

# Vegetation Analysis of the Spring Water Surroundings at the Wanagama Rehabilitated Forest

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**Abstract.** Water is a basic need for all living things on earth. The existence of water on Earth cannot be separated from the hydrological cycle. The presence of vegetation has an impact on the water absorption process and protects the soil surface from the kinetic energy of rainwater. Vegetation measurements were carried out on plots measuring 8 m x 60 m. The measuring plot is made perpendicular to the contour direction or in the direction of the slope. Data processed with Ms. Excel continued with SEI-FS software. Vegetation data was collected to create a profile diagram with horizontal and vertical projections as well as calculate the relative dominancy (DR), relative frequency (FR), and relative density (KR) to determine the important index (INP) value. The research results showed that the percentage of canopy cover varied from 33.13% in Tuk Umbul, followed by Sendang Tahunan and Sendang Ayu at 46.87% and 42.08%, then Sendang Mojo (74.17%) and the best is at the Salak Spring area (87.71%). The highest important index values are at teak (*Tectona grandis*), followed by Jabon (*Neolamarckia cadamba*), and Beringin (*Ficus sp.*).

## 1 Introduction

Land use cannot be separated from daily human activities. Humans utilize land for various purposes in order to improve their quality of life. There are factors that need to be considered in land use, such as the condition and capacity of the land, so that it does not have a negative impact on the land [1]. One of the negative impacts that may occur is the formation of critical land. Critical land is land that has lost its function as a regulator of water management, and land productivity has decreased [2].

Determining critical land is based on several main characteristics, including aridity to the appearance of rocks on the ground surface and generally having hilly topography with steep slopes [3]. Apart from that, the criticality of land can be seen from the parameters of the level of soil erosion and the condition of its canopy cover [1]. The existence of critical land continues to increase every year due to various factors. The lack of basis and information regarding the capacity of land resources for development related to land development is one

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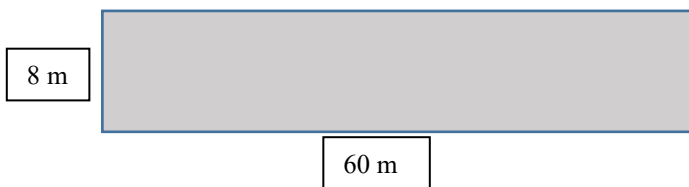
of the causes of critical land. The form of treatment that can be carried out on critical land is land rehabilitation.

Land rehabilitation is an effort to restore the condition of land with the help of conservation treatment [4]. Land rehabilitation efforts can be carried out by planting pioneer vegetation to improve soil fertility. The success of land rehabilitation efforts can be seen from the impact in the form of increasing the percentage of land cover, increasing soil fertility, reducing erosion, and creating a better microclimate. One embodiment of critical land rehabilitation in Indonesia is in the Wanagama forest.

Wanagama is an educational forest managed by the UGM Forestry Faculty. The Wanagama forest area includes a karst hill area along the southern mountains of Yogyakarta. Karst hills are areas formed from porous limestone rocks which cause difficulty in retaining water because it always seeps and flows into the ground. According to [5] Wanagama is an area in the form of hills with arid and barren conditions. Characteristics of karst areas include difficulties in storing water and frequent droughts [6]. The difficulty of storing water in Wanagama has an impact on water resources, which is one of the natural elements that plays an important role and is really needed by living creatures, especially humans [7]. Based on the description of the characteristics of the study location, it is deemed necessary and important to carry out this research immediately in order to assess the condition of the vegetation in the area around the water source.

## 2 Material and methods

Vegetation data collection was carried out on plots measuring 8m x 60m (Fig. 1). The measuring plot is made perpendicular to the contour direction or in the direction of the slope. The vegetation taken is at the growth level of poles and trees. Data collection includes species name, height, circumference, branch-free stem height (TBBC), canopy width, and x and y coordinates on the plot [8]. The data that has been obtained is processed with Ms. Excel is then continued with SEXI-FS software. Vegetation data is collected to create profile diagrams with horizontal and vertical projections. The horizontal projection shows an overview of the forest floor covered by the tree canopy, while the vertical projection shows the stratification of the tree canopy. Based on the visual appearance obtained, we apply descriptive analysis.



**Fig. 1.** Vegetation Data Collection Measurement Plot

The Important Value Index (INP) was obtained from vegetation data taken on plots measuring 8 m x 60 m. INP calculations were only carried out at the tree growth level in one plot size. All species found in the measuring plot were recorded with the species name and circumference of each individual. These parameters are measured to calculate relative density (KR), relative frequency (FR), and area of closure/dominance (DR), so that an Important Value Index (INP) will be obtained. The INP calculation is carried out using the following Equation(1).

$$INP = KR+FR+DR \quad (1)$$

Description:

K = Number of individuals/Area of all measuring plots

KR = (Density of a species/Density of all species) x 100%

$F$  = Number of sample plots found for a type/Number of all sample plots

$FR$  = (Frequency of a type/Frequency of all types) x 100%

$D$  = Total basal area of species  $i$ /Area of all measuring plots

$DR$  = (Closure of the itch species/Closure of all species) x 100%

### 3 Results and discussion

Water is a basic need for all living things on earth. The existence of water on Earth cannot be separated from the hydrological cycle. One important factor in the hydrological cycle is the presence of vegetation. Vegetation has a function in the processes of interception, through-fall, stem-flow, and transpiration. In general, the influence of vegetation on water is indirect. Vegetation can change the physical and chemical properties of soil in relation to water storage rates [9]. The presence of vegetation has an impact on the water absorption process and protects the soil surface from the kinetic energy of rainwater that causes erosion. Water will gradually pass through tree roots and soil pores and become a water reserve [10]. The existence of tree roots can reach shallow groundwater layers, where in certain geological conditions, the presence of these roots opens the way for the emergence of new springs [11].

