Malays. Appl. Biol. (2017) 46(2): 67–76

SPATIAL ANALYSIS ON DISTRIBUTION OF GREEN BELT TO REDUCE IMPACTS OF CLIMATE CHANGE IN MEDAN CITY, NORTH SUMATRA

RAHMAWATY[1*], PINDI PATANA[1] and SITI LATIFAH[1]

[1]*Forestry Study Program, Faculty of Forestry, University of Sumatera Utara, Jl. Tri Dharma Ujung No. 1 Kampus USU, Medan 20155, Indonesia*
[*]*Email: rahma2107usu@gmail.com*

Accepted 3 May 2017, Published online 27 June 2017

ABSTRACT

Medan, the capital city of North Sumatra Province, which consists of 21 sub-districts, encompasses 26.510 ha or 3.6% of the total province area. One way to reduce emissions and air pollution in urban areas is to create open green space. This study aimed to analyse and map trees in the green belt of Medan City as an effort to alleviate negative effects of climate change. Global Positioning System (GPS) was used to record the coordinate's points of trees. The Geographic Information System (GIS) was used to analyze the distribution of green belt. Tree inventory was conducted by census method to analyze the composition and density of tree species. The results showed that most of the green belt was dominated by trees with species composition including the category of very low (84.4%). Tree density levels were dominated by very tightly category (78.1%). The Location of green belt with the highest density level was Jalan Sunggal, Medan Sunggal Sub District with a value of 1,893.75 trees/ha (very tightly). *Pterocarpus indicus* was the highest Importance Value Index (88.47%), followed by *Switenia macrophylla* (57.30%) and *Oreodoxa regia* (53.64%). Species diversity classified as average category (1.45). There are similarity of plant community among sampled green belt locations. The map of green belt resulted from this research could be used as one of the basis in a decision making to reduce negative effects of climate change in Medan city. As one of the largest cities in Indonesia, the existence of green belt area in Medan City is a must. Therefore, it is necessary to develop green belt area in several sub districts in Medan City.

Key words: GIS; GPS; Green belt; Climate Change; Medan City

INTRODUCTION

The increasing of urban development activities will affect the area of green open space. The reduction of green open space in urban and climate change are important issues in Medan City (Environmental Agency of North Sumatra Province, 2015). Efforts to reduce green house gas emissions, especially carbon dioxide (CO_2) can be done in various ways, one of which is by reducing its emission to maintain and sustain the existing carbon stocks and to increase its uptake through various urban forest development programs. One way to reduce emissions and air pollution in urban areas is by maintaining green open space (Dahlan, 2011). Green open space in urban areas must be present in approximately 30% of the area of the city (The Regulation of the Law on Spatial Planning No. 26, 2007), the regulation of the Minister of Public Works No. 5 (2008) about Guidelines for the Provision and Use of Green Open Space in Urban Area and the Regional Regulation of Medan City (*Perda Kota Medan*) No. 13 (2011). Green open space is an absorber of carbon (carbon sink) and is effective in reducing carbon emissions in the atmosphere.

Distribution of the green belt in Medan City can be presented in the form of maps using Geographic Information System (GIS) technology. Geographic Information Systems is a system-oriented operation relating to the collection, storage and manipulation of referenced geographical data conventionally, by using the computer (hardware and software) that is capable of handling data. The GIS capabilities, among others, are; a. data input, (b) data management (storage and retrieval) and (c) manipulation and analysis and (d) the development of products and printing (Aronoff, 1989; Prasetyo *et al*., 2002; Prahasta, 2004). Among other functions of map are

* To whom correspondence should be addressed.

to show the spatial distribution of geographical phenomena including the nature and characteristics of the different positions on the surface of the earth.

As a metropolitan city, Medan City has high transportation activity. Therefore, the role of the green belt is very important, because it has the ability to reduce air pollutants (Rawat *et al.,* 1996). Since information regarding the distribution of green belt in several Sub districts in Medan city is lacking, this research needs to be done. This study aimed to analyse and map trees in the green belt of Medan City as an effort to reduce effects of global warming. This study is expected to provide information to determine the management plan and environmental development in Medan City.

MATERIALS AND METHODS

This study was conducted from January to May 2015 on several locations of green belts (32 Streets) in Medan City. Sampling was done by selecting the green belt in several sub districts (16 sub district from 21 sub district) in Medan City. A randomly selected street within the green belt in each district of Medan was used to find sample plots using the criteria of arterial roads in Regulation No.13 (2011). The sampling design used in this study was also based on Regulation No. 13 (2011) on Spatial Planning (2011-2031) in order to obtain secondary arterial lines in some districts in Medan City and note how the distribution of plants in the path.

Green belt in each sub district of Medan City was determined by purposive sampling technique. Tree Inventory was made of all tree species (census methods), located at the green belt that has been determined. Global Positioning System (GPS) was used to record the coordinate's points of trees. The GIS was used to analyze the distribution of green belt. Tree inventory was also conducted by census method within the green belt. The composition of tree species was determined by the important value index (IVI). The IVI was the sum of the relative frequency (RF), relative density (Rde) and the relative dominance (Rdo). Mastery level of the species in the community indicated by the IVI (Kusmana, 2017). Diversity of species was also calculated using the Shannon-Wienner (Kent & Paddy, 1992). Dominance Index refers to Misra (1980) and the index of similarity between the two communities was calculated using the formula Sorenson (1948) cited by Odum (1971).

RESULTS AND DISCUSSION

Total number of tree that was found on the 32 green belt in several sub-districts in Medan City was 6,002. There were 19 families and 38 species of plants planted on the green belt in the research area (Table 1). Trunk diameter varies indicating that affects the content of organic or materials of living trees (Manuri *et al.,* 2014). Diameter is a function of the age of the tree. The older the age of a tree, the greater the diameter depending on a type of plant. The green belts of the study sites were dominated by trees with a diameter of 20 cm so that the potential of biomass on the green belt is also greater.

