Identification of environmental conditions based on the carrying capacity and holding capacity analysis (case study: Kecamatan Barat, Magetan)

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Abstract. A rapid increase in population and unsustainable land use changes that are not following its capability are likely to lead to severe urban problems. An analysis of the carrying capacity and holding capacity of the environment is needed to determine whether lands can sustain the increasing population. The present research aims to identify the environmental conditions of the Kecamatan Barat based on the carrying capacity and holding capacity of land, water, and demography. Further, an overlay analysis is used to understand the overall carrying capacity level of the sub-district. Qualitative descriptive analysis is used to elaborate the study results. Two villages have deficits in the carrying capacity and capacity of land in West District in 2020, including Purwodadi and Tebon. Six villages are experiencing a water deficit in 2020, including Purwodadi, Karangsono, Bogorejo, Tebon, Manjung, and Mangge. All villages in Kecamatan Barat are still able to accommodate the projected population increase until 2042. The overlay of land, water, and demographic carrying capacity and water holding capacity shows 8, 4, and 2 villages with very high, high, and low overall carrying capacity values.

Keywords: Carrying Capacity, Holding Capacity, Natural Resource Management, Kecamatan Barat, Magetan

1. Introduction

Unsustainable development often leads to environmental degradation. Although natural resources to support human activities are limited in quantity and quality, development often sacrifices ecological protection [1]. The quality and quantity of natural resources may decline due to excessive long-term uses. Sustainable natural resource management must consider the balance while meeting human needs by paying attention to the welfare of social, economic life and the preservation of environmental functions [2].

Rapid population increase often requires land expansion as a container for activities. Unless properly controlled, land use changes may favor activities that are not suitable with land capabilities, leading to decreasing environmental carrying capacity and holding capacity [3]. History has revealed that population increase is inversely proportional to the environmental carrying and holding capacity, where the higher the population pressure, the lower the carrying and holding capacity [4]. Development needs to consider carrying capacity and holding capacity to prevent natural resource degradation [5]. Carrying capacity and holding capacity relate to the balance between natural resource availability and demand. Environmental carrying capacity and holding capacity include three aspects, namely population activities, natural resources, and the environment [6].
Kecamatan Barat is one of the sub-districts in Magetan Regency that has potential for rapid development. Kecamatan Barat experiences increasing population and land use changes that are not following its land capability. The present study aims to estimate the carrying and holding capacity of land, water, and demography to monitor the environmental conditions in the Kecamatan Barat. The results of this study are expected to become a reference for spatial planning processes.

2. Literature

2.1. Carrying Capacity
Carrying capacity and holding capacity of the environment describe the ability of the environment to support humans and other living things. The carrying capacity and holding capacity of the environment help monitor spatial planning so that natural resource uses do not exceed the environment's limits in supporting and accommodating human activities [7]. This capability includes the ability to provide space and to recover from disruptions. Spatial planning that ignores the environmental carrying and holding capacity will degrade environment quality, leading to recurrent disaster events.

2.2. Supply and Demand
Natural resources provide goods and services that can be used to meet the needs of the population. The carrying capacity and holding capacity concepts can be described using a supply and demand framework. The demand side is related to the consumption patterns of natural resources and environmental services, influenced by population increase and rapid development. The interaction of the demand and resources extracted will leave an ecological footprint that shows the ecosystem footprint per unit use of the resource. The supply-side describes how much (quantity and quality) natural resources can support human needs. This supply-side can be described, for example, with water and land balance. The interaction between supply and use will determine the carrying capacity and holding capacity of the environment.

2.3. Carrying Capacity Analysis
Carrying capacity analysis is a planning tool that provides an overview of the relationship between population, land uses, and the environment. Carrying capacity analysis can provide the necessary information in assessing the level of land capability to support human activities. Land use that is not following its capabilities tends to reduce environmental quality. Comparing land areas and the number of existing residents, the analysis can reveal a region's ability to support a development process. For example, the land's carrying capacity to support land uses will significantly depend on the primary factors of land, such as hydrological environment, slope, rock/soil, and others. The analysis will result in a critical threshold for the number of populations supported without degrading the natural environment.

