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Economic value of trees based on water influence function in Universitas Negeri Semarang (UNNES), Sekaran Campus

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Abstract. UNNES has moral responsibility in reducing the decline of green open space in Gunungpati District. Due to the development of Semarang city towards the periphery is by conducting tree planting movements and adding green open space in the campus area. Trees in green open spaces have an important role for environmental quality and human health, but these roles and values have not been widely known because they are considered not to provide direct economic benefits. Regarding this, the assessment of the economic value of trees, especially based on the function of water absorption is necessary. The purpose of this study was to estimate the economic value of trees based on the function of water absorption on the UNNES campuss. The economic value of trees based on the water absorption function is estimated through the calculation of the price of water infiltration by trees and the calculation of stand volume through field measurements of stand parameters, such as diameter, height, and number of trees, which collected from April to September 2018. The results showed that the total economic value of trees based on the function of water absorption on the campus is now around Rp. 49.937/ m^2/day.

1. Introduction

The population increase that occurred in Semarang City due to the pace of urbanization has caused a high environmental burden in the city of Semarang. The policy taken to reduce the environmental burden is by developing cities to the periphery. Gunungpati District, one of the suburbs of Semarang City which became the expansion of the city community and its development is very faster. The government policies that have been taken, example the moving of Universitas Negeri Semarang (UNNES) campus to the Gunungpati Subdistrict area and developing new settlements in the area.

Gunungpati District is a protected area that functions as a buffer zone (water catchment area) for the City of Semarang. This protection function has been determined based on the Semarang City Spatial Plan for 2010-2030. The development of Gunungpati Subdistrict is feared to disrupt the function of water absorption due to reduced conversion of vegetated lands into residential areas. Based on research, residential areas in Gunungpati Subdistrict have increased by 257.779 Ha from 762.238 ha in 1992 [1]. Plantation land, rice fields, shrubs, and fields which were originally infiltration areas had turned into residential areas.

The impact caused by the reduction of vegetated lands is the decreasing availability of ground water, which in turn has an impact on decreasing the quality of the city environment. This is because land that is covered by buildings or without vegetation has low water infiltration. On land that has vegetation stands, the foliage system can play a role in holding back the rate of water, while the root system helps to absorb rainwater and put it in the soil [2]. Understanding of the environmental, economic, and also community benefits of nature, in particulary trees, forests, can lead to better vegetation management and designs to be optimize the quality of environmental, the human health for current and the future of generations [3] . UNNES declared ias a Conservation University in March 2010, so the university had a moral responsibility to participate in suppressing the ecological impact due to reduced green space in Gunungpati District. The effort taken is to implement a tree planting movement to increase the area of green open space as a water catchment area especially within the campus area. The tree planting movement has been regulated in the Rector Regulation of UNNES No. 26 th. 2009 Regarding the Planting of One Student One Tree Movement [4]. Poviding green open space can be one way to reduce greenhouse gas emissions, especially CO2 gas, which is the most implement compared to other methods [5]. The purpose of this study was to calculate the economic value of trees based on the function of water absorption in UNNES.

2. Methods

The research was carried out on the main campus of UNNES in Sekaran Village, Gunungpati District, Semarang City, located between 110° 04" 32.78" BT and 07° 03" 02.21" LS with an area of approximately 1.262.804 Km^2. Data processing was carried out at the Semarang State University Biology Laboratory. The study was conducted for six months, namely April - September 2018.

The tool used in this study is a measuring tape (meter) measuring 50 m long, sewing meter, plastic rope measuring 100 m and 20 m long, 1.3 m long wooden stick to mark the tree to be measured in diameter, 1 m long wooden stakes for permanent plot markers, hagameter for measuring machete trees, GPS, DSLR cameras, laptops with Microsoft office (word and excel), crop scissors, color markers, observation sheets, and label paper. The material used is a tree stand in UNNES. Data collected includes primary data and secondary data. Primary data is data obtained directly from the field and secondary data is information related to research. The types of data are listed in Table 1.

