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Analysis of green open space requirement based on the oxygen needs in Tasikmalaya City, West Province, Indonesia

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Abstract: *Climate change poses a grave threat to the economies, healthcare, societies, and natural environment. It is caused by various factors, such as the rapid growth of human population, transportation, technology advance, and land use change. The change of land utilization from vegetation to urban areas affects the ecological balance of city environment, especially oxygen needs and the surrounding climate. This present study aims at determining the coverage area of green open space required in Tasikmalaya city, Indonesia, based on the oxygen needs Gerakis formula is employed to calculate the needs of oxygen for human, vehicles, and livestock. The result showed that the green open space in Tasikmalaya city was 342.27 Ha. It is smaller than the required green open space necessary to increase the participation oh the community and business practitioners as the strategy to develop the green open space of the area. Furthermore, optimizing the green open space of the green line, median roads,and river borders or adding tree density and plant stratification is also suggested.*

Keywords: *climate change, green open space, oxygen needs*

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I. Introduction

Tasikmalaya is a city in the southeastern West Java, Indonesia. Its is situated around 105 kilometers southeast from the provincial capital of Bandung and 255 southeast kilometers from Indonesian capital and largest city, Jakarta. With its strategic geographic location, Tasikmlaya gets advantages both in economic growth and development. As having the rapid progress in various sectors, the city is usually called "The Pearl of East Priangan".

Tasikmalaya becomes the center of East Priangan, because almost 70% of the business and industrial centers, it triggers the rapid growth of Tasikmalaya city. The condition affects economic and population growth. Looking back in the beginning of 2002, Tasikmalaya's population was 546,871 people. Todays, the statistic shows that the total population of the city increase to 659,606 people. This phenomenon inevitably leads to the conversion of land use, from vegetation to urban areas (high rise buildings, road, and housing settlements). This has impacts on the ecological balance of city environment, especially on air pollution.

Air pollution accompanied by the increasing levels of carbon dioxide in the air causes the urban environment unhealthy and is able to reduce human health and well-being. Therefore, it is necessary to avoid the increase of the concentration of carbon dioxide gas in the air. One way to reduce carbon dioxide in urban areas is by reducing carbon emissions and building urban forests[1]. Carbon dioxide gas is the greenhouse gasthat contributes most to the occurrence of global warming. Currently, the Government of Indonesia is committed to a 29% reduction in greenhouse gas emissions by its own efforts and 41% with international assistance up to 2030[2].

At present, Tasikmalaya city experienced a rise in temperature that caused inconvenience for the population of Tasikmalaya city. So, to overcome the problem, the existence of green open space is indispensable. The presence of vegetation in urban areas brings great influence, especially in improving the comfort temperature[3]. Plants as the main component of green open space fillers have the ability in absorbing CO_2 emissions so that they can reduce CO_2 emissions concentration in nature. Trees also help removing pollutants from the air absorbed by leaves and deposited on the leaf surface, so urban green trees can help the city stay cool and act as a natural filter as well as a silencer[4].

Green open spaces have afunction in repairing, regulating, and maintaining microclimate or functioning in microclimate amelioration[3]. The role of green open space in the sustainability and comfort of the city increases with the increasing impacts of urbanization[5]. Well-managed green open spaces can provide various ecological benefits and support the sustainability of the city[6]. Thus, this present study aims at determining the

coverage area of green open space based on the oxygen needs in Tasikmalaya city, so that it can reduce carbon dioxide gas emissions.

II. Material And Methods

This research was conducted in Tasikmalaya, for three months, starting from September until November 2017. The equipment used is stationery, calculation tool, Microsoft Word, and Excel software. The materials needed in this research are land use map, population data, livestock, and motor vehicle in Tasikmalaya city[7].

This study employed observation and literature study as the data collection techniques and procedures. The data obtained through this process are then analysed to determine the extent of green open space that exists today and the needs of green open space based on the fulfilment of the oxygen needs[7].

