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Integrated of remote sensing and geographic information system for analysis of green open space requirement in Jember City

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Abstract. The oxygen in the city of Jember largely generated by green open space of vegetation stand. The green space that is the focus of this research is woody / cambium standing vegetation, which is able to produce oxygen through the process of photosynthesis. Remote sensing data through SPOT-7 image is used to know the condition of green open space in Jember City more quickly and accurately. The purposes of this research are: (1) studying SPOT-7 image capability for extraction of green open space data viewed from its accuracy; (2) to know the amount of oxygen supply produced by the actual standing vegetation green open space and the oxygen supply needs of the population, motor vehicles, and livestock; (3) to know the adequacy of green open space based on oxygen demand in Jember City. This research uses quantitative method and field measurement. The analysis of the adequacy of green space is known through the extraction of information from SPOT-7 images and related secondary data. The parameters used are the determination of the area of green open space demand based on oxygen demand, and the amount of oxygen produced by the actual standing vegetation green open space. The analysis of the adequacy of green open space based on oxygen demand is calculated in the vicinity of Jember City. The results of this study indicate that the spread of green open space around the city of Jember uneven, this is caused by the spread of green space that actually clustered in certain sub-districts. Therefore, it is better to balance the ecological and natural environment aspects of urban areas can be a concern in the management of green open space in the city of Jember.

1. Introduction

The development of urban areas, one of which is marked by the increase in built land which is dominated by economic activities. Increased construction of facilities in urban areas will result in reduced vegetation or green space. In addition, the density of activities in the city from the actual population, motorized vehicles, and the existence of livestock activities requires oxygen for the respiration process and the burning of energy for motorized vehicles. Oxygen in the City of Jember is mostly produced by stand green vegetation. The green open space which is the focus of this research is woody / cambium stand vegetation, which is able to produce oxygen through photosynthesis. Remote sensing data through SPOT-7 imagery is used to find out green open space conditions in Jember City more quickly and accurately.

According to Fandeli et al [2], every 1 m^2 of green open space is able to produce 50,625 grams of oxygen / day. Then the more land vegetation stands or the resulting oxygen green space will increase. Dense activity in urban areas from morning to evening which involves the activities of residents, motorized vehicles, and livestock requires oxygen for respiration and the combustion process of the fuel. Oxygen demand in the city is met from photosynthesis of greenhouse vegetation. Information about the adequacy of oxygen produced by green open space is important to know in order to obtain information on meeting the needs of oxygen for residents, motor vehicles, and livestock.

Remote sensing has examined a lot of urban phenomena, especially regarding green space. Chlorophyll possessed by green vegetation can uniquely absorb and emit electromagnetic waves from sensors. SPOT-7 imagery on multispectral channels is expected to be able to tap information on green open space vegetation stands. Information regarding the green open space vegetation stand obtained from the multispectral classification of SPOT-7 images will be used as a reference for taking sample points of chest diameter at the height of the tree. The results of field measurements will calculate the biomass estimation using the allometric equation which is then converted to the quantity of oxygen to determine the value of the oxygen supply produced by the actual green open space.

This study aims to: (1) review the ability of SPOT-7 imagery for the extraction of green open space data from its accuracy; (2) knowing the amount of oxygen produced by vegetation green space actual stand and oxygen demand from residents, motorized vehicles and livestock; (3) knowing the adequacy of green open space based on oxygen requirements in the City of Jember.

2. Method

2.1. Research Locations and Data

This research was conducted in Jember Regency which is located in the eastern part of Java Island, the focus of the research is only on a few sub-districts which show urban characteristics, namely Patrang, Arjasa, Sumbersari, Pakusari and Kaliwates Districts. The absolute position of Jember Regency is located at 7059'6 "- 8033'56" mT and 113016'28 "- 114003'42" mU. The area of Jember Regency is 3,293.34 Km2 or 329,334 Ha consisting of 31 sub-districts. For the 5 districts, the focus of the research will be 171.84 Km2 or 17,184 Ha.