Table 1. Types of data used in research

No	Data type	Method	Source
1.	Vegetation data: tree diameter and height	*non destructive*	Field data
2.	Price of water	Interviews	Local residents
4.	Botanical name	Study of literature	Atlas kayu Indonesia
5.	General location conditions	Study of literature	Data Unnes, Unnes Master plan

Determination of plot sampling uses a purposive sar ing method which is first carried out field observations to see and ensure the suitability of plot placement. The sampling intensity used is 1% and the plot used is square. The shape of a square plot is a plot that is relatively often used in the analysis of forest vegetation in Indonesia. The number of plots used is 43 plots with a size of 20 m x 20m [6].

Tree volume measurement is carried out by conducting direct observations to the field by collecting data on vegetation types, number of individuals per species, diameter at breast height (DBH = 1.3 m above ground level), and branch-free tree height. The water price data is obtained through interviews with residents around the research area, and literature studies.

Analysis of this data is used to determine the potential volume of trees and the economic value of trees based on the function of water absorption at Green Opening Space in UNNES. Tree volume analysis is done by knowing the area of the base and height of the tree. Tree volume can be searched by:

$$V\ tree = (11/140000) \times D^2 \times T \times f, \quad (1)$$

Where V is tree volume (m^3), D is diameter (cm), T is tree height (m), and f is form factor.

The economic value of trees from water infiltration can be known by calculating the price of water infiltration by trees by first knowing the amount of water infiltration by trees and the price of water in the study area [7].

$$Hra = Jra \times Ha, \tag{2}$$

Where *HRa* is the price of water infiltration by trees (Rp/ m^3), *JRa is* the amount of water infiltration by trees (m^3), 1 m3 of trees can absorb 1.4 m^3 of water and *Ha* is the prices of water in the study area (Rp/ m^3).

3. Results and Discussion

3.1. Tree Type Composition at UNNES Campus

The Sekaran UNNES campus is located in a sub-urban area or the outskirts of Semarang with a topography in the form of hills with fairly tight vegetation cover. The UNNES campus area now has a fairly wide green space which is around 80% while the rest is in the form of buildings. This illustrates the potential of existing stands in the UNNES region is still relatively high. Based on the results of the inventory, there were 52 species in total, belonging to 42 genera and 24 family, as shown in Table 2.

Table 2. Number of species, tribes and clans of trees on the UNNES campus, Sekaran

No	Scientific name	Family	Growth Rate			Total	Protection Status
			Pole	stake	Tree		
1	*Mangifera indica*	Anacardiaceae	0	6	6	12	DD
2	*Anacardium occidentale*		0	0	8	8	NE
3	*Polyalthia longifolia*	Annonaceae	3	19	89	111	NE
4	*Cerbera manghas*	Apocynaceae	1	0	0	1	NE
5	*Schefflera grandiflora*	Araliaceae	0	0	1	1	NE
6	*Elaeis guineensis*	Arecaceae	0	1	1	2	LC
7	*Roystonea regia*		3	2	10	15	NE
8	*Wodyetia bifurcate*		0	1	0	1	LC
9	*Phoenix roebelinii*		0	2	0	2	NE
10	*Calophyllum inophyllum*	Clusiaceae	0	0	1	1	LC
11	*Terminalia catappa*	Combrettaceae	2	3	10	15	NE
12	*Terminalia mantaly*		3	3	0	6	NE
13	*Pinus merkusii*	Coniferaceae	1	0	0	1	VU
14	*Diospyros blancoi*	Ebenaceae	1	0	0	1	NE
15	*Muntingia calabura*	Elaeocarpaceae	0	1	1	2	NE
16	*Acacia auriculaeformis*	Fabaceae	0	0	104	104	LC
17	*Bauhinia purpurea*		2	3	6	11	LC
18	*Pelthoporum pterocarpum*		0	0	9	9	LC
19	*Tectona grandis*	Lamiaceae	3	2	42	47	NE
20	*Cinnamomum verum*	Lauraceae	5	18	25	48	NE
21	*Pterocarpus indicus*	Leguminosae	0	0	20	20	VU
22	*Tamarindus indica*		0	1	0	1	NE
23	*Delonix regia*		0	0	9	9	LC
24	*Inocarpus fagiferus*		0	1	0	1	NE
25	*Senna siamea*		0	0	1	1	NE
26	*Maniltoa grandiflora*		1	2	3	6	NE
27	*Paraserianthes falcataria*		0	0	2	2	NE

