

Optimization for Urban Forest Planning Vegetation Homogeneous and Heterogeneous

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Abstract
Planning the urban forest in the city of Surabaya is very important, because it is very influential on the availability of water which will have an impact on the activities of urban activity. Planning a good urban forest is strongly influenced by the composition or combination of homogeneous vegetation quantity. The aim of this study was to determine the amount of vegetation optimization homogeneous and heterogeneous urban forest planning in the city of Surabaya, East Java, Indonesia. This research method using goal programming. The results showed that the optimal amount for urban forest planning in homogeneous and heterogeneous vegetation in the city of Surabaya as many as 11,242 trees with the following details; 1) 287 tamarind, 2) 3,854 mahogany, 3) 4,013 angsana, and 4) 3,088 landi acid.
Keywords; optimization, planning, urban forest, vegetation, homogeneous, heterogeneous

1. Introduction

Data from Surabaya Regional Water Company Surabaya mention that every 5 years, since 2005, the need for clean water supply for the city of Surabaya constant increase, which is equal to 10%-15%. In 2005, for example, the need for the availability of clean water is 8,901 liter's and second and rose by 15% in 2010 to become 10,314 liters/second. The increase in the same percentage range also occurred in 2015, and the increase in 2020 amounted to 11,935 liters/second, an increase of 1,621 liters/second (13%) is predicted to occur in 2015, and amounted to 1,707 liters/second (14%) in 2020, ie 13, 643 liter's second (Kompas, 2010).

Contrary to predictions of sizable upside every five years, 10%-15%, the net water production capability to utility companies are expected to remain in the range of 7,930 liters/second. In other words, the threat of water supply crises will become a very serious threat in 10 years to come. The implication of all this can be estimated to be, no probably not, in most communities in Surabaya (almost 50%), in the future must meet the needs of their water from groundwater. Therefore, the design and planning of areas that have an impact on the maximization of rainwater catchment should be a serious concern of all stakeholders in the city of Surabaya. Related to this, one of the efforts that should be done is to maximize the hydrological function of the entire potential of green open spaces, including the urban forest, as the catchment areas and rainwater storage.

The decline in the quality of the urban environment as a result of the conversion of open land into residential green also adds another problem that had already become a classical problem, namely the pollution of air, soil, and water which is a direct result of industrialization and transportation activities (Dahlan, 1992; Purnomohadi, 1995). Accumulation continuing impact of the declining quality of the urban environment which then leads to declining health and productivity of citizens is becoming counter-productive to the goal of development, namely improving the quality of human resources (Dahlan, 2007).

Booth (1979) states that the green line in the middle of the city with 183 m width can be reduced to 75% of air pollution. This is supported by the results of the study by Grey and Deneka (1978) who concluded that the trees with other vegetation can improve the city temperatures through evapo-transpiration. In addition, research conducted by Irwan (1994) mentions that the urban forest can also lower the temperature of the surrounding city by 3.46% at noon at the beginning of the rainy season, protect the city from various environmental problems of the city, and can reduce the adverse effects of urban development that caused by the activity of the city that is triggered by the growth of urban population is increasing every year.

To realize this all, in Indonesia, efforts to maintain and develop the forest where the city is done through the city greening movement, which is an attempt to fill the green open space to grow and utilize vegetation in an urban ecosystem. Unfortunately, existing program for greening the city are still on the level of "just" planting trees; without considering the function tree/urban forest vegetation are more optimal in improving the quality of the urban environment, including optimization of hydrological functions.s.

Considering the above, need to be optimized planning of urban forest in the city of Surabaya for heterogeneous and homogeneous vegetation to maximize absorption of rain water, especially in the case of the discovery of the structure of the forest and the choice of type of tree stand as a constituent of the vegetation. Outcomes over study in this area will make an important contribution in preserving the quality from the urban environment, particularly in the hydrological function optimization. In this regard all, this study specifically conducted to assess forest a planning optimization of urban forest in the city of Surabaya as rain water catchment.

