GREEN OPEN SPACE IN URBAN AREAS: A CASE IN THE GOVERNMENT OFFICE OF BOYOLALI, INDONESIA

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Abstract

Green open space has a necessary environmental role especially in urban areas where the demand for built-up land increases persistently. Its significance also applies to the integrated government office complex of Boyolali Regency. This research aimed to analyze the available and required green open space in the complex using a survey method, as well as aerial photo interpretation and field observation for data acquisition. The data was then analyzed to identify the available green open space by type, as classified in Act No. 26/2007 and the Regulation of the Ministry of Public Works No. 5/2008, and the required green open space using the Gerarkis method. This research also employed in-depth interviews with several key informants to sharpen the analysis. The results showed that the area of the office complex was 21.7 ha and the available green open space was 10.4 ha, which is larger than the recommended 30% of the total area. This research also found that the required green open space according to the oxygen need in the office complex was 0.006355 ha. Therefore, the available green open space has already met not only the legal requirement but also the oxygen need.

Keywords: availability, need, offices complex, urban green open space
JEL classification: O18, O20

1. Introduction

A city is an open system, which is physically and socio-economically non-static and dynamic, or commonly called as a system with temporary nature (Irwan 2005). A city is sometimes established as the government center of an area, but empirically it constitutes a place where various communities engage in social activities in different dimensions. A sustainable urban city is characterized by a balanced interaction and a reciprocal relationship between nature and human in the middle of their coexistence (Rahmy et al. 2012).

The development in several cities in Indonesia leads to widespread land use change in a relatively short time. It mostly changes green open space to urban infrastructures and buildings. Moreover, the industrial revolution has added to the deterioration of the environment in the urban areas (Patarkalashvili 2017). In the meantime, one of the conditions in urban area planning is the availability of green open space, which has become a necessity due to its abundant functions.

Open space accommodates specified activities of the people in its surroundings, either individual or communal. Its shape highly depends on the pattern and structure of the building mass (Hakim 1987). It is also essential in providing a window into social life in urban areas as well as into rural development (Leng and Li 2016).

Open space is equipped with roads, parking lots, pedestrian walkways, and trash cans to meet the needs of the community (Kristianova 2016). Furthermore, it has to meet the five elements, namely (a) good, (b) consisting of natural scenery, (c) encouraging the engagement and connection with the surrounding environment, (d) comfortable, and (e) harmonious (Lau, Gou, and Liu 2014).

Urban green open space is the interface between natural and artificial systems in an urban environment. Act No. 26/2007 on Spatial Planning explains that a region/city is obligated to allocate 30% of its total area for green open space, i.e., 20% for public use and 10% private green space. Green open space includes public parks and recreation areas, grass-covered

public parks, unroofed urban spaces and undeveloped natural landscapes, pieces of land between buildings, and any open urban spaces that are accessible to the public (Shabak et al. 2015). Open accessibility, as the key to effective social and ecological functions, optimizes the benefits of green open space (Gong, Zheng, and Ng 2017). Green open space comprises parks, cemeteries, yards and gardens, urban forests, wetlands, rivers, and lakes that provide services for the urban population (Breuste and Rahimi 2015).

On one hand, urban green open space is urgently needed by the population of a city due to its abundant roles. It functions as (a) a protection area, (b) a means to create cleanliness, health, harmony, and environmental aesthetics, (c) a media for microclimate improvement, and (d) a control to urban water management. On the other hand, urban green space is currently faced with many problems that often develop into land use conflict, i.e., the presence of green open space in densely populated areas.

Urban green open space also necessarily facilitates the interaction between human and nature (Hussain and Said 2015; Malek, Mariapan, and Rahman 2015; Mathers, Dempsey, and Molinc 2015). This interaction has been known to benefit human's health, such as reducing stress and encouraging sustainable pro-social behavior (Maller et al. 2006 in Roberts 2017) because green open space provides essential recreational services for urban population (Robert and Yengue 2017). Despite the acknowledgment to the many benefits, most urban green open space has gradually disappeared in various countries (Haas et al. 2015 in Southon et al. 2017).

