JAUR, Vol. 3 (2) April (2020) ISSN: 2599-0179 (Print) ISSN: 2599-0160 (Online)
10.31289/jaur.v3i2.3331

JOURNAL OF ARCHITECUTRE AND URBANISM RESEARCH

Available online http://ojs.uma.ac.id/index.php/jaur

ANALISIS KAPASITAS PERAWATAN AIR UNTUK PERENCANAAN PERENCANAAN DAERAH DI KABUPATEN MALANG

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

*** Nadia Paramitha Kusumawardhani[1&2]**

1)Master of Urban and Regional Planning, Faculty of Engineering, Universitas Gadjah Mada
2) Graduate School of Media and Governance, Keio University

Diterima: Februari 2020; Disetujui: April 2020; Dipublikasi: 30 April 2020
**Corresponding Author*: E-Mail : nadiaparamitha89@yahoo.com

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.*

How to Cite: *Kusumawardhani, N.P. (2020). Analysis of Water Carrying Capacity for Regional Planning Development in Malang Regency, J ournal of Architecture and Urbanism Research, 3 (2): Hal 166-174.*

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

$$C = \frac{\sum(ci\ x\ Ai)}{\sum Ai}$$

$$\sum Ri$$

Note:
SA = water availability (m3/year)
C = coefficient of weighted runoff
Ci = coefficient of land use runoff i as shown on 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 level of water availability, require 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

Tabel 1. Water Availability Analysis

No	Water Resources	KOEFISIEN LIMPASAN (Ci)	LUAS LAHAN Ai (Ha)	Ci x Ai
	DESKRIPSI PERMUKAAN			
1	LAHAN PERTANIAN			
A	LAHAN SAWAH			
	IRIGASI TEKNIS	0.3	33110.299	9933.09
	IRIGASI SETENGAH TEKNIS	0.3	12777.929	3833.379
	IRIGASI SEDERHANA	0.3		0
	IRIGASI DESA	0.3		0
	TADAH HUJAN	0.3		0
	PASANG SURUT	0.3		0
	LEBAK	0.3		0
	POLDER	0.3		0
B	BUKAN LAHAN SAWAH			0
	TEGAL/KEBUN	0.2	91390.301	18278.06
	LADANG/HUMA	0.4	110364.459	44145.78
	PERKEBUNAN	0.4		0
	HUTAN RAKYAT	0.18		0
	TAMBAK	0.4		0
	KOLAM/TEBAT/RUMPUT	0.3	3213.412	964.0236
	PADANG PENGEMBALAAN/RUMPUT	0.4		0
	SEMENTARA TIDAK DIUSAHAKAN	0.4		0
	LAINNYA	0.4		0
2	LAHAN BUKAN PERTANIAN			0
	PEKARANGAN TIDAK DITANAMI	0.15		0
	HUTAN NEGARA	0.18	40249.808	7244.965
	PEMUKIMAN	0.7	33630.49	23541.34
	BELUKAR	0.07	18801.142	1316.08

No	Water Resources	KOEFISIEN LIMPASAN (Ci)	LUAS LAHAN Ai (Ha)	Ci x Ai
	HUTAN RAWA	0.07	148.604	10.40228
	RAWA	0.07	84.2	5.894
	PASIR PANTAI	0.2	1069.554	213.9108
	EMPANG	0.05	122.751	6.13755
	TANAH BERBATU	0.2	191.153	38.2306
	TOTAL		345154.102	109531.3
		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 (m^3/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	2,284,754,000	571,188,500
Kalipare	60,349	18,008	2,202,738,500	550,684,625
Pagak	45,755	13,041	1,670,057,500	417,514,375
Bantur	68,862	19,773	2,513,463,000	628,365,750
Gedangan	53,041	14,739	1,935,996,500	483,999,125
Sumbermanjing	90,324	25,784	3,296,826,000	824,206,500
Dampit	118,982	32,481	4,342,843,000	1,085,710,750
Tirtoyudo	60,814	17,171	2,219,711,000	554,927,750
Ampelgading	52,530	15,471	1,917,345,000	479,336,250
Poncokusumo	92,779	25,022	3,386,433,500	846,608,375
Wajak	80,946	21,756	2,954,529,000	738,632,250
Turen	114,418	30,530	4,176,257,000	1,044,064,250
Bululawang	71,544	17,370	2,611,356,000	652,839,000
Gondanglegi	85,071	20,790	3,105,091,500	776,272,875
Pagelaran	67,412	17,795	2,460,538,000	615,134,500
Kepanjen	107,323	26,862	3,917,289,500	979,322,375
Sumberpucung	54,036	14,332	1,972,314,000	493,078,500
Kromengan	38,209	10,829	1,394,628,500	348,657,125
Ngajum	49,207	13,058	1,796,055,500	449,013,875
Wonosari	41,332	11,605	1,508,618,000	377,154,500
Wagir	88,166	20,083	3,218,059,000	804,514,750
Pakisaji	89,091	20,899	3,251,821,500	812,955,375
Tajinan	54,051	13,720	1,972,861,500	493,215,375