2. Literature Review

2.1. Urban Forest

Grey and Deneke (1978) gives the definition of the urban forest as a broad area of woody vegetation and planting distance is open to the public, easily accessible by the residents of the city, and can fulfill the functions of protection a, such as conservation of soil, water management, climate amelioration, an antidote to air pollution , noise and others. Furthermore, Fakuara (1987) defines the urban forest as any vegetation or woody vegetation in urban areas that provide environmental benefits much in the utilities protection, aesthetics, recreation, and other special uses.

The limitation of other urban forest developed by Miller (1988), is all trees and other vegetation that is in it, which was about either human settlements from small communities with the narrow region to a very large metropolitan area. Irwan (2005) states that the urban forest as a community in the form of trees and associated vegetation that grows in the city or surrounding land, in the form of lines, spread, or accumulate, and its structure mimics (resembling), causing forest healthy environment, the atmosphere is comfortable, cool and aesthetically.

2.2. The form of Forest City

Given the limited availability of land, and in order to obtain the effectiveness of its functions to the formation of micro-climate, retain moisture, reduce noise and dust, as well as in maintaining the hydrological functions of the urban forest to maintain the sustainable conservation of water resources (water resources sustainability) as ensuring the quantity and quality of ground water, control surface run-off and flood, the urban forest can be found in three-forms, namely huddle, spread, and pathways (Irwan, 1994). Form of clustered or heaped urban forest is the vegetation communities concentrated in an area with a number of vegetation at least 100 trees, with a spacing of irregular meetings. The second form of the urban forest is spread from. The feature of the urban forest in this form is not to have a specific pattern, vegetation growing community spread as individually and clump-clump or small. The third form of the urban forest is characterized by the shape of the path of vegetation communities growing on land as straight or curved paths, following the formation of a river, road, beach, channel and so on.

2.3. Vegetation Structure of The Urban Forest

The structure of vegetation or plant communities that make up the urban forest, urban forest can be classified into two, namely the two stratified urban forest, urban forest and many stratified (Irwan, 1994). In a stratified two urban forest, plant communities consisting of trees and grass or other ground cover. While the urban forest in the category of many stratified urban forest, vegetation communities consist of a constituent other than trees with irregular spacing of the meeting, have the characteristics of strata and the composition of the plant community resemble natural forests, to him also there is grass, shrubs, theme, lianas, epiphytes, puppies, and other ground cover. The second form of the urban forest is an ideal form of urban forest. Therefore, in addition to try to get land for urban forest, also sought an increase in plant community structure making up the forest.

2.4. The selection of Urban Forest Vegetation

According to Irwan (2005) the choice of plants or vegetation for urban forest is highly dependent on the primary functions of the urban forest. Requirements that must be considered include horticultural or ecological aspects and physical plant requirements. Horticultural or ecological terms are: a) requirements for growth and tolerance to temperature, water, pests, disease, light, soil, wind, trimming, and pollution; b) the nature of the spread of flowers and fruit; c) the nature of adaptation, propagation, transfer and autumn leaves. While the physical requirements, such as: a) the purpose of the construction of urban forest based on its primary function; b) the size of an adult; c) the speed of growth; d) the nature of life; e) shape; f) texture; g) color; h) scent and i) cultivation conditions. According to Dahlan (1992), a determination of selected plant species for urban forest must also consider the requirements edhapis, meteorological, silviculture, plant general requirements, requirements for roadside trees, aesthetic requirements, requirements for special use.