Open space in offices or educational areas has a diverse use, for instance, as a playground, a gathering spot, and a place for sports, ceremonies, music performances, and other activities (Sintani, Ramli, and Zubair 2013). These open spaces should also be utilized for the development of urban forests. Office buildings can have a green space when their open lands are planted with trees and flowers and arranged optimally.

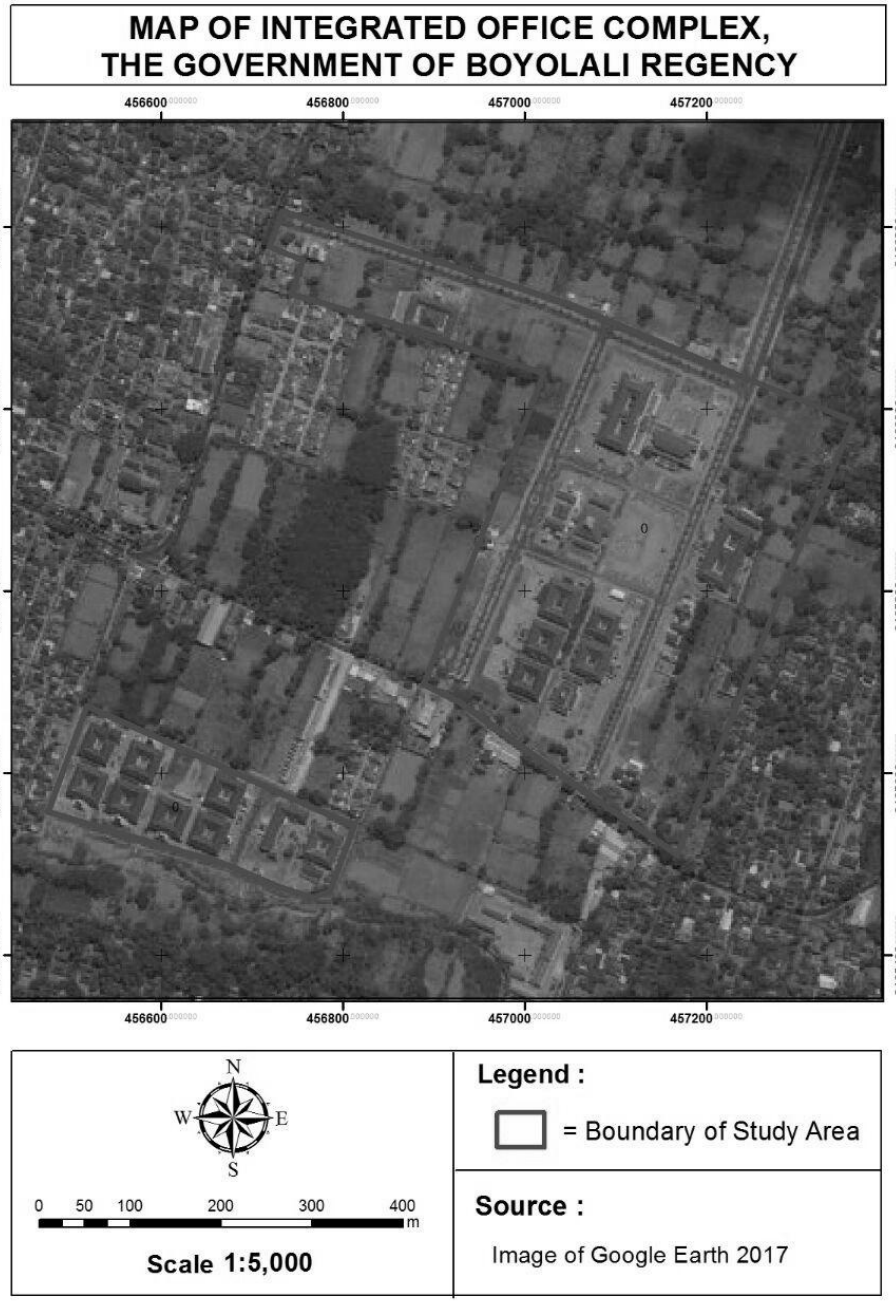
In addition to producing oxygen and absorbing carbon dioxide, the vegetation in green open space also breaks down harmful gases released during the combustion of fuels in vehicle engines. One of the factors affecting air quality is the increase in the number or volume of vehicles as a means of transportation, as it remains the primary source of air pollution in urban areas (Mutia, Ramli, and Zubair 2013).

