ANALISIS KAPASITAS PERAWATAN AIR UNTUK PERENCANAAN PERENCANAAN DAERAH DI KABUPATEN MALANG

ANALYSIS OF WATER CARRYING CAPACITY FOR REGIONAL PLANNING DEVELOPMENT IN MALANG REGENCY

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Abstrak
Peningkatan jumlah penduduk di Kota Malang memiliki pengaruh yang signifikan terhadap degradasi lingkungan di zona penyangga, Kabupaten Malang. Kabupaten ini menyediakan sumber daya alam dan mengumpulkan sisa-sisa aktivitas manusia dari daerah perkotaan mengalami tren penurunan daya dukung lingkungan, sehingga menyulitkan untuk memenuhi kebutuhan penduduknya sendiri. Penelitian ini bertujuan menganalisis daya dukung air sebagai modal dasar perencanaan pembangunan di Kabupaten Malang. Metode penelitian menggunakan pendekatan Supply-Demand, yang berarti perhitungan daya dukung air berdasarkan kebutuhan masa depan dan kondisi saat ini. Hasil penelitian menunjukkan bahwa daya dukung Kabupaten Malang menunjukkan wilayah ini mengalami defisit pasokan air sebesar 0,95% per tahun.

Kata Kunci: Daya Dukung, Sumber Daya Air, Kabupaten Malang, Layanan Ekosistem

Abstract
The increase of population in Malang City has a significant effect on environmental degradation in the buffer zone, Malang Regency. This regency provides natural resources and collect the remnants of human activity from urban areas experiences a declining trend in environmental carrying capacity, thus it makes difficult to meet the needs of its own population. This research was aimed at analyzing the water carrying capacity as the capital base for development planning in Malang Regency. The research method uses the Supply-Demand approach, which means the calculation of the carrying capacity of water based on future needs and current conditions. The result showed that the carrying capacity of Malang Regency indicated this region experienced a water supply deficit of 0.95% per year.

Keywords: Carrying Capacity, Water Resource, Malang Regency, Ecosystem Service.

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INTRODUCTION

The city is a small part of the total land area of the world, only 5% of the total area of the world today. However, a small portion of the planet Earth will be inhabited by more than 65% of the total population of the earth by 2050. This is caused by an inalienable process of urbanization. The city life has attracted everyone living in the city. Therefore, to accommodate the growing urban population, various facilities and utilities are built, such as building for housings and offices, roads for transportation so that the city will be filled with buildings, increased gas emission, concrete, asphalt, lack of vegetation, and high energy consumption. Finally, they will deliver to the urban warming phenomenon.

Increasing the number in population has an impact on enhancement the pace of development in various economic sectors in order to meet the needs of living organism. This has resulted in degradation of environmental conditions worldwide due to the increasing consumption of natural resources to accommodate human activities. Meanwhile, the availability of natural resources has a limited quantity.

The current trends of water resources are experiencing a downward in both quality and availability. This happens because the management of water resources that does not pay attention to the carrying capacity of the environment in upstream, as well as in downstream.

In an attempt to achieve the goal of sustainable development, the environment is one of the important aspects, thus economic growth and social welfare achievement are expected not to neglect the preservation of environmental functions. As an effort to give attention to the current environmental conditions for future development, a review of environmental aspects is very important to be carried out and integrated into development planning. Therefore, the implementation of environmental review that emphasizes the limits of environmental capabilities and standards for human needs is important for future development. This is also included in the Malang Regency as one of the largest providers of ecosystem services for the East Java.

Geographically, Malang Regency is one of the ecological support basis in Indonesia. This regency consist of large range of paddy field, which produce the biggest agricultural product and also stimulus of agricultural commodity market in East Java. A half of the total area in Malang Regency is paddy field, so agricultural is the main economy sector and biggest contributor towards Gross Regional Domestic Product. On the other hand, incessant of development implementation often neglected environmental quality, such as industrial development and housing in Malang Regency resulted in the conversion of rice fields.