SPOT-7 image of Jember urban area coverage is used as primary data to tap information about green open space. SPOT-7 imagery has a capacity of 12 bits andcapabilities stereoscopic. SPOT-7 images work on multispectral and panchromatic channels. Multispectral channels work at wavelengths 0.450 - 0.520 μm (blue), 0.530 - 0.590 μm (green), 0.625 - 0.695 μm (red), and 0.760 - 0.890 μm (near infrared). The panchromatic channel works at a wavelength of 0.450 - 0.745 μm. The SPOT-7 image used in this study was recorded on December 23, 2016. The geometric correction was carried out orthorectively by the data provider.

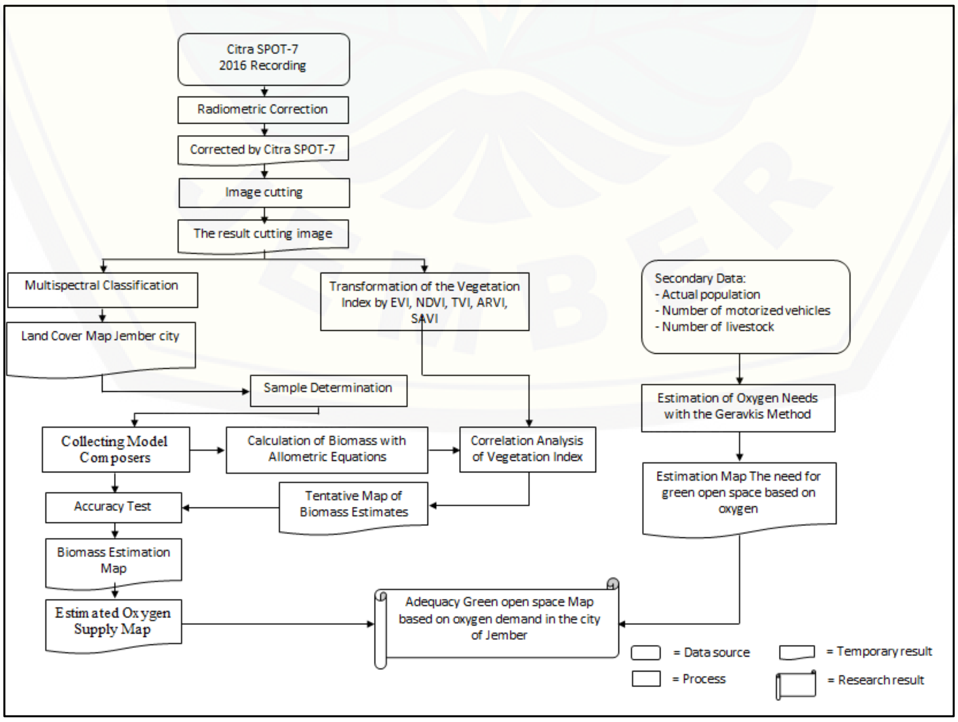

Figure 1. Research the Flow Chart

2.2. Initial Data Processing

SPOT-7 image of a multispectral channel is corrected radiometrically by changing the digital number value to radians, and changing the radians value to reflectance's Top of Atmosphere value. Images that have been corrected radiometrically and orthorectified are then cut according to the research area, so as to facilitate the data analysis process. The image that has been truncated will then be carried out by themultispectral classification method maximum likelihood and transformation of the vegetation index (according to the flow diagram in Figure 1).

