Potential of Urban Forest as an Alternative Substitution of Air Conditioner Case Study in IPB Darmaga Campus and Surabaya

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Abstract- Most of the societies used the air conditioners to reduce overwarming. However, besides apart from costly, air conditioner can increase global warming. One attempt to control temperatures in urban areas is to develope urban forest. The purpose of this research was to assess the ability of urban forest vegetation in absorbing heat in replacing air conditioner, hence the efficiency of urban forest. The research were conducted in Bogor Agricultural University Darmaga Campus and the city of Surabaya. The research was initiated by performing measurements at room with Room Air Conditioner methods. The potential of urban forest made through measuring the heat flux density on vegetation. Based on data analysis, in IPB Darmaga Campus, it is known that the trees had the capability of heat absorption on average by 3.192 KJ/hour. Thus an air conditioning unit 1 PK (capacity 9.495 KJ/h) can be substituted by three trees, while one unit of AC 1,5 PK (capacity 18.990 KJ/h) can be substituted with six trees and one air conditioning unit 2 PK (capacity 28.485 KJ/h) can be substituted with nine trees. The efficiency of urban forest for the room that is 2-9 times cheaper than the use of air conditioning. While the total efficiency of the eight rooms studied is Rp 44.765.259,-/year. Then in Surabaya, the result show that the heat absorption ability of the trees was 2958.7 KJ/h (Bratang urban forest) and 2589 KJ/h (Wonorejo urban forest). One unit of 1 PK air conditioner (capacity of 9495 KJ/h) can be substituted by 3-4 trees, one unit of 1.5 PK air conditioner (capacity of 18990 KJ/h) can be substituted by 6-7 trees and one unit 2 PK of air conditioner (capacity 28458 KJ/h) can be substituted with 9-10 trees. The total efficiency of the eight rooms studied was found token Rp 22.811.042,-/year (Bratang Urban Forest) and Rp.20.365.265,-/year (Wonorejo Urban Forest). Thus, The development of urban forests to replace air conditioner is rational because it could significantly save the cost of a room spending.

Index Terms- air conditioner, IPB Darmaga campus, substitution, Surabaya, urban forest

I. INTRODUCTION

Background of the Study

One of the changes of the quality of environment is the increasing air temperature in urban area. Fluctuation of the temperature tends to increase each year. Between 1950 and 2000, the air temperature in Indonesia has increased as much as 0.3°C (Hulme and Sheard, 1999). The Meteorology, Climatology, and Geophysics Agency--BMKG (2010) conveyed that between 2001 and 2010, there had been an increase of air temperature as much as 0.25°C around the environment of the Bogor Agricultural University (IPB), Darmaga. The air temperature in Surabaya during day was approximately 33-35° C. The BMKG at Juanda explained that the highest temperature could reach up to 35°C (BMKG, 2010).

In general, to overcome the increasing temperature of the environment, the society uses air conditioner (AC) in houses and offices. AC truly increases comfort for the people, but the charge needed to obtain and operate the cooling device is costly. The benefit gained is limited to size and room (indoor), while the heat blown will raise the temperature outside of the room.

One attempt to control the temperature in urban areas is by developing an urban forest. The research conducted by Yamada (1993) referred in Fatimah's (2004) had proven that urban forest could decrease the temperature in urban area in Kurihashi in the province of Saitama, Japan. Nevertheless, a study should be conducted in advance on the ability of urban forest in stabilizing the micro climate therefore able to replace the function of the AC. In addition, economic calculation should be performed in relation to the development and conservation of urban forest, as well as the purchase and operational cost of AC, so as to figure out the efficiency of urban forest in replacing AC.

Objective of the Study

The objective of this research is to study the ability of urban forest in substituting the function of Air Conditioner (AC) as well as to compare the cost of the urban forest development with the AC utilizing.

Benefits of the Study

The benefits of the study expected are as follows:

1. To provide information regarding the ability of trees in the urban forest as a substitution for the room air conditioner, in order to decrease the usage level of the air conditioner.
2. To provide information for the society about the values of the urban forest, in order to open their minds to participate in keeping and improving the forest.
3. To provide a foundation for the decision-making in the environment-based urban management.