The increasing number of industrial and residential area without regard for environmental condition can lead to higher levels of pollution and environmental degradation. Based on report data, environmental quality standard especially in watershed area still below the parameter standard. Classification of water quality in East Java Province has been established by Government Regulation No 82/2001 on water quality management and water pollution. To minimalize all of the negative effect and to sustain environmental condition as the supporting role for development, Malang Regency have to balancing between development rate and environment preservation.

Environment carrying capacity is the ability to support humans, other living things, and the balance between those two. Based on that definition, the concept of carrying capacity in general can be seen from two sides, namely:
In terms of availability, by seek regional characteristics and potential natural resources in a region, and in terms of needs, i.e. see human needs and other living creatures and directives priority policy of a region

Malang Regency is a region with a relatively high population growth rate with high water needs. Thus, to be able to always meet the needs of the population, it is necessary to arrange the potential and utilization of water so that its availability is maintained throughout the year. Therefore, this study wants to analyze the current state of water carrying capacity, especially in rural landscape based on supply and demand side.

**METODE PENELITIAN**

In general, the concepts of carrying capacity can be illustrated through the framework of demand and supply side framework. The demand side calculated based on needs and consumption patterns of natural resources such as land, water and other resources. This demand will be much influenced by the increase of population. While the supply side illustrates how many amount (either in quantity and quality) of natural resources is able to support people needs.

The analytical method used to determine the carrying capacity is Stock Analysis (KLH, 2014), by calculating the availability of available natural resources. The results of the comparison will indicate whether the water carrying capacity is in a state of surplus (not exceeded) or deficit (exceeded). The surplus indicates that the availability of water in an area is still sufficient for domestic and non-domestic water needs, while the deficit situation shows that the availability of water is no longer able to meet the needs of water resources.

The data were collected from primary and secondary sources in relevant institutions, journals, and others. Then, the data analysis was conducted by applying a quantitative and descriptive analysis method. The quantitative method was used to analyze the water carrying capacity involving mathematical formulas. Meanwhile, the descriptive method was utilized to analyze the recommendations resulted from the calculation. The formulas used for calculating the water carrying capacity by Widodo et al. (2015) are as follows:

(i). **Water Resources Carrying Capacity**

\[ DDA = \frac{SA}{DA} \]

Note:
- DDA = Water Resources Carrying Capacity
- SA = Water Availability
- DA = Water Demand

- DDA<1 = The Water Resources Carrying Capacity is overshoot;
- DDA 1-3 = The Water Resource Carrying Capacity is conditionally-save;
- DDA>3 = The Water Resource Carrying Capacity is save.

(ii). **Water Availability**

\[ C = \frac{\sum (ci \times Ai)}{\sum Ai} \]

Note:
- \( S_i \) = water availability (m³/year)
- \( C_i \) = coefficient of weighted runoff
- \( C_i \) = coefficient of land use runoff i as shown in the following table
- \( Ai \) = extent of land use i (Ha)
- \( R \) = average of annual rainfall of the area (mm/year)
- \( Ri \) = annual rainfall on i station
- \( m \) = number of rainfall observation stations
- \( A \) = extent of the area (Ha)
- \( 10 \) = conversion factor

(iii). **Water Demand**

\[ DA = DAD + DAND \]
a. Demand for domestic water (DAD)
- Village (rural): 80 liters/day/capita
- City (urban): small city 100 liters/day/capita. And average big city 150 liters/day/capita

b. Demand for Non-Domestic Water (DAND)
- Livestock: 40 liters/day/lives for cows/buffalos/horses, 5 liters/day/lives for goats/sheep, 6 liters/day/lives for pigs, and 0.6 liters/day/lives for pultry;
- Fishery: 7 liters/day/lives for ponds with the depth < 70 cm;
- Agriculture: 1 liters/second/hectare for paddy, and 0.3 liters/second/hectare for dry-crops, dry-land paddy, and moorland plants/garden;
- Industry, based on the number of employees, assumed: 500 liters/day/employee.

RESULT
To determine the water carrying capacity of an area can be done by comparing the availability of water with the demand in the region. To calculate the level of water availability, require the extent of land utilization and runoff coefficient, the average rainfall is also needed. The result from the calculation, the value water carrying capacity is 0.95. It can be concluded that The Water Resources Carrying Capacity in Malang Regency has been overshoot.

