ISSN: 978-602-71169-7-9

Carbon Sinks of Morphologic Tree Stands in Bandung City Green Space: Case Study Taman Balai Kota, KebunBinatang, and Taman LaluLintas Ade Irma Suryani

Nurvita Cundaningsih[1,a], Teguh Husodo[2,b] and Herri Y. Hadikusumah[3,c]

[1,2,3] Biology Department, Math and Science Faculty, UniversitasPadjadjaran. Jl. Raya Jatinangor KM 21, Sumedang 45363, Jawa Barat, Indonesia.

[a]nctavita@gmail.com, [b]dozhusodo@gmail.com, [c]hy.hadikusumah@yahoo.com

Abstract. One of the greenhouse gases which have a big contribution at global warming issues is carbon dioxide gas (CO_2). Open green spaces in Bandung city are urban forest that can sequester carbon dioxide gases and store it into biomass at stems, branches, or roots. The research was conducted from June to July 2015 at green spaces that the carbon sinks haven not been examined. The purpose of this research was to count the tree stands (DBH >5 cm) ability at Bandung green spaces in sequestrating carbon with quantitative approached. The carbon sequestration was estimated by allometric equations at RaCSA (Rapid Carbon Assessment) [1]. The research has been conducted in Kebun Binatang (KB), we found 35 families with 95 species. Taman Lalu Lintas (TLL) with 22 familiesand 47 species. Taman Balai Kota (TBK) has 19 families and 35 species. From the examined green spaces, there was structure differences which shown by the ISs of KB-TLL and TBK-TLL in the amount of 52.11% and 51.22%. It's different with KB-TBK's ISs index is 43.08 %. Based on the stands structure (amount of individual, DBH size, and height average), it shows the difference among KB (745 individual, DBH 60 cm, and 11.3 m height), TLL (321 individual, DBH 14.97 cm, and 6.76 m height), while TBK (145 individual, DBH 25 cm, and 6.74 m height). Those stands structure also made different biomass density at KB (85.63 ton/Ha), TBK (36.64 ton/Ha), and TLL (33.04 ton/Ha). From the biomass density, the green space's carbon and CO_2 sequestration can be estimated at KB (41.81 tonC/Ha and 309.42 tonCO_2/Ha), TBK (18.32 tonC/Ha and 135.57 tonCO_2/Ha), and TLL (16.52 tonC/Ha with 122.24 tonCO_2/Ha). The analysis shows that the carbon sequestration difference caused by the variance of stands ages, size of tree (DBH), and stands structure value (amount of species and individual).

Keywords: Biomass, Tree, RACSA, Green Space, Carbon Sink

Introduction

The pace of city development from small to large sized have an impact on many sectors, one of the sectorsare the environment (especially green space). Disruption of green spaces lead the changes of urban environment and brings critical urban physical environment. The critical condition of the urban physical environment is characterized by two criteria: (a) green areas recessive, and (b) increasing the temperature of the urban microclimate atpopulous area [2].

Environmental issues related to green area services is raising of the world temperatureorknown as global warming. Currently, when the urban and developments activity increases, the greenhouse gas emissions that cause global warming also rose. One of the greenhouse gases that contribute significantly to the global warming is CO_2 gas. CO_2emissions that result from activities in Bandung can be absorbed by the urban forest vegetation then stored into carbon in plant biomass.

Trees stand has the ability to store and sequester carbon with greater amount than the most categories of lower plants (ground cover and shrubs), necromass, and soil. Soil organic matter are capable of storing carbon but can not absorb the CO_2gas. The existence of maintenance (cleaning and pruning) necromass and the undergrowth in a city park cause unstable carbon storage at that category.

The study of public green space area has been done, while the private green space with a large area yet to be implemented. The green space area include Taman Balai Kota,

ISSN: 978-602-71169-7-9

Kebun Binatang Bandung, and Taman Lalu Lintas Ade Irma Suryani, each of them have area over 10,000 m^2 in addition to the three parks that have dense vegetation structure. This research aims to estimated the biomass and carbon stocks at trees stand in Bandung private green space.