Green open space in an office complex is related to oxygen availability for human beings, i.e., the employees, and their vehicles (Nastiti, 2018). The vegetation in green open space produces oxygen and contributes to the reduction of climate change impact by absorbing carbon dioxide (Abbasi, Alalouch, and Bramley 2016; Nero et al. 2017). One hectare of vegetation releases 600 kg O_2 to the atmosphere and absorbs 900 kg CO_2 (Frick and Setiawan 2002 in Baharuddin 2011). Green open space has to cover at least 30% of the total area of a region, which includes 20% public space and 10% private space (UU RI No. 26/2007).

Urban development also occurs in the integrated government office complex of Boyolali Regency. The change of the location of the central government prompted the necessary construction of new buildings to support the government activities, as seen in Figure 1. The government office of Boyolali Regency was originally located in Boyolali District. However, due to the space limitation for the expansion of the government building, the office complex was moved to Mojosongo District in 2013. The construction of the integrated office complex aimed to facilitate the implementation of an executive region and local government agency in one same zone. Nowadays, many constructions take place in Boyolali Regency due to the increasing demand for public facilities. The development occurs on the land that was originally a green space like gardens or green fields, as presented in Figure 2.

The change of the central government's location and the construction of the new office building have reduced the extent of green open space. Green infrastructure in urban areas is defined as a planned network of natural and semi-natural lands that is strongly recommended to be included in city planning due to its role in providing ecosystem services, preserving biodiversity, and producing a viable urban environment (European Commission 2003 in Mesimaki et al. 2017). This definition accentuates the necessity of available green open space in urban areas.

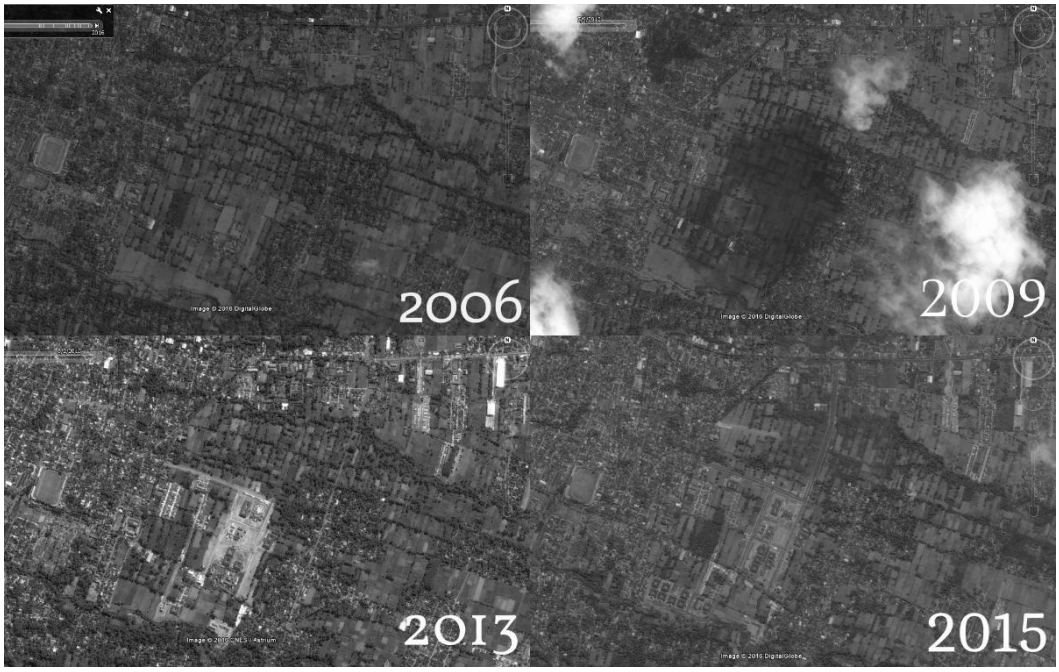
Figure 1: The Integrated Government Office Complex of Boyolali Regency



