Use of Geographical Information System (GIS) and remote sensing in development of urban forest types and shapes in Tangerang Selatan City

Gumilar Adam, Rachmad Hermawan* and Lilik Budi Prasetyo
Urban Forest and Environmental Services Division, Forest Resources Conservation and Ecotourism, Forestry Faculty Bogor Agricultural University Darmaga Campus, Bogor, 16680, Indonesia

E-mail: racher67@gmail.com

Abstract. The development of a city could create adverse effects, such as increase in air pollutant, and decrease in amenity. One of the ways to overcome these adverse effects is developing urban forest. For maximizing the function of urban forest, the appropriate types of urban forest to be developed, should be determined first. The aims of this study were to determine the appropriate types of urban forest and to identify the shape of urban forest in Tangerang Selatan City by using GIS and remote sensing. Urban forest shape was identified on the basis of shape and distribution of land unit. The steps of the study comprised data collection, map preparation and data analysis. Landsat 8 satellite imagery was interpreted for land use/cover classification. Scoring based on air temperature, land slope, and soil types was used to determine priority of urban forest locations. Besides that, land use planning was considered to determine the appropriate urban forest type. The results of the study show that the appropriate urban forest types are residential area urban forest, industry urban forest, and recreation urban forest. On the other hand, the appropriate urban forest shapes are strip, scattered, and clustered pattern.

1. Introduction
City is an area which constitutes a center of activities with main activities in the form of service and trade. Consequence of being the center of activities is that the city area exhibits rapid development in economic sector and often be accompanied with problems of environmental quality deterioration, such as increasing in air pollution, occurrence of urban heat island (UHI), decreasing in convenience and decreasing in biodiversity [1, 2, 3]. Such city or urban problem should be controlled so that the area does not go toward necropolis condition [4].

Tangerang Selatan town is a satellite city situated around Jakarta city. The city exhibits rapid development as shown by development of shopping centers and residential areas, traffic jam prevalence, decreasing in biodiversity and others, so that the city possesses problems similar with those of other big cities.

One of the efforts to overcome problems in urban areas is development of urban forest. According to RI Government Regulation Number 63 Year 2002 [5], urban forest was defined as land covered with tree growth in public or private land, which is formally established as urban forest by authorized official, with minimum area size of 0.25 ha. Furthermore, Irwan [6] defined urban forest more completely as vegetation community in the form of trees and their associates which grow in urban land or around urban area, and could be in the form of strips, scattered spots, or clumps with structure resembling natural
forest, creating habitat which facilitate life for wild animals and create aesthetics and healthy and convenient environment. Urban forest exhibits social benefits, aesthetics, recreation, and phenomena of engineering, economy and ecology.

For creating maximum function, development of urban forest should be preceded by determining the type of the urban forest. Determination of urban forest type is based on the objective of urban forest development and objects which will be protected, while considering problems and potential problems existing in the area and functional potency of the area. According to RI Government Regulation Number 63 Year 2002 [5], urban forest types comprise residential area type, industrial area type, recreation type, germplasm conservation type, protection type, and security type. Shapes of urban forest to be developed is based on forms of land unit and distribution of land unit in the urban areas [5,6], whereas Fahutan IPB [7] distinguished shapes of urban forest on the basis of location, important function, vegetation, and management intensity.

GIS and remotes sensing are valuable tools in planning urban forest. Rushayati et al. [1] used these tools in determining location priority of green open spaces based on surface temperature in Bandung Regency. These tools also were used by Humaida et al. [8] in determining location priority of green open spaces based on vegetation density (NDVI), temperature humidity index (THI), population density, and land price in Banjarbaru City.

The objectives of this study were determining the appropriate types of urban forest and identifying shapes of urban forest in Tangerang Selatan City by using GIS and remote sensing. The benefit of this study is to provide an input for the local government in determining types and shapes of urban forest to be developed.