Research Methods

The method used in the study was quantitative methods approach. Primary data collected by the survey (total census), the measurement technique was done directly in the field (the diameter at breast height /DBH of trees, tree species, number of individuals, and trees height). In this study also needed secondary data collection (the wood's densityaccording to Zanne et al. [3]. Trees recorded were woody stem and plant morphology with certain diameter.The stands category was taken as a tree with DBH (Diameter Breast Height)> 5cm [4].

Floristic data analysis is required to determine the structure of the vegetation in the survey locations that affect the rate of carbon fixation by vegetation tree on the green spaces. Similarity index is the magnitude of a similarity value types that make up two different habitats. Similarity index value is calculated by the following formula:

$$ISs = \frac{2c}{a+b} \times 100\ \% \ . \quad (1)$$

$$IDs = 100 - ISs. \quad (2)$$

Explan.: ISS = similarity index; IDs = Inequality Index Sorensen; a = number of species at the first location; b = the number of species at a second location; c = number of species that exist in both locations.

The carbon stocks is estimated using RaCSA(Rapid Carbon Stock Assessment) approach [1]. In addition to the calculation of carbon stored, CO_2 sequestration on each green space also have been estimated [5]. According Hairiah et al.[1], to estimate the biomass of trees in the tropics, it is recommended to use the equations developed by Chave et al. [6]. Allometric general formula to estimate the biomass of trees in humid climate zones/humid [6]:

$$Biomass = 0{,}0509 \times \pi D^2 H \ . \quad (3)$$

Explan.: D = Trees diameter/DBH (cm); H = Trees height (cm); π = Wood's density (g/cm^3)

Analysis of the carbon stocks at green space vegetation using the biomass approach [1]. General formulation used is as follows:

$$C = 0{,}5 \times Biomass \ . \quad (4)$$

Explan.: C = Carbon stocks (tC); Biomass = Biomass (kg); 0,5 = Coefficient of carbon stocks in plants.

CO_2reserve density(CRD)counted by [5]:

$$CRD\left(\frac{ton CO_2}{Ha.}\right) = Cx\ 3{,}7^* \ . \quad (6)$$

Explan.: C = Carbon stocks (tC); (*)the conversion of carbon to carbon dioxide [7].

Descriptive analysis was used to analyze the green space excisting both composition and vegetationstructure. The information is analyzed and harmonized or compared with the value of the carbon stored in each of the green spaces studied.

Results and Discussion

Based on observations in the field, it is known that Kebun Binatang hastrees composition in the number of 35 families and 95 species by the number of individuals reached 745 individuals Table 1. While the Taman Balai Kota and Taman Lalu Lintas have composition and the vegetation type relatively equals. Taman Balai Kota area of 1.5 hectares has 19 families and 35 species. Taman Lalu Lintas with 22 families and 47 species has 321 number of individuals because it has a garden area which is larger than the Taman Balai Kota of 3,5 hectares.

Table 1. The Composition of Tree Stands at Each Green Space

Green Space	Family	Species Amount	Individual Amount	DBH (Mode value) (cm)	Height Average (m)
Kebun Binatang (11 Ha)	35	95	745	60	11,3
Taman Balai Kota (1,5 Ha)	19	35	145	25	6,74
Taman Lalu Lintas (3,5 Ha)	22	47	321	14,97	6,76

Source: Primary Data, 2015

Kebun Binatang-Taman Lalu Lintas with Taman Balai Kota-Taman Lalu Lintas has a fairly high similarity index indicated by the value of Iss. Figure 1 amounted to 52.11% and 51.22%. Unlike the Kebun Binatang-Taman Balai Kota which has a similarity index lower at 43.08% and has an index of inequality (IDs) is relatively high at 56.93%. It shows that the two communities have a different composition from each other. This difference can occur because of differences in the function of both green space. Kebun Binatang as green space is also used as a collection area of plant species has more diversity of species than Taman Balai Kota which has a function as the lungs of the city and the center of public activity.

Highest potential biomass Table 1 owned by Kebun Binatang because of the green space has a number of species and number of individuals of the highest (95 species and 745 individuals). The biomass density is obtained from the calculation of many species and individuals, causing differences in DBH, height, density thus affecting the amount of biomass Table 1. From the ratio of the individuals density per unit area, Kebun Binatang has the fewest number of individuals (68 ind/Ha) compared to other green space (See Table 2).