3. Methods

3.1. Location and Sample

Tree canopy architecture and hydrological study of individual tree in the rainy season (April-May 2012) through field surveys. Location and sample trees of study include; 1) highway roundabout Waru in South Surabaya which has some dominant vegetation as mahogany (Mahogany Swietania King.) and Angsana (Pterocarpus indicus Willd); 2) highway roundabout in West Surabaya at Mayjend Sungkono which have a dominant vegetation tamarind (Samanea saman Merr.); 3) roundabout ITS in the Surabaya east has landi acid (Pithecellobium dulce Bth.) dominant vegetation; and 4) Park Flora in East Surabaya which has a heterogeneous of dominant vegetation.

3.2. Data analysis
Analysis of the cumulative infiltration using anava, while the urban forest planning optimization on homogeneous and heterogeneous vegetation using goal programming method based on the stem flow, escapes canopy, interception, and the cumulative infiltration for two hours with a distance of 3 meters from the trees.

4. Results and Discussion

4.1. Cumulative infiltration in Homogeneous Forests (Three Meters Distance from Standing Tree)
4.1.1. Tamarind
The highest cumulative infiltration obtained over 15 minutes of 141.68 mm, while the lowest cumulative infiltration values obtained from cumulative infiltration for 2 minutes at 1.87 mm. The pattern of infiltration is less well on a city dominated forest vegetation which does not happen tamarind anava on infiltration that occurs in from 2 to 5 minutes. However, the 5% anava test showed significant differences over the infiltration that occurs from 5 to 10 minutes and 10 to 15 minutes. In addition, the accumulation of infiltration that occurs in a city dominated the forest vegetation tamarind, at a distance of three feet from the stands, showing the amount of infiltration that is not too large, ie. 141 mm. This situation shows little influence tamarind tree roots at a distance greater than or equal to three meters from tree stands.

4.1.2. Angsana
The highest cumulative infiltration obtained over 15 minutes at 97.51 mm, while the lowest cumulative infiltration values obtained from cumulative infiltration for 2 minutes at 2.00 mm. The pattern of infiltration is less well on a city dominated forest vegetation which does not happen Angsana anava on infiltration that occurs in from 2 to 5 minutes. However, the 5% anava test showed significant differences over the infiltration that occurs from minute to 5 to 10 minutes and 10 to 15 minutes. In addition, the accumulation of infiltration that occurs in a city dominated the forest vegetation tamarind, at a distance of three feet from the stands, showing the amount of infiltration that is not too big, and even tend to be small, which is 97.5 mm. This situation shows little influence tamarind tree roots at a distance greater than or equal to three meters from the trees as are characteristic of the Angsana tree roots tend to vertical.

4.1.3. Landi Acid
The highest cumulative infiltration obtained over 15 minutes of 202.13 mm, while the lowest cumulative infiltration values obtained from cumulative infiltration for 2 minutes at 2.7 mm. Good infiltration pattern of forest vegetation dominated the city where always there Landi acid anava on infiltration that occurs either from 2 to 5 minutes, 5 to 10 minutes, and 10 to 15 minutes. In addition, the accumulation of infiltration that occurs in a city dominated forest vegetation Landi acid, at a distance of three meters from the stand, showing a large amount of infiltration when compared with the two types of vegetation that has been shown previously, the tamarind and Angsana, which amounted to 202 mm at 15 minutes, this situation shows that the tamarind tree roots Landi still give effect to the accumulative infiltration at a distance of 3 meters. This information also indicates that rooting landi acid has a characteristic that tends to the horizontal.

4.1.4. Mahogany
The highest cumulative infiltration obtained over 15 minutes at 88.57 mm, while the lowest cumulative infiltration values obtained from cumulative infiltration for 2 minutes at 1.55 mm. Good infiltration pattern in the urban forest vegetation dominated mahogany. Where there is a anava on infiltration that occurs in from 2 to 5 minutes. Similarly, 5% anava test showed significant differences over the infiltration that occurs from 5 to 10 minutes and 10 to 15 minutes. Accumulation of infiltration that occurs in a city dominated forest vegetation mahogany, at a distance of three feet from the stands, showing the amount of infiltration that is not too large, ie 88.57 mm. even the smallest amount among the three trees that had been presented previously. This situation shows little influence mahogany tree rooting at a distance greater than or equal to three meters from tree stands.