2. Method
2.1. Location and time of study
This study was conducted in Tangerang Selatan City, the province of Banten (figure 1) from August through December 2015. Data processing was conducted in Laboratory of Environmental Analysis and Spatial Modeling, Department of Forest Resources Conservation and Ecotourism, Faculty of Forestry, Bogor Agricultural University (IPB).

![Figure 1. Map of Tangerang Selatan City](image)

2.2. Materials and equipments
Equipment being used in this study were pro-summer camera for activities documentation, GPS (Global Positioning System), Microsoft Office software, Arc GIS 10.2 software, Erdas Imagine 9.1 software. Materials being used were: (1) from BAPPEDA (Municipal Development Planning Agency) of Tangerang Selatan City namely Administration Map of Tangerang Selatan City, Land use Map of Tangerang Selatan City of Year 2011, Soil Types Map of Tangerang Selatan City of Year 2011;
2. Landsat 8 satellite imagery with acquisition date 13th September 2014 Path/Row 122/064; and (3) Digital Elevation Model (DEM) produced by Shuttle Radar Topography Mission (SRTM).

2.3. Stages of Study

2.3.1. Data collection
Data collection was conducted by literature review, observation and ground check. The types of data collected were air temperature, rainfall, soil types, land use, topography, and land cover.

2.3.2. Preparation of maps
2.3.2.1. Map of air temperature
Air temperature is classified into three classes, namely below convenient level (< 24 °C), convenient level (24°C - 28°C) and above convenient level (> 28 °C) [9]. Determination of surface temperature value used Erdas Imagine 9.1 software. Afterwards, a model was constructed in the available model maker to convert pixel values at landsat 8 and band 10. DN (Digital Number) value was converted to radiation value [10]. The next stages were as follows: calculation of albedo, calculation of net radiation, calculation of reflected short wave radiation, calculation of incoming short wave radiation, calculation of reflected long wave radiation, estimation of Normalized Differential Vegetation Index (NDVI), calculation of soil heat flux, calculation of sensible heat flux [11], and determination of values of temperature [12].

2.3.2.2. Maps of rainfall, soil types and land use.
Maps of rainfall, soil types and land use were obtained from BAPPEDA (Municipal Development Planning Agency) of Tangerang Selatan City.

2.3.2.3. Topographic/slope map
Topographic map was processed from DEM produced by SRTM. Slope classes were categorized into seven classes [13], namely: (a) nearly level: 0 - 3%; (b) gently sloping/undulating: 3 - 8%; (c) rolling: 8 - 15%; (d) hilly: 15 - 30%; (e) moderately steep: 30 - 45%; (f) steep: 45 - 65%; (g) very steep: > 65%. The creation of such map was conducted by processing DEM produced by SRTM, into slope map.

2.3.2.4. Land use/cover
This map was obtained by interpreting landsat 8 imagery year 2014 with acquisition date 13th September 2014 Path/Row 122/064 with Supervised Classification Method. Land cover were classified into water bodies, tree vegetation, non tree vegetation, and built-up.

2.4 Data analysis
2.4.1 Determination of priority location of urban forest.
Determination of priority location of urban forest was conducted by scoring techniques [8]. For each criteria being used (temperature map, soil type map, and slope classes map) there was classification and labeling of different values. Labeling of values for each class referred to research by Humaida et al. [8] and Kridalaksna [14]. Stages in determination of types and shapes of urban forest are presented in figure 2.
Combination of the three criteria would produce maximal score 9 and minimal score 3. Maximal and minimal values (scores) were divided into 3 ranges, namely score ≥3 - <5, ≥5 - <7 and ≥7 - 9.
Those scores will be used as reference for determining location of urban forest in Tangerang Selatan city. Those ranges will serve as reference in determination of location priority, where the first priority was for area which have score $\geq 7 - 9$; second priority for area with score $5 - <7$, and third priority for area with score $3 - <5$ as shown table 1.