District	Population Number	Household	Domestic Water Deman (L/year)	Non-domestic Water Demand (L/year)
Tumpang	75,532	20,622	2,756,918,000	689,229,500
Pakis	157,173	36,067	5,736,814,500	1,434,203,625
Jabung	74,198	20,145	2,708,227,000	677,056,750
Lawang	110,754	26,505	4,042,521,000	1,010,630,250
Singosari	180,982	44,031	6,605,843,000	1,651,460,750
Karangploso	83,404	20,299	3,044,246,000	761,061,500
Dau	76,403	20,645	2,788,709,500	697,177,375
Pujon	67,851	17,536	2,476,561,500	619,140,375
Ngantang	56,388	15,970	2,058,162,000	514,540,500
Kasembon	31,152	8,539	1,137,048,000	284,262,000
			93,464,6	23,366,1

District	Population Number	Household	Domestic Water Deman (L/year)	Non-domestic Water Demand (L/year)
			37,500	59,375

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:

$$Q_E = \left(q_{(1)} \times P_{(1)} + q_{(2)} \times P_{(2)} + q_{(3)} \times P_{(3)}\right)$$

Keterangan :
QE = kebutuhan air untuk ternak, (lt/hari).
q(1) = kebutuhan air untuk sapi, kerbau, dan kuda, (lt/ekor/hari).
q(2) = kebutuhan air untuk kambing, dan domba, (lt/ekor/hari).
q(3) = kebutuhan air untuk unggas, (lt/ekor/hari).
P(1) = jumlah sapi, kerbau, dan kuda, (ekor).
P(2) = jumlah kambing, dan domba, (ekor).
P(3) = jumlah unggas, (ekor).

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)	Swine Water Demand (L/year)	Total Water Demand (L/year)
Donomulyo	11350	2914	0	165710000	5318050	0	171,028,050
Kalipare	14854	5459	0	216868400	9962675	0	226,831,075
Pagak	11541	4702	0	168498600	8581150	0	177,079,750
Bantur	13235	7276	595	193231000	13278700	1303050	207,812,750
Gedangan	15582	6188	0	227497200	11293100	0	238,790,300
Sumbermanjing	9881	6513	632	144262600	11886225	1384080	157,532,905
Dampit	8809	19294	2279	128611400	35211550	4991010	168,813,960
Tirtoyudo	2286	46470	154	33375600	84807750	337260	118,520,610
Ampelgading	1163	51117	75	16979800	93288525	164250	110,432,575
Poncokusumo	16342	5561	0	238593200	10148825	0	248,742,025
Wajak	18305	7639	0	267253000	13941175	0	281,194,175
Turen	9870	5190	0	144102000	9471750	0	153,573,750
Bululawang	2376	2935	0	34689600	5356375	0	40,045,975
Gondanglegi	7048	3500	0	102900800	6387500	0	109,288,300

District	Cow/Buffalo/ Horse Pop	Goat/ Sheep Pop	Swine 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	0	58,321,525
Kepanjen	1702	2778	2596	24849200	5069850	5685240	35,604,290
Sumberpucung	4323	859	214	63115800	1567675	468660	65,152,135
Kromengan	1961	6345	5112	28630600	11579625	11195280	51,405,505
Ngajum	14668	7526	0	214152800	13734950	0	227,887,750
Wonosari	2919	20095	0	42617400	36673375	0	79,290,775
Wagir	6951	3477	48	101484600	6345525	105120	107,935,245
Pakisaji	2560	2652	0	37376000	4839900	0	42,215,900
Tajinan	7044	3604	98	102842400	6577300	214620	109,634,320
Tumpang	6621	1726	70	96666600	3149950	153300	99,969,850
Pakis	8634	1455	0	126056400	2655375	0	128,711,775
Jabung	20237	6046	7	295460200	11033950	15330	306,509,480
Lawang	10606	6052	0	154847600	11044900	0	165,892,500
Singosari	13012	2891	0	189975200	5276075	0	195,251,275
Karangploso	7417	4170	63	108288200	7610250	137970	116,036,420
Dau	8418	16249	1311	122902800	29654425	2871090	155,428,315
Pujon	21081	6460	8	307782600	11789500	17520	319,589,620
Ngantang	15819	8668	0	230957400	15819100	0	246,776,500
Kasembon	6698	2084	0	97790800	3803300	0	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 deman, with lt (75%) and a (1), is:

Perhitungan penggunaan air untuk padi per tahun adalah :

$$A = L \times I_t \times a$$

A	= Pengunaan air irigasi dalam
L	= Luas daerah irigasi (Ha)
I t	= Intensitas tanaman dalam prosen (%) musim/ tahun
a	= Standar penggunaan air (1 L/det/ha) atau
A	= 0,001 m/det/ha x 3600 x 24 x 120 hari / musim

Tabel 4. Water Demand Analysis for Irrigation

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

Tabel 5. Water carrying capacity of Malang regency is: Based on the calculation of Water Availability in Malang regency, the total tren of carrying capacity is:

Water Supply		101,075,000,000	Liter/year
Water Demand			
A	Domestic and Non-domestic use	116,830,796,875	Liter/year
B	Animal Husbandry	5,022,893,480	Liter/year
C	Irrigation	34,538	Liter/year
Total		121,853,724,893	Liter/year
Carrying Capacity		-5,596,095,885	Water deficit
		0.95	

Based on 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.