3. Research Methods

3.1. Data Collection
Data used in the present study are primary and secondary. Information related to environmental conditions and land use changes is obtained from field observations and in-depth interviews with village officers. Secondary data are obtained from governmental reports and literature reviews. Secondary data includes population data (i.e., Kecamatan Barat in Figures), rainfall data, land use types, and administrative boundaries.

3.2. Land Carrying Capacity and Holding Capacity
The land carrying capacity and holding capacity describes whether land availability in an area is in a surplus or deficit state. A surplus or a deficit condition indicates that either land availability (S_L) in an area can (or cannot) meet the land demand (D_L). Assumptions are applied to estimate the land
availability and demand in the study area. Land availability is estimated using commodity production (rice and non-rice). Population, rice equivalent to decent living (360 kg/person/year), and rice productivity estimate land demand. It is worth noticing that a person consumes approximately 115.27 kg of rice/year in Indonesia [10].

The formulas are as follows:

a) Land Availability

\[
S_L = \frac{Pb_i \times Pnp_i}{Ptv_b}
\]

where:
- \( S_L \): Land availability (ha)
- \( Pb_i \): Rice production (kg)
- \( Pnp_i \): Non-rice production equivalent to rice (kg)
- \( Ptv_b \): Rice productivity (kg / ha)

b) Land Demand

\[
D_L = N \times KHL_L
\]

\[
KHL_L = \frac{Kb}{Ptv_b}
\]

where:
- \( D_L \): Total land requirement equivalent to rice (ha)
- \( N \): Population (people)
- \( KHL_L \): The area of land required for proper living per person: the need for decent living per person equivalent rice (Kb) divided by local rice productivity (Ptvb)
- \( Kb \): Assumed rice equivalent to decent living = 360 kg/person/year
- \( Ptv_b \): Rice productivity (kg/ha). Note: Regions that do not have data on local rice productivity can use the national average rice productivity data of 2400 kg/ha/year.

The land carrying capacity and holding capacity status is obtained from a comparison between land availability (\( S_L \)) and land demand (\( D_L \)).
- If \( S_L > D_L \), the land carrying capacity and holding capacity is a surplus.
- If \( S_L < D_L \), the carrying capacity and holding capacity is a deficit.

3.3. Water carrying capacity and holding capacity

The water carrying capacity and holding capacity analysis considers the supply and demand of water resources for the population in the study area. The analysis is used to determine whether the water resource is in a surplus or deficit state. If the availability of water in the study area is sufficient, this condition is surplus. On the other hand, the condition is a deficit when the water needs in the study area cannot be met.

Several assumptions are used to estimate the water supply and demand in the study area. The water supply in the study area is estimated using the runoff coefficient method modified from the rational method. The total water demand is a product of water demand for decent living and population. The amount of water demand for decent living is estimated using rice equivalent to decent living (480 kg/person/year) and water requirements per kg of rice (4m³/kg). It is worth mentioning that the value of rice equivalent to decent living 480 kg/person/year is higher than the value used in the estimation of land carrying capacity and holding capacity. The reason is that water is needed for varying activities, including domestic, industrial, and agricultural activities.
4

a) Calculation of water supply

\[ C = \frac{\sum (C_i \times A_i)}{\sum A_i} \]
\[ R = \frac{m}{\sum R_i} \]
\[ S_A = 10 x C x R x A \]

where:
- \( S_A \): Water supply (m\(^3\) / year)
- \( C \): Weighted runoff coefficient
- \( C_i \): Land use runoff coefficient
- \( A_i \): Area of land use (ha)
- \( R \): Algebraic mean of the region’s annual rainfall (mm/year)
- \( R_i \): Annual rainfall at a station (mm)
- \( m \): Number of rainfall observation stations
- \( A \): Area (ha)
- 10: Conversion factor of mm.ha becomes m\(^3\)

b) Water Demand

\[ D_A = N \times KHL_A \]
\[ KHL_A = Kb \times Q_{ab} \]

where:
- \( D_A \): Total water requirement (m\(^3\) / year)
- \( N \): Population (people)
- \( KHL_A \): Water demand to live properly
- \( Kb \): Rice equivalent to decent living = 480 kg/person/year
- \( Q_{ab} \): Water Requirements per Kg of rice = 4m\(^3\) / kg