Source: Google Earth, 2017

Until recently, there has been no specific research documenting the available and required green open space in the integrated government office complex of Boyolali Regency. According to the scientific background elaborated above, this research becomes necessary and, thereby, it aims to (1) analyze the availability of green open space in the integrated government office complex of Boyolali Regency and (2) analyze the required green open space in the office complex. This research is expected to give two benefits, namely theoretical-academic benefit and empirical-practical benefit. From the theoretical-academic perspective, this research is believed to be able to develop sciences especially in the field of urban geography. Meanwhile, from the empirical-practical point of view, it is expected to contribute significantly to the formulation of development policies in urban areas that especially concern on the management of green open space.

Figure 2: Land Use Change in the Integrated Government Office Complex of Boyolali Regency in 2006-2015



Source: Google Earth, 2006, 2009, 2013, and 2015

2. Methodology

This research used survey method and acquired data from aerial photo interpretation and field observation. The data processing technique used to achieve the first objective was the interpretation of aerial photo obtained from Google Earth. The research utilized the feature 'calculate area' in Arc GIS software to identify the extent of the available green open space, as interpreted from the aerial photo. The available green open space in the office complex was presented along with the ability of this space to produce oxygen and absorb carbon dioxide. One hectare of green open space can release 600 kg O_2 to the atmosphere and absorb 900 kg CO_2 (Frick and Setiawan 2002 in Baharuddin 2011).

The second research objective was achieved using the Gerarkis method, which relied on the indicators of oxygen needs, namely the oxygen need of the employees of the office complex and the oxygen need of the vehicles. In one day, the employees work for averagely 9 hours. At the same time, adult humans require averagely 14,400 liters of air. Therefore, the oxygen need of the employees in one working day is 0.315 kg (Sintani, Ramli, and Zubair 2013). The equation used to calculate the oxygen need of the employees is as follows.

$$The\ oxygen\ need\ of\ employees = Total\ employees\ \times 0.315\ kg \quad (1)$$

A vehicle can function when it generates energy from fuel combustion. This process requires a specified amount of oxygen. A motorcycle needs 0.5817 kg/hour, while a car or a passenger vehicle requires 11.636 kg/hour (Wisesa 1988 in Ramadhan 2012). The oxygen required by vehicles can be estimated from the following equation.

$$The\ oxygen\ need\ of\ vehicles = Total\ vehicles\ \times O_2\ need\ per\ vehicle \quad (2)$$

The required area for green open space was calculated based on the volume of necessary oxygen consumption. The calculation used the Gerarkis method (1974) that had been slightly adjusted by Wijayanti (2003).

$$Lt = \frac{Pt + Kt + Tt}{(54)(0.9375)} m^2 \quad (3)$$

where Lt = Area of green open space (m^2), Pt = The oxygen need of employees (kg/hour), Kt = The oxygen need of vehicles (kg/hour), and Tt = The oxygen need of

livestock (kg/hour). Meanwhile, 54 and 0.9375 are constants that, respectively, represent 1 hectare of land producing 54 grams of plant dry weight per day and 1 gram of plant dry weight equal to the production of 0.9375 gram of oxygen.