### Table 1. Value for each criteria for determination of urban forest location

| No. | Criteria            | Classes | Score |
|-----|---------------------|---------|-------|
| 1   | Temperature         | $> 28^\circ$ C | 3     |
|     |                     | $< 24^\circ$ C | 2     |
|     |                     | $24^\circ$ C - $28^\circ$ C | 1     |
| 2   | Land slope          | $> 15$ %   | 3     |
|     |                     | 8 - 15 %   | 2     |
|     |                     | 0 - 8 %    | 1     |
| 3   | Soil types *)       | Regosol   | 3     |
|     |                     | Latosol   | 2     |
|     |                     | Aluvial   | 1     |

*) [15, 16]

2.4.2 **Determination of types and shapes of urban forest in Tangerang Selatan city**

After the urban forest location priority had been obtained, the next step was determining the types and shapes of urban forest. Determination of urban forest types was based on data of field observation, and land use map which referred to RI Government Regulation Number 63 Year 2002 [5] and Irwan [6], and the types were as follows (1) Residential area urban forest, (2) Industry urban forest, (3) Recreation urban forest, (4) Conservation urban forest, (5) Protection urban forest, and (6) Security urban forest.

Afterwards, on the basis of the dominant land form, the shapes of urban forest were determined by referring to RI Government Regulation Number 63 Year 2002 [5] and Irwan [6] and were categorized into 3 shapes (forms), namely: (1) Clumped, which is a category of urban forest whose vegetation community is concentrated in a particular area with vegetation abundance of minimally 100 trees with close spacing and irregular arrangement; (2) Scattered, which is a category of urban forest which does not have particular pattern, whose vegetation community grows in scattered pattern in the form of...
clusters or small clusters; (3) Strip, which is a category of urban forest whose vegetation community grow in land in the form of straight or curved strip following the path of river, road, canal and others.

Besides that, shapes of urban forest were also identified by referring to Fahutan IPB [7] with the following categories: (1) City park; this shape of urban forest is allocated for areas which have industrial urban forest type, residential areas and center of activities; (2) Plantation/home garden; this shape of urban forest is suitable for residential area urban forest type occurring in fertile area; (3) Green belt; this shape of urban forest is developed in road area and conservation area; (4) Forest; this shape of urban forest is suitable to be established in protected area.

3. Results and Discussion

3.1. Physic environment condition

3.1.1. Air temperature

One of the problems which is often faced by urban community recently is decreasing of convenience due to temperature increase. Temperature of > 28°C covered area of 5,066.19 ha or 36.36% of the area size of Tangerang Selatan city as shown on figure 3.

![Air Temperature Map in Tangerang Selatan City](image)

**Figure 3.** Air Temperature Map in Tangerang Selatan City

3.1.2. Soil types and land slope

Soil types in Tangerang Selatan is dominated by soil association of Alluvial, Latosol, and Regosol. Soil type which exhibited the largest area was Reddish Brown Latosol which covered area of 8,403.30 ha or 50.80% of the total area of Tangerang Selatan City. Area in Tangerang Selatan City is dominated by slope of 3 - 8% with area size of 88,041.43 ha or 53.21% of the area size, whereas the smallest area was for slope class > 65% (steep). Maps of soil types and land slope can be seen on figure 4.
3.1.3. Land cover dan land use

Land cover constitutes the physical manifestation of an area surface without considering the allocated use of that area [17]. Land cover in Tangerang Selatan city was dominated by built-up with area size of 10,525.75 ha or 63.65% of the total area size. Land use in Tangerang Selatan City are categorized into 15 types with domination by moderate density residential area, with area size of 6,751.70 ha or 38.17% of the total area. Open space such as plantation/farm land, rice field, or bushes occupied only 20.59% of the total area. Maps of land cover and land use are shown on figure 5.