Based on Table 1, *Pterocarpus indicus* has the highest IVI (88.47%), followed by *Switenia macrophylla* (57.30%) and *Oreodoxa regia* (53.64%). The value of diversity index of the study sites was 1.45 (classified as moderate category). It means that environmental conditions were still relatively stable. The dominance index value was 0.165. It means that the pattern of species was relatively spreads to each species. Similarity index of plant community in green belt among sampled locations (32 locations) ranged from 66.7%–100%. If the similarity index value of community was high, then the similarity of the two communities that compared was uniform. The results showed that 72% similarity index value in the study sites was greater than 80% and 28% having a similarity index value between 50–80%. It means that similarity of plant community among sampled green belt locations were the similarities species (Odum, 1971). According to Payne *et al.* (2014), plant community composition was significantly correlated to air pollution variable.

Plants play role as carbon dioxide absorbent. The Fabaceae family was the dominant plants in study area, especially *Pterocarpus indicus* (Table 1) as agree with Purwasih *et al.* (2013) and Manik *et al.* (2016). Besides, Casuarinaceae, Moraceae, Sapindaceae, Meliaceae, Myrtaceae and Sapotaceae family were also found in Medan City. The Fabaceae family constitutes 23.68% of plant population in the green belt. Based on the result, *Samanea saman*, *Leucanea leucocephala*, *Adenanthera pavoninna*, *Acacia mangium*, *Tamarindus indica*, *Para-serianthes falcataria*, *Delonix regia* and *Erythrina crystagalii* were found in the study area. *Oreodoxa regia* from Arecaceae family was the second dominant species (1,239 individual trees) that was found in the study area after *Pterocarpus indicus* (3,082 individual trees) (Table 1). *Switenia macrophylla* (1,084 individual trees) from Meliaceae family was the third dominant species that was found in the study area as agree with Sitorus *et al.* (2014); Banurea *et al* (2013) (Table 1). The Fabaceae family was found to be the most widely grown plants in the urban areas because they are fast-growing, beautiful and good absorber of air pollution (Purwasih *et al.,* 2013). According to Dahlan (2011),

Table 1. Species number and important value index (IVI) at green belt in Medan City

No.	Tree species	Family	Number of tree species	RF	Rde	Rdo	IVI
1	*Pterocarpus indicus*	Fabaceae	3,082	13.46	51.35	23.66	88.47
2	*Thuja occidentalis*	Casuarinaceae	12	1.15	0.20	0.26	1.62
3	*Ficus elastic*	Moraceae	3	0.77	0.05	0.12	0.94
4	*Filicium decipiens*	Sapindaceae	7	0.77	0.12	0.12	1.00
5	*Switenia macrophylla*	Meliaceae	1,069	13.85	18.06	25.40	57.30
6	*Mangifera indica*	Anacardiaceae	228	6.54	3.80	6.00	16.33
7	*Polyathia longifolia*	Annonaceae	74	8.46	1.23	8.41	18.10
8	*Melia azedarach*	Meliaceae	8	0.77	0.13	0.12	1.02
9	*Oreodoxa regia*	Arecaceae	1,239	12.31	20.64	20.69	53.64
10	*Samanea saman*	Fabaceae	36	3.46	0.60	1.85	5.91
11	*Artocarpus heterophyllus*	Moraceae	11	0.38	0.18	0.03	0.60
12	*Paraserianthes falcataria*	Fabaceae	10	1.92	0.17	0.44	2.53
13	*Muntingia calabura*	Muntingiaceae	36	0.77	0.60	0.06	1.43
14	*Delonix regia*	Fabaceae	19	3.46	0.32	1.59	5.37
15	*Hibiscus tillaceus*	Malvaceae	15	0.38	0.25	0.03	0.66
16	*Terminalia catappa*	Combretaceae	5	2.69	0.08	0.82	3.60
17	*Tectona grandis*	Verbenaceae	3	1.92	0.05	0.44	2.41
18	*Gnetum gnemon*	Gnetaceae	16	1.15	0.27	0.18	1.60
19	*Sterculia foetida*	Sterculiaceae	23	2.31	0.38	0.88	3.57
20	*Erythrina crystagalii*	Fabaceae	1	1.54	0.02	0.35	1.91
21	*Ficus benjamina*	Moraceae	17	0.38	0.28	0.03	0.70
22	*Alstonia scholaris*	Apocynaceae	1	5.77	0.02	3.97	9.75
23	*Tamarindus indica*	Fabaceae	4	0.38	0.07	0.03	0.48
24	*Eucalyptus deglupta*	Myrtaceae	1	1.54	0.02	0.24	1.79
25	*Lansium domesticum*	Meliaceae	1	0.38	0.02	0.03	0.43
26	*Psidium guava*	Myrtaceae	1	0.38	0.02	0.03	0.43
27	*Manilkara zapota*	Sapotaceae	1	0.38	0.02	0.03	0.43
28	*Acacia mangium*	Fabaceae	21	0.38	0.35	0.03	0.76
29	*Mimusops elengi*	Sapotaceae	22	3.08	0.37	1.41	4.85
30	*Nepheleum lappaceum*	Sapindaceae	3	3.46	0.05	1.85	5.36
31	*Pinus merkusii*	Pinaceae	1	0.38	0.02	0.03	0.43
32	*Dimocarpus longan*	Sapindaceae	1	0.38	0.02	0.03	0.43
33	*Leucanea leucocephala*	Fabaceae	3	0.38	0.05	0.03	0.46
34	*Syzygium aqueum*	Myrtaceae	4	1.92	0.07	0.44	2.43
35	*Morinda citrifolia*	Rubiaceae	4	1.15	0.07	0.26	1.49
36	*Casuarina equisetifolia*	Casuarinaceae	3	0.38	0.05	0.03	0.46
37	*Casuarina junghuniana*	Casuarinaceae	1	0.77	0.02	0.06	0.84
38	*Adenanthera pavonia*	Fabaceae	1	0.38	0.02	0.03	0.43
	Total		6,002	100.00	100.00	100.00	300.00

Note : IVI = important value index, RF = relative frequency, Rde = relative density (Rde), Rdo = relative dominance.

however, *Switenia macrophylla* has a high absorption CO_2 (295.73 kg CO_2 /tree/yr).