II. METHOD OF THE STUDY

Location and Time of the Research

The research was conducted at IPB Darmaga campus, Bogor in February-May 2011, and in Surabaya, East Java in August-December 2012. The data of the research were acquired in the Arboretum of the Faculty of Forestry at IPB and the Tropical Forest Germ Plasm Arboretum which is also located in Bratang Urban Forest and Wonorejo Urban Forest. Moreover, the data acquisition was conducted in several offices, department stores, and housing complex around the locations of the research.

Tools and Materials

The tools and materials used in the research are air conditioners, rooms, thermometers, cameras, calculators, measuring instruments, raffias, ladders, compasses, and stationery.

Data Analysis Procedure

Tabel 1: Research Methodology Systematics

Data variant	Acquirement method	Data analysis
Primary data: a. Room measurement and description (including the usage level of AC and electricity b. Temperature under the tree canopy c. Area of the tree canopy (L) and density	a. Room measurement and check list b. The measurement of difference on vertical temperature (1m-6m) c. Measurement of canopy areal	a. Quantitative description (calculation of the room air conditioner) (Handoko, 1979) b. Calculating H (the heat transfer coefficient; Fourier Law) c. Rn = a X i X L
Secondary Data: a. Surface latent heat (λ) b. Evapotranspiration (E) c. Sunlight intensity (i) d. Forest albedo (a) e. Urban forest cost f. General condition	a. Literature b. Literature c. BMKG data d. Literature e. Literature f. Literature	([a.] to [d.]) $G = Rn - H - \lambda E$ (Campbell and Norman, 2000)

Measurement on the Requirements of Air Conditioning of Room(s)/Building(s)

The measurement to obtain the data on the requirements of air conditioning level of a room is conducted by using the instrument in the form of check list and the calculation of room air conditioner (RAC) loads as according to Handoko (1979). The calculation of RAC loads is carried out through these steps:

1) A = (a) x (b)
2) C = (c) x (b)
3) D = (d) x (b)
4) E = (e) x(b)
5) F = (f) x (b)
6) G = (g) x (b)
7) H = (h) x (b)
8) I = (i) x (b)
9) J = A+C+D+E+F+G+H+I
10) Approximate total value of air conditioning loads (BTU/hour) = J x (b)

Description:

(a) = area of the window from every side
(b) = total length of the walls facing outward
(c) = total length of the walls facing inward
(d) = total roof area
(e) = total floor area
(f) = total person(s) in the room
(g) = total power of the lamps and electrical device used in the room
(h) = width of the door or wall opened or constantly opened and connected to the other room of which air is not conditioned
(i) = correction factor of each part of the room of which value is adjusted as according to Handoko (1979).

The next step is calculating the electricity and purchasing cost, as well as the sum of AC(s) in the room. The calculation of the cost on the AC usage is conducted using equation 1.

$$\mathbf{BAC = BU + BL} \qquad \mathbf{(1)}$$

Description:

BAC = Cost of AC usage in a room
BU = Cost of AC unit purchasing
BL = Cost of electricity power covering the device usage (AC usage level assumption is for eight hours/day).

Vegetation Potential Ability of Urban Forest

The potential ability of urban forest in decreasing the temperature is known through the estimation using the secondary data, which are the rate of surface latent heat, sunlight intensity, albedo, the rate of evapotranspiration, and the evapotranspiration latent heat. Based on the calculation, the quantity of trees needed to create a comfortable temperature regarding the loads measurement of the RAC can be revealed. Nonetheless, a calculation on the heat flux density in the vegetation should be conducted initially. The data of temperature difference is used to

calculate the heat transfer coefficient, H, (Fourier Law), in order to transfer heat calculated using equation 2.

$$H = -k\,A\,\frac{\Delta T}{\Delta Z} \qquad (2)$$

Description:
H = heat flux density (W/m^2) in the vegetation
A = canopy area (m^2)
ΔT = temperature (^{0}C)
ΔZ = height (meter)
k = Air conductance (-5,7 x 10^{-5} Cal/cm.sec.^{0}C)
(Sears and Zemansky, 1960)