A. Water Availability

### Table 1. Water Availability Analysis

| No | Water Resources | KOEFISIEN LIMPASAN (Ci) | LUAS LAHAN Ai (Ha) | Ci x Ai |
|----|-----------------|-------------------------|--------------------|--------|
| A  | LAHAN SAWAH     |                         |                    |        |
| 1  | LAHAN PERTANIAN |                         |                    |        |
|    | PEKARANGAN AN TIDAK DITANAMI | 0.15 | 0 |
Analysis of Carrying Capacity for Regional Planning Development

| Water Resources | KOEFISIEN LIMPASAN (Ci) | LUAS LAHAN Ai (Ha) | Ci x Ai | Water Resources | Koefisien Limpasan (Ci) | Luas Lahan Ai (Ha) | Ci x Ai |
|-----------------|--------------------------|--------------------|---------|-----------------|--------------------------|--------------------|---------|
| HUTAN RAWA      | 0.07                     | 148.604            | 10.40228| PASIR PANTAI    | 0.2                      | 1069.554           | 213.9108|
| RAWA            | 0.07                     | 84.2               | 5.894   | EMPANG          | 0.05                     | 122.751           | 6.13755|
| PASIR PANTAI    | 0.2                      | 122.751            | 26.82   | TANAH BERBATU   | 0.2                      | 191.153           | 38.2306|
| TOTAL           |                          | 345154.102         | 1095.313| TOTAL           |                          |                    |         |

C = 0.31734

LUAS WILAYAH = 2997705

R = 1596 mm/tahun

S = 10 X C X R X A

DAS Brantas = 101,075,000,000

TOTAL = 116,257,629,008 L/tahun

B. Water Demand for Domestic and Non-domestic Use per Year

KA = N x KHLA

Keterangan:
KA = Total kebutuhan air (m³/tahun)
N = Jumlah penduduk (orang)
KHLA = Kebutuhan air untuk hidup layak

Domestic water demand is the water required for households obtained individually from water sources made by each household such as shallow wells, pipes or public hydrants or can be obtained from PDAM Water Supply System (SPAM) service. While non-domestic water demand is the water required for fulfill urban activities.

Tabel 2. Water Demand Analysis of Domestic and Non-domestic Use

| District | Population Number | House Hold | Domestic Water Deman (L/year) | Non-domestic Water Demand (L/year) |
|----------|-------------------|------------|-------------------------------|-----------------------------------|
| Donomulyo| 62,596            | 18,502     | 2,284,75                      | 571,188                           |
| Kalipare | 60,34             | 18,000     | 2,202,73                      | 550,684                           |
| Pagak    |                   |            | 13,041                        | 1,670,05                          |
| Bantur   |                   |            | 19,773                        | 2,513,46                          |
| Gedangan |                   |            | 14,733                        | 1,935,99                          |
| Sumbermanjing |         |            | 25,784                        | 3,296,82                          |
| Dampit   |                   |            | 32,481                        | 4,342,84                          |
| Tirtoyudo |                   |            | 17,174                        | 2,219,71                          |
| Ampelgaing |                |            | 15,471                        | 1,917,34                          |
| Poncokusumo |            |            | 25,022                        | 3,386,43                          |
| Wajak    |                   |            | 21,756                        | 2,954,52                          |
| Turen    |                   |            | 30,530                        | 4,176,25                          |
| Bululawang|                 |            | 17,374                        | 2,156,90                          |
| Gondanglegi |              |            | 17,795                        | 2,156,90                          |
| Pagelaran |                   |            | 26,845                        | 3,927,62                          |
| Kepanjen |                   |            | 10,822                        | 1,394,62                          |
| Sumberpwung |              |            | 10,822                        | 1,394,62                          |
| Kromengan |                   |            | 18,502                        | 3,204,16                          |
| Ngajum   |                   |            | 13,058                        | 1,796,05                          |
| Wonoasari |                   |            | 13,058                        | 1,796,05                          |
| Wagir    |                   |            | 20,083                        | 3,218,05                          |
| Pakisaji |                   |            | 20,083                        | 3,218,05                          |
| Tajinan  |                   |            | 13,722                        | 1,972,86                          |