The water carrying capacity and holding capacity status is obtained from the comparison between water availability (\( S_A \)) and water demand (\( D_A \)):
- \( S_A > D_A \), water carrying capacity is surplus
- \( S_A < D_A \), water carrying capacity is a deficit

3.4. Demographic carrying capacity and holding capacity

Demographic carrying capacity is the minimum productive land area capable of supporting a decent living. The demographic carrying capacity and holding capacity of Kecamatan Barat is estimated using land area and population data. The input for the analysis is the population projection, which can be obtained with an exponential model:

\[ r = \frac{1}{t} \ln \left( \frac{P_t}{P_0} \right) \]
\[ P_t = P_0 \times e^{nt} \]

where:
- \( P_t \): population in year \( t \)
- \( P_0 \): population in the starting year
- \( r \): population growth rate (%), using population data in 2006, 2013, 2015, 2017, 2019
- \( t \): the period between the initial year and the year \( t \)
- \( e \): the base number of the natural logarithmic system (2.7182818)
- \( n \): year period
The standard per capita land requirement to determine the quality of demographic carrying capacity is based on Yeates [8] and KLH [9].

### Table 1. Per Capita Land Requirements

| No. | Population | Minimum Land Consumption (Klm) (ha/person) | Population Density (person/ha) |
|-----|------------|-------------------------------------------|--------------------------------|
| 1   | 10,000     | 0,1                                       | 10                             |
| 2   | 25,000     | 0,091                                     | 11                             |
| 3   | 50,000     | 0,086                                     | 12                             |
| 4   | 100,000    | 0,076                                     | 13                             |
| 5   | 250,000    | 0,070                                     | 14                             |
| 6   | 500,000    | 0,066                                     | 15                             |
| 7   | 1,000,000  | 0,061                                     | 16-17                          |
| 8   | 2,000,000  | 0,057                                     | 18                             |

The formula for calculating the demographic carrying capacity:

\[ A = \frac{L}{P} \]

where:
- A : Demographic carrying capacity
- L : Land area (ha)
- P : Population

The demographic carrying capacity and holding capacity status is obtained from the comparison between Demographic Capacity (A) and Minimum Land Consumption (Klm):

- A < Klm, demographic carrying capacity is surplus
- A > Klm, demographic carrying capacity is a deficit

### 3.5. Combining land, water, and demographic carrying capacity and holding capacity

Overlay analysis is performed to understand the overall carrying capacity and holding capacity level of villages in Kecamatan Barat. The maps of land, water, and demographic carrying capacity and holding capacity are superimposed and classified into five classes from very low to very high. An interval method is used to categorize the results. The minimum and maximum scores for each aspect with a very low and a very high level are 1 and 5, respectively. Thus, the minimum and maximum scores for a very low and a very high carrying capacity and holding capacity level are 3 and 15, consecutively, combining the three aspects.

### Table 2. Class Interval

| Class   | Score |
|---------|-------|
| Very Low| 3 – 6 |
| Low     | 7 – 8 |
| Moderate| 9 – 10|
| High    | 11 – 12|
| Very High| 13 – 15|
4. Result and Discussions

4.1. Land Carrying Capacity and Holding Capacity

Table 3 and Figure 1 show a table and a map of the level of land carrying capacity and holding capacity (D3TLH) in Kecamatan Barat. Two villages, namely Purwodadi and Tebon, have a deficit of D3DTLH in 2020. Meanwhile, twelve other villages still have land surplus conditions.