II.1. Green Open Space based on Oxygen needs

The calculation of the need for green open space to meet the oxygen needs of a city area is based on Gerakis formula developed by Wisesa [8].

$$Lt = \frac{Pt + Kt + Tt}{(54)(0{,}9375)} m^2 \quad (1)$$

Information :

Lt = areas of green open space (m^2)
Pt = oxygen demand for the population at year t ($gramsday^{-1}$)
Kt = oxygen demand for a motor vehicle in year t ($grams\ day^{-1}$)
Tt = oxygen demand for livestock in year t ($gramsday^{-1}$)
54 = constants indicating 1 m^2 of land area yielding 54 grams of plant dry weight per day ($gramm^{-2}$)
0.9375 = constants which indicate that 1 gram of plant dry weight is equivalent to 0.9375 gram Oxygen production

Assumptions used:

- The oxygen requirement per day per population is the same.
- Oxygen supply is only done by plants.
- Oxygen users are humans, motor vehicles,and livestock.
- Motor vehicle emissions are considered equal.
- Leaves are not molting throughout the year.

III. Result

III.1. Oxygen Needs

The calculation of oxygen demand by humans, motor vehicles, and livestock in Tasikmalaya employs a formula developed by Gerarkis. The preliminary data required in the equation are population data, the number of vehicles, and the number of livestock in Tasikmalaya. Population and the number of farm animals is obtained data are obtained from the Central Bureau of Statistics of Tasikmalaya city and, while the data of motor vehicles are obtained by calculating the number of vehicles on the main road segments in Tasikmalaya, as seen in Tables no 1 and 2.

Table no 1 : Number of Population and Vehicles in Tasikmalaya City

Districts	Amount				
	Population (people)	Motor Vehicle (units)			
		Motorcycle	Passenger Vehicle	Bus	Truck
Kawalu	88,255	23,932	2,512	589	978
Tamansari	65,856	17,95	1,689	43	354
Cibeureum	63,359	19,326	1,489	27	682
Purbaratu	39,324	10,305	821	15	58
Tawang	65,355	24,605	3,82	487	2,174
Cihideung	74,17	25,511	3,942	354	1,997
Mangkubumi	88,605	26,956	3,894	871	1,181
Indihiang	49,396	16,594	2,681	1,578	589
Bungursari	47,595	13,574	2,147	219	641
Cipedes	77,691	28,675	3,894	214	1,984

Source: Anonymous, 2017 [9] and Primary Data, 2017

Table no 2 : Number of Livestock in Tasikmalaya City

Districts	Number of Livestock (head)						
	Cow	Buffalo	Horse	Goat	Sheep	Chicken	Duck
Kawalu	511	81	44	343	1,033	296,472	3,779
Tamansari	606	104	34	518	1,59	416,754	5,588
Cibeureum	175	41	96	324	1,654	258,586	7,77
Purbaratu	171	39	84	303	1,036	249,002	5,422
Tawang	24	3	0	8	36	1,862	2,4
Cihideung	15	0	5	31	179	7,186	562
Mangkubumi	349	102	48	611	4,322	273,522	5,002
Indihiang	621	54	60	232	740	71,51	4,676
Bungursari	407	248	57	447	1,524	277,163	5,536
Cipedes	49	7	7	197	217	43,949	4,586

Source: Anonymous, 2017 [9]

Humans needs oxygen per person per day is 0.864 $kgday^{-1}$ for metabolism. Besides humans, motor vehicles and livestock also need oxygen. Motor vehicles require oxygen for the process of fuel combustion. The amount of oxygen demand constants for motor vehicles and livestock can be seen in Table no 3.