4.2. Cumulative Infiltration in Heterogeneous Forests (Three Meters Distance from Standing Tree)
The highest cumulative infiltration obtained over 15 minutes at 11.94 mm, while the lowest cumulative infiltration values obtained from cumulative infiltration for 2 minutes at 0.09 mm. The pattern of infiltration is less well on a mix of urban forests where not happen anava on infiltration that occurs in from 2 to 5 minutes. However, the 5% anava test showed significant differences over the infiltration that occurs from 5 to 10 minutes and 10 to 15 minutes. In addition, the accumulation of infiltration that occurs in urban forest heterogeneous, at a distance of three feet from the stands, showing the amount of infiltration that is not small, ie 11.9 mm. This condition again showed little effect of tamarind tree roots at a distance greater than or equal to three meters from tree stands.

The movement of water infiltration into the soil or an event into the ground water movement through small channels in the soil until it reaches the root layer, the flow of water in the lateral and experienced percolation or drainage (Hiller, 1980; Susswein et al., 2001; Schaap, 2006). Conditions related to soil components, there are at least four things that affect infiltration. The fourth thing is the type of soil and soil conditions (Lado et al., 2004), grass covering the ground (Rachman et al., 2004), structure and nutrient conditions (Eshel et al., 2004), and the gas composition and gas pressure on the ground (Lazarovitch et al., 2005; Prunty and Bell, 2007).

Furthermore, regarding the condition of the soil components, Rachman et al. (2004) explained that an area covered by the events canopy grass increased saturation to water (saturated hydraulic conductivity-field) was seven times higher than the saturation conditions in plants lined up, and 24-fold higher when compared to areas not vegetated. It can be concluded that the grass canopy can enhance the ability of an area of infiltration when compared with crop management march. Infiltration is also influenced by the structure and nutrient conditions, that the higher the emission spectrum of colors produced by the lower layers of soil nutrients held by the soil, which means that the lower the ability of the soil in the infiltration (Eshel et al., 2004).

4.3. Infiltration Optimization Planning Urban Forest Vegetation Communities with Distance Meter Three of Standing Trees

Cumulative infiltration coefficient with distance of three meters from the trees of the calculation of linear programming Landi acids obtained from trees of 2.25, while the optimal cumulative infiltration for 2 minutes at 6.20 mm, 49.53 mm for 5 minutes, 10 minutes at 149. 93 mm, and 15 minutes for 454.22 mm. Cumulative infiltration coefficient with distance of three meters from the trees of the calculation of linear programming Landi acids obtained from a tree by 2,247, while the optimal cumulative infiltration for 2 hours at 602.25 mm.

Lazarovitch et al. (2005) were made to test the mathematical model is formulated that there are differences at the level of high-pressure drop on nutrient that has a field-saturated hydraulic conductivity is low. That is, the ability of the soil with low infiltration pressure's entry of water into the ground quickly shrink that therefore water can be absorbed very little. Prunty and Bell (2007) suggest that CO_2 has a considerable influence on infiltration. CO_2 gas has a higher speed in the water absorb during 1.6 to 1.9 times greater than the atmospheric air.

In, on the condition of the soil components, physically, the formation of channels in the soil is the result of the root system of the vegetation (especially trees) are able to suppress (Suprayogo et al. , 2002). The presence of vegetation, especially trees into the key macro pore maintenance and guard aggregate stability. Thus, rain water can get into the ground smoothly and distributed as a lateral flow or percolation of water by proportional (Riha et al., 1999; Banun et al., 2003).

