |           | Panggunharjo   | 0.25 | 7.87 | 29152  | 0.0008 | 286.89 | 25.39 |
|          |           | Wake upharjo   | 0.25 | 5.11 | 25249  | 0.0041 | 483.00 | 13.61 |
|          |           | Tamantirto     | 0.25 | 9.85 | 24767  | -0.0070| 151.50 | 37.95 |
|          |           | Pity           | 0.25 | 3.72 | 14802  | 0.0111 | 146.88 | 31.73 |
|          |           | Tirtonirmolo   | 0.25 | 5.11 | 25249  | 0.0041 | 483.00 | 13.61 |
|          |           | Tamantirto     | 0.25 | 9.85 | 24767  | -0.0070| 151.50 | 37.95 |
|          |           | Sewon          | 0.25 | 7.72 | 32889  | -0.0003| 176.00 | 45.81 |
|          |           | Panggunharjo   | 0.25 | 7.87 | 29152  | 0.0008 | 286.89 | 25.39 |
|          |           | Wake upharjo   | 0.25 | 5.11 | 25249  | 0.0041 | 483.00 | 13.61 |
|          |           | Tamantirto     | 0.25 | 9.85 | 24767  | -0.0070| 151.50 | 37.95 |

Source: Analysis results, 2021
3.5. **Agricultural Land Carrying Capacity**

The value of carrying capacity of agricultural land among the research locations varied from one village to another, but the gap was not too high. The value of the carrying capacity among the areas was $\alpha<1$, meaning that they are not capable of self-sufficiency in food and the population has exceeded the optimal number of populations. The highest value of land carrying capacity is in Tamanan Village, Banguntapan District, Bantul Regency with a land carrying capacity value of 0.49. Meanwhile, the lowest value of land carrying capacity is in Condongcatur with the value of 0.03. The more detailed information is presented in Table 4 and figure 4.

![Figure 4 Map of the Distribution of Land Carrying Capacity](image)

Increasing the carrying capacity of agricultural land can be done with land intensification by using new technology and land conservation [14]. The carrying capacity of the land increases when the harvested area of food crops is wider. If an area is able to meet the minimum physical needs of its population, the area has a proportional land carrying capacity.
Table 4. The Value of The Carrying Capacity in The Suburbs of Yogyakarta in 2020

| Districts | Sub-districts | Villages   | Harvested Area | Total Population | X         | KFM       | Average Rice Production | k   | a    |
|-----------|---------------|------------|----------------|------------------|-----------|-----------|-------------------------|-----|------|
| Bantul    | Banguntapan   | Wirokerten | 416.00         | 16465            | 0.0253    | 265       | 3876.00                 | 0.0684 | 0.37 |
|           |               | Singosaren | 20.00          | 4521             | 0.0044    | 265       | 3876.00                 | 0.0684 | 0.06 |
|           |               | Tamanan    | 491.00         | 14802            | 0.0332    | 265       | 3876.00                 | 0.0684 | 0.49 |
|           |               | Baturetno  | 416.00         | 17771            | 0.0234    | 265       | 3876.00                 | 0.0684 | 0.34 |
|           |               | Banguntapan | 324.00       | 41528            | 0.0078    | 265       | 3876.00                 | 0.0684 | 0.11 |
| Bantul    | Sewon         | Panggungharjo | 168.00   | 32889            | 0.0051    | 265       | 3876.00                 | 0.0684 | 0.07 |
|           |               | Bangunharjo | 279.79        | 29152            | 0.0096    | 265       | 3876.00                 | 0.0684 | 0.14 |
| Bantul    | Kasihan       | Tirtonirmolo | 246.60    | 25249            | 0.0098    | 265       | 3876.00                 | 0.0684 | 0.14 |
|           |               | Tamantirto | 284.60         | 24767            | 0.0115    | 265       | 3876.00                 | 0.0684 | 0.17 |
| Sleman    | Gamping       | Ambarketawang | 637.00   | 23527            | 0.0271    | 265       | 4131.24                 | 0.0641 | 0.42 |
|           |               | Banyuraden  | 286.00         | 18033            | 0.0159    | 265       | 4160.84                 | 0.0637 | 0.25 |
|           |               | Nogotirto   | 267.00         | 19890            | 0.0134    | 265       | 4011.24                 | 0.0661 | 0.20 |
|           |               | Trihanggo   | 466.00         | 19960            | 0.0233    | 265       | 4131.07                 | 0.0641 | 0.36 |
| Sleman    | Depok         | Catur Tunggal | 161.70   | 47768            | 0.0034    | 265       | 3221.15                 | 0.0823 | 0.04 |
|           |               | Maguwoharjo | 644.70         | 37347            | 0.0173    | 265       | 3221.16                 | 0.0823 | 0.21 |
|           |               | Condongcatur | 101.50   | 45890            | 0.0022    | 265       | 3221.19                 | 0.0823 | 0.03 |
|           | Mlati         | Sinduadi    | 155.00         | 37649            | 0.0041    | 265       | 4113.32                 | 0.0644 | 0.06 |
|           |               | Sendangadi  | 342.00         | 20167            | 0.0170    | 265       | 4115.31                 | 0.0644 | 0.26 |

Source: Analysis results, 2021

4. Conclusion
Along with population growth and development, the conversion of agricultural land into built-up land has begun. Uncontrolled conversion of agricultural land can threaten the capacity of food providers and in the long run, it will cause social losses. The suburb of Yogyakarta is an effective area for agricultural land. However, population growth along with regional development resulted in changes in land use which resulted in a decrease in the area of agricultural land.

The results of the analysis showed that there has been population pressure on agricultural land on the suburbs of Yogyakarta (TP>1). The results can be used to determine the level of land carrying capacity in the area. This is because the value of the carrying capacity of the land contradict when compared to the value of population pressure. The results of the analysis indicate that the suburbs of Yogyakarta have low land carrying capacity so that the area is not able to be self-sufficient in food and the population has exceeded the optimal population. If this situation continues, environmental degradation can occur which then causes environmental quality to decline.

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