Table no 3 : Oxygen needs constants

Type	Oxygen needs	
	$Kgday^{-1}$	$Gramday^{-1}$
Human	0.864	864.00
Motorcycle	0.5817	581.70
Passenger vehicle	11.634	11,634.00
Bus	45.76	45,760.00
Truck	22.88	22,880.00
Buffalo	170.208	1,702.08
Cow	170.208	1,702.08
Pig	170.208	1,702.08
Horse	185.472	1,854.72
Goat	0.31392	313.92
Sheep	0.31392	313.92
Chicken	0.16704	167.04
Duck	0.16704	167.04

Source: Wisesa [8]

Based on the data obtained, the amount of oxygen needs for humans, motor vehicles, and livestock in Tasikmalaya city can be calculated as follows (Tables no 4 and 5).

Table no 4 : Population Oxygen Needs and Motor Vehicles of Tasikmalaya City

Subdistrict	Oxygen needs ($kgday^{-1}$)				
	Population	Motorcycle	Passengger Vehicle	Bus	Truck
Kawalu	76,252.32	13,921.24	29,224.61	26,952.64	22,376.64
Tamansari	56,899.58	10,441.52	19,649.83	1,967.68	8,099.52
Cibeureum	54,742.18	11,241.93	17,323.03	1,235.52	15,604.16
Purbaratu	33,975.94	5,994.42	9,551.51	686.40	1,327.04
Tawang	56,466.72	14,312.73	44,441.88	22,285.12	49,741.12
Cihideung	64,082.88	14,839.75	45,861.23	16,199.04	45,691.36
Mangkubumi	76,554.72	15,680.31	45,302.80	39,856.96	27,021.28

Indihiang	42,678.14	9,652.73	31,190.75	72,209.28	13,476.32
Bungursari	41,122.08	7,896.00	24,978.20	10,021.44	14,666.08
Cipedes	67,125.02	16,680.25	45,302.80	9,792.64	45,393.92

Source: Primary Data, 2017

Table no 5 : Livestock Oxygen Needs

Subdistrict	Oxygen needs ($kgday^{-1}$)						
	Cow	Buffalo	Horse	Goat	Sheep	Chicken	Duck
Kawalu	869.76	137.87	81.61	107.67	324.28	49,522.68	631.24
Tamansari	1,031.46	177.02	63.06	162.61	499.13	69,614.59	933.42
Cibeureum	297.86	69.79	178.05	101.71	519.22	43,194.21	1,297.90
Purbaratu	291.06	66.38	155.80	95.12	325.22	41,593.29	905.69
Tawang	40.85	5.11	0.00	2.51	11.30	311.03	400.90
Cihideung	25.53	0.00	9.27	9.73	56.19	1,200.35	93.88
Mangkubumi	594.03	173.61	89.03	191.81	1,356.76	45,689.11	835.53
Indihiang	1,056.99	91.91	111.28	72.83	232.30	11,945.03	781.08
Bungursari	692.75	422.12	105.72	140.32	478.41	46,297.31	924.73
Cipedes	83.40	11.91	12.98	61.84	68.12	7,341.24	766.05