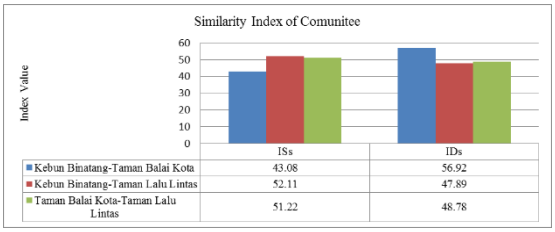

Figure 1. Similarity Index of Comunitee for Three Green Space. Explan.: ISs: Similarity Index of Comunitee; IDs: Disimilarity Index of Comunitee. Source: Primary Data, 2015

Table 2. Biomassa (ton/Ha) pada Tiga RTH Kota Bandung

Green Space	Individual Density Ratio (individual/Ha)	Biomass (ton/Ha)	CD* (ton C/Ha)	CRD* (ton CO2/Ha)
Kebun Binatang (11 Ha)	68	83,63	41,81	309,42
Taman Balai Kota (1,5 Ha)	97	36,64	18,32	135,57
Taman Lalu Lintas (3,5 Ha)	92	33,04	16,52	122,24

*CD (Carbon Density); CRD (CO_2Reserve Density). Source: Primary Data, 2015

However, individuals at Kebun Binatang has DBH with a mode value of 60 cm, while others only have a value mode by 25 cm and 14,97 cm. This means that tree stands at Kebun Binatang relatively old with big DBH and has a large biomass density. The ages of the trees, or the size of the trees (DBH) are affect C storage and sequestration [8]. Generally, large healthy trees store and sequester more C than small health trees [8].

Referring to the potential of biomass, the value of these calculations are used to determine the carbon sinks in green space expressed in CD (Carbon Density) with units tonC/Ha. From the potential of biomass can also examine the CO_2 that can be absorbed seen from biomass store approach. Here are the results of the analysis of carbon stored in the open green space.

CD (Carbon Density) is the ability of a vegetation community to store carbon in the

ISSN: 978-602-71169-7-9

form of biomass. Carbon sinks is influenced by the amount of biomass potential in a green space. The greater biomass, the carbon sinks in the open green space is also growing. It is seen from the Kebun Binatang's CD greatest in the amount of 41.81 tonC/Ha compared to the two other parks. Kebun Binatang has the greatest potential for biomass [Table 2]. While most small CD owned by the Taman Lalu Lintas with 16.52 tonC/Ha. Taman Lalu Lintas has an area larger than the Taman Balai Kota. MeanwhileTaman Balai Kota has the greatest biomass from DBH categories of 11-30 cm and 31-50 cm so if the number of biomass was accumulated, this park has the higher biomass density.

Based on Afrian [9], from seven parks and urban forests Bandung that studied, Maluku Park and Cibeunying Park are city parkswith good ability to sequestrate carbon, i.e. 84,13 tonC/Ha for Maluku Parks and 82.70 tonC/Ha for Cibeunying Park. Carbon uptake value on both park are still higher than the three green space which just studied. The difference is thought to occur because of differences in the species and made the variance in DBH trees. In the Maluku Park has more number of individuals up to 971 people. Structural differences cause differences in the value of the biomass is supported by research Liu and Li [10] in China, comparing biomass reserves in Shenyang and Shenyang Beijing where more composed of plants with fast-growth rate than urban forest in Beijing. A similar study in the urban forest of Jakarta conducted by Lubis [6], it was estimated the largestcarbon stock in Jakarta are trees at the Universitas Indonesia urban forest with 178,82 tonC/Ha, Srengseng urban forest amounted to 24,04 tonC/Ha and PT JIEP urban forest by 23,64 tonC/Ha.

From the biomass potential can be calculated the Density of CO_2 Reserves (CRD) with units tonCO_2/Ha. The most highest CRD owned by the large Kebun Binatang with 309,42 tonCO_2/Ha. According to Kow [3], factors suspected to affect CRD is the density of tree populations, dominant tree species and diversity index. Kebun Binatang has the greatest area, while the most dense tree population density is also owned by Kebun Binatang.