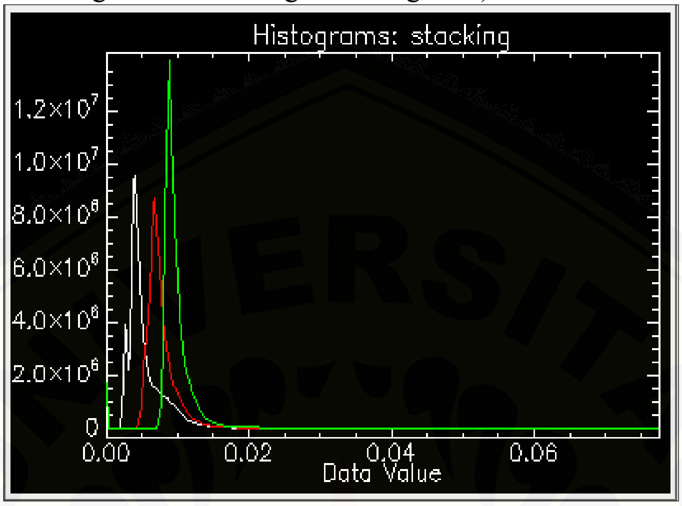

Figure 2. SPOT-7 image value histogram corrected by relecting ToA

2.3. Classification of Land Cover

Classification of land cover is done by supervised technique usingmethod maximum likelihood. The object of stand vegetation is the main object of study in this study. Visually the vegetation object has a texture that tends to be coarser, making it easier to take training area for land cover class vegetation greenhouse open space. The classification system used is the classification system of Anderson et al (1976) in Sidiq [6] with modifications. The accuracy of the results of the interpretation of land cover conducted in the study area was 87%. Interpretation results with accuracy of 80-85% can be used forther analysis [3]. The results of the interpretation of land cover will then be used as a reference for taking sample plots, especially in the land cover class of vegetation greenhouse open space. The Jember City Land Cover Map can be seen in Figure 3 below

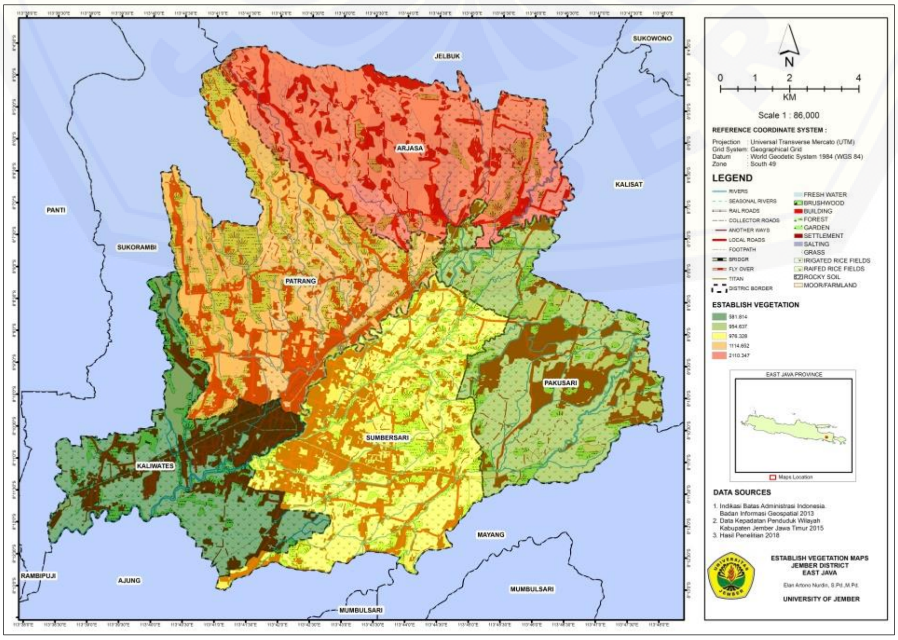

Figure 3. Establish Vegetation Maps Jember District

2.4. Transformation of Vegetation Index Vegetation

Index transformation was used in this study to obtain the best vegetation index to estimate the value of oxygen supply. Vegetation indices used are ARVI, EVI, NDVI, SAVI, and TVI. The selection of the vegetation index is based on its sensitivity to the appearance of water, soil and atmospheric influences. Each vegetation index will be correlated with the value of oxygen supply from field measurements to obtain tentative oxygen supply values. Then correlated with the value of oxygen supply in the accuracy test to get the best vegetation index estimation of oxygen supply value. Best vegetation indices correlation results will be selected based on the value of the coefficient of determination (R2)and the correlation coefficient (r). The oxygen supply value is calculated based on the regression equation resulting from the correlation of the vegetation index with the value of oxygen supply in each modeling sample plot.