The result of the calculation above and the field data is in the form of energy absorption through photosynthesis, of which the secondary data is later used to calculate the thermal storage ability of trees/vegetation. According to the principle of energy balance on the vegetation surface which shows the input, output, or storage energy using equation 3 (Campbell and Norman, 2000).

$$G = Rn - H - \lambda E \qquad (3)$$

Description:

G = the rate of thermal storage in vegetation and soil,

R_n = radiation absorption flux density by the surface or sunlight net intensity received by the tree

H = the rate of heat release (heat flow through the convection or conduction determined by temperature difference),

λE = the rate of the surface latent heat,

E = the rate of water evapotranspiration,

λ = the evapotranspiration latent heat (the heat absorbed 1 gram of water evaporated).

Urban Forest Efficiency

The calculation of the value on the urban forest efficiency is analyzed by comparing and finding the difference between the costs needed to use air conditioner and the cost of urban forest development on air conditioning fulfillment of the same room. Thereby, the cost comparison of the both object studied should be revealed. The economic value of the urban forest is calculated using equation 4.

$$NHK = BAC - BHK \qquad (4)$$

Description:
NHK = Economic value of the urban forest
BAC = Cost of AC usage (purchasing and electricity cost)
BHK = Cost of urban forest development (trees to fulfill the needs for air conditioner based on the calculation of RAC loads)

III. RESULTS AND DISCUSSION

Requirements of Air Conditioning in Room/Building

The calculation of the air conditioning requirement is conducted in eight rooms in every location, which are situated in IPB Darmaga Campus and Surabaya. Based on the measurement using Room Air Conditioner method, the air conditioning requirements varied for each room.

The calculation result shows that the library room in the Faculty of Agriculture of IPB Darmaga campus requires the most air conditioning as much as 141.059 KJ/hour. Whereas, the room which requires the least air conditioning is the room in Soil Science Department of the Faculty of Agriculture, that is 22.771 KJ/hour. In Surabaya, the ground floor of the Moslem Department Store "Bibah Dibah" requires the most air conditioning, that is 156316.11 KJ/hour. Whereas, the bedroom in the Rungkut Harapan Housing Complex G/31 requires the least air conditioning, that is 4738.64 KJ/hour. It shows that the measurement of air conditioning requirement of a room is determined by the size of the room, walls, the quantity and area of window(s), room capacity, and the electrical devices used.

The Ability of Trees to Absorb Heat

Sunlight is one of factors that trigger overwarming, including the ambient air. The trees in urban forest are able to absorb heat through the sunlight absorption mechanism which is applied in the process of photosynthesis. Thereby, the heat radiation of the sun does not warm up the ambient air in the coverage of the trees. The air conditioning effect occurs due to the heat (radiation of the sun) absorption, often namely as endothermic (absorbing heat). Based on the measurement and secondary data, as well the analysis using the equation presented by Campbell and Norman (2000), the vegetation ability in absorbing heat is revealed (Table 1 and Table 2). The density of the vegetation, variant, and the rate of evapotranspiration of the trees will affect the individual ability of a tree.

Table 1: Summary of the calculation on the tree ability of absorbing heat in IPB Darmaga campus

No.	Location	Canopy area	Density	A Set of Trees Ability to Absorb Heat	Individual Tree Ability to Absorb Heat
1.	Arboretum in Faculty of Forestry	400 m^2	19 trees/400 m^2	51.455,72 KJ/hour	2.708 KJ/hour
2.	Tropical Forest Germ Plasm Arboretum	400 m^2	14 trees/400 m^2	51.455,72 KJ/hour	3.675 KJ/hour

Table 2: Summary of the calculation on the tree ability of absorbing heat in Surabaya

No	Location	Canopy area	Density	A Set of Trees Ability to Absorb Heat	Individual Tree Ability to Absorb Heat
1	Bratang Urban Forest	400 m^2	14 trees/ 400 m^2	41421.86 KJ/hour	2958.7 KJ/hour
2	Wonorejo Urban Forest	400 m^2	16 trees/ 400 m^2	41422.82 KJ/hour	2589 KJ/hour

The individual tree ability obtained is the calculation result based on the assumption that the ability of vegetation set in the urban forest and is also the combination of the abilities of the trees as the constituent components of the urban forest vegetation. Based on the calculation, the values of heat absorption among the urban forest vegetation have differences depends on the density of the vegetation. The ability of heat absorption that belongs to the trees in the Arboretum in the Faculty of Forestry is lesser than the trees in the Tropical Forest Germ Plasm Arboretum. It is due to the trees in the Arboretum of Faculty of Forestry have the lesser canopy areal, that is 21 m^2/tree, whereas the trees in the Tropical Forest Germ Plasm Arboretum have the approximately greater canopy areal, that is 28 m^2/tree.