Table 3. Land Carrying Capacity of Kecamatan Barat

| Villages   | (N) Population 2019 | (Ptvb) Rice Field Productivity 2017 (Kg/Ha) | DL (Land Demand) (ha) | (Pb) Rice Production 2017 (Kg) | (Pnp) Non Rice Production 2017 (Kg rice equivalent) | (SL) Land Availability (Ha) = (Pb+Pnp)/Ptvb | Land Carrying Capacity Value (πL = SL/DL) | Carrying Capacity Status |
|------------|---------------------|-------------------------------------------|-----------------------|--------------------------------|-----------------------------------------------------|------------------------------------------|------------------------------------------|--------------------------|
| Banjarrejo | 1.264               | 6016                                      | 76                    | 547.500                        | 51.600                                              | 100                                      | 1,3166                                   | Surplus                  |
| Purwodadi  | 2.528               | 6032                                      | 151                   | 549.000                        | 24.300                                              | 95                                       | 0,6299                                   | Deficit                  |
| Karangsono | 2.347               | 5955                                      | 142                   | 851.700                        | 0                                                   | 143                                      | 1,0080                                   | Surplus                  |
| Bogorejo   | 2.468               | 6150                                      | 144                   | 2.011.100                      | 87.100                                              | 341                                      | 2,3616                                   | Surplus                  |
| Tebon      | 1.941               | 6098                                      | 115                   | 555.000                        | 13.600                                              | 93                                       | 0,8137                                   | Deficit                  |
| Manjung    | 2.655               | 5918                                      | 162                   | 1.394.500                      | 23.600                                              | 240                                      | 1,4837                                   | Surplus                  |
| Panggung   | 2.832               | 6078                                      | 164                   | 3.495.400                      | 35.100                                              | 581                                      | 3,4629                                   | Surplus                  |
| Klagen     | 3.061               | 6153                                      | 179                   | 3.593.600                      | 48.900                                              | 592                                      | 3,055                                   | Surplus                  |
| Ngumpul    | 1.285               | 6194                                      | 75                    | 1.362.800                      | 29.000                                              | 225                                      | 3,0086                                   | Surplus                  |
| Bangunsari | 1.822               | 6151                                      | 107                   | 1.519.400                      | 29.100                                              | 252                                      | 2,3608                                   | Surplus                  |
| Blaran     | 2.492               | 5989                                      | 150                   | 2.276.000                      | 22.300                                              | 384                                      | 2,5619                                   | Surplus                  |
| Mangge     | 3.150               | 5998                                      | 189                   | 2.969.200                      | 0                                                   | 495                                      | 2,6183                                   | Surplus                  |
| Jonggrang  | 2.202               | 6061                                      | 131                   | 3.454.900                      | 0                                                   | 570                                      | 4,3583                                   | Surplus                  |
| Rejomulyo  | 1.855               | 6123                                      | 109                   | 1.402.200                      | 41.500                                              | 236                                      | 2,1619                                   | Surplus                  |

Source: Analysis, 2020

Figure 1. Land Carrying Capacity and Holding Capacity (D3TLH)

Source: Analysis, 2020
4.2. Water Carrying Capacity and Holding Capacity

Water demands are calculated based on the requirement of a decent life. If water availability is higher than water demand, the water carrying capacity is declared a surplus. On the contrary, if water availability is less than water demand, the carrying capacity is a deficit [9]. Table 4 and Figure 2 show a table and map of the level of water carrying capacity (D3TLH) in Kecamatan Barat. Six villages, including Purwodadi, Karangsono, Bogorejo, Tebon, Manjung, and Mangge experienced water deficits in 2020. Eight other villages still had a water surplus status in 2020. It is worth noticing that the present study does not directly measure the river discharge. The discharge serves as an input for estimating the water availability. The discharge value is obtained from the product of rainfall, area, and weighted discharge coefficient. The weighted discharge coefficient value is 0.94 and is derived for the sub-district based on land uses [9]. The rainfall is assumed similar for the whole villages. Thus, the river discharge values are also similar for the whole villages.