2.5. Determination of Green Open Space Needs Based on Oxygen

Needs green open space requirements are calculated by looking at the oxygen requirements of the actual population, motor vehicles, and livestock. green open space requirements are calculated using the Geravkis method. The assumption used to calculate the population's oxygen demand is that human oxygen consumption per day is 600 liters or 86,400 kg [4].The figure of population oxygen demand is obtained by multiplying the number of population by consuming oxygen per day.

Calculation of oxygen requirements for motorized vehicles is affected by the type of fuel used, vehicle power, and vehicle operating time [5]. The types of vehicles counted are passenger cars (private cars and public transport), load cars (trucks), buses and motorbikes. The oxygen needs of livestock are calculated using assumptions, each weight of 100 kg of livestock bodies requires oxygen of 5,054.4 liters / day [2].

After calculating the oxygen demand of each oxygen consumer, it is known that the oxygen demand is calculated using the Geravkis method Fandeli et al. [2], with the equation as below.

$$\boldsymbol{Lt(m^2) = \frac{Xt + Yt + Zt}{(54)\ x\ (0,9375)}}$$

Note:
Lt : the area of green space required
Xt : the amount of oxygen needed by humans in aregion
Zt : the amount of oxygen needed by motor vehicles
Yt : the amount of oxygen needed by livestock
54 : constant stating that every 1 m2 of green space produces aweight plant dryof 54 grams
0,9375 : a constant stating that every 1 gram of dry weight of the plant is equivalent to oxygen production of 0.9375 grams / day

2.6. Calculation of Oxygen Supply Based on Estimated Biomass

Oxygen supply of vegetated green open space green space in Jember urban areas is known through estimation of biomass calculated by allometric equation Brown [1] results of field measurements. The results of field measurements in each sample plot are then calculated for their biomass value estimates and converted to oxygen values. The known oxygen supply value in each sample plot is then correlated with the vegetation index used to obtain the empirical equation for estimating the value of oxygen supply in the field. Accuracy test is done by correlating the vegetation index with field sample accuracy test to get the best vegetation index estimation of oxygen supply. The equation used to calculate the value of oxygen supply from biomass values (Yanua, 2012 in Rini [5] is as follows.

$$\boldsymbol{Volume\ O_2\ (kg/m^2) = mol\ O_2\ x\ Mr\ O_2\ x\ koefisien}$$

Note:
1 mol $C_6H_{12}O_6$ setara dengan 6 mol O_2
Mol $C_6H_{12}O_6$ = Berat Biomassa/Mr $C_6H_{12}O_6$

$$\text{Volume } O_2 = \text{mol } O_2 \text{ x Mr } O_2 \text{ x koefisien} = \text{Mr } O_2 \text{ x mol } C_6H_{12}O_6$$
$$\text{Volume } O_2 = 32 \text{ x (Berat Biomassa/Mr } C_6H_{12}O_6) \text{x } 6$$
$$\text{Volume } O_2 = 32 \text{ x (Berat Biomassa/180)x } 6$$

2.7. *Potential Adequacy of Green Open Space in Jember City Area*

Potential adequacy of green open space based on oxygen requirements in this study is presented in the form of maps. The green open space adequacy map is known byoverlaying an oxygen demand estimation map and an oxygen supply estimation map. Both maps will each be given a weight thenoverlaid. The green open space adequacy map based on oxygen needs is presented per sub-district and then it is seen how fulfillment of green open space needs in each sub-district in Jember.