Source: Primary Data, 2017

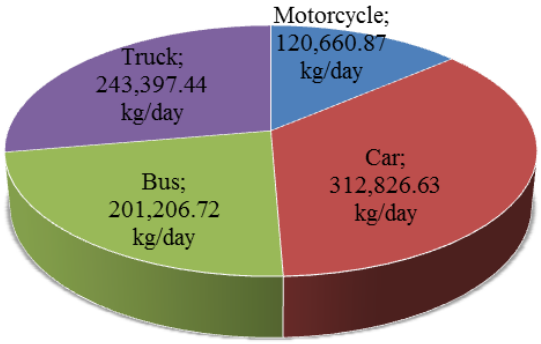

Figure no 1: Passenger Vehicle Oxygen Needs

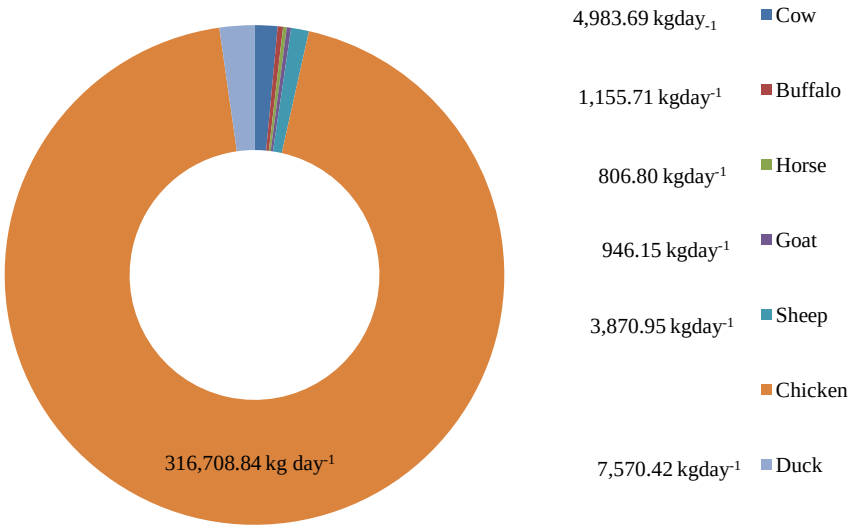

Figure no 2 : Livestock Oxygen Needs

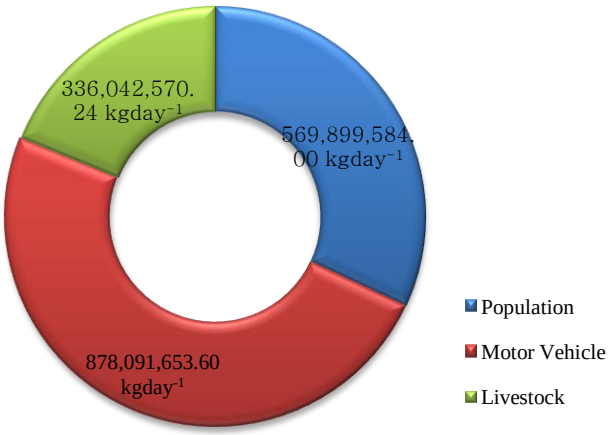

Figure no 3 : The Composition of Tasikmalaya City Oxygen Needs

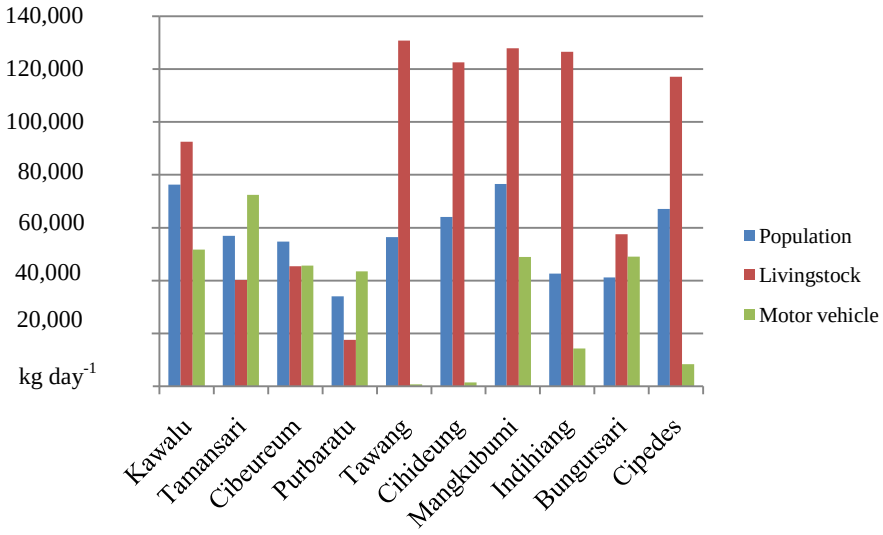

Figure no 4 : Oxygen Needs in Each Subdistrict

III.2. Area of Green Open Space based on Oxygen Needs

Tasikmalaya city has 342.27 Ha of green open space spread in over ten districts. The needs for green open space based on oxygen demand in Tasikmalaya city are calculated using *Gerakis* formula, as shown in Table no 6.