3.2. Priority location of urban forest development

From results of overlay process for air temperature map, slope and soil types map, and of the scoring process, there were obtained priority locations for urban forest development. Area size of 1st priority was only 1,521.33 ha or 9.22% of the city area size. More complete information of each forest location priority is shown in table 2, with distribution as shown in figure 6.
Table 2. Area size of each priority classes of urban forest development for each sub district in Tangerang Selatan city

| No | Sub district        | 1st Priority | 2nd Priority | 3rd Priority |
|----|---------------------|--------------|--------------|--------------|
| 1  | Serpong Utara       | 637.47       | 1,247.99     | 339.70       |
| 2  | Pondok Aren         | 42.52        | 1,054.17     | 1,896.03     |
| 3  | Ciputat             | 60.56        | 797.67       | 1,255.78     |
| 4  | Pamulang            | 85.50        | 1,342.51     | 1,446.44     |
| 5  | Serpong             | 435.55       | 1,490.40     | 909.17       |
| 6  | Ciputat Timur       | 53.45        | 656.73       | 1,067.94     |
| 7  | Setu                | 206.26       | 841.14       | 626.13       |
|    | Total               | 1,521.33     | 7,430.64     | 7,541.26     |

On the basis of Table 2, it could be seen that sub district which possessed the largest area for 1st priority was sub district of Serpong Utara with area size of 637.47 ha, followed with sub district of Serpong as large as 435.55 ha, while that of the smallest area size was Ciputat Timur with area size of 53.45 ha. Afterwards, 1st priority area was further categorized into area which became location of urban forest priority as strategy of urban forest development acceleration, namely area which had possessed vegetation, dominated either by tree or non tree vegetation, as shown in figure 6.

After the location of urban forest was known, the next step was determination of urban forest types which constituted an initial step and reference for future development of urban forest. Determination of urban forest type was based on objectives and objects being protected, which was adjusted with present condition of land use and plan for the future. Afterwards, on the basis of overlay between location map urban forest development and land use, there could be determination of types of urban forest, and therefore there were obtained urban forest types of residential area, industry and recreation, with area size of each type shown in table 3, while the distribution is shown in figure 6.

Table 3. Area size of development of urban forest type in each sub district in Tangerang Selatan City

| No | Sub district      | Residential area | Recreation | Industry |
|----|------------------|------------------|------------|----------|
| 1  | Pamulang         | 12.47            | 0.00       | 0.00     |
| 2  | Ciputat Timur    | 6.22             | 0.00       | 1.14     |
| 3  | Serpong          | 166.34           | 2.63       | 0.00     |
| 4  | Serpong Utara    | 132.04           | 22.82      | 9.67     |
| 5  | Setu             | 38.50            | 0.00       | 0.00     |
|    | Total            | 355.57           | 25.45      | 10.81    |
Figure 6. Maps used to determination of urban forest type in Tangerang Selatan City: (a) urban forest priority map; (b) map of location of urban forest development; (c) map of location of urban forest types

Identification of urban forest shapes was conducted by reference to two approaches, namely Fahutan IPB [7] and RI Government Regulation Number 63 Year 2002 [5] and Irwan [6]. Determination of urban forest shapes by Fahutan IPB [7] was based on location, important function, vegetation condition and management intensity, whereas that of RI Government Regulation Number 63 Year 2002 [5] and Irwan [6] were based on land shapes and their distribution.

Results of identification show that shapes of urban forest according to Fahutan IPB [7] which are suitable for: (1) Residential area urban forest type are city park, home garden and green belt along road sides in residential area; (2) Industry urban forest type are city park and green belt surrounding industrial area. This city park functions as absorbent and adsorbent of pollutant, and as resting places for workers. Green belts function as buffer for the surrounding areas which are affected by air pollution; (3) Recreation forest type are city park which is dominated by scenic tree species and managed with high intensity level of management.

Identification of urban forest shapes by RI Government Regulation Number 63 Year 2002 [5] and Irwan [6] shows that in sub district of Pamulang and sub district of Ciputat Timur, the suitable shape of urban forest is that which has scattered pattern, whereas for those of sub districts of Serpong, Serpong Utara and Setu, the shape of urban forests are those with clumped/clustered pattern. More complete description of urban forest shapes of each sub district of Tangerang Selatan City is presented in table 4.
### Table 4. Development of urban forest shapes for each sub district in Tangerang Selatan City