Tree species grown in the green belt in Medan City were those that have criteria as road side plants and as junction region plants. The primary requirement for a plant to be used as a landscape plant in streets are (1) its roots do not damage the road construction, (2) it is easy to maintain, (3) its stems and branches are not easily broken, (4) its leaves do not easily fall down and (5) it should be safe and give comfort to motorists and other road users (the Regulation of the Minister of Public Works No. 033 (1996). Furthermore, Sharma *et al.* (1994); Nowak *et al.* (2002) explain that an ideal tree for planting in the green belt should have the following characteristics: fast growth rate for quick development of canopy, strong branches, thick and durable canopy which can withstand storm, large leaf size for greater retention of pollutants, dense foliage for better trapping of pollutants. The species should be indigenous, and resistant to specific air pollutants, diseases and insects.

The green belt was found either along the edge and median of the road or along the edge of the road only. The green belt at the median has function for steering road, forming views and retaining glare

from other vehicles, while that on the edge of the road serves as a pollution absorbent, shade, noise canceling and wind breaker (Ministry of Public Works, 1996; Sharma *et al.,* 1994; Nowak *et al.*, 2002; Rauf *et al*., 2016). Species composition and density and the category based on location of green belt can be seen in Figure 1, Figure 2 and Figure 3.

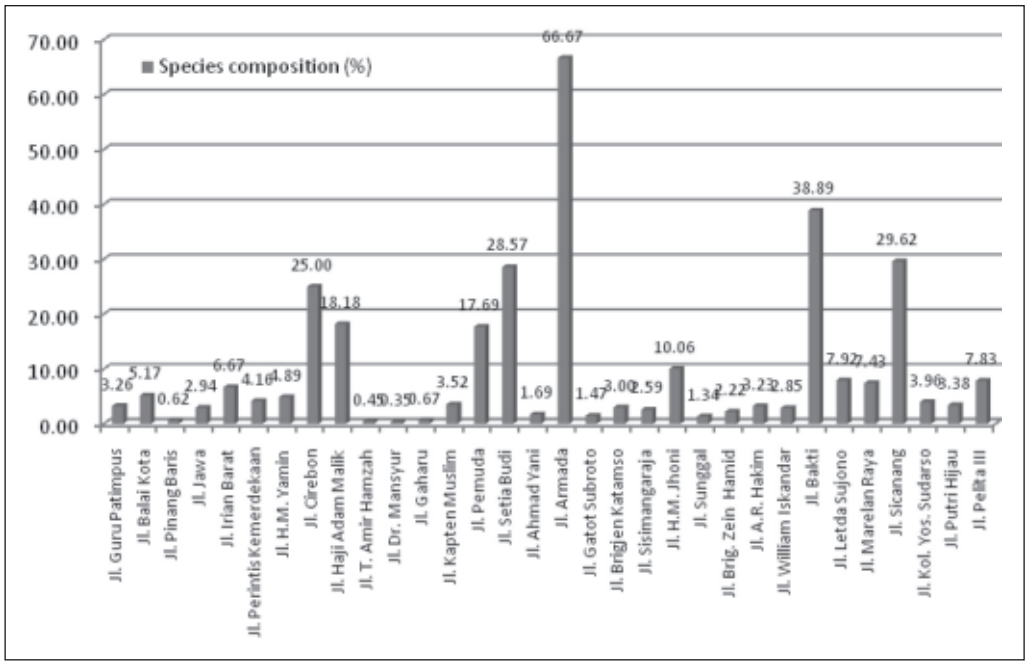

Fig. 1. Species composition in the green belt in Medan City.