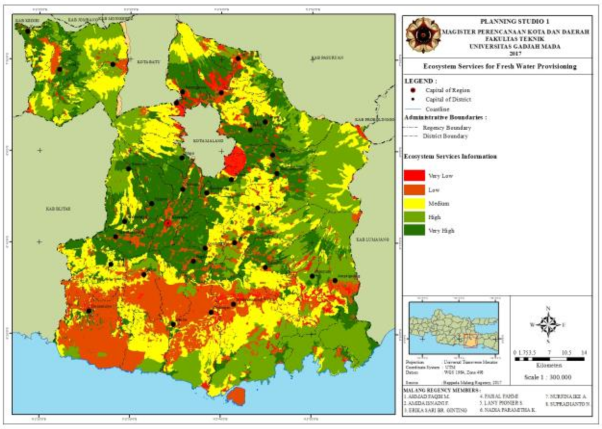

Figure 1. Map of Water Supply Ecosystem Service in Malang Regency

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.

REFERENCES

Alcamo, Joseph et. al.,ed. Ecosystems and Human Well-being: a Framework for

Assessment/ Millenum Ecosystem Assessment. Island Press, 2003.

B Barus, and DO. Pribadi, Development of Ecovillage in Regional Development and Planning Framework, in Academic Document for Ecovillage Development, IPB, 2009.

B Barus, LS. Iman, DR. Panuju, and BH.Trisasongko, Sustainable Rice Field to Assure Food Security in Garut Regency, West Java. Proceeding of Interseminar: Geospatial and Human-Dimensions on Natural Resource Management. Crespent IPB, 2011.

B. Burkhard,Kroll, F., Muller, F. dan Windhorst,W, Landscapes Capacities to Provide Ecosystem Services – a Concept for Land-Cover Based Assessment, Landscape Online, 15, 2009. 1-22.

R, De Groots ,Wilson M, Boumans R., A Typology for The Classification, Description, and Valuation of Ecosystem Functions, Goods and Services, Ecologycal Economics, 41, 2002, 393-408

De Groots, R., Alkamade, R., Braat, L., Willemen, L. Challenges in Integrating The Concept of Ecosystem Services and Values in Landscape Planning, Management and Decision Making, Ecologycal Complexity, 7, 2010, 260-272.

A. Fauzi, Valuasi Ekonomi dan penilaian Kerusakan Sumberdaya Alam dan Lingkungan. Bogor: IPB Press, 2014.

A.B. Firdian, Barus, and DO.Pribadi. Study of Spatial Pattern of Environmental Carrying Capacity in Garut, Journal ITSL, 12(2), 2010, 40-46.

R. Forman, Land Mosaics: The Ecology of Landscapes and Regions. Harvard University, Massachutes, 1995.

KLH. Pedoman Daya Dukung dan Daya Tampung Lingkungan Hidup Perkotaan. Jakarta: Kementerian Lingkungan Hidup, Republik Indonesia, 2014.

Muta'ali, Luthfi. Daya Dukung Lingkungan untuk Perencanaan Pengembangan Wilayah. Yogyakarta: Badan Penerbit Fakultas Geografi UGM, 2011.

Muta'ali, Luthfi. Hubungan Tekanan Penduduk dan Daya Dukung Lingkungan di Wilayah Perdesaan Provinsi Yogyakarta. Laporan Penelitian. LPPM UGM, 2013.

Muta'ali Lutfhi. Environmental Carrying Capacity Based on Spatial Planning. Indonesian Journal of Geography. Vol 43, No 2 , 2011.

Permen LH Nomor 17 Tahun 2009 tentang Pedoman Penentuan Daya Dukung Lingkungan Hidup dalam Penataan Ruang Wilayah

E. Rustiandi,, B.Barus, Prastowo, dan La Ode S.I., Kajian Daya Dukung Lingkungan Hidup Provinsi Aceh. Crespent Press. Sitanala Arsyad. 1989. Konservasi Tanah dan Air. IPB. Bogor .xi, 2010.

B. Widodo,, Lupyanto, R., Sulistiono, B., Harjito, D. A., Hamidin, J., Hapsari, E., … Ellinda, C. Analysis of Environmental Carrying Capacity for the Development of Sustainable Settlement in Yogyakarta Urban Area. Procedia Environmental Sciences, 28(SustaiN 2014), pp 519–527. https://doi.org/10.1016/j.proenv.2015.07.062