3. Result and Discussion

3.1. *Area and Distribution Area of Jember City*

Based on the results of the multispectral classification that has been done, it is known that the area of green space in the study area is 8,862 ha or 51% of the area. The green open space that was calculated for its area consisted of stand vegetation green space covering 5,738 Ha and non-standing vegetation green open space of 3,124 Ha (Figure 4). Judging from the percentage, the availability of green space in the City of Jember is sufficient, in accordance with the mandate in Law No. 26 of 2007 concerning Spatial Planning. In this study the discussion of green open space requirements based on oxygen demand will be focused on green open space vegetation stands, because the largest oxygen producer is woody / Cambodian stand vegetation.

Percentage of overall vegetation green open space in the City of Jember is 33% of the total area or equal to 5,738 Ha (Figure 4). Arjasa Subdistrict is the district with the widest vegetation green open space of 2,110,347 Ha. Stand vegetation in Arjasa subdistrict is dominated by mixed trees on plantations with private ownership or private green open space status. The sub-district with the smallest vegetation open green space is Kaliwates sub-district with an area of 581,814 Ha. The lack of stand vegetation due to more dominating physical buildings. Kaliwates Subdistrict is one of the sub-districts with the smallest area so that the land that is functioned as a green space tends to be limited.

3.2. *Calculation of Green Open Space Requirements Based on Oxygen*

Needs green open space requirements in the study area were calculated by the Geravkis method which involved actual population oxygen needs, motorized vehicles and livestock. The results of the calculation of oxygen demand from oxygen consumers can be seen in Table 1 below.

Table 1. Needs Oxygen Consumers Oxygen Territory Jember City

Consumer Oxygen		total	oxygen demand (kg / day)
Population Actual (soul)		427 632	367 763
Vehicle (units)	Passenger Cars	15 230	42 510
	Public transport	893	2493
	Bus	92	1,174
	Truck	866	4755
	Motorcycle	106 756	2229
Livestock		29,731	976,770
Total Oxygen Needs (kg / day)			**1,397,694**

Source: Data Processing, 2018

Amount of oxygen demand from each oxygen consumer in Table 1 will be used as input to calculate green open space requirements using the Geravkis method. Based on the results of the calculations, the estimated green space requirements in the City of Jember amounted to 2,760,878 Ha. This amount is smaller than the availability of actual green open space, meaning that the availability of actual green open space in the City of Jember is sufficient to meet the oxygen demand of actual residents, motorized vehicles and livestock (Table 2). When viewed specifically, there is a green space surplus of 6,101.122 Ha. The results of calculation of green open space requirements based on oxygen requirements in the City of Jember can be seen in Table 2 below.

Table 2. Calculation of Green Open Space in the Region of Jember City

Consumer Oxygen	oxygen demand (kg / day)	Needs of green open space (ha)	Actual of green open space (ha)	Information
Actual Population	367 763	2760.878	8862	Surplus 6.101.122 hectares
Motor Vehicles	53 161			
Livestock	976 770			
Total	**1,397,694**			

Source: Data Processing, 2018

Distribution of oxygen demand in the city of Jember is seen in each class of land cover which is presented in the form of maps. The map for oxygen needs was obtained by overlaying the map of oxygen requirements for each kelurahan unit with a land cover map. Oxygen needs were then grouped into 3 classes, namely low, medium and high oxygen requirements in each land cover class (Table 3).

Table 3. Oxygen Requirement Class

Land Cover Class	Oxygen Needs Category
Built Land	In desperate need of oxygen
Transportation Infrastructure	Simply need oxygen
Open land, body of water, vegetation green space stand, non-stand vegetation green space	Less need oxygen

Source: Data Processing, 2018

Land consisting of residential buildings , industry, office area, trade and service area desperately need oxygen. The assumptions used are that in each function the area has a high population density and the lack of stand vegetation availability. So that the addition of vegetation green open space needs to be done to supply the oxygen needs of the population who are active in the cover of the built land class. Transportation infrastructure that is dominated by highways requires oxygen for the combustion process for motorized vehicles that pass through and requires vegetation green space stands as shelters and noise absorbers. Open land, water bodies, stand vegetation green openings, non-standing vegetation green open spaces need less oxygen because they are oxygen suppliers. Map of Jember City Oxygen Needs in Figure 5 below.