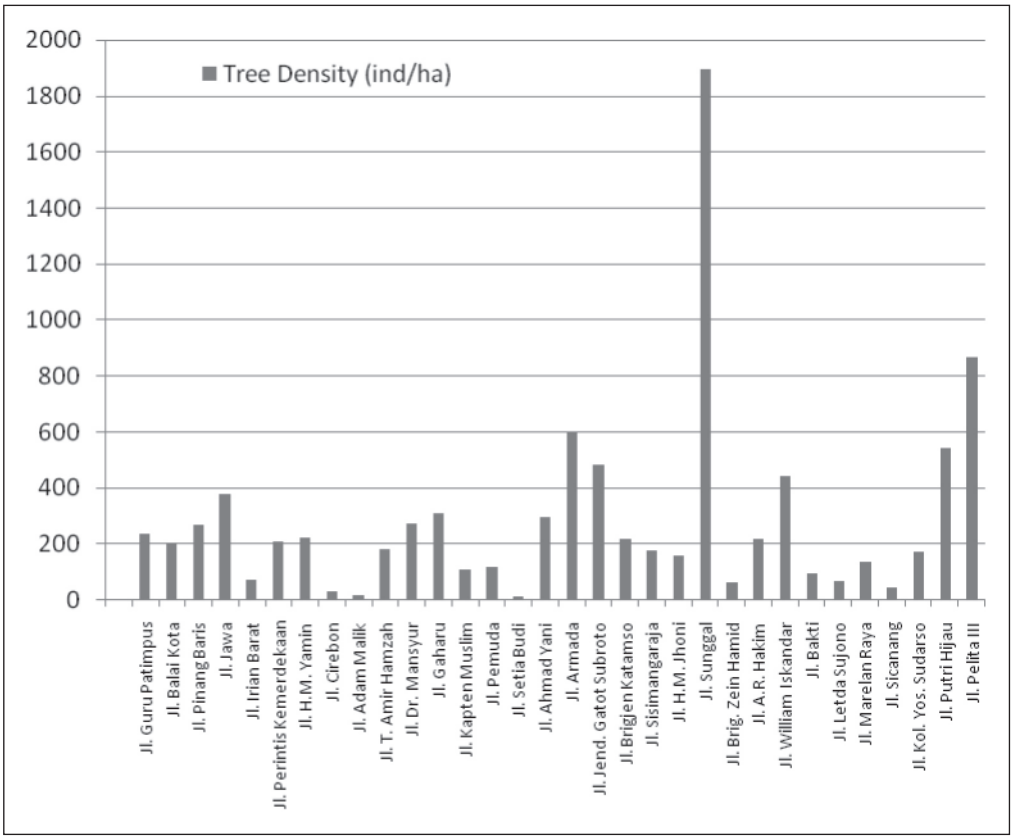

Fig. 2. Trees density in the green belt in Medan City.

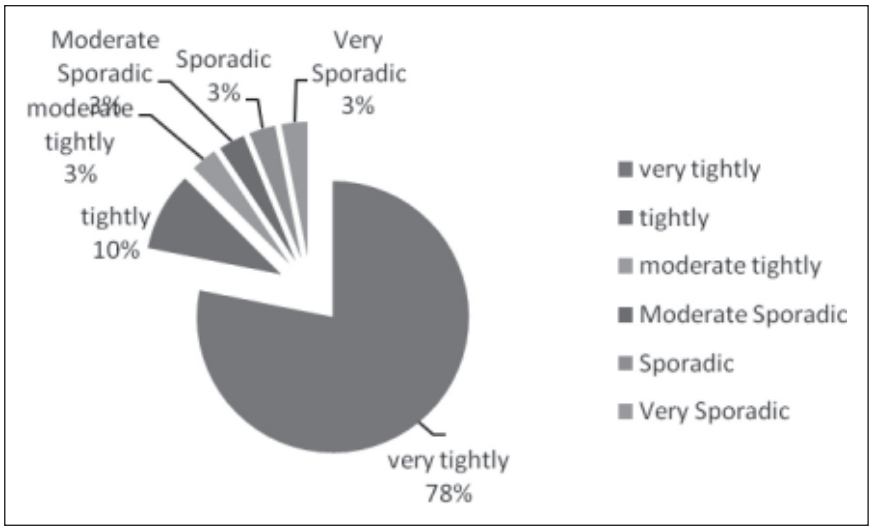

Fig. 3. Percentages of density criteria in the green belt in Medan City.

The distribution map of trees can be seen in Figure 4 and Figure 5. The data was used to determine the species composition of tree types existing in the green belt of certain area. The more the types of plants in the green belt, the higher the composition of the green belt will be. The more the number of trees in the green belt, the more dense is the green belt (Figure 1). Tree density ranged from very low to very high (Figure 3). The very low density green belt was found in Jalan Setia Budi Medan Helvetia Sub District with a value of 12.17 individual plants/ha. A sporadic density was found in Jalan Adam Malik Medan Petisah Sub District with a value of 18.64 individual/ha. Moderate sporadic density was found in Jalan Cirebon Medan City Sub District with a value of 33.33 individual/ha (Figure 3). The high density green belt was found in Jalan Irian Barat Medan Timur Sub District (75.00 plants/ha), Jalan Letda Sujono Medan Tembung Sub District (68.42) and Jalan Brigjen Zein Hamid Medan Johor Sub District (63.89). The average density of the green belt was 285.92 plants/ha (very high).

The species composition ranged from very low until high (average 9.88%). In the green belt, the very low composition will give the impression of a more organized and neat on the basis of the aesthetic aspect and the layout of the city. The density of trees among the green belts was different; depending on the number of trees and the area of green belt. Trees with high density give protective function because it reduces the air temperature (hot and sunny) during the day. According to Lakitan (2002), at night, the tree serves as thermal insulation, so that the temperature under the canopy becomes warmer. Climate is usually defined as the "average weather" in a place. It includes patterns of temperature, precipitation (rain or snow), humidity, wind and seasons. Climate patterns play a fundamental role in shaping natural ecosystems, and the human economies and cultures that depend on them. The climate change is due to the average global temperature increase. The increase in these green house gas emissions in the atmosphere, especially CO_2, has been trapping heat in the Earth's atmosphere. It affects global weather systems that cause everything from unpredictable rainfall to extreme heat wave (Department of Ecology State of Washington, 2016).

Trees have an important role to reduce effects of climate change. Trees provide such things as: food, shade, wood-energy, building and fencing materials. They regulate micro-climates and rainfall patterns, hold soil to the ground, serve as habitats for other life forms and help to harvest and retain rainwater. They sequester carbon and thereby clean the air as reported by Maathai (2009). According to Berutu (2014), preparing for a changing climate, rising levels of carbon dioxide and other heat-trapping gases in the atmosphere have warmed the earth and are causing wide-ranging impacts, including rising sea levels; melting snow and ice; more extreme heat events, fires and drought; and more extreme storms, rainfall and floods. Scientists project that these trends will continue and in some cases accelerate, posing significant risks to human health, our forests, agriculture, freshwater supplies, coastlines, and other natural resources that are vital to our quality of life.