| Subdistrict         | Residential area                  | Industry                        | Recreation                  |
|---------------------|-----------------------------------|---------------------------------|-----------------------------|
|                     | A\(^{(*)}\) B\(^{(**)}\)         | A\(^{(*)}\) B\(^{(**)}\)       | A\(^{(*)}\) B\(^{(**)}\)   |
| Pamulang            | City park, Home garden,           | Scattered                       |                             |
| Ciputat Timur       | City park, Home garden            | Scattered                       | City park, Green belt       |
|                     |                                   |                                 | Scattered, clustered, strip |
| Serpong             | City park, Home garden, Green belt| Clustered, Strip                | City park                   |
| Serpong Utara       | City park, Home garden, Green belt| Clustered, Strip                | Clustered                   |
| Setu                | City park, Home garden, Green belt| Clustered, Strip                | Clustered                   |

\(^{(*)}\)[5] **[6,7]

### 3.3 Implication of development of types and shapes of urban forest.

The priority locations of urban forest are those which have high air temperature [3, 18], steep slope and high susceptibility to erosion [19]. Therefore, as an initial step, the arrangement and choice of planted tree species are directed toward overcoming problem of inconvenience and soil erosion [20, 21]. Such directives should be further specified on the basis of urban forest types to be developed. Analysis results show that in Tangerang Selatan city, urban forest can be developed with three types as follows:

1. **Residential area urban forest type.** Urban forests which are developed in residential area have the main function in microclimate amelioration, noise reduction, oxygen producer, carbon dioxide absorbent and wind break [5, 22, 23, 24], so the residents could enjoy tranquility, convenience and health. This type of urban forest possesses the largest area size, namely 355.57 ha. This could be understood because 61.79% of the territory of Tangerang Selatan City was in the form of residential area. To create maximum benefits, the tree species to be developed should have strong root system, strong branch and twigs which do not break easily, leaves which are not easily shed, and produce flower/fruit/seeds which have economic value [5, 7, 25].

2. **Industry urban forest.** Urban forests which are developed in industrial area have the main function to reduce air pollution and noise created by industrial activities [5, 7, 26, 27, 28]. Development of this urban forest type was in accordance with policy of Pemkot Tangsel [21] concerning the control of pollution and environmental destruction; tree species which could be developed should have leaves which are wide and shady, hairy or pubescent, have rough/lobed surface; thick crown, and high ability to absorb and adsorb air pollutant [7, 25, 29, 30, 31, 32, 33].

3. **Recreation urban forest type;** this type of urban forest is developed with the main function to fulfill the need for recreation by urban people community [5, 7], while also could serve as facilities for environmental education [7, 34]. Tree species being planted for this type possesses high aesthetic value, either in terms of crown shape, leaf color, flower color; does not shed much leaves, are not thorny, and does not produce dangerous fruits [15, 25, 26, 35]. This type of urban forest is developed by considering the presence of blocking allocation, namely intensive block and non intensive block, circulation path, facility types, and activities [35].

As one of the efforts to conserve biodiversity, there can be developed species which are endemic/rare/protected [36, 37, 38], especially for urban forest with residential area type and recreation type, while the species should remain fulfilling the required characteristics for those types. Species which
could be developed are among others *Stelechocarpus burahol*, *Diospyros celebica*, *Sterculia foetida*, and *Dalbergia latifolia*.

In accordance with RI Government Regulation Number 63 Year 2002 [5], urban forest should have minimal area size of 0.25 ha. Therefore for each classification, urban forests in the shape of strip or clusters should remain to have minimal area of 0.25 ha. Urban forest with scattered form constitutes one management unit comprising separate strip shape and clustered shape, and each of them should be minimally 0.25 ha. Therefore, as a follow up action, there is a need to identify management units of urban forests in accordance with shapes which will be developed.