No	Scientific name	Family	Growth Rate			Total	Protection
28	*Samanea saman*		0	1	17	18	NE
29	*Parkia speciosa*		0	0	2	2	NE
30	*Bombax ceiba*	Malvaceae	2	0	2	4	NE
31	*Michelia champaca*	Magnoliaceae	0	1	0	1	LC
32	*Michelia alba*		0	2	0	2	NE
33	*Sandoricum koetjape*		0	1	0	1	NE
34	*Stelechocarpus burahol*	Meliaceae	2	0	0	2	NE
35	*Swietenia mahagoni*		28	60	118	206	EN, CITES II
36	*Ficus benjamina*		1	3	3	7	NE
37	*Ficus elastica*		0	0	1	1	NE
38	*Ficus ribes* Reinw	Moraceae	0	0	2	2	NE
39	*Ficus septica*		0	3	0	3	NE
40	*Syzygium cumini*		0	1	1	2	NE
41	*Syzygium aqueum*		0	1	0	1	NE
42	*Syzygium myrtifolium*	Myrtaceae	2	0	0	2	NE
43	*Syzygium jambos*		1	0	4	5	NE
44	*Syzygium polyanthum*		0	0	3	3	NE
45	*Antidesma bunius*	Phyllanthaceae	4	1	6	11	NE
46	*Gigantochloa* sp	Poaceae	5	0	0	5	NE
47	*Neolamarckia cadamba*	Rubiaceae	0	0	5	5	NE
48	*Dimocarpus longan*		0	0	2	2	NT
49	*Filicium decipiens*	Sapindaceae	1	0	7	7	NE
50	*Nephelium lappaceu*		1	0	1	2	LC
51	*Manilkara kauki*	Sapotaceae	2	1	6	9	NE
52	*Mimusops elengi*		3	3	7	13	NE
	Total		77	143	535	754	

Description: NE (Not Evaluated), VU (Vulnerable), LC (Least Concern), DD (Data Deficient), EN (Endangered), LR (Low Risk), NT (Near Threatened).

Leguminosae was recorded as a family which has the most species of 9 species, while the least species are found in the Annonaceae, Apocynaceae, Araliaceae, Clusiaceae, Coniferaceae, Ebenaceae, Elaeocarpaceae, Lamiaceae, Lauraceae, Malvaceae, Phyllanthaceae, Poaceae, and Rubiaceae ie -one only one type. Of the 53 species included in the category of endangered (threatened) according to the IUCN (International Union for Conservation of Nature and Natural Resources), namely *Swietenia mahagony*. *Swietenia mahagony* is also included in CITES Appendix II (Convention on International Trade in Endangered Species of Wild Fauna and Flora). The total number of all types is 754 stems with an average of 1.949,17 stems /ha. It is known that the largest number in the *Swietenia mahagony* group is 206 stems or 671,67 stems /ha. The type of *Swietenia mahagony* is the most dominant type on the UNNES campus. *Swietenia mahagony* dominates for the level of poles, stakes and trees. *Swietenia mahagony* still dominates at the stake with an average number of 200 stems per hectare followed by *Polyalthia longifolia* of 63,33 stems per hectare and *Cinnamomum verum* of 60 stems per hectare, while at the tree level dominance is in the average number of *Swietenia mahagony* of 98,33 stems per hectare, followed by *Acacia auriculaeformis* with an average amount of 86,67 stems per hectare and

Polyalthia longifolia with an average number of 74,17 stems per hectare. The dominance of *Swietenia mahagony* is suspected because this type has always been a priority in every greening activity in UNNES. *Swietenia mahagony* have characteristics as shade trees with rapid growth and can grow on arid land such as in urban areas, so that it is in line with UNNES goal to accelerate the reduction of arid land in the campus area [8].