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### Tabel 3. Water Demand Analysis for Animal Husbandry

| District | Cow/Buffalo/Horse Pop | Goat/Sheep Pop | Swine Pop | C.B.H Water Demand (L/year) | G.S. Water Demand (L/year) | Total Water Demand (L/year) |
|----------|-----------------------|----------------|-----------|-----------------------------|-----------------------------|----------------------------|
| Donomulyo| 11350                 | 2914           | 0         | 165710000                   | 5318050                     | 171,028,050                |
| Kalipare | 14854                 | 5459           | 0         | 216868400                   | 9962675                     | 226,831,075                |
| Pagak    | 11541                 | 4702           | 0         | 168498600                   | 8581150                     | 177,079,750                |
| Bantur   | 13235                 | 7276           | 595       | 193231000                   | 13278700                    | 207,812,750                |
| Gedangan | 15582                | 6188           | 0         | 227497200                   | 11293100                    | 238,790,300                |
| Sumbermanjing | 9881          | 6513           | 632       | 144262600                   | 11886225                    | 157,532,905                |
| Dampit  | 8809                  | 19294          | 2279      | 128611400                   | 35211550                    | 168,813,960                |
| Tirtoyudo | 2286               | 46470          | 154       | 33375600                    | 84807750                    | 118,520,610                |
| Ampelgading | 1163              | 51117          | 75        | 16979800                    | 93288525                    | 110,432,575                |
| Ponokusumo | 16342             | 5561           | 0         | 238593200                   | 10148825                    | 248,742,025                |
| Wajak   | 18305                 | 7639           | 0         | 267253000                   | 13941175                    | 281,194,175                |
| Turen   | 9870                  | 5190           | 0         | 144102000                   | 9471750                     | 153,573,750                |
| Bululawang | 2376             | 2935           | 0         | 34689600                    | 5356375                     | 40,045,975                 |
| Gondanglegi | 7048          | 3500           | 0         | 102900800                   | 6387500                     | 109,288,300                |

### C. Water Demand for Animal Husbandry

Generally, water requirements for animal husbandry can be estimated by multiplying the number of cattle with level of water requirements based on the following equation:

\[
Q_x = (q_{x1} \times P_{x1}) + (q_{x2} \times P_{x2}) + (q_{x3} \times P_{x3})
\]

Keterangan:
- \( q_{x1} \) = kebutuhan air untuk ternak, (l/hari)
- \( q_{x2} \) = kebutuhan air untuk kambing, dan domba, (l/hari)
- \( q_{x3} \) = kebutuhan air untuk unggas, (l/hari)
- \( P_{x1} \) = jumlah sapi, kerbau, dan kuda, (ekor)
- \( P_{x2} \) = jumlah kambing, dan domba, (ekor)
- \( P_{x3} \) = jumlah unggas, (ekor)
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| District       | Cow/Buffalo/ Horse Pop | Goat/ Sheep Pop | C.B.H Water Demand (L/year) | G. S. Water Demand (L/year) | Swine Water Demand (L/year) | Total Water Demand (L/year) |
|----------------|------------------------|----------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|
| Pagelaran      | 3565                   | 3437           | 0                           | 52049000                    | 6272525                    | 58,321,525                  |
| Kepanjen       | 1702                   | 2778           | 2596                        | 24849200                    | 5069850                    | 5685240                     |
| Sumberpucung   | 4323                   | 859            | 214                         | 63115800                    | 1567675                    | 468660                      |
| Kromengan      | 1961                   | 6345           | 5112                        | 28630600                    | 11579625                   | 11195280                    |
| Ngajum         | 14668                  | 7526           | 0                           | 214152800                   | 13734950                   | 227,887,750                 |
| Wonoasari      | 2919                   | 20095          | 0                           | 42617400                    | 36673375                   | 79,290,775                  |
| Wagir          | 6951                   | 3477           | 48                          | 101484600                   | 6345525                    | 105120                      |
| Pakisaji       | 2560                   | 2652           | 0                           | 37376000                    | 4839900                    | 42,215,900                  |
| Tajinan        | 7044                   | 3604           | 98                          | 102842400                   | 214620                     | 109,634,320                 |
| Tumpang        | 6621                   | 1726           | 70                          | 96666600                    | 3149950                    | 99,969,850                  |
| Pakis          | 8634                   | 1455           | 0                           | 126056400                   | 2655375                    | 128,711,775                 |
| Jabung         | 20237                  | 6046           | 7                           | 295460200                   | 11033950                   | 306,509,480                 |
| Lawang         | 10606                  | 6052           | 0                           | 154847600                   | 11044900                   | 165,892,500                 |
| Singosari      | 13012                  | 2891           | 0                           | 189975200                   | 5276075                    | 195,251,275                 |
| Karangploso    | 7417                   | 4170           | 63                          | 108288200                   | 137970                     | 116,036,420                 |
| Dau            | 8418                   | 16249          | 1311                        | 122902800                   | 2871090                    | 155,428,315                 |
| Pujon          | 21081                  | 6460           | 8                           | 307782600                   | 17520                      | 319,589,620                 |
| Ngantang       | 15819                  | 8668           | 0                           | 230957400                   | 15819100                   | 246,776,500                 |
| Kasembon       | 6698                   | 2084           | 0                           | 97790800                    | 3803300                    | 101,594,100                 |
| **Total**      |                        |                |                             |                             |                            | **5,022,893,480**           |
D. Irrigation Water Demand per Year