4. **Conclusion**

Location and priority for development of each type of urban forest are as follows: (a) residential area urban forest type with area size of 355.57 ha was distributed in sub districts of Pamulang, Ciputat Timur, Serpong, Serpong Utara, and Setu; (b) Industry urban forest type with area size of 10.81 ha was distributed in sub district of Ciputat Timur and Serpong Utara; (c) recreation urban forest type with area size of 25.45 ha was distributed in sub districts of Serpong and Serpong Utara. On the basis of land forms and their distribution, the shapes of urban forest that could be developed in: (a) residential urban forest type are clustered/clump, scattered, and strip; (b) industrial urban forest type are clustered/clump, scattered, and strip; (c) recreation forest type are clustered/clump. On the other hand, on the basis of location, important function, and management intensity, the forms of urban forest which are developed in: (a) residential area urban forest type are city parks, home garden, and green belt; (b) industry urban forest type are city park, and green belt; (c) recreation urban forest type are city park.

**References**

[1] Rushayati S B, Alikodra H S, Dahlan E N and Purnomo H 2011 Green open space development based on distribution of surface temperature in Bandung regency *Forum Geografi* Vol. 25 17 - 26
[2] [DKP-DKI Jakarta] Marine and Agricultural Services of DKI Jakarta 2012 *Master plan of urban forest in DKI Jakarta* (Jakarta: Marine and Agricultural Services of DKI Jakarta)
[3] Rushayati S B and Hermawan R 2013 Characteristics of urban heat island condition in DKI Jakarta. *Media Konservasi* Vol. 18 96-100
[4] Marbun B N 1990 *Indonesia city future: problem and prospect* (Jakarta: Penerbit Erlangga)
[5] [RI Government] Government of Republic of Indonesia 2002 Government regulation number 63 year 2002 concerning urban forest (Jakarta: State Secretariat of RI)
[6] Irwan Z J 1997 *Environmental challenge and landscape of urban forest* (Jakarta: PT Pustaka CIDESINDO)
[7] [Fahutan IPB] Faculty of Forestry, Bogor Agricultural University 1987 *Concept of urban forest development* (Bogor: Faculty of Forestry, IPB)
[8] Humaida N, Prasetyo L B and Rushayati S B 2016 Priority assessment method of green open space (case study:Banjarbaru City) *Procedia Environmental Sciences* 33 354 – 364
[9] Karyono T H 2001 Research on thermal comfort in Jakarta as reference for convenient temperature for Indonesian people *Dimension Architectural Technique* Vol 29 24 – 33
[10] [USGS] United States Geological Survey 2013 *Landsat 8 science data user handbook* (America: USGS)
[11] Khomarudin M R 2005 *Estimation of regional scale evapotranspiration using remote sensing satellite data* [thesis] (Bogor: Bogor Agricultural University)
[12] Monteith J L and Unsworth M H 1990 *Principles of environmental physics*. 2nd ed. (London: Edward Arnold)
[13] [Deptan] Department of Agriculture 2008 *Technical guidelines of upstream watershed conservation* (Jakarta: Directorate of Land Management)
[14] Kridalaksana A 2014 Application of geographic Information System (GIS) for determining location of urban forest and example of pre-design of urban forest in subdistrict of Banyuwangi, District of Banyuwangi [undergraduate thesis]. (Bogor: Faculty of Forestry Bogor Agricultural University)
[15] Department of Public Works 2007 Regulation of Public Works Minister Number: 41/PRT/M/2007 concerning Guidelines on Technical Criteria of Cultivation Area (Jakarta: Department of Public Works)

[16] Rachim D A and Suwardi 2002 Morphology and classification of soils (Bogor: Faculty of Agriculture, Bogor Agricultural University)

[17] Lillesand T M and Kiefer R W 1997 Remote sensing and image interpretation (Third Ed. Suitanto) (Yogyakarta: Gadjah Mada University Press)

[18] Rushayati S B, Prasetyo L B, Puspaningish N and Rahmawati E 2016 Adaptation strategy toward urban heat island at tropical urban area Procedia Environmental Sciences 33 221 – 229

[19] Mahon J R and Miller R W 2003 Identifying high-value greenspace prior to land development Journal of Arboriculture 29 25-33

[20] Armson D, Stringer D and Ennos A R 2013 The effect of street trees and amenity grass on urban surface water runoff in Manchester, UK Urban Forestry and Urban Greening 12 282-286