Table 4. Water Carrying Capacity of Kecamatan Barat

| Villages  | (N) Population 2019 (person) | (Dₐ) Total water need (m³/year)* | Rainfall (mm/year) | Discharge** (A) Area (ha) | Water Carrying Capacity (πA = Sₐ/Dₐ) | Water Carrying Capacity Status |
|-----------|-----------------------------|----------------------------------|-------------------|-------------------------|--------------------------------------|-------------------------------|
| Banjarrejo | 1.264                       | 2.426.880                        | 3969              | 2730.86                 | 95                                   | 2.594.317,00                 | Surplus                       |
| Purwodadi  | 2.528                       | 4.853.760                        | 3969              | 2730.86                 | 123                                  | 3.358.957,80                 | Deficit                       |
| Karangsono | 2.347                       | 4.506.240                        | 3969              | 2730.86                 | 93                                   | 2.539.699,80                 | Deficit                       |
| Bogorejo   | 2.468                       | 4.738.560                        | 3969              | 2730.86                 | 151                                  | 4.123.598,60                 | Deficit                       |
| Tebon      | 1.941                       | 3.726.720                        | 3969              | 2730.86                 | 75                                   | 2.048.145,00                 | Deficit                       |
| Manjung    | 2.655                       | 5.097.600                        | 3969              | 2730.86                 | 135                                  | 3.686.661,00                 | Deficit                       |
| Panggung   | 2.832                       | 5.437.440                        | 3969              | 2730.86                 | 253                                  | 6.909.075,80                 | Deficit                       |
| Klagen     | 3.061                       | 5.877.120                        | 3969              | 2730.86                 | 316                                  | 8.629.517,60                 | Surplus                       |
| Ngumpul    | 1.285                       | 2.467.200                        | 3969              | 2730.86                 | 107                                  | 2.922.020,20                 | Surplus                       |
| Bangunsari | 1.822                       | 3.498.240                        | 3969              | 2730.86                 | 132                                  | 3.604.735,20                 | Surplus                       |
| Blaran     | 2.492                       | 4.784.640                        | 3969              | 2730.86                 | 188                                  | 5.134.016,80                 | Surplus                       |
| Mangge     | 3.150                       | 6.048.000                        | 3969              | 2730.86                 | 191                                  | 5.215.942,60                 | Surplus                       |
| Jonggrang  | 2.202                       | 4.227.840                        | 3969              | 2730.86                 | 266                                  | 7.264.087,60                 | Deficit                       |
| Rejomulyo  | 1.855                       | 3.561.600                        | 3969              | 2730.86                 | 147                                  | 4.014.364,20                 | Surplus                       |
| Total      | 31.902                      | 61.251.840                       | 55566             | 38232,04                | 2.272                                | 62.045.139,20                | Surplus                       |

* Dₐ = (Kb) rice equivalent to decent living (kg/person/year) x (Qab) Water Requirements per Kg of Rice (4m³/kg) * population (N)

** Discharge: (Rainfall *0.94) – 1000.

Source: Analysis, 2020
4.3. Demographic Carrying Capacity and Holding Capacity
Table 5 shows that all villages in Kecamatan Barat have a positive population growth rate. The highest and lowest growth rates are in Banjarejo and Klagen villages, with a value of 1.17% and 0.88%, respectively.

Table 6 provides the population projection for all villages in Kecamatan Barat until 2042. Table 6 and Figure 3 show the demographic carrying capacity of Kecamatan Barat. All villages can still support population growth until 2042. Nevertheless, both spatial and aspatial (i.e., facilities and infrastructure) are needed to balance the supply and demand of demographic carrying capacity and holding capacity.

The population in an area tends to increase every year. This increase represents the need for land for settlements and other uses. Table 7 shows that the demographic capacity in all villages in Kecamatan Barat is below the minimum land consumption (ha/person). Thus, it can be concluded that the sub-district can still accommodate population increase until 2042.

Table 5. Population growth rate (%) Kecamatan Barat

| Villages  | 2006 | 2013 | 2015 | 2017 | 2019 | Growth Rate (%) |
|-----------|------|------|------|------|------|-----------------|
| Banjarrejo| 1,078| 1,114| 1,220| 1,247| 1,264| 1.1725          |
| Purwodadi | 2,374| 2,401| 2,376| 2,454| 2,528| 1.0649          |
| Karangsono| 2,500| 2,591| 2,253| 2,290| 2,347| 0.9388          |
| Bogorejo  | 2,368| 2,402| 2,354| 2,386| 2,468| 1.0422          |
| Tebon     | 2,031| 2,042| 1,918| 1,925| 1,941| 0.9557          |
| Manjang  | 2,877| 2,935| 2,627| 2,589| 2,655| 0.9228          |
| Panggung | 3,000| 2,968| 2,836| 2,775| 2,832| 0.9440          |
| Klagen    | 3,442| 3,437| 2,965| 2,996| 3,061| 0.8893          |
| Ngumpul  | 1,235| 1,271| 1,313| 1,289| 1,285| 1.0405          |
| Bangunsari| 1,690| 1,696| 1,773| 1,786| 1,822| 1.0781          |
| Villages | Population | Growth Rate (%) |
|----------|------------|-----------------|
|          | 2006 | 2013 | 2015 | 2017 | 2019 |          |
| Blaran   | 2,685 | 2,748 | 2,491 | 2,494 | 2,492 | 0.9281 |
| Mangge   | 3,269 | 3,304 | 3,178 | 3,166 | 3,150 | 0.9636 |
| Jonggrang| 2,339 | 2,393 | 2,216 | 2,180 | 2,202 | 0.9414 |
| Rejomulyo| 1,973 | 1,981 | 1,828 | 1,831 | 1,855 | 0.9402 |