The available green open space also plays a significant role in absorbing the carbon dioxide emitted from human activities. Humans oxidize 3,000 calories per day from their foods, consume 600 liters of oxygen or 840 grams of oxygen per day, and release 480 grams of carbon dioxide per day (White et al. 1959 in Sintani, Ramli, and Zubair 2013). The CO_2 emitted by the employees of the office complex was calculated based on the length of the office activities, i.e., averagely 9 hours/day. Accordingly, every employee in the office released 180 grams of carbon dioxide.

$$The\ amount\ of\ CO_2\ emission = Total\ employees\ \times 0.18\ kg \quad (4)$$

From the estimated amount of the carbon dioxide emitted by the employees, this research was able to determine whether the available green open space has met the demand for one. Furthermore, it also conducted in-depth interviews with several key informants to sharpen the analysis.

3. Results

Green open space becomes the primary contributor to the sustainability of the social life and ecological function in an urban environment (Hussain and Said 2015). It increases the ambient water quality by filtering urban water runoff, conserves energy, minimizes air pollution, and reduces the effects of greenhouse gases (Madurapperuma and Kuruppuarachchi 2016). The availability of green open space has a direct relationship with oxygen production and carbon dioxide absorption. A green open space is considered sufficient when it has met the oxygen need of the employees (as the main actors who conduct the activities in the office) and the oxygen need of the vehicles. Furthermore, a sufficient green open space is actualized when it can absorb the carbon dioxide emitted by the employees and their vehicles.

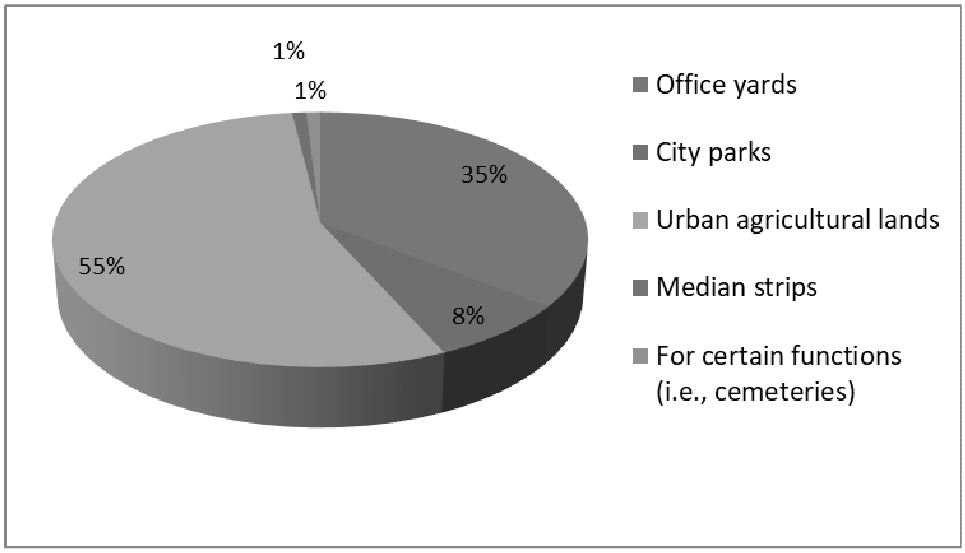
The available green open space in the integrated government office complex of Boyolali Regency was identified from the extent of the land that was not covered with buildings but planted with a variety of green plants. The office complex has 23 office buildings and 5 public facilities for worship. The extent of the available green space was interpreted from the aerial photo of the office complex. The results showed that the integrated government office complex of Boyolali Regency was built on 21.7 ha land. Meanwhile, the green open space in the complex was 10.4 ha. The distribution of available green open space in the study area is presented in Table 1, while the different types of green open space and their proportions are presented in Figure 3.