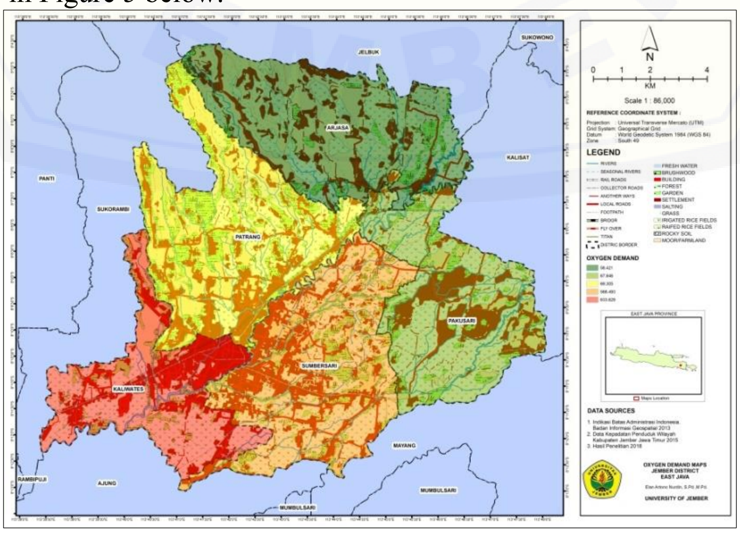

Figure 4. Oxygen Demand Maps Jember District

3.3. Calculation of Oxygen Supply Based on Estimation of Biomass

Quantity Oxygen supply value is known by estimating biomass values with allometric equations from field measurements. Sample plots to calculate the biomass value of 30 samples with a total amount of biomass of 184,326 tons / pixel or equivalent to an oxygen supply of 196,615 tons / pixel. Determination of sample plots based on land cover class vegetation green space stand of multispectral classification results. Field measurements were carried out by calculating the diameter at breast height to calculate the biomass value using the allometric equation. After the biomass value is known, it is then converted to the amount of oxygen supply value in each sample plot.

Statistical analysis of regression equations was used to obtain empirical equations resulting from the correlation between the value of oxygen supply in each sample plot with vegetation indices ARVI, EVI, NDVI, SAVI, and TVI. Before the regression analysis is carried out, first a classic assumption test consisting of normality test and heteroscedasticity test will be done to see whether the data distribution in each vegetation index is normal if it has a significance value> 0.05 and does not form a specific pattern shown in the transmit diagram. If the criteria for normality test and heteroscedasticity test are fulfilled, linear regression analysis will be carried out. The results of the classic assumption test on the normality test showed that the vegetation index of TVI had a significance value of <0.05, while the 4 other vegetation indices were normally distributed. While the transmit diagram in heteroscedasticity test shows that each vegetation index does not form a particular pattern. Looking at the results of the classic assumption test, the statistical analysis that will be used is linear regression analysis.

Regression equation is done by correlating the value of oxygen supply as a result of field measurements with vegetation index resulting from transformation on SPOT-7 images. The correlation results will produce a coefficient of determination (R2)and the correlation coefficient (r). The selection of the best vegetation index for the estimation of oxygen supply is known after an accuracy test between the value of oxygen supply in the test sample accuracy with the pixel value of each vegetation index. Test accuracy using standard error estimates. Vegetation index with a standard estimated value of the smallest error is likely to be used to estimate the value of oxygen supply. Selection of the best vegetation index is seen from the determination coefficient value, correlation coefficient, classical assumption test results, and standard error estimation value. The value of oxygen supply in each vegetation index can be seen in Table 4 below.