The ability of heat absorption belongs to the trees in the Bratang Urban Forest is greater than of the trees in Wonorejo Urban Forest. The difference is because the trees in Bratang Urban Forest have greater approximate canopy areal, that is 28.6 m^2/tree, whereas the trees in Wonorejo Urban Forest have canopy areal as wide as 23.5 m^2/tree. Regarding on that fact, the greater canopy area is able to absorb greater radiation heat of the sun.

The Potential Ability of Trees Substituting the Air Conditioner (AC)

Based on the calculation result of the tree ability in absorbing heat, it is revealed that trees are able to substitute the functions of Air Conditioner. It is supported by several results of the research, one of whom is Fandeli *et al.* (2004), stated that hot air is able to decrease by planting trees in the area as the source of the heat pollution. The result of the research shows that the existence of the urban forest vegetation is able to substitute or decrease the usage of air conditioner. Based on the data analysis result, the trees have the ability of heat absorption for as much as 3.192 KJ/hour in IPB Darmaga campus, therefore a single unit of AC 1 PK (with the capacity of 9.495 KJ/hour) can be substituted by three trees, while a single unit of AC 1,5 PK (with the capacity of 18.990 KJ/hour) can be substituted by six trees, and for a single unit of AC 2 PK (with the capacity 28.485 KJ/hour) can be substituted by nine trees. Based on the research in Bratang and Wonorejo Urban Forests, 1 unit of AC 1 PK (with the capacity of 9.495 KJ/hour) can be substituted by 3-4 trees, 1 unit of AC 1.5 PK (with the capacity of 18.990 KJ/hour) can be substituted by 6-7 trees, 1 unit of AC 2 PK (with the capacity of 28.485 KJ/hour) can be substituted by 9-10 trees. Thus, it can be said that the existence of the urban forest is able to decrease the usage quantity of AC(s).

The quantity of trees to fulfill the requirement of a room is based on this calculation should be adjusted with the density of the vegetation in the urban forest measured. In addition, trees that are able to well absorb heat generally are the ones which aged 10 years or more, with a shady and dense canopy. To fulfill the air conditioning requirement of a room, the trees should be planted around the area. The quantity of trees required to substitute the AC(s) depends on the amount of the air conditioning requirement of the room (Table 3 and Table 4).

Table 3: The potential ability of tree(s) substituting Air Conditioner (AC) in IPB Darmaga campus

No.	**Room Name**	**Requirements of Air Conditioning (KJ/hour)**	**Tree(s) required**
1.	Auditorium 1, Faculty of Forestry	86.648	27 Trees
2.	Silva Thesis Defence Room, Faculty of Forestry	106.881	34 Trees
3.	Soil Science Department Room, Faculty of Agriculture	22.771	7 Trees
4.	Library, Faculty of Agriculture	141.059	44 Trees
5.	Lecture Hall B1, Faculty of Agriculture Technology	133.050	42 Trees
6.	Lecture Hall H101, Faculty of Agriculture Technology	103.771	33 Trees
7.	RK OFAK B11, Faculty of Agriculture	133.050	42 Trees

Table 4: The potential ability of tree(s) substituting Air Conditioner (AC) in Surabaya

No	Room Name	Requirements of Air Conditioning (KJ/hour)	Tree(s) required	
			Bratang UF	Wonorejo UF
1	WG (Working Group) Room, Surabaya	48.752,9	17	19
2	PKK (Family Welfare Movement) Chief Room, Surabaya	12.764,6	5	5