The higher density level of trees will reduce solar radiation. Trees absorb heat from the sun. So that will provide cool air under the canopy of trees. According to Schmidt *et al.* (2014), vegetation cover is a crucial component of the earth's climate system. The existence of the tree will provide a cool microclimate for the city. The green belt is one the

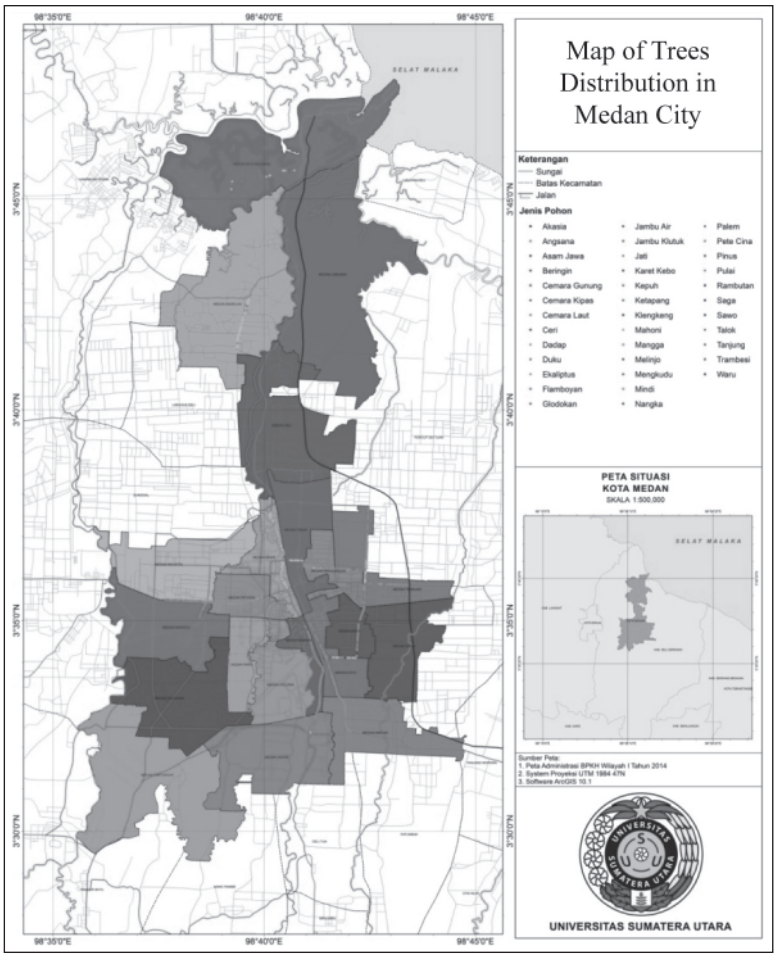

Fig. 4. Map of trees distribution in Medan City.

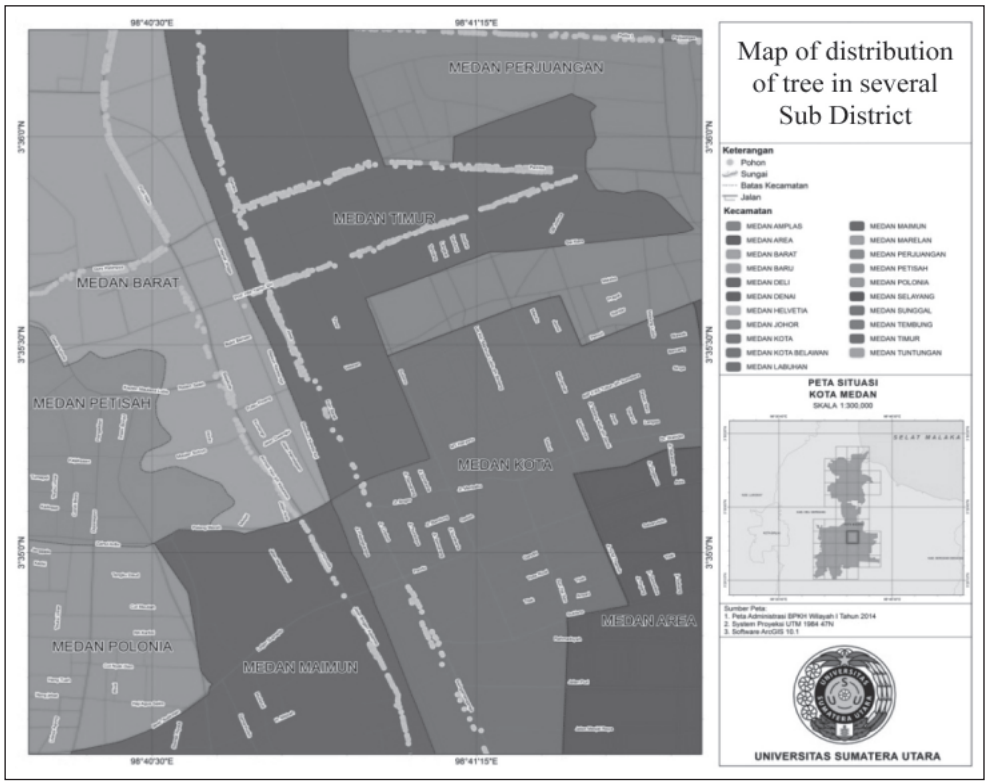

Fig. 5. Map of distribution of tree in several sub district in Medan City.

form of green open space that have an important role as an absorber of CO_2 and storing carbon (C), which still needs development and expansion as well as the increase in the number of trees, because it will give a positive impact on efforts to reduce vehicle emissions and GHG tempetures are rising because of an increase of green house gases (GHG) in the atmosphere.