### Table 6. Population Projection of Kecamatan Barat

| Villages     | Growth rate (%) | Population projection |
|--------------|-----------------|-----------------------|
|              | 2022 | 2027 | 2032 | 2037 | 2042 |
| Banjarrejo   | 1.1725 | 1.326 | 1.436 | 1.555 | 1.661 | 1.823 |
| Purwodadi    | 1.0649 | 2.576 | 2.658 | 2.743 | 2.748 | 2.921 |
| Karangsono   | 0.9388 | 2.303 | 2.231 | 2.162 | 2.044 | 2.030 |
| Bogorejo     | 1.0422 | 2.499 | 2.551 | 2.604 | 2.570 | 2.714 |
| Tebon        | 0.9557 | 1.915 | 1.872 | 1.830 | 1.774 | 1.749 |
| Manjung      | 0.9228 | 2.592 | 2.490 | 2.392 | 2.241 | 2.207 |
| Panggung     | 0.9440 | 2.783 | 2.704 | 2.628 | 2.502 | 2.480 |
| Klagen       | 0.8893 | 2.955 | 2.877 | 2.628 | 2.426 | 2.337 |
| Ngumpul      | 1.0405 | 1.300 | 1.326 | 1.353 | 1.384 | 1.408 |
| Bangunsari   | 1.0781 | 1.864 | 1.935 | 2.009 | 2.045 | 2.166 |
| Blaran       | 0.9281 | 2.437 | 2.348 | 2.262 | 2.181 | 2.099 |
| Mangge       | 0.9636 | 3.115 | 3.058 | 3.002 | 2.962 | 2.892 |
| Jonggrang    | 0.9414 | 2.162 | 2.098 | 2.036 | 1.956 | 1.917 |
| Rejomulyo    | 0.9402 | 1.821 | 1.766 | 1.712 | 1.639 | 1.610 |

### Table 7. Demographic Carrying Capacity and Holding Capacity of Kecamatan Barat

| Village | Area (ha) | Population Projection | A=Demographic Capacity (ha/person) | Minimum Land Consumption (Klm) (ha/person)* | Surplus / Deficit** |
|---------|-----------|-----------------------|-----------------------------------|---------------------------------------------|--------------------|
|         | 2022 | 2027 | 2032 | 2037 | 2042 | 2022 | 2027 | 2032 | 2037 | 2042 | Minimum Land Consumption (Klm) (ha/person)* | Surplus / Deficit** |
| Banjarrejo | 95   | 1.326 | 1.436 | 1.555 | 1.661 | 1.823 | 0.07 | 0.07 | 0.06 | 0.06 | 0.05 | 0.1 | A<Klm |
| Purwodadi   | 123  | 2.576 | 2.658 | 2.743 | 2.748 | 2.921 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.1 | A<Klm |
| Karangsono   | 93   | 2.303 | 2.231 | 2.162 | 2.044 | 2.030 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.1 | A<Klm |
| Bogorejo    | 151  | 2.499 | 2.551 | 2.604 | 2.570 | 2.714 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.1 | A<Klm |
| Tebon       | 75   | 1.915 | 1.872 | 1.830 | 1.774 | 1.749 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.1 | A<Klm |
| Manjung     | 135  | 2.592 | 2.490 | 2.392 | 2.241 | 2.207 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.1 | A<Klm |
| Panggung    | 253  | 2.783 | 2.704 | 2.628 | 2.502 | 2.480 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.1 | A<Klm |
| Klagen      | 316  | 2.955 | 2.787 | 2.628 | 2.426 | 2.337 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.1 | A<Klm |
| Ngumpul     | 107  | 1.300 | 1.326 | 1.353 | 1.384 | 1.408 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.1 | A<Klm |
| Bangunsari   | 132  | 1.864 | 1.935 | 2.009 | 2.045 | 2.166 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.1 | A<Klm |
| Blaran      | 188  | 2.437 | 2.348 | 2.262 | 2.181 | 2.099 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.1 | A<Klm |
| Mangge      | 191  | 3.115 | 3.058 | 3.002 | 2.962 | 2.892 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.1 | A<Klm |
| Jonggrang   | 266  | 2.162 | 2.098 | 2.036 | 1.956 | 1.917 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.1 | A<Klm |
| Rejomulyo   | 147  | 1.821 | 1.766 | 1.712 | 1.639 | 1.610 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.1 | A<Klm |
4.4. Overlaying Carrying Capacity and Holding Capacity