4.3. Forest City Planning Optimization based Spatial Model Standing

Spatial model of urban forest stands of vegetation to maximize absorption of rain water is clustered with mixed vegetation. Trees with stands 3 meters, has a good ability of the cumulative infiltration, tamarind at 1.49 and Angsana at 0.66. While the optimal cumulative infiltration for 2 minutes at 15.47 mm, 78.10 mm for 5 minutes, 10 minutes at 281.13 mm, 983.35 mm for 15 minutes, and 2 hours of 1438.6 mm.

The best root structure at the distance of 1 meter from the trees is a tree and a distance of 3 meter's tamarind is landi acid tree, this is due to that the porosity of the soil under a tamarind tree stands and Landi acid is greater than the porosity condition on tree stand other (Schaap, 2006). Moreover, referring to the results of research conducted by Lazarovitch et al. (2005), the pressure caused by the variation of the gas under a tamarind tree stands greater than the pressure on the ground under the stands of other trees. It also means that the CO_2-producing biota under a tamarind tree stands bigger than the other some vegetation (Eshel et al., 2004). Over it all, the land has a high infiltration, it can be suspected that the roots of the vegetation where the land is located has a high penetration of roots. Bartens et al. (2008) stated that the penetration of roots in the subsoil layers can increase the infiltration of up to 153%. In addition, infiltration capability tingginnya tamarind tree likely caused by plants in the under story (Rachman et al., 2004).

The basis for determining the equation of goal programming as a mathematical model of optimization of the number of trees is to know the average value of stem flow, crown passes, and an interception. Average data stem flow, escaped canopy, and interception are shown in Table 1.

Table 1. Average Value Stem Flow, Escaped Canopy, and Interception

Tree	Stem flow (mm)	Ecscaped canopy (mm)	Interception (mm)
Tamarind	4.35	4.13	5.52
Mahagony	3.61	4.45	3.13
Angsana	5.34	3.14	2.69
Landi acid	2.00	2.99	4.45

The number of trees in the study sites were identified, mahogany at 47, Angsana at 54, Landi acid at 87, and the trees in the forest tamarind homogeneous 16. Total number of trees required as many as 9,513 trees at five study sites. This value is obtained from the calculation of the total area in the forest and a homogeneous mixture is 15.22 hectare's or 152,200 m^2. If one considered the same type of tree requires area (4x4 m) = 16 m^2, it is obtained from 152,200/16 = 9,513 trees. While the initial data and the results of simulation calculation's goal programming with four barrier ie, stem flow, escaped canopy, interception, and the cumulative infiltration for 2 hours with a distance of 3 meters from tree stands are presented in Table 2.

Table 2. Preliminary Data Goal Programming

Variable	Vegetation's			
	Tamarind	Mahagony	Angsana	Landi acid
Total tree	16	47	54	87
Stemflow (mm)	4.35	3.61	5.34	2.00
Escaped canopy (mm)	4.13	4.45	3.14	2.99
Interception (mm)	5.52	3.13	2.69	4.45
cumulative infiltration (mm)	184	116	128	268

Result of optimization calculations of forest planning in the city of Surabaya by using goal programming with a barrier or obstacle to stem flow passes through the canopy, interception, and the cumulative infiltration for two hours with a distance of 3 meters from tree stand is as much as 11,242 trees with the following details; 1) 287 tamarind, 2) 3,854 mahogany, 3) 4,013 angsana, and 4) 3,088 landi acid.

5. Conclusions

Optimization of urban forest planning in the city of Surabaya in homogeneous vegetation by limiting stem flow, escaped canopy, interception, and the cumulative infiltration for two hours with a distance of 3 meters from tree stands is as much as 11, 242 trees with the following details; 1) 287 tamarind, 2) 3,854 mahogany, 3) 4,013 angsana, and 4) 3,088 landi acid.

Suggestions from this study are the need to conduct further research on the difference on the conditions that affect the porosity of the soil, rooting characteristics of the dominant vegetation in the landscape, character rooting vegetation, land cover, the effect of differences over the allotment of urban forest, and forest types of soil in the city of Surabaya.

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