Instead the smallest CRD owned by the Taman Lalu Lintas in the amount of 122.24 tonCO_2/Ha. The area of the park is a factor that affects CRD in Taman Lalu Lintas case. But the most influential factors suspected is the density of tree populations. This can be represented by seeing the highest RD (Relative Density) in the Taman Lalu Lintas is pine (*Pinus merkusii* Jungh. & De Vriese) while in Taman Balai Kota is Kisabun (*Filicium decipiens* (Wight & Arn.) Thwaites). According Zanne et al. [3], Kisabun has the highest wood's density (0,960) whereas smaller Pinus (0.530) thus affecting the biomass at each park. In addition, compared with the research by Strohbach et al. [11] in the city of Leipzig, Germany, green space with park-like design and maintenance is less effective than forest-like design and maintenance. Leipzig has a green space with park-like design that has CRD estimated at 137-162 tonCO_2/Ha. This value is not much different from the Taman Lalu Lintas which has the same characteristics, namely design such as parks and their treatment by humans.

Conclusion

Based on the results, it can be concluded that the ability of trees in Bandungprivategreen space at storing carbon stocks include the Kebun Binatang is as much as 41.81 tonC/Ha, Taman Balai Kota as much as 18.32 tonC/Ha, and the Taman Lalu Lintas as many as 16,52 tonC/Ha. The analysis showed that the factors that made the difference between carbon storage and sequestration in locations including stand age, tree size (DBH), and stand structure (number of species and number of individuals).

Acknowledgements

Thanks to all those who have helped during the research process, in particular the Kebun Binatang Foundation, Taman Lalu Lintas Ade Irma Suryani Nasution Foundation, Taman Balai Kota and the business. For Riana Cundasari, Cunda Bayu Satria, and Evanti Arosyani who had helped at the field. To various parties that have a lot of help and support that can not be mentioned one by one.

Reference

[1] K. Hairiah, A. Ekadinata, R.R. Sari, S. Rahayu, Pengukuran Cadangan Karbon: dari tingkat lahan ke bentang lahan. Petunjuk praktis., Second edition ed., World Agroforestry Centre, ICRAF SEA Regional Office, Bogor, 2011.

[2] S.E. Siwi, Kemampuan Ruang Hijau dalam Menyerap Gas KarbonDioksida (CO2) di Kota Depok, in: Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Indonesia., Depok, 2012.

[3] A.E. Zanne, G. Lopez-Gonzalez, D.A. Coomes, J. Ilic, S. Jansen, S.L. Lewis, R.B. Miller, N.G. Swenson, M.C. Wiemann, J. Chave, Global wood density database - Dryad, (2009).

[4] D. Mueller-Dombois, H. Ellenberg, Aims and Methods of Vegetation Ecology, Wiley, 1974.

[5] E. Kow, Analisis Potensi Cadangan Dan Penambatan Karbon Dioksida Taman Kota Di Kota Bandung, in: Program Studi Teknik Lingkungan ITB., Institut Teknologi Bandung, Bandung, 2014.

[6] J. Chave, C. Andalo, S. Brown, M. Cairns, J. Chambers, D. Eamus, H. Fölster, F. Fromard, N. Higuchi, T. Kira, Tree allometry and improved estimation of carbon stocks and balance in tropical forests, Oecologia, 145 (2005) 87-99.

[7] E.G. McPherson, Structure and sustainability of Sacramento's urban forest, Journal of Arboriculture, 24 (1998) 174-190.

[8] D.J. Nowak, Atmospheric carbon dioxide reduction by Chicago's urban forest, Chicago's urban forest ecosystem: results of the Chicago Urban Forest Climate Project. Gen. Tech. Rep. NE-186. Radnor, PA: US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, (1994) 83-94.

[9] C. Afrian, Taman Kota sebagai Rosot Karbon di Kawasan Perkotaan (Studi Kasus Kota Bandung), in: Program Pasca Sarjana, Universitas Padjadjaran. , Bandung, 2012.

[10] C. Liu, X. Li, Carbon storage and sequestration by urban forests in Shenyang, China, Urban Forestry & Urban Greening, 11 (2012) 121-128.

[11] M.W. Strohbach, D. Haase, Above-ground carbon storage by urban trees in Leipzig, Germany: Analysis of patterns in a European city, Landscape and Urban Planning, 104 (2012) 95-104.