3	Department of General Development Meeting Room, Surabaya	117.023	40	45
4	Moslem Department Store “Bibah Dibah”, Floor 1	156.316	53	60
5	Moslem Department Store “Bibah Dibah”, Floor 2	124.914,4	42	49
6	BMKG Employee Room	72.085	25	28
7	Principal Chief of BMKG Room, Juanda	10.519,1	4	4
8	Bedroom, Rungkut Harapan Housing Complex G/31	4.739	2	2

Urban Forest Development Efficiency

1. AC Usage Cost

The surplus value of the urban forest can be known by comparing the cost needed for the AC usage and for the provision of the trees as the urban forest components. The AC usage cost can be calculated by observing the cost of AC unit and electricity in the operation (Table 5 and Table 6).

Table 5: The AC usage cost in IPB Darmaga campus

No.	Room	AC used	Wattage (1 unit AC)	Electricity cost (1 unit AC for 1 month)	AC Price(s) (1 unit)	Total Cost (10 years)
1.	Auditorium 1, Faculty of Forestry	2 units AC 1,5 PK (18000 BTU/hour)	1.170 watt	Rp207.376,-	Rp3.443.000,-	Rp56.656.240,-
2.	Silva Thesis Defence Room, Faculty of Forestry	6 units AC 1,5 PK (18000 BTU/hour)	1.150 watt	Rp204.928,-	Rp3.712.000,-	Rp169.820.160,-
3.	Soil Science Department Room, Faculty of Agriculture	2 units AC 1,5 PK (18000 BTU/hour)	1.420 watt	Rp 241.638,-	Rp3.170.000,-	Rp64.333.120,-
4.	Library, Faculty of Agriculture	4 units AC 2 PK (27000 BTU/hour)	1.650 watt	Rp266.110,-	Rp7.340.000,-	Rp157.092.800,-
5.	Lecture Hall B1, Faculty of Agriculture Technology	2 units AC 1,5 PK (18000 BTU/hour)	1.170 watt	Rp207.376,-	Rp3.443.000,-	Rp56.656.240,-
6.	Lecture Hall H101, Faculty of Agriculture Technology	4 units AC 1,5 PK (18000 BTU/hour)	1.170 watt	Rp207.376,-	Rp3.443.000,-	Rp106.426.480,-
7.	RK OFAK B11, Faculty of Agriculture	2 units AC 1,5 PK (18000 BTU/hour)	1.170 watt	Rp207.376,-	Rp3.443.000,-	Rp56.656.240,-
8.	RK OFAK B12, Faculty of Agriculture	2 units AC 1,5 PK (18000 BTU/hour)	1.170 watt	Rp207.376,-	Rp3.443.000,-	Rp56.656.240,-
	Total cost for eight rooms					**Rp724.297.520,-**

Table 6: Air Conditioner (AC) usage cost in Surabaya

No	Room	AC used	Wattage (1 unit AC)	Electricity cost (1 unit AC for 1 month)	AC Price(s) (1 Unit) (Rp)	Total Cost (10 years) (Rp)
1	WG (Working Group) Room, Surabaya	2 units AC 1 PK (9000 BTU/hour)	1,450 watt	389,719	3,650,000	50,416,280
2	PKK (Family Welfare Movement) Chief Room, Surabaya	1 units AC 1 PK (9000 BTU/hour)	1,450 watt	389,719	3,650,000	50,416,280
3	Department of General Development Meeting Room, Surabaya	4 units AC 1 PK (9000 BTU/hour)	1,450 watt	389,719	3,650,000	50,416,280
4	Moslem Department	4 units AC 2 PK	1,650 watt	558,682	4,700,000	71,741,840

	Store "Bibah Dibah", Floor 1	(27000 BTU/hour)				
5	Moslem Department Store "Bibah Dibah", Floor 2	3 units AC 2 PK (27000 BTU/hour)	1,650 watt	558,682	4,700,000	71,741,840
6	BMKG Employee Room	1 units AC 1 PK (9000 BTU/hour)	1,170 watt	322,163	3,443,000	42,102,560
7	Principal Chief of BMKG Room, Juanda	1 units AC 1 PK (9000 BTU/hour)	1,170 watt	322,163	3,443,000	42,102,560
8	Bedroom, Rungkut Harapan Housing Complex G/31	1 units AC 1 PK (9000 BTU/hour)	1,150 watt	313,414	3,170,000	40,779,680

Based on the calculation of purchasing and electricity costs, it can be known that the AC usage spends a lot of expenses. The AC usage cost is calculated for 10 years usage due to the fact that AC can endure in 10 years and also due to the consideration that the trees as the comparison can also endure in 10 years after the planting. It is due to the fact that the approximate age of the tree is 20-30 years old (Widiarti, 2003).