Overlay analysis of land, water, and demographic carrying capacities is performed to understand villages' overall carrying capacity level in Kecamatan Barat. Figure 4 shows that villages that have very high level with score (13-15) are Banjarrejo, Panggung, Klagen, Ngumpal, Bangunsari, Blaran, Jonggrangan, and Rejomulyo. Village with a high level (score 11-12) are Mangge, Manjung, Karangsono, and Bogorejo. Finally, Purwodadi and Tebon have a low level (score 7-8).
5. Conclusions
The present study concludes that two villages (Purwodadi and Tebon) have a land deficit, and six villages (Purwodadi, Karangsono, Bogorejo, Tebon, Manjung, and Mangge) are experiencing a water deficit in 2020. All villages are still able to accommodate the projected population growth until 2042. Finally, the overlay analysis of the land, water, and demographic carrying capacity and holding capacity shows that eight, four, and two villages have very high, high, and low carrying capacity values, respectively.

The present study is not without limitations. Data to estimate the land and water carrying capacity and holding capacity is assumed to be rice equivalent. Other approaches to estimate the carrying capacity and water holding capacity can enrich information to support sustainable development in the study area. Also, the present study only focuses on the natural resource quantity to support activities. Further studies incorporating the quality of natural resources are recommended.

6. References
[1] Efendi, “Penerapan Prinsip Pengelolaan Lingkungan Hidup dalam Peraturan Perundang-undangan Bidang Sumber Daya (Kajian dari Perspektif Politik Pembangunan Hukum)”, Kanun Jurnal Ilmu Hukum, No. 58, (Desember 2012), hlm. 346.
[2] Sabila S. (2020). Daya Dukung Pangan Dalam Mendukung Ketersediaan Pangan Provinsi Sumatera Selatan. Jurnal Tanah dan Sumberdaya Lahan. Vol 7 No.1:59-68,2020
[3] Clark, J. R. 1992. Integrated Management Of Coastal Zones. FAO Fisheries Technical Paper No. 327. United Nations/FAO, Rome. 167 PP.
[4] Muta'ali, L. (2012). Daya Dukung Lingkungan untuk Perencanaan Pengembangan Wilayah. Yogyakarta: Badan Penerbit Fakultas Geografi (BPF) UGM
[5] Muta'ali, L. (2015). Teknik Analisis Regional untuk Perencanaan Wilayah, Tata Ruang dan Lingkungan. Yogyakarta: Badan Penerbit Fakultas Geografi (BPF) Universitas Gadjah Mada

Figure 4. Overlay of Land, Water, and Demographic Carrying Capacity and Holding Capacity
Source: Analysis, 2020
[6] Maria, R. P., Sangkertadi, & Supardjo, Suryadi. (2018). Analisis Daya Dukung Dan Daya Tampung Lahan Di Kecamatan Malalayang Kota Manado, 15(2), 36–49.

[7] Kementerian Lingkungan Hidup. (2014). Pedoman Penentuan Daya Dukung dan Daya Tampung Lingkungan Hidup. Kementerian Lingkungan Hidup, 1–47.

[8] Yeates, M. 1980. "The North American Cities." Ontario: Queen University Ontario.

[9] KLH. 2014. Pedoman Penentuan Daya Dukung dan Daya Tampung Lingkungan Hidup. Deputi Menteri Lingkungan Hidup Bidang Tata Lingkungan. Kementerian Lingkungan Hidup. Jakarta.

[10] BPS. 2017. Kajian Konsumsi Bahan Pokok Tahun 2017. ISBN : 978-602-438-277-3