Table 1. The Available Green Open Space in the Integrated Government Office Complex of Boyolali Regency

Types of Green Open Space	Area (ha)
Office yards	3.7
City parks	0.8
Urban agricultural lands	5.7
Median strips	0.1
For certain functions (i.e., cemeteries)	0.1
Total	**10.4**

Source: Data analysis in 2017

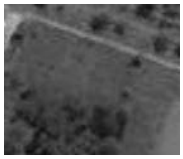
Figure 3: The Proportions of Available Green Open Space in the Integrated Government Office Complex of Boyolali Regency by Type



Source: Data analysis in 2017

Table 2 shows the available green open space in the study area, as seen on the satellite imagery and in the field. The extent of the available green open space, i.e., 10.4 ha from the total 21.7 ha of the office complex, has met the legal condition, namely 30% of the total area. The following quotes support this fact. "The green open space is sufficient because there are many annual plants around the office." (in-depth interview with DW on April 19, 2017) "The office complex is located in a village and surrounded by many trees, as well as the environmental parks in the office area. All of which provide sufficient green open space." (in-depth interview with WP on March 30, 2017)

Table 2. The Available Green Open Space Identified in the Integrated Government Office Complex of Boyolali Regency from Satellite Image and Field Observation

Types of Green Open Space	Locations of Green Open Space	Appearances in Google Earth Satellite Image	Appearances in the Filed
Office yards	The Office of BP3D		
City parks	The south town square		
Urban agricultural lands	Papaya cultivation land on Jl. Ahmad Yani		
Median strips	Jl. Merdeka Timur		

Types of Green Open Space	Locations of Green Open Space	Appearances in Google Earth Satellite Image	Appearances in the Filed
Certain functions	Public cemeteries		

Source: Data analysis in 2017

Based on the requirement issued by the law, i.e., 30% of the total area, the extent of green open space in the office complex was at least 6.51 ha. The study area had nearly twice the extent of the recommended green open space. Therefore, the green open space can provide various benefits for the office employees to be able to perform their activities comfortably. The extent of the green space, i.e., 47.92%, positively affects the amount of oxygen released to the atmosphere and the volume of absorbed carbon dioxide. The available green open space benefits the health condition of the people because it increases oxygen availability and pollutant absorption, all of which make the activities and the social contacts of the population become more comfortable (Tamosiunas et al. 2014). Moreover, the presence of green open space that produces oxygen and, at the same time, absorbs pollutants can reduce the risk of death due to chronic diseases (Wolch, Byrne, and Newell 2014).

Table 3 presents the amount of oxygen produced and the carbon dioxide absorbed by the vegetation area in the integrated government office complex of Boyolali Regency.

Table 3. The Weight of O_2 Produced and CO_2 Absorbed by Green Open Space

Types of Green Open Space	Area (ha)	Produced O_2 (kg/day)	Absorbed CO_2 (kg/day)
Office yards	3.7	2,220	3,330
City parks	0.8	480	720
Urban agricultural lands	5.7	3,420	5,130
Median strips	0.1	60	90
Certain functions	0.1	60	90
Total	**10.4**	**6,240**	**9,360**

Source: Data analysis in 2017

The results showed that 6,240 kg O_2 was produced in 12 hours per day from the green open space in the office complex. Also, the green plants in the office complex were able to absorb 9,360 kg CO_2. Accordingly, the amount of oxygen produced by the green open space also represents the available oxygen useful for human respiration (i.e., the office employee) and for dealing with the harmful gases generated by the fuel combustion process in vehicle engines. Because the widest green open space was in the form of urban agricultural lands, the highest oxygen production and carbon dioxide absorption by plants were contributed by urban agricultural lands found in the integrated government office complex of Boyolali Regency.

The need for green open space in urban areas is imperative to the actualization of environmental harmony. It also has a direct relationship with oxygen needs, which highly depend on several indicators, namely population size, number of vehicles, and number of livestock. Aside from producing oxygen, green plants also play a role in absorbing carbon dioxide and some other dangerous gases that, in this case, are generated by the use of vehicles in the office complex.

Humans oxidize 3,000 calories per day from their foods, consume 600 liters of oxygen or 840 grams of oxygen per day, and release 480 grams of carbon dioxide per day (White et al. 1959 in Sintani, Ramli, and Zubair 2013). All of the employees who performed the day-to-day activities in the office complex worked for averagely 9 hours per day—equal to the general working hours.