A room which is rendered with two units of AC 1.5 PK required the cost for as much as 50 million to 60 million rupiahs in 10 years period. A room which is rendered with four units of AC 1.5 PK required the cost for as much as 150 million rupiahs in 10 years period. A room which is rendered with six units of AC 1.5 PK required the cost for as much as 170 million rupiahs in 10 years period. Whereas a room which is rendered with four units of AC 2 PK required the cost for as much as 160 million rupiahs in 10 years period. The total cost for the AC operation in eight rooms in IPB Darmaga campus in 10 years period is Rp724,297,520,- or worth of Rp72,429,752,-/year. While in Surabaya, a room which is rendered with 2 units of AC 1 PK required the cost for as much as 50 million to 60 million rupiahs in 10 years period. A room which is rendered with 4 units of AC 2 PK required the cost for as much as 70 million rupiahs in 10 years period. The AC usage cost is calculated for 10 years usage due to the fact that AC can endure approximately in 10 years and also due to the consideration that the trees as the comparison can also endure in 10 years after the planting. It is due to the fact that the approximate age of the tree is 20-30 years old (Widiarti, 2003).

2. Urban Forest Development Cost

The trees which are able to decrease air temperature, does not grow by itself, although there are these trees that does. The variants of cost for a tree to grow are the seedling provision cost, planting cost, replantation cost, fertilization cost, watering and monitoring cost adjusted with the Gerhan Standard which is referred by Asyravy (2008) (Table 7 and Table 8).

7: Plantation and conservation cost of a tree in 10 years period in IPB Darmaga campus

Year	Kinds of Activity	Units of measurement	Volume	Unit(s) cost	Total Cost	Description
0	Planting	HOK	1	Rp 50,000,-	Rp 50,000,-	
	Watering	HOK	1	Rp 2,270,-	Rp 2,270,-	
1	Watering	HOK	48	Rp 2,270,-	Rp 108,960,-	Every week
	Fertilization	HOK	12	Rp 10,000,-	Rp 120,000,-	12 times/year
	Weeding	HOK	12	Rp 25,000,-	Rp 300,000,-	12 times/year
2	Fertilization	HOK	12	Rp 10,000,-	Rp 120,000,-	12 times/year
	Weeding	HOK	1	Rp 25,000,-	Rp 25,000,-	Once/year
3	Fertilization	HOK	12	Rp 10,000,-	Rp 120,000,-	12 times/year
	Weeding	HOK	1	Rp 25,000,-	Rp 25,000,-	Once/year
	Monitoring	HOK	12	Rp 1,000,-	Rp 12,000,-	12 times/year
4-10	Monitoring	HOK	72	Rp 1,000,-	Rp 72,000,-	72 times
	Seedling provision	Seedling	1	Rp 26,000,-	Rp 26,000,-	Once
	Fertilizer provision	Kg	36	Rp 1,100	Rp 39,600	12 times/year for the 1st, 2nd, and 3rd year
			Total Cost		Rp 1,020,830,-	

Table 8: Plantation and conservation cost of a tree in 10 years period in Surabaya

Year	Kinds of Activity	Units of measurement	Volume	Unit(s) cost	Total Cost	Description