Table 4. The Quantity of Oxygen Supply Value for the Vegetation Index Vegetation

Index	Regression Equation	R2	R	Estimated Standard	Oxygen Supply (ton)
ARVI	y = 0,033x + 0,200	0,924	0,961	4,84782	201,9697
EVI	y = 0,002x + 0,017	0,893	0,945	18,99009	242,5
NDVI	y = 0,028x + 0,107	0,941	0,970	16,95046	201,1071
SAVI	y = 0,002x + 0,005	0,921	0,959	4,69319	286,05
TVI	y = 0,070x + 0,154	0,817	0,904	3,986604	197,6714

Source: Data Processing, 2018

Based on the results of the standard error estimation in Table 4, the vegetation index of EVI and NDVI has the largest standard error value. The vegetation index of TVI has the smallest standard error value, but the normality test data is not normally distributed. The SAVI vegetation index has the highest value of oxygen supply and has a large difference with the value of oxygen supply as a result of field measurements which is only 196,615 tons. Based on the description, the vegetation index EVI, NDVI, SAVI, and TVI are not used to estimate oxygen supply. The selected vegetation index for estimating oxygen supply is ARVI. ARVI has a standard error value that is not too high and the oxygen supply does not have a large difference, besides the distribution of ARVI vegetation index data is normally distributed and does not form a particular pattern, and the RR values2 andare high.

3.4. The potential for green space

The Openings in the City of Jember area of green open space sufficiency in the city of Jember is known by seeing the green open space requirement based on oxygen requirements and the value of oxygen supply produced by the green open space of the actual stand vegetation. as previously described, actual green open space in the area of Jember City is an area of 8,862 Ha or 51% of the total area in 5 sub-districts. The results of calculation of green open space needs based on oxygen requirements by the Geravkis method is 2,760,878 Ha, meaning that the actual green open space in the City of Jember is able to meet the green space needs of actual residents, motor vehicles, and livestock. however, if viewed per district, the level of adequacy of green space will differ between one sub-district and another. green open space requirements based on oxygen demand in each sub-district in the City of Jember can be seen in Table 5 below.

Table 5. The Green Open Space Requirements per District in the City Area of Jember

District	Area Area (Ha)	The green open space vegetation stand (ha)	Availability of oxygen (ton / day)	Oxygen needs (ton / day)	Requirements for green open space (ha)
Arjasa	4.375	2.110,347	1.250,067	58,421	107,382
Pakusari	2.911	954,637	342,641	67,846	135,321
Kaliwates	2.494	581,814	25,794	633,629	1.264,463
Sumbersari	3.705	976,328	24,517	568,493	1.127,426
Patrang	3.699	1.114,652	248,107	69,305	126,286
Total	**17.184**	**5.738**	**1.891,126**	**1.397,694**	**2.760,878**

Source: Data Processing, 2018

Availability of oxygen to Table 5 above is calculated based on the opinion of Fandeli et al [2], which states that 1 m2 of vegetation or green space is able to produce oxygen by 50.625 grams / day or 0.050625 kg / day. The area of vegetative green open space in the city of Jember is 5,736 ha, so that if the area of vegetation green space is actually multiplied by 0.050625 kg of oxygen, the availability of oxygen in the city of Jember is 2,903,850 kg / day or the oxygen that can be produced is 2,903,850 ton / day.

Green open space requirements based on oxygen requirements in each sub-district in the City of Jember have a wide range. This is due to the fact that each sub-district has a different composition of population, motorized vehicles, and the number of livestock. Districts with a relatively smaller area have a high population density, this is directly proportional to the number of vehicles that tend to be higher, so that oxygen demand will be greater. In table 5 it can be seen that not all sub-districts have sufficient area to increase green open space in accordance with estimated green open space requirements resulting from calculations using the Geravkis method.