United Nations Framework Convention on Climate Change (UNFCCC) grouped GHG into : carbon dioxide (CO_2), methane (CH_4), dinitro oxide (N_2O); hydrofluorocarbon (HFCs), perfluorocarbon (PFCs), and sulfur hexafluoride (SF_6). Of the six types of GHG, CO_2 contributed the highest to the concentration of GHGs in Medan City. According to the Environment Agency North Sumatra Province (2015), energy consumption and CO_2 emissions released from the industrial sector and the transport sector, as agree with Rival *et al.* (2016); Akhmetov (2015); Karakaya & Ozcag (2005). CO_2 is one of green house gases. As we know that plants perform photosynthesis process that converts carbon dioxide gas with water into carbohydrates and oxygen with the help of sunlight. The chemical process is the formation of carbohydrates and oxygen $6CO_2$ + $6H_2O$ + energy and chlorophyll into $C_6H_{12}O_6 + 6O_2$. The ability of plants to absorb carbon dioxide gas is different. According to Prasetyo *et al.* (2002), trees are capable of absorbing carbon dioxide at 1,559.10 kg/ha.day or 569.07 tons/ha.yr. Tree has higher CO_2 absorption than other vegetation types. Further Berutu (2014) and Shannigrahi (2003) suggested that plants have a very important role in absorbing CO_2 emissions from transportation activities on the motorway. The gaseous pollutants are transferred from the atmosphere to vegetation by the combined forces of diffusion and flowing air movement. Green Open Space is increasingly widespread and more and more trees are planted. This will increase CO_2 absorption and oxygen production in photo-synthesis. Thus, a green belt could play important roles in reducing the impact of climate change.

Green belt with the highest density level was found in Jalan Sunggal Medan Sunggal Sub District (1,893.75 plants /ha) (very tightly) (Figure 2 and Figure 3), followed by that found in jalan Pelita III Medan Perjuangan Sub District (868), Jalan Armada Medan Kota Sub District (600), Jalan Putri Hijau Medan Barat Sub District (544.74), Jalan Gatot Subroto Medan Helvetia Sub District (483.11), Jalan Wiliam Iskandar Medan Tembung Sub District (443.04), Jalan Jawa Medan Timur Sub District (377.78), Jalan Ahmad Yani Medan Barat Sub District (296.66) and Jalan Dr. Mansyur Medan Selayang Sub District (273.08) (Figure 6).

Medan as a metropolitan city requires large areas of green open space. Carbon dioxide (CO_2) is a greenhouse gas that can cause global warming. Absorption by plants is one way to reduce CO_2 emissions. Carbon dioxide emissions are the emission or discharge of carbon dioxide gas (CO_2) into the air. CO_2 emissions are usually expressed in equivalent tons of carbon dioxide. Sources of carbon dioxide gas emissions are classified into four categories, namely mobile transportation, stationary combustion, industrial processes and solid waste disposal. The CO_2 emissions can be categorized into two, namely direct emissions (such as CO_2 emissions from motor vehicles) and indirect emissions (such as electrical energy consumption in households) (Berutu, 2014). Provision of green open space has been regulated in the Law on Spatial Planning No. 26 (2007). Further, provision on the supply and use of green open space is contained in the Regulation of the Minister of Public Works No. 5 (2008), about Guidelines for the Provision and Use of Green Open Space in Urban Area. Under the regulation, the proportion of the provision of green space in urban area should be at least 30% is and composed of 20% of public green open space and 10% of private green

Fig. 6. Green belt in Jalan Dr. Mansyur Medan Selayang Sub District.

open space. The policy on the minimum proportion of green open space is intended to support the balance of the ecological system of the urban environment i.e. hydrological system, macroclimate and other ecological systems to ensure the availability of clean air required by the community and can also provide aesthetic value to the spatial structure of the city. The presence of green belt in the city field can serve as a CO_2 sink.

According to Banurea *et al.* (2013), from 4,254 trees in green open space at the University of Sumatera Utara in Medan City, the potential of CO_2 absorption was 3,327.25 kg/hr lower than the burden of emissions the resulting from a motor vehicle that was 6,088.14 kg/hr. This absorption was not sufficient to reduce the burden of the resulting CO_2 emissions from motor vehicles. Furthermore, according to Fadillah *et al.* (2013), the amount of CO_2 emissions released in Medan City in 2012 amounted to 2,449,399.15 ton/yr and in 2014 was 2,659,091.01 ton/yr and the capacity of urban forest in absorbing CO_2 in Medan City only amounted to 14,683.84 ton/yr (Rivai *et al*., 2016). Ideally, the urban forest absorption to fulfill the function as absorbing CO_2 and producing O_2 was 4,304.21 ha in 2012 in Medan City based on research of Fadillah *et al.* (2013).

One way to reduce the impact of global warming is to grow trees. For big cities, such as Medan City, presence of urban forests (such as green belt) is necessary. According to Maathai (2009), with program green belt movement, tree planting can reduce the impact of climate change. To mitigate climate change, especially in Medan city, needs a policy and real action of the government which involve all stakeholders (integrated approach). According to Rahmawaty *et al.* (2011), integrated approach can provide effective support by involving stakeholders such as community and academia in the decision-making. In this way, the program is expected to be sustainable. Community involvement in climate change mitigation program aims to strengthen the understanding and capacity to take action against climate change. This will increase national awareness of the role of communities in tackling climate change as suggested by Maathai (2009); Regulation of the Minister of Public Works No. 5, 2008).

Ongoing mitigation efforts are urgently required to reduce the risk of climate change and that is the reason why this research was conducted especially in protecting green belt and intensifying reforestation. Planting trees is the first step and ensuring their survival is essential. The long-term survival of trees is urgent in tree planting strategy. This is monitored by the art of GIS technology. The role of government, academy and community is needed. By doing the green belt reviews periodically in collaboration with government agencies and community will help safeguard against climate change problem especially in Medan City. This activity is not only carried out in the Medan city, but can also be disseminated to other regions. The role of the academy is also needed in order to spread information to the government and community. An integrated approach involving all stakeholders in the Medan city is urgently needed as part of efforts to mitigate climate change.