0	Planting Watering	HOK	1	Rp50,000	Rp 50,000	
		HOK		Rp2,270	Rp 2,270	
1	Watering Fertilization	HOK	48	Rp 2,270	Rp 108,960	Every week 12
	Weeding	HOK	12	Rp 10,000	Rp 120,000	times/year 12
		HOK	12	Rp 25,000	Rp 300,000	times/year
2	Fertilization Weeding	HOK	12	Rp 10,000	Rp 120,000	12 times/year
		HOK	1	Rp 25,000	Rp 25,000	Once/year
3	Fertilization Weeding	HOK	12	Rp 10,000	Rp 120,000	12 times/year
	Monitoring	HOK	1	Rp 25,000	Rp 25,000	Once/year 12
		HOK	12	Rp 1,000	Rp 12,000	times/year
4-10	Monitoring	HOK	72	Rp 1,000	Rp 72,000	72 times
	Seedling provision	Seedling	1	Rp 26,000	Rp 26,000	Once
	Fertilizer provision	Kg	36	Rp 1,100	Rp 39,600	12 times/year for the 1st, 2nd, and 3rd year
	Total Cost				**Rp 1.020.830,-**	

The development and conservation cost for the trees to contribute ecological benefits requires 10 years period as assumed. During the 10 years period, it will cost from year 0 until year 10. Based on the calculation on tree(s) provision cost above, therefore the cost to spend for the air conditioning requirement for a room can be revealed. The Auditorium 1 in the Faculty of Forestry which requires 27 trees spends Rp27,562,410, the Silva Thesis Defence Room in the Faculty of Forestry which requires 34 trees spends Rp34,708,220, the Soil Science Department Room in the Faculty of Agriculture which requires 7 trees spends Rp7,145,810, the Library in the Faculty of Agriculture which requires 44 trees spends Rp44,916,520, Lecture Hall B1 in the Faculty of Agriculture Technology, RK OFAK B11, RK OFAK B12 which require 42 trees spend Rp42,874,860, and the Lecture Hall H101 in the Faculty of Agriculture Technology which requires 33 trees spends Rp33,687,390. Based on the calculation on tree(s) provision cost in Surabaya, therefore the cost to spend for the trees fulfillment in Surabaya can be revealed (Table 9).

Table 9: Trees fulfillment cost in Surabaya

No	Room Name	Tree(s) required		Price of 1 tree for 10 years period (Rp)	Price of all trees	
		Bratang UF	Wonorejo UF		Bratang UF	Wonorejo UF
1	WG (Working Group) Room, Surabaya	17 Trees	19 Trees		16,821,044	19,223,029
2	PKK (Family Welfare Movement) Chief Room, Surabaya	5 Trees	5 Trees		5,104,150	5,104,150
3	Department of General Development Meeting Room, Surabaya	40 Trees	45 Trees		40,833,200	46,141,595
4	Moslem Department Store "Bibah Dibah" Floor 1	53 Trees	60 Trees	1,020,830	54,103,990	61,634,632
5	Moslem Department Store "Bibah Dibah" Floor 2	42 Trees	49 Trees		43,098,782	49,253,135
6	BMKG Employee Room	25 Trees	28 Trees		25,520,750	28,583,240
7	Principal Chief of BMKG Room, Juanda	4 Trees	4 Trees		4,083,320	4,083,320
8	Bedroom, Rungkut Harapan Housing Complex G/31	2 Trees	2 Trees		2,041,660	2,041,660

3. Urban Forest Development Rationality

The expenditure efficiency of the urban forest improvement can be known by comparing the cost needed for the AC usage and for the provision of the trees as the urban forest components (Table 10 and Table 11). Thereby, the cost usage difference can be known, as well as the efficiency.

Table 10: The comparison of the AC usage cost with the trees provision cost in IPB Darmaga campus

No.	Room	AC cost (A)	Tree(s) cost (P)	Difference (A – P)
1.	Auditorium 1, Faculty of Forestry	Rp 56.656.240,-	Rp 27.562.410,-	Rp 29.093.830,-
2.	Silva Thesis Defence Room, Faculty of Forestry	Rp 169,820,160	Rp 34,708,220	Rp 135,111,940
3.	Soil Science Department Room, Faculty of Agriculture	Rp 64,333,120	Rp 7,145,810	Rp 57,187,310
4.	Library, Faculty of Agriculture	Rp 157,092,800	Rp 44,916,520	Rp 112,176,280
5.	Lecture Hall B1, Faculty of Agriculture Technology	Rp 56,656,240	Rp 42,874,860	Rp 13,781,380
6.	Lecture Hall H101, Faculty of Agriculture Technology	Rp 106,426,480	Rp 33,687,390	Rp 72,739,090
7.	RK OFAK B11, Faculty of Agriculture	Rp 56,656,240	Rp 42,874,860	Rp 13,781,380
8.	RK OFAK B12, Faculty of Agriculture	Rp 56,656,240	Rp 42,874,860	Rp 13,781,380
	Total Cost	**Rp724,297,520**	**Rp 276,644,930**	**Rp47,652,590**