In addition to the oxygen need of the employees, the oxygen need of vehicles was also included in the calculation of the required green open space in the study area. Vehicles consume a particular amount of oxygen and, thereby, become necessary to consider. The

oxygen needs of the employees and their vehicles are the indicators in estimating the extent of the required green open space in the office complex. The oxygen needs were analyzed using the Gerarkis method with an adjustment proposed by Wijayanti (2003). The calculation of the required green open space excluded the oxygen consumption by livestock because no cattle or poultry was found in the office complex. Table 4 presents the analysis results of the required green open space based on oxygen need.

Table 4. The Required Green Open Space Based on the Gerarkis Method

Number of Employees	The O_2 Need of Employee (kg)	Number		The O_2 Need of Vehicles (kg)	The Required Green Open Space(ha)
		Motorcycles	Cars		
1,222	384.93	733	207	2,834.62	0.006355

Source: Data analysis in March 2017

The results showed that the required green open space to meet the oxygen needs of the employees and their vehicles was small, i.e., 0.006355 ha. Also, the green open space has sufficiently met the oxygen need of the vehicles, especially during the disposal of harmful gases produced by fuel combustion.

Aside from identifying the required green open space, the Gerarkis method also provides information on oxygen need and the ability of green open space to absorb carbon dioxide. Based on these two indicators, the required green open space is presented in Table 5.

Table 5. The Required Green Open Space Based on Oxygen Need and the Capacity to Absorb CO_2

Oxygen Need(kg)	Required Green Open Space (ha)	CO_2 Emission (kg)	Required Green Open Space (ha)
3,217.36	5.36	219.96	0.244

Source: Data analysis in March 2017

Based on the oxygen need, the required green open space was identified from the capacity of 1 hectare of green open space to produce 600 kg O_2 and absorb 900 kg CO_2. This research found that the integrated government office complex needed 5.36 ha of green open space to produce 3,217.36 kg of oxygen needed by employees who worked for 9 hours and their vehicles. Another 0.255 ha of green open space was also required to absorb 219.96 kg of carbon dioxide produced daily during the nine working hours in the office complex. The carbon dioxide emission came only from the employees in the office complex because not many vehicles pass by and emit carbon dioxide in the office complex during the working hour. Therefore, the carbon dioxide emission from vehicles was excluded.

The results of the Gerarkis method showed that the available green open space in the study area was considered sufficient in every criterion. The criteria were oxygen need, the capacity to absorb carbon dioxide emitted by the employees and their vehicles, and the condition issued by the law.

Green open space is the only public service free for many people every day, and it is available to everyone regardless of demographic characteristic and socio-economic status (Abbasi, Alalouch, and Bramley 2016).

4. Conclusion and Recommendation

4.1. Conclusion

The available green open space in the integrated government office complex of Boyolali Regency was 10.4 ha. It consisted of urban agricultural lands (55%), office yards (35%), city parks (8%), and median strips and cemeteries (2%). It has met the legal requirement issued in the Act No. 26/2007 on National Spatial Planning, i.e., 30% of the total area in question. Compared to the area of the office complex (21.67 ha), the available green open space covered 47.92% of the area.

The required green open space in the study area was only 0.006355 ha because the number of the office employees was small (i.e., 1,222 people) and not all of them used a vehicle to work. The currently available green open space has met various requirements, namely oxygen needs, the ability to absorb carbon dioxide, and legal criteria issued in Act No. 26/2007. Therefore, the preservation of urban green open space, as well as its ratio to built-up land, has to be intensified.

4.2. Recommendation

Based on the results, this research recommends the preservation of green open space and the increase of tree numbers especially in the parking lots of the office (i.e., the concentration of motor vehicles). Based on the findings of this research, the percentage of parking lots and environmental parks in every office needs a thorough attention primarily to maintain the high ratio of plants to vehicles.

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