One of the efforts to tackle climate change in a big city is by planting trees. Trees are planted along the edges and middle of the road, forming the socalled a green belt. The presence of the trees can absorb carbon originating from vehicles, factories that are mostly located in large cities such as Medan City. Availability of green open spaces, one of which is a green belt in Medan City is the responsibility of municipal government. As mentioned earlier, the minimum is 30% of the total area of Medan City. According to Maathai (2009), tree planting continues to bring communities together, build a common purpose, promote more sustainable livelihoods and over time build resilience. Successful tree planting also requires capacity, commitment, proper financing, political will and good governance. It demands ownership by communities involved, respect for rights and most importantly, that local people remain united behind a common vision.

Preventing deforestation and increasing tree cover is challenging but the rewards to communities and country are manifold and provide benefits far beyond simply absorbing carbon. Trees and forests have a significant role to play in a global climate deal when the right trees are planted in the right places and their survival is ensured. They should also simultaneously improve the livelihoods of local communities. The green belt movement's integrated and holistic approach to climate change addresses livelihoods of communities, adaptation, mitigation and sustainable development (Maathai, 2009). To reduce vulnerability of communities to climate change, not only continuing to plant trees, but also reducing deforestation and forest degradation. Climate change is our problem. Therefore, it needs government policies, programmes and strategies to protect environment (such as to protect green belt and do tree planting) in collaboration with all stakeholders.

Green open space in Medan City encompasses 2,120.8 ha or 8% of the total of Medan City area (Environment Agency of North Sumatra Province, 2015). Whereas, according to the Regional Regulation of Medan City No. 13 (2011) (Article 38), minimum of 30.58% required to improve environmental quality and reduce the impact of climate change in Medan City. Therefore, the

reduction of CO_2 emissions through the planting of trees on the green open spaces, especially green belt is a strategic step to reduce the concentration of GHG in the atmosphere in order to achieve better air quality and reduce the impact of climate change in Medan City (Regulation of the Minister of Public Works No. 5 (2008); the Regional Regulation of Medan City No. 13 (2011). A green belt is a very important element to maintaining the balance of the elements of a city (Zmelik *et al.*, 2011). A green belt is the main element in the form of natural vegetation that absorbs pollutants in the form of gas and dust particles through the leaves (Basri, 2009). In addition, tree planting also can be done in the home garden, tourism areas, urban forests, parks, a public cemetery and fields (the Regional Regulation of Medan City No. 13 (2011, article 35).

CONCLUSION

Total number of tree that was found on the 32 green belt in several sub-districts in Medan City was 6,002. *Pterocarpus indicus* was the first dominant species, follow by *Oreodoxa regia* and *Switenia macrophylla*. The value of diversity index of the study sites was classified as moderate category, so the environmental conditions are still relatively stable. The pattern of species was relatively spreads to each species. The similarity of plant community among sampled green belt locations were the similarities species. The green belt with the highest density level was that in Jalan Sunggal Medan Sunggal Sub District with a value of 1,893.75 plants/ha (tight). The green belt with the lowest density level was Jalan Setia Budi Medan Helvetia Sub District with a value of 12.17 individu/ha (very sporadic). Planting trees in the green belt of Medan City are still needed especially along Jalan Setia Budi (Medan Helvetia), Jalan Haji Adam Malik (Medan Petisah) and Jalan Cirebon (Medan Kota) and also in the homegarden, tourism areas, urban forests, parks, a public cemetery, and fields in order to absorb more CO_2 and to reduce the impact of climate change in Medan City.

ACKNOWLEDGMENTS

We are grateful to the Indonesian Directorate General of Higher Education (*DIKTI*) and University of Sumatera Utara for providing financial assistance, the Committee of International Seminar "Improving Food Security: the Challenges for Enhancing Resilience to Climate Change" (UISFS) 2016 University of Lampung for supporting dissemination part of this work on August 23-25, 2016, at Emersia Hotel, Bandar Lampung. We also thank to the students of the Faculty of Forestry University of Sumatera Utara who assisted with field work.

REFERENCES

Akhmetov, A. 2015. Decomposition analysis of industry sector CO_2 emissions from fossil fuel combustion in Kazakhstan. *International Journal of Energy and Environment*, **6(1)**: 37-46.

Aronoff, S. 1989. Geographic information systems and rural development. In: *The Proceedings of Franco-Thai Workshop on Remote Sensing,* Khon-kaen, Thailand. pp.162-166.

Basri, I.S. 2009. The green belt for air pollution control in relation to quality of life in urban. *SMARTek Journal*, **7(2)**: 113-120.

Banurea, I., Rahmawaty. & Afifuddin, Y. 2013. Green open space capability analysis on reducing concentration of CO_2 from motor vehicles at campus USU Medan *Peronema Forestry Science Journal*, **2(2)**: 126-129.

Berutu, G. 2014. Importance of vegetation role in the green open space to reduce CO_2 emissions from transport activity results in highway (case study of toll road Bogor ring road section I). Accessed on 2016 August 1 from http://gibranius51e.blogstudent.mb.ipb.ac.id/2014/11/19/.

Dahlan, E.N. 2011. Adequacy area of urban forests as sinks of CO_2 gas to anticipate decrease of green open space area in Bogor City. *Forum Geografi*, **25(2)**: 164-177.

Department of Ecology State of Washington. 2016. What is climate change? Accessed on 2016 July 21 from http://www.ecy.wa.gov/climatechange/whatis.htm.

Environment Agency of North Sumatra Province. 2015. *Regional environmental status in North Sumatra Province*. The Environment Agency of North Sumatra Province, Medan. 122 pp. (Bahasa Indonesia).

Fadillah, S., Latifah, S. & Sukmana, A. 2013. Predicting of urban forest width as the Carbondioxide (CO_2) absorber in Medan. *Peronema Forestry Science Journal*, **2(2)**: 152-156.