Table 3. Volume of trees in UNNES

Plot	Growth Rate			Total
	Tree	stake	pole	
1	3.029,38	577,97	123,09	3.730,45
2	3.918,98	507,53	147,79	4.574,29
3	4.734,36	178,78	182,19	5.095,34
4	5.079,40	138,23	301,28	5.518,92
5	5.391,81	484,61	66,78	5.943,20
6	5.282,91	1.064,72	101,69	6.449,32
7	4.910,38	506,33	48,82	5.465,53
8	5.451,14	572,18	49,61	6.072,93
9	3.893,57	72,8	36,54	4.002,91
10	3.718,05	85,05	36,43	3.839,53
11	2.418,53	1425,97	286,82	4.131,33
12	3.126,95	1220,17	180,25	4.527,37
13	3.510,17	50,4	37,8	3.598,36
14	4.207,81	34,51	27,3	4.269,61
15	2.426,98	75,6	15,75	2.518,34
16	2.433,29	42	11,81	2.487,1
17	2.397,52	450,45	28,7	2.876,67
18	2.846,08	414,75	27,12	3.287,95
19	3.778,95	178,85	0	3.957,8
20	3.256,06	48,91	17,32	3.322,25
21	3.268,13	136,67	0	3.404,8
22	436,27	138,34	0	574,61
23	410,16	311,73	57,52	779,41
24	1.827,31	255,29	41,76	2.124,36
25	0	45,49	0	45,49
26	0	50,4	37,8	88,2
27	0	0	19,6	19,6
Total	81.754,17	9.067,74	1.883,81	92.705,71
Average	3.027,93	335,84	69,77	3.433.54
ha	75,698.30	33.584.24	27.908,22	137.190.76
m^2	7,57	3,36	2,79	13.72

3.2. Tree Volume at the UNNES Campus

To find out the volume of trees in UNNES, 27 sampling plots were made using the purposive sampling method. Based on the results of research in the field, the total volume of trees in 27 observation plots was 92.705,71 m^3, which consisted of 81.754,17 m^3 as the tree vegetation volume, while 9.067,74 m^3 constituted the stake level vegetation volume and 1.883,81 m3 were pole level vegetation volume. The volume of trees found in all observation plots is shown in Table 3.

3.3. Water Prices and Economic Value of Trees Based on Water Absorption of UNNES Campus

Trees have an important role for environmental quality and human health [9]. However, not many know about the important role of trees and their value for human life. To assess the ecological services of a tree is not an easy task. This is because many ecosystem services do not have a market so they do not have a price [10]. One of the relatively easy benchmarks is to provide a perception of the value of the benefits of goods enjoyed by humans [11], through giving prices to goods and services produced by an ecosystem [12]. The value of nonmarket goods or services produced by an ecosystem is transformed into monetary value to monetary value [13][14]. The economic value of tree recharge can be obtained from the calculation of the ability to hold water (reflected in the value of its wood potential) and the amount of costs incurred by the community on water use [2]. The ability of trees to maintain the water needed by humans in their lives can be calculated using the absorption of water from the tree into the soil. One 10 year old tree is assumed to be able to hold ± 7 m3 of water which is equivalent to 5 m3 of wood. Based on the results of the survey, the highest water prices obtained were valued at Rp. 6.000 while the lowest price is Rp. 0.00. The lowest water price is caused by water obtained from the well by drawing. So that the economic value of trees is Rp. 49.937/m^2/day.

4. Conclusion

The results of this research indicate that the volume of trees in UNNES was 13.72 m^3/m^2/day and the average price of water around the study area is Rp. 2.600,00. Also the economic value of trees based on water absorption in UNNES was Rp. 49.937/ m^2 /day.

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