Vegetation measurements were carried out on plots measuring 8m x 60m. The measuring plot is made perpendicular to the contour direction or in the direction of the slope. Data processed with Ms. Excel is then continued with SEI-FS software. Vegetation data is collected to create profile diagrams with horizontal and vertical projections [12]. The horizontal projection shows an overview of the forest floor covered by the tree canopy, while the vertical projection shows the stratification of the tree canopy. Based on the percentage of canopy cover, it can be classified into 5 classes, namely: (1) very good with a percentage of >80%; (2) good with a percentage of 61-80%; (3) moderate with a percentage of 41-60%; (4) bad with a percentage of 21-40%; (5) very bad with a percentage <20% [13]. Based on its height, it can be classified into 5 classes, namely: (1) stratum A with height criteria >30 m; (2) stratum B with height criteria of 20-30 m; (3) stratum C with height criteria of 4-20 m; (4) stratum D with the criteria for bushes and shrubs 1-4 m high; (5) stratum E with the criteria for plants <1 m tall [14]. The profile diagram of the area around the spring in this study is as follows.

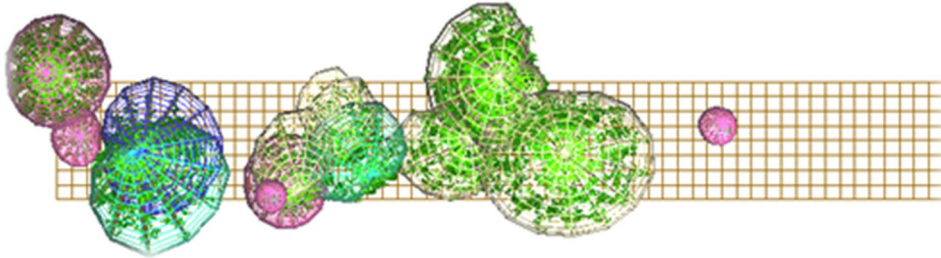
#### 3.1 Sendang Tahunan

Figure 2, from left to right, shows the conditions in the field from the lower slope to the upper slope. This condition illustrates the form of canopy cover above the Annual Spring water source. Based on the horizontal projection, it can be seen that the canopy on the lower slope is denser than the upper slope. The percentage of canopy cover in Sendang Tahunan reached 46.87%, which is included in the medium class.

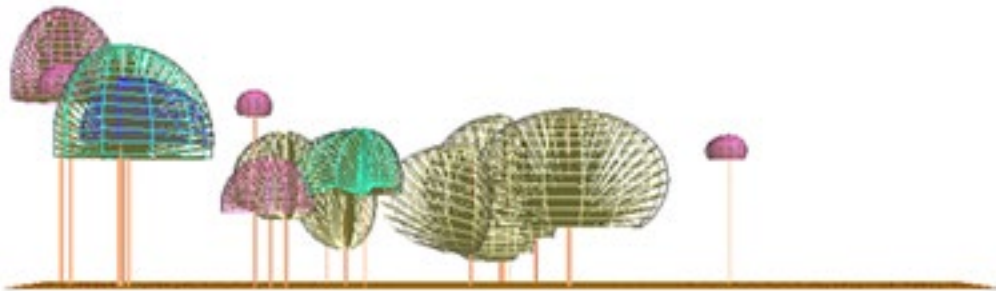
The crown diameter can reach 2.5-12.3 meters. A wide and dense canopy can store more water through an interception process so that rainwater that falls does not fall directly to the ground. With vegetation, water can slowly enter the soil so as to minimize surface runoff. If water can be absorbed into the soil optimally, it can impact the availability of groundwater reserves.

Based on vertical projections (Fig. 3), vegetation in annual springs has tree heights that vary between 6-18 meters. In the canopy strata classification, this height is still included in the same stratum, namely in stratum C (4-20 meters). Most of the site conditions in Sendang Tahunan are still rocky, so the vegetation often found is the Fabaceae family because it is a pioneer plant. The type that grows most is Gamal (*Gliricidia sepium*). Apart from that, there are also other types, including Jamblang (*Syzygium cumini*), Ki putri (*Podocarpus neriifolius*), Waru (*Hibiscus tiliaceus*), Eucalyptus (*Malaleuca leucadendra*). Apart from

these types, in Sendang Tahunan, there is also a banyan tree (*Ficus benjamina*), under which the water source in Sendang Tahunan emerges. The roots of this tree are able to reach the aquifer where groundwater flows so that it can open a new flow to the ground surface and emerge as a spring [15].



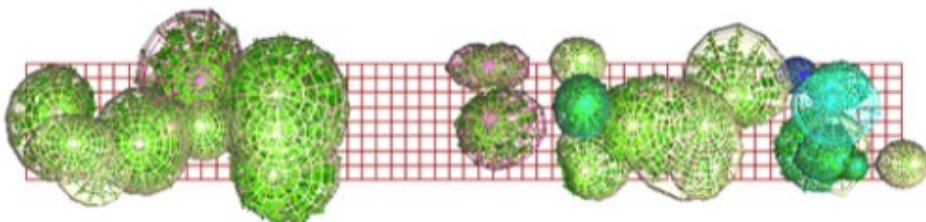
**Fig 2.** Sendang Tahunan Plot Horizontal Projection