Based on the results of the previous multispectral classification, it was shown that the non-stand vegetation green open space in each sub-district was greater than the size of the vegetation green open space. One effort that can be done is maximizing land use. Maximizing land use is important to be done to meet green open space needs in each sub-district, especially sub-districts with narrow and densely populated areas. One alternative that can be done is by adding vegetation to cambium stands on non-stand vegetation green space. The adequacy of green open space based on oxygen demand in the city of Jember was seen based on the difference between the estimated value of oxygen availability calculated by the equation of Fandeli et al [2] with the estimated value of oxygen demand calculated using the Geravkis method. Both of these values are abandoned according to the sub-districts in the study area and thenoverlaid to get information about the adequacy of open green space in the City of Jember.

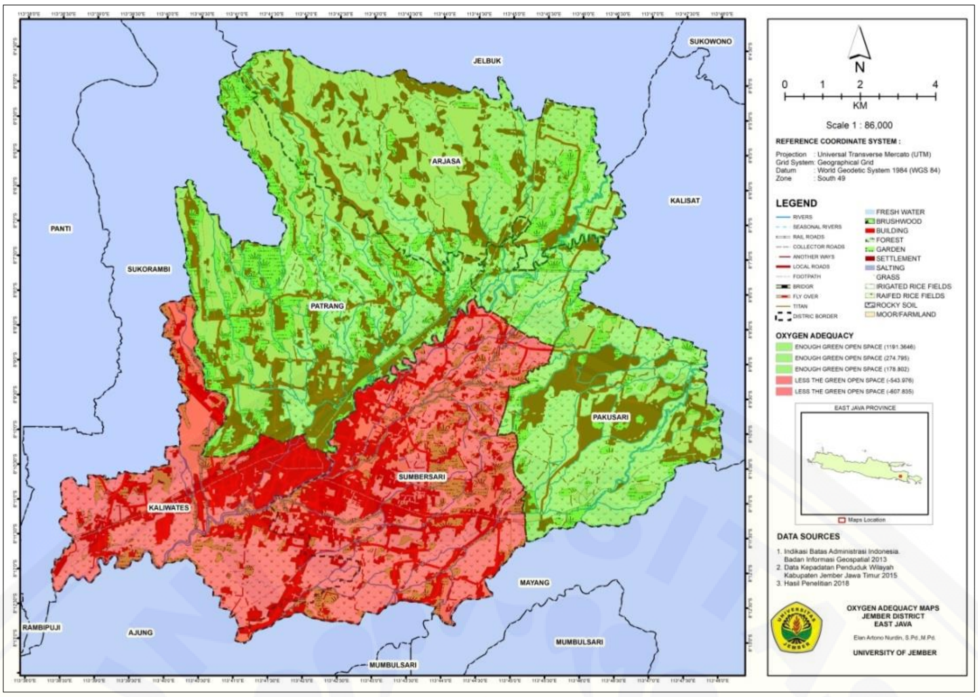

Figure 5. Oxygen Adequacy Maps Jember District

4. Conclusion

Accuracy of the recording of SPOT-7 image on 23 December 2016 in the coverage area of Jember City used in the study was 87%. The results of field measurements on 30 sample plot models builder, obtained an estimated value of oxygen supply of 196.615 tons / pixel. The sample plot was distributed in the land cover class of vegetation green space in each district. Green open space in the study area has an uneven distribution, the location with the largest green space area is in the suburbs with hill topography. Actual population oxygen demand, motorized vehicles and livestock in the study area were 1,114,273 tons / day. Taking more sample plots can increase the calculation of oxygen supply estimates.

Based on the results of the mutispectral classification and field check, the area of open green space in the study area was 8,862 Ha, consisting of stand vegetation green space covering 5,738 Ha and non-stand vegetation green space of 3,124 Ha. Green open space requirements based on oxygen requirements calculated by the Geravkis method are 2,760,878 Ha. Overall, the actual green open space in the study area is able to meet the demand for green open space based on oxygen requirements. However, if further analyzed at the sub-district level, meeting green space needs is uneven. This means that each sub-district has different capabilities in meeting demand for green open space based on oxygen requirements. This is because each sub-district has the characteristics of oxygen consumers that are different from each other, so the need for green space in each sub-district will be different.

Acknowledgment

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