[21] Municipal Government of Tangerang Selatan City 2011 Local Regulation of Tangerang Selatan City Number 15 year Tahun 2011 concerning Spatial plan of Tangerang Selatan City area year 2011 – 2031 Government of Tangerang Selatan City

[22] Cho S H, Poudyal N C and Roberts R K 2008 Spatial analysis of the amenity value of green open space. Ecological Economics 66 403-416

[23] Nasir R A, Ahmad S S, Ahmed A Z and Ibrahim N 2015 Adapting human comfort in an urban area: the role of tree shades towards urban regeneration Procedia - Social and Behavioral Sciences 170 369 – 380

[24] Moufida B and Jamel A 2012 Impact of vegetation on thermal conditions outside, thermal modeling of urban microclimate, case study: the street of the republic, Biskra Energy Procedia; 73 – 84

[25] Dahlan E N 2013 Green city of urban forest (Bogor: Department of Forest Resources Conservation and Ecotourism, Faculty of Forestry, Bogor Agricultural University)

[26] Grey G W and Denike F J 1986 Urban forestry (second edition) (New York: J. Wiley & Sons, Inc)

[27] Miller R W 1988 Urban forestry: planning and managing urban green spaces (New Jersey: Prentice Hall)

[28] Tyrväinen L, Pauleit S, Seeland K and de Vries S 2005 Benefits and uses of urban forests and trees. In: Urban forest and trees (Eds: Konijnendijk CC, Nilsson K, Randrup TB, Schiperrijn J. (Springer: Berlin Heidelberg New York)

[29] Cavanagh J E, Reza P Z and Wilson G J 2009 Spatial attenuation of ambient particulate matter pollution with an urbanized native forest patch Urban Forestry & Urban Greening 8 21-30

[30] Hermawan R 1997 Effects of simulated acid rain on the growth and leaf anatomical structure of Mimusops elengi L. Seedlings (Goettingen: Georg-August University)

[31] Hermawan R, Kusmana C, Nasrullah N and Prasetyo L B 2011 The effects of the plant row number of roadside vegetation in reducing lead (Pb) particles emitted by motor vehicle (Case study of Acacia mangium green belt, Jagorawi highway) Media Konservasi Vol. 16 55-64

[32] Lei W, Lian-you L, Shang-yu G and Zhi W 2006 Physical characteristics of ambient particle setting upon leaf surfaces of urban plan in Beijing J Environ Sci 18 921-926

[33] Purnomohadi S 1995 Role of green open space in control of air quality in DKI Jakarta [dissertation] (Bogor: Graduate Program, Bogor Agricultural University)

[34] Hermawan R, Kosmaryandi N and Ontario O 2008 Study on type and shape of urban forest in Danau Raja area, Rengat City, Indragiri Hulu Regency, Riau Province Media Konservasi Vol. 13 71-78

[35] Faculty of Forestry Bogor Agricultural University 2008 Compilation of master plan for urban forest Bundayati Tanjung Selor, District of Bulungan. Cooperation between Faculty of Forestry, IPB with Forestry Service Agency, Bulungan District

[36] IUCN International Union for Conservation of Nature and Natural Resources 2014 IUCN Red List of Threatened Species. [Internet]. [downloaded 2016 April 22]. Available at: http://www.iucnredlist.org/
[37] [LIPI] Indonesian Scientific Institute 2001 Indonesian rare plants. Bogor (ID): Puslitbang Biologi-LIPI

[38] Yuniastuti E, Handayani T and Djoar D W 2009 Identification and selection of pranajaya (Sterculiafoetida Linn.) plant diversity and technology of in vitro plant propagation for raw material supply of biofuel. [Internet], [downloaded 2016 April 21]. Available at: http://lppm.uns.ac.id/identifikasi-dan-seleksi-keragaman-tanaman-pranajaya-sterculia-foutida-linn-serta-teknologi-perbanyakan-tanaman-secara-in-vitro-untuk-penyediaan-bahan-baku-biofuel-universitas-sebelas-maret.html