The use of water for rice irrigation is calculated on the basis of the technical, semi-technical and simple irrigation rice fields contained in the Malang regency watershed. The calculation for measuring irrigation water demand, with \( L \) (75%) and a (1), is:

\[
A = L \times I \times a
\]

| NO. | WETLAND BASIC AREA BY LOCAL IRRIGATION (Ha) | Irrigation Water Demand (lt./tahun) |
|-----|--------------------------------------------|-----------------------------------|
| 1   | PUJON 2965                                 | 2,223.75                          |
| 2   | SINGOSARI 3781                             | 2,835.75                          |
| 3   | MALANG 2756                                | 2,067.00                          |
| 4   | TUMPANG 5481                               | 4,110.75                          |
| 5   | BULULAWANG 4077                            | 3,057.75                          |
| 4   | GONDANGLEGI 6200                           | 4,650.00                          |
| 5   | KEPANJEN 8098                              | 6,073.50                          |
| 6   | TUREN 8214                                 | 6,160.50                          |
| 7   | NGAJUM 4479                                | 3,359.25                          |
|     | Total 46051                                | 34,538.25                         |

By the analysis of water carrying capacity in Malang regency, the availability of ground and surface water in this regency has been exceeded. Other technical efforts are needed to be able to supply the needs of the people who live in this area. One of them is to pay attention to the condition of water supply ecosystem services. The carrying capacity map based on the following ecosystem services below, maps which areas have the potential to produce high water service ecosystem services. Unfortunately, the central area which is actually the Malang Raya agglomeration area is a high potential area for water storage. So that future spatial development must pay attention to these conditions.

**CONCLUSION**

Natural and environmental resources is one of the important capitals in development at the national and regional level. Nevertheless, this nature capital is often conditioned as "used" and "abused" so that it raises "Cost" of development in the form of damage environment that must be paid not only by the current population but also future generation. The phenomenon of "used" and "abused" this happens because of lack of attention of carrying capacity and
capacity the environment itself in supporting development. Strengthening of water carrying capacity can be done through the construction of green open spaces, limiting the amount of land conversion, rainwater management, and control of water use.

One of the crucial things in determine the carrying capacity is concerning threshold or critical threshold, i.e. value where when value the critical is traversed then carrying capacity already overshoot. Theoretically, because of the complexity of nature's interactions and environment, indeed there is no size universal to determine critical threshold due to resilience from the environment itself. Therefore, in determine the critical threshold, as stated by Nijkamp (1999), used range minimum critical threshold and maximum critical threshold.

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