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Analysis of Green Open Space Needs Based on Oxygen Needs Approach in Palembang City

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ABSTRACT

The city of Palembang has experienced quite rapid urban growth in the last decade, which has resulted in a reduction in green open spaces that function as oxygen producers. The Central Statistics Agency noted that the population density in the capital city of South Sumatra Province reached 4,317 people per km². This study aims to obtain information on the distribution of green open spaces available in the city of Palembang at present, to obtain the area of green open spaces needed to meet the oxygen needs of residents and livestock in the city of Palembang, and to obtain a comparison of the need for green open spaces based on oxygen needs with the available green open spaces, so that the area of green open spaces that are still lacking in each sub-district can be identified. The results of the identification of the availability of green open spaces and the results of the calculation of the area of green open spaces needed to meet the oxygen needs of residents and livestock, then the status of green open spaces can be known from each sub-district in Palembang City, where 5 sub-districts still lack green open spaces, these sub-districts are located in the central part of Palembang City, namely Bukit Kecil, Ilir Barat II, Ilir Timur I, Kemuning, and Seberang Ulu I Sub-districts, while the other 13 sub-districts already have sufficient green open spaces.

Keywords: *Green Open Space, NDVI, Oxygen Needs, Green Open Space Needs*

1. Introduction

The growth and development of a city will affect physical changes and land use. Along with the increasing population and infrastructure needs, previously existing green areas are converted into settlements, highways, or other buildings. This results in the loss of green open space areas that are very important for the health and quality of life of city residents. In the Regulation of the Minister of Home Affairs Number 1 of 2007 concerning Spatial Planning, Open Green Urban Areas, it is explained that urban development and growth with rapid land conversion have resulted in environmental damage and can worsen the carrying capacity of land to support the lives of residents in urban areas, so efforts must be made to maintain and improve environmental quality by providing sufficient green open spaces [1].

The rapid urban growth in the last decade has been experienced by the City of Palembang which has had an impact on the reduction of green open spaces that function as oxygen producers. The Central Statistics Agency noted that the population density in the capital city of South Sumatra Province reached 4,317 people per km². This means that every 1 km² in this city is inhabited by an average of 4,317 people [2]. With such a very high population density, the City of Palembang should provide large open green spaces so that oxygen needs can be met. However, the Head of the PUPR (Public Works and Spatial Planning)

Service of Palembang City, Ahmad Bastari Yusak, explained that the area of green open spaces in Palembang only reached 3,247 hectares. This number is still around 14% of the target, which is 30% of the total area of Palembang City, around 40,000 hectares.

With the current condition of Palembang City, which is still in the process of optimizing green open space, analysis of green open space needs based on oxygen needs can help in realizing optimal green open space planning in Palembang City. One method to identify green open space is by utilizing remote sensing technology using the Normalized Difference Vegetation Index (NDVI) method, which is to calculate indicators of density, greenness and conditions of vegetation in an area. This indicator is influenced by vegetation land cover, density to the greenness value of a vegetation and represents the photosynthetic capacity of the vegetation covering the ground surface [3].

This study aims to obtain information on the distribution of green open spaces available in the city of Palembang at present, obtain the area of green open spaces needed to meet the oxygen needs of residents and livestock in the city of Palembang, and obtain a comparison of the need for green open spaces based on oxygen needs with the available green open spaces, so that it can be known the area of green open spaces that are still lacking in each sub-district. Thus, the results of the research conducted can be used as a reference by the local government in planning, developing and arranging green open spaces in the future.

2. Research Methodology

The location of this research is in Palembang City, the capital city of South Sumatra Province. Palembang City is located between 2° 52’ - 3° 5’ South Latitude and 104° 37’ - 104° 52’ East Longitude with an average height of 8 meters above sea level. Palembang City is divided into 18 sub-districts and 107 villages. Administratively, the area of Palembang City is directly adjacent to; Banyuasin Regency to the north, east and west, while thesouthern part borders Muara Enim Regency and Ogan Ilir Regency.