Table no 6 : Green Open Space Requirement by Oxygen Needs

Districts	Green Open Space Needs (Ha)	Existing Green Open Space (Ha)	Lack of Green Open Space (Ha)
	1	2	3 = (1-2)
Kawalu	435.36	137.28	298.08
Tamansari	334.89	50.53	284.36
Cibeureum	288.01	22.81	265.21
Purbaratu	187.59	13.73	173.86
Tawang	371.40	10.96	360.43
Cihideung	371.49	19.11	352.38
Mangkubumi	500.44	54.08	446.36

Indihiang	362.47	6.68	355.79
Bungursari	291.84	15.17	276.67
Cipedes	380.52	11.91	368.61
Total	3,524.02	342.27	3,181.75

Source: Primary Data, 2017

IV. Discussion

Tables no 4 and 5 show that Mangkubumi is a subdistrict with the highest population oxygen requirement (76,554.72 kg day^{-1}). This is because the district is considered the most densely populated area in Tasikmalaya city. The highest oxygen demand for motor vehicles is in Tawang subdistrict (130,780.85 kg day^{-1}) whereas the highest oxygen requirement for livestock is in Tamansari subdistrict (72,481.29 kg day^{-1}). The high oxygen requirements for livestock are because of a large amount of chicken population in Tamansari subdistrict.

The oxygen requirements for motor vehiclesare mostly needed by passenger vehicles (cars), amounting to 312,826.63 kg day^{-1}. Meanwhile, for livestock, the highest oxygen requirements are for chickens (316,708,84 kg day^{-1}), as seen on figures no 1 and 2.

The total oxygen requirements in Tasikmalaya are mostly needed by motor vehicles (878,091.65 kg day^{-1}), followed by the population (569,899.58 kg day^{-1}) and livestock (336,042,57 kg day^{-1}), as seen on figure no 3. The comparison of oxygen requirement in each sub-district of Tasikmalaya city can be seen in figure no 4.

Based on Table no 6, it is seen that the requirement of green open space in Tasikmalaya is 3,524.02 Ha. It is smaller if compared to the existing green open space which is only 342.27 Ha. Therefore, Tasikmalaya still needs 3,181.75 Ha addition of green open space. The largest green open space addition is located in Mangkubumi subdistrict (446.36 Ha) and the smallest is in Purbaratu subdistrict (173.86 Ha).

Green open space has so many benefits. It can provide health benefits for humans, such as public health including physical, social, and mental especially for urban communities[10]. Then, green open space is very important to development in Tasikmalaya. The development of green open space needs the active involvement of urban planning, designers, and ecologists, to produce a green urban strategy aimed at promoting public health and the environment and social justice in urban communities[11], because this green open space planning in Indonesia is still largely based on their quantity needs, not their effectiveness to cool urban temperatures[12].

The nice green open space of the city can be utilized by the community as a means to socialize, rest, and health restoration[13]. The selection of vegetation types in urban parks determines the ability of urban parks in absorbing air pollution[14] and safeguarding environmental quality by absorbing carbon dioxide gas emissions[15].

V. Conclusion

For the purpose of maintaining the environmental balance, the areas of green open space in Tasikmalaya city is considered as inadequate. The minimum green open space required to meet the needs of oxygen in Tasikmalaya is amounted to 3,524.02Ha. However, in reality, the current public green open space area is only 342.27 Ha. Therefore,there is a lack of green open space of 3,181.75 Ha.

The strategy to develop the green open space of the area is by increasing the participation of the community and business practitioners to build green open space. Optimizing the green open space of the green line, median roads, and river borders or adding tree density and plant stratification is also suggested.

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