Table 11: The comparison of the AC usage with the trees provision cost in Surabaya

No	**Room**	**AC cost (A) (Rp)**	**Tree(s) cost in Bratang UF (P) (Rp)**		**Difference (A-P) (Rp)**	
			Bratang UF	**Wonorejo UF**	**Bratang UF**	**Wonorejo UF**
1	WG (Working Group) Room, Surabaya	50,416,280	16,821,044	19,223,029	33,595,236	31,193,251
2	PKK (Family Welfare Movement) Chief Room, Surabaya	50,416,280	51,04,150	5,104,150	45,312,130	45,312,130
3	Department of General Development Meeting Room, Surabaya	50,416,280	40,833,200	46,141,595	9,583,080	4,274,685
4	Moslem Department Store	71,741,840	54,103,990	61,634,632	17,637,850	10,107,208
5	Moslem Department Store	71,741,840	43,098,782	49,253,135	28,643,058	22,488,705
6	BMKG Employee Room	42,102,560	25,520,750	28,583,240	16,581,810	13,519,320
7	Principal Chief of BMKG Room, Juanda	42,102,560	4,083,320	4,083,320	38,019,240	38,019,240
8	Bedroom, Rungkut Harapan Housing Complex G/31	40,779,680	2,041,660	2,041,660	38,738,020	38,738,020
	Total Cost	419,717,320	191,606,896	216,064,761	**228,110,424**	**203,652,559**

The calculation result above shows that the urban forest development cost is smaller compared to the AC usage cost, thus the urban forest development as an alternative substitution for AC is rational indeed. The trees usage in air conditioning for a room is more efficient in suppressing the level of expenditure compared to the AC usage. The owner of the rooms in IPB Darmaga campus can save as much as Rp447,652,590 in 10 years period or worth of Rp44,765,259/year if the AC usage is substituted by the trees. Apparently, the quantity of AC unit(s) in the Auditorium 1 in the Faculty of Forestry, Lecture Hall B1 in the Faculty of Agriculture Technology, Lecture Hall H101 in the Faculty of Agriculture Technology, RK OFAK B11 in the Faculty of Agriculture, and RK OFAK B12 in the Faculty of Agriculture are insufficient to fulfill the air conditioning of the rooms. The owner of the rooms in Surabaya can save as much as Rp228,110,424/10 years (based on the calculation in Bratang UF) or Rp203,652,559/10 years (based on the calculation in Wonorejo UF), or Rp22,811,042/year (based on the calculation in Bratang UF) or Rp20,365,256/year (based on the calculation in Wonorejo UF). The trees usage in air conditioning for a room is more efficient in suppressing the level of expenditure compared to the AC usage.

IV. CONCLUSION

Trees have the heat absorption ability from 2,589 KJ/hour to 3,192 KJ/hour. Therefore, one unit of AC 1 PK (with the capacity of 9,495 KJ/hour) can be substituted by three trees, while one unit of 1.5 PK AC (with the capacity of 18,990

KJ/hour) can be substituted with six trees, and for one unit of 2 PK AC (with the capacity of 28,485 KJ/hour) can be substituted by nine tress. The result of the research shows that the existence of the urban forest vegetation is able to substitute or decrease the usage of air conditioner which requires a greater cost and has various kinds of deficiency. The urban forest efficiency for a room with an appropriate installment of the AC, that is twice, even nine times less expensive than the sole usage of the AC. The substitution efficiency usage of the AC replaced by the urban forest is about Rp203,652,559/10 years to Rp447,652,590/10 years or Rp20,365,256/year to Rp44,765,259/year.

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