Karakaya, E. & Ozcag, M. 2005. Driving forces in Central Asia: A decomposition analysis of air pollution from fossil fuel combustion. *Arid Ecosystems Journal*, **11(26-27)**: 49-57.

Kusmana, C. 2017. *Survey methods and vegetation data interpretation*. IPB Press, Bogor. 68 pp. (Bahasa Indonesia).

Kent, M. & Paddy, C. 1992. Vegetation description and analysis a practical approach. Belhaven Press, London. 428 pp.

Lakitan, B. 2002. *Basics of Climatology*. Penerbit Raja Grasindo, Jakarta. 174 pp. (Bahasa Indonesia).

Maathai, W. 2009. Responding to climate change from the grassroots: the green belt movement approach. Accessed August 3, 2016 from http://www.greenbeltmovement.org/sites/greenbeltmovement.org/files/2009_climate_change_report_GBM.pdf.

Manik, E., Latifah, S. & Patana, P. 2016. Estimation of Carbon Stored in Different Green Line Arterial Road Secondary Central Part of Medan City. *Peronema Forestry Science Journal,* **5(1)**: 204-213.

Manuri, S., Brack, C., Nugroho, N.P., Hergoualc'h, K., Novita, N., Dotzauer, H., Verchot, L., Putra, C.A.S. & Widyasari, E. 2014. Tree biomass equations for tropical peat swamp forest ecosystems in Indonesia. *Forest Ecology and Management*, **334**: 241-253.

Ministry of Law and Human Right of the Republic of Indonesia. 2007. *The Law of the Republic of Indonesia No. 26 (2007) on Spatial Planning.* Ministry of Law and Human Right of the Republic of Indonesia, Jakarta. 95 pp. (Bahasa Indonesia).

Ministry of Public Works. 1996. *Planning procedure of technique landscape road No. 033/TBM/1996.* The Directorate General of Highways. Ministry of Public Works, Jakarta. 58 pp. (Bahasa Indonesia).

Ministry of Public Works. 2008. *Guidelines of green open space provision and utilization in urban areas. No. 05 / PRT / M / 2008*. The Directorate General of Spatial Planning. Ministry of Public Works, Jakarta. 84 pp. (Bahasa Indonesia).

Misra, K.C. 1980. Manual of Plant Ecology. 2nd ed. Oxford and IBH Publishing Co, New York. 491 pp.

Nowak, D.J., Stevens, J.C., Susan, M.S. & Christopher, J.L. 2002. Effects of urban tree management and species selection on atmospheric carbon dioxide. *Journal of Arboriculture,* **28**: 113-121.

Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders Co., Philadelphia and London. 546 pp.

Payne, R.J., Simon, J.M.C., Christoper, D.F., Jacky, A.C., Jill, L.E., Andrea, B. & Nancy, B.D. 2014. Heather moorland vegetation and air pollution: a comparison and synthesis of three national gradient studies. *Water Air Soil Pollution*, **225(1998)**: 1-13.

Prahasta, E. 2004. *Geographic Information System: Tutorial ArcView*. CV. Informatika, Bandung. 456 pp. (Bahasa Indonesia).

Prasetyo, L.B., Rosalina, U., Murdiyarso, D., Saito, G. & Tsuruta, H. 2002. Integrating remote sensing and GIS for estimating aboveground biomass and green house gases emission. *CEGIS Newsletter*, **1**: 2002.

Purwasih, H., Latifah, S. & Sukmana, A. 2013. Identification of plant species at a few streets green belt of Medan City. *Peronema Forestry Science Journal*, **2(2)**: 108-116.

Regional Development Planning Board of Medan City. 2011. *Medan City spatial management planning related to regional land uses (2011-2031) No. 13 (2011).* Regional Development Planning Board of Medan City, Medan. 41 pp. (Bahasa Indonesia).

Rahmawaty, Villanueva, T.R. & Carandang, M.G. 2011. Participatory Land Use Allocation (Case Study in Besitang Watershed, Langkat, North Sumatera, Indonesia). Lambert Academic Publishing, Germany. 199 pp.

Rauf, A., Rahmawaty. & Syofyan, A. 2016. *Land use technology-base on watershed management.* USU Press, Medan. 26 pp. (Bahasa Indonesia).

Rawat, J.S. & Banerjee, S.P. 1996. Urban forestry for improvement of environment. *Journal of Energy Environment Monitor*, **12(2)**: 109-116.

Rival, A., Patana, P. & Latifah, S. 2016. Estimation of CO_2 emissions and O_2 needs and absorption of CO_2 and producer of O_2 at city park and the green line in Medan City. *Peronema Forestry Science Journal*, **5(1)**: 131-138.

Shannigrahi, A.S., Sharma, R.C. & Fukushima, T. 2003. Air pollution control by optimal green belt development for Victoria Memorial Monument, Kolkata (India). *International Journal of Environmental. Studies,* **60(3)**: 241-249.

Schmidt, M., Klein, D., Conrad, C., Dech, S. & Paeth, H. 2014. On the relationship between vegetation and climate in Tropical and Northern Africa. *Theoretical and Applied Climatology,* **115**: 341-353.

Sharma, S.C., Sharga, A.N. & Roy, R.K. 1994. Abatement of industrial pollution by land-scaping. *Indian Journal of Environmental Protection,* **14(2)**: 95-97.

Sitorus, N.A., Rahmawaty. & Rauf, A. 2014. Estimation of carbon stock above ground biomass in Ahmad Yani Parks in Medan City. *Peronema Forestry Science Journal*, **3(2)**: 40-44.

Zmelik, K., Schindler, S. & Wrbka, T. 2011. The European green belt: international collaboration in biodiversity research and nature conservation along the former Iron Curtain. *Innovation: The European Journal of Social Science Research*, **24(3)**: 273-294.