In this study, the data used include administrative boundaries of Palembang City, Sentinel 2-B satellite imagery downloaded from the Copernicus Open Access Hub website, and population and livestock data in Palembang City obtained from the Badan Pusat Statistik website used to calculate the approach to the amount of oxygen needed in Palembang City. The NDVI processing stage begins by performing image resampling on the 2-B sentinel image, because the spatial resolution in the sentinel image varies, so image resampling must be performed to equalize the resolution of each band in order to carry out further processing, this stage is carried out using the S2 resampling processor tool in the SNAP software and selecting a resolution of 20 so that the visual quality of the sentinel image is better. To determine vegetation density, NDVI calculations are carried out on the SNAP software using the band maths tool, then entering the NDVI formula, namely (NIR-Red)/(NIR+Red), according to the band on the sentinel image where the NIR value is in band 8 and the Red value is in band 4, then the formula (Band 8 – Band 4)/(Band 8 + Band 4) is entered in band maths.

Figure 1. Research Sites

Table 2. Data for research

Data	Use	Source
Sentinel 2-B satellite imagery	Used to Create Vegetation Density Maps	Copernicus Open Access Hub
Data on the number of residents and livestock in Palembang City	Used for Calculation of Oxygen Requirements	Badan Pusat Statistik
Administrative Boundaries of Palembang City	Used for Image Cropping According to Research Area	Ina Geoportal

Classify the NDVI values obtained from processing in SNAP software into 5 classes according to the density class table [5, 6]. This processing is done in ArcGIS software by entering sentinel image data that has been processed from SNAP software, then using the reclassify tool and entering the NDVI range value for each density class listed in Table 3, namely for class 1, namely the non-vegetation class, it is in the range of -1 to -0.03; for class 2, namely the very low greenness class, it is in the range of -0.03 to 0.15; for class 3, namely the low greenness class, it is in the range of 0.15 to 0.25; while for class 4, namely the medium greenness class, it is in the range of 0.25 to 0.35; and for class 5, namely the high greenness class, it is in the range of 0.35 to 1.

Table 3. NDVI Value Class

NDVI Value	Vegetation Density
-1 to -0,03	Non-Vegetation
0,03 to 0,15	Very Low
0,15 to 0,25	Low
0,25 to 0,35	Medium
0,35 to 1	High

Table 4. Green Open Space Classification

Vegetation Density	Green Open Space	Information
Non Vegetation	Water bodies such as rivers and lakes.	Non-RTH
Very Low	Very dense settlements, dry open land and asphalt roads.	Non-RTH
Low	Settlements, dirt roads, vacant land and rice fields.	Non-RTH
Medium	Plantations, gardens, grass and reed vegetation.	RTH
High	Forested vegetation.	RTH

To obtain the area of green open space per sub-district, it is necessary to cut the image based on the sub-districts in Palembang City using the clip tool, so that the data can be processed into more detail, namely per sub-district [7]. Then the area of each NDVI value class is obtained in the attribute table for one sub-district, then provide information for classes that are not green open spaces (RTH), namely classes 1, 2 and 3 (non-vegetation classes, very low greenness and low greenness) by providing the information "NON-RTH" and for classes that are green open spaces (RTH), namely classes 4 and 5 (medium greenness and high greenness classes) by providing the information "RTH" according to Table 4.

After creating a vegetation density map and identifying the area of available vegetation land, the next step is to analyze oxygen needs by calculating using the Gerarchical equation. The Gerarchical equation that was developed by Wisesa in 1988, uses an oxygen need approach calculation for population data and livestock in an area in a certain year multiplied by the oxygen needs per data, then all parameters can be added up to get the amount of oxygen needed in the area [8]. Furthermore, the amount of oxygen needed is divided by the amount of oxygen that can be produced in 1m² of green open space. The Gerarchical equation formula to get the area of green open space to meet oxygen needs:

$$L_t = \frac{Pt+Tt}{54 \times 0{,}9375} \quad (1)$$

Lt is define to the required area of green open space (m^2), Pt is amount of oxygen needed by humans, *Tt* is amount of oxygen needed by livestocks, 54 is Constant 1 m^2 of green open space produces a dry weight of plants of 54 grams, and 0.9375 is Constant 1 gram of dry weight of plants produces 0.9375 grams of oxygen/day.

3. Results and Discussion

3.1. Vegetation Density Map

The vegetation density map is the result of NDVI processing from sentinel 2B imagery. On this map you can see the vegetation density in Palembang City which has been divided into 5 classes according to the NDVI value class table consisting of; non-vegetation areas, very low greenness, low greenness, medium greenness and high greenness. Each class is marked with a different color as in the image below.

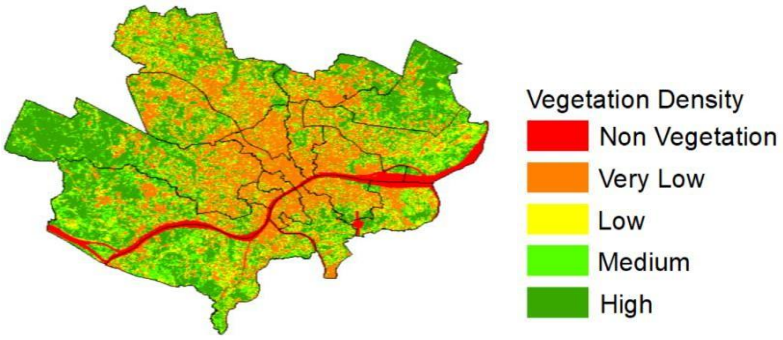

Figure 3. Vegetation Density Map

After the accuracy test was carried out, the next step was to calculate the area of each vegetation density class. The results of the calculation of the area of each vegetation density class per sub-district in Palembang City are presented in the following table.

Table 5. Area of Vegetation Density Per District

SUBDISTRICT	NV (ha)	VL (ha)	L (ha)	M (ha)	H (ha)
ALANG ALANG LEBAR	0,830	897,260	382,869	340,842	675,193
BUKIT KECIL	9,315	171,503	33,657	15,776	5,763
GANDUS	404,436	881,323	662,804	1.088,117	1.853,904
ILIR BARAT I	5,096	1.368,958	688,844	843,801	2.714,651
ILIR BARAT II	21,973	187,529	47,645	23,748	15,094
ILIR TIMUR I	10,964	438,655	46,577	22,731	7,058
ILIR TIMUR II	204,552	576,775	158,103	116,624	129,269
ILIR TIMUR III	9,769	437,077	120,772	81,875	99,361
JAKABARING	46,692	465,589	244,770	213,832	314,750
KALIDONI	301,948	739,039	670,866	597,090	672,882
KEMUNING	0,067	506,144	92,417	46,819	42,828
KERTAPATI	282,969	865,201	798,806	1.033,254	1.304,383
PLAJU	216,974	371,419	296,365	247,652	253,692
SAKO	2,488	652,204	251,093	206,605	547,417
SEBERANG ULU I	42,137	246,946	49,851	24,244	29,980
SEBERANG ULU II	97,850	448,911	153,331	98,446	159,213
SEMATANG BORANG	0,021	405,784	338,938	498,789	1.388,457
SUKARAMI	5,894	1.529,514	984,818	837,454	1.227,573
TOTAL	1.663,972	11.189,831	6.022,526	6.337,699	11.441,468
PERCENTAGE	4,539	30,527	16,430	17,290	31,214

The density classes that include green open spaces are medium and high vegetation density classes, while for non-vegetation areas, very low vegetation density and low vegetation density are not green open spaces. The area of green open spaces and those that are not green open spaces per sub-district in Palembang City can be seen in the following table.

Table 6. Area of Green Open Space Per District

SUBDISTRICT	NON RTH (ha)	RTH (ha)
ALANG ALANG LEBAR	1.280,958	1.016,036
BUKIT KECIL	214,475	21,539
GANDUS	1.948,563	2.942,021
ILIR BARAT I	2.062,898	3.558,453
ILIR BARAT II	257,146	38,842
ILIR TIMUR I	496,195	29,789
ILIR TIMUR II	939,431	245,893
ILIR TIMUR III	567,617	181,235
JAKABARING	757,051	528,582
KALIDONI	1.711,853	1.269,972
KEMUNING	598,629	89,647
KERTAPATI	1.946,976	2.337,637
PLAJU	884,757	501,344
SAKO	905,785	754,021
SEBERANG ULU I	338,934	54,223
SEBERANG ULU II	700,092	257,659
SEMATANG BORANG	744,743	1.887,245
SUKARAMI	2.520,226	2.065,027
TOTAL	18.876,330	17.779,167
PERCENTAGE	51,497	48,503

Furthermore, it is visualized in the form of a map of the distribution of green open spaces in the City of Palembang by creating a map of the distribution of green open spaces, for non-green open space areas it is colored yellow and those included in the green open space area are marked with green.

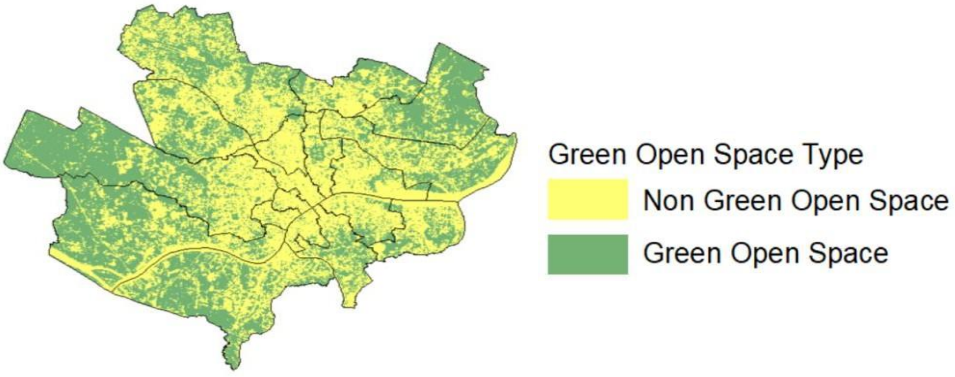

Figure 3. Green Open Space Distribution Map

3.2. Oxygen Requirements Analysis

The amount of oxygen needed by humans and livestock is obtained by multiplying the number of humans or livestock by their respective different oxygen requirements. The oxygen requirements of humans and each livestock can be seen in Table 6.

Table 7. Oxygen Needs Based on Consumers [8]

Consumers	**Oxygen Needs**
Human	0,864 kg/day
Cows and Buffaloes	1,7 kg/day
Goats and Sheep	0,31 kg/day
Poultry	0,17 kg/day
Horses	2,86 kg/day
Pigs	1,24 kg/day

The calculation of human oxygen needs is done by multiplying the population by the oxygen needs of each person, which is 0.864 kg/day. The following table presents the oxygen needs of the population per sub-district in Palembang City.

Table 8. Population Oxygen Needs

SUBDISTRICT	TOTAL POPULATION	NEED FOR OXYGEN	O^2 HUMAN (kg/day)	O^2 HUMAN (g/day)
ALANG ALANG LEBAR	113.578	0,864	98.131,392	98.131.392
BUKITKECIL	38.226	0,864	33.027,264	33.027.264
GANDUS	81.146	0,864	70.110,144	70.110.144
ILIR BARAT I	151.894	0,864	131.236,416	131.236.416
ILIR BARAT II	69.665	0,864	60.190,560	60.190.560
ILIR TIMUR I	66.260	0,864	57.248,640	57.248.640
ILIR TIMUR II	84.949	0,864	73.395,936	73.395.936
ILIR TIMUR III	74.431	0,864	64.308,384	64.308.384
JAKABARING	93.830	0,864	81.069,120	81.069.120
KALIDONI	130.828	0,864	113.035,392	113.035.392
KEMUNING	81.977	0,864	70.828,128	70.828.128
KERTAPATI	98.434	0,864	85.046,976	85.046.976
PLAJU	98.426	0,864	85.040,064	85.040.064
SAKO	115.585	0,864	99.865,440	99.865.440
SEBERANG ULU I	94.662	0,864	81.787,968	81.787.968
SEBERANG ULU II	105.784	0,864	91.397,376	91.397.376
SEMATANGBORANG	67.447	0,864	58.274,208	58.274.208
SUKARAMI	205.370	0,864	177.439,680	177.439.680
TOTAL	1.772.492		1.531.433,088	1.531.433.088

Furthermore, the oxygen requirements of each type of animal are added up, namely cows and buffaloes, goats and sheep, poultry, horses, and pigs to obtain the oxygen requirements of livestock per sub-district in Palembang City.

Table 9. Oxygen Requirements of Livestock

SUBDISTRICT	TOTAL O^2 OF LIVESTOCK (g/day)
ALANG ALANG LEBAR	28.248.720
BUKITKECIL	3.060
GANDUS	348.100
ILIR BARAT I	7.980.550
ILIR BARAT II	52.950
ILIR TIMUR I	92.200
ILIR TIMUR II	7.345.810
ILIR TIMUR III	469.470
JAKABARING	170.200
KALIDONI	1.200.000
KEMUNING	410.500
KERTAPATI	949.980
PLAJU	391.260
SAKO	2.049.000
SEBERANG ULU I	217.080
SEBERANG ULU II	193.680
SEMATANGBORANG	152.360
SUKARAMI	3.620.180
TOTAL	53.895.100

The results of the calculation of livestock oxygen requirements show that Alang Alang Lebar District has the highest oxygen requirements for livestock, this is because this district is the only one that has pigs and with a very high number, and the number of poultry in this district is also the highest. Meanwhile, Ilir Barat Satu District and Ilir Timur Dua District also have quite large oxygen requirements for livestock, this is driven by the number of poultry in the district which is also higher than other districts. Meanwhile, Bukit Kecil District has the lowest oxygen requirements for livestock because in this district there are only poultry and the number is also the smallest.

3.3. Need for Green Open Space

The calculation of the need for green open space to meet the oxygen needs per sub-district is carried out using the gerarchical formula, namely by adding up the oxygen needs of the population and livestock, then dividing it by the oxygen that can be produced in 1m² of green open space, which is 50.625 grams, so that the area of green open space needed to meet the oxygen needs of each sub-district in Palembang City is obtained.

Table 10. Area of Green Open Space Required

	O^2 HUMAN (g/day)	O^2 LIVESTOCK (g/day)	GREEN SPACE AREA (m²)	GREEN SPACE AREA (ha)
ALANG ALANG LEBAR	98.131.392	28.248.720	2.496.397,274	249,640
BUKIT KECIL	33.027.264	3.060	652.450,844	65,245
GANDUS	70.110.144	348.100	1.391.767,783	139,177
ILIR BARAT I	131.236.416	7.980.550	2.749.964,760	274,996
ILIR BARAT II	60.190.560	52.950	1.189.995,259	119,000
ILIR TIMUR I	57.248.640	92.200	1.132.658,568	113,266
ILIR TIMUR II	73.395.936	7.345.810	1.594.898,686	159,490
ILIR TIMUR III	64.308.384	469.470	1.279.562,548	127,956
JAKABARING	81.069.120	170.200	1.604.727,309	160,473
KALIDONI	113.035.392	1.200.000	2.256.501,570	225,650
KEMUNING	70.828.128	410.500	1.407.182,775	140,718
KERTAPATI	85.046.976	949.980	1.698.705,304	169,871
PLAJU	85.040.064	391.260	1.687.532,326	168,753
SAKO	99.865.440	2.049.000	2.013.124,741	201,312
SEBERANG ULU I	81.787.968	217.080	1.619.852,800	161,985
SEBERANG ULU II	91.397.376	193.680	1.809.206,044	180,921
SEMATANG BORANG	58.274.208	152.360	1.154.105,047	115,411
SUKARAMI	177.439.680	3.620.180	3.576.491,062	357,649
TOTAL			31.315.124,701	3.131,512

The results of the calculation of the need for green open space area obtained a total need for green open space area in all sub-districts in Palembang City of 3,131.512 hectares, Sukarami sub-district is the sub-district with the highest need for green open space area, which is 357.649 hectares, while the lowest need for green open space area is in Bukit Kecil sub-district with an area of 65.245 hectares.

Next, compare the area of open space needed to meet oxygen needs with the area of green open space available, by subtracting the area of green open space available from the area of green open space needed which is obtained from the gerarchical calculation in Table 9 above, so that we can find out which sub-districts already have sufficient green open space and which sub-districts still have insufficient green open space.

In the table below, it can be seen that as many as 5 sub-districts in Palembang City still do not have sufficient green open space. The sub-district with the greatest shortage of green open space is Seberang Ulu Satu Sub-district, which is 107,762 hectares, while the sub-district with the greatest excess of green open space is Ilir Barat Satu Sub-district, which is 2,802,845 hectares. Furthermore, it is presented in the form of a map of the distribution of green open space needs in Palembang City.

Table 11. Green Open Space Needs Status

SUBDISTRICT	REQUIREMENTS FOR GREEN SPACE AREA (ha)	AVAILABLE GREEN SPACE AREA (ha)	GREEN SPACENEEDS STATUS (ha)	INFORMATION
ALANG ALANG LEBAR	249,640	1.016,036	766,396	ENOUGH
BUKIT KECIL	65,245	21,539	-43,706	NOT ENOUGH
GANDUS	139,177	2.942,021	2.802,845	ENOUGH
ILIR BARAT I	274,996	3.558,453	3.283,456	ENOUGH
ILIR BARAT II	119,000	38,842	-80,158	NOT ENOUGH
ILIR TIMUR I	113,266	29,789	-83,477	NOT ENOUGH
ILIR TIMUR II	159,490	245,893	86,403	ENOUGH
ILIR TIMUR III	127,956	181,235	53,279	ENOUGH
JAKABARING	160,473	528,582	368,109	ENOUGH
KALIDONI	225,650	1.269,972	1.044,322	ENOUGH
KEMUNING	140,718	89,647	-51,071	NOT ENOUGH
KERTAPATI	169,871	2.337,637	2.167,767	ENOUGH
PLAJU	168,753	501,344	332,591	ENOUGH
SAKO	201,312	754,021	552,709	ENOUGH
SEBERANG ULU I	161,985	54,223	-107,762	NOT ENOUGH
SEBERANG ULU II	180,921	257,659	76,739	ENOUGH
SEMATANG BORANG	115,411	1.887,245	1.771,835	ENOUGH
SUKARAMI	357,649	2.065,027	1.707,378	ENOUGH
TOTAL	3.131,512	17.779,167		

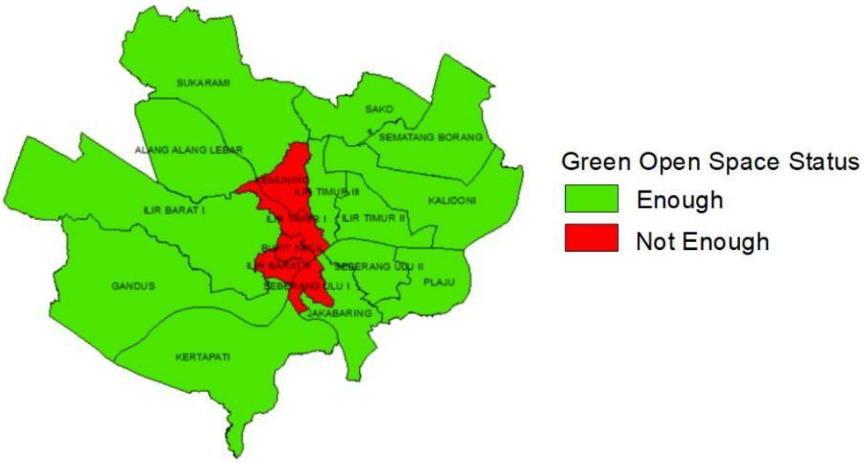

Figure 4. Map of Distribution of Green Open Space Needs

In Figure 4.8, it can be seen that sub-districts that lack green open spaces tend to be located in the central part of Palembang City, because the dense population in the center of Palembang City has created very dense settlements in the central part of Palembang City, while the outskirts of Palembang City tend to have sufficient green open spaces to meet the oxygen needs of residents and livestock in each sub-district.

Kecamatan yang masih kekurangan ruang terbuka hijau di Kota Palembang ada sebanyak 5 kecamatan, antara lain; Kecamatan Seberang Ulu I seluas 107,762 hektar, kecamatan Ilir Timur I seluas 83,477 hektar, kecamatan Ilir Barat II seluas 80,158 hektar, kecamatan Kemuning seluas 51,071 hektar dan kecamatan Bukit Kecil seluas 43,706 hektar. Sedangkan untuk 13 kecamatan lainnya sudah memiliki ruang terbuka hijau yang cukup untuk kebutuhan oksigen penduduk dan hewan ternaknya.

4. Conclusion

Based on the results of the identification of the availability of green open space using vegetation density calculations from NDVI processing, the area of non-vegetation is 1,663.972 hectares (4.539%), the area with very low vegetation density has a total area of 11,189.831 hectares (30.527%), the area with low vegetation density is 6,022.526 hectares (16.430%), the area with medium vegetation density is 6,337.699 hectares (17.290%), and the area with high vegetation density is 11,441.468 hectares (31.214%). The density classes included in green open space are high and medium vegetation density classes, so that the total area of green open space in Palembang City is 17,779.167 hectares. The results of the calculation of the population's oxygen needs obtained the total oxygen needs of the Palembang City population of 1,531,433,088 g/day, while for the oxygen needs of livestock, the total livestock needs of Palembang City were obtained as much as 53,895,100 g/day. So after the calculation of the gerarchical formula, the area of green open space needed for each sub-district in Palembang City was obtained, for the total area of green open space needed to meet the oxygen needs of the population and livestock, namely 3,131.512 hectares. The results of the identification of the availability of green open space and the results of the calculation of the area of green open space needed to meet the oxygen needs of the population and livestock, it can be seen the status of green open space from each sub-district in Palembang City, where 5 sub-districts still lack green open space, these sub-districts are located in the central part of Palembang City, namely Bukit Kecil, Iir Barat II, Ilir Timur I, Kemuning, and Seberang Ulu I sub-districts, while the other 13 sub-districts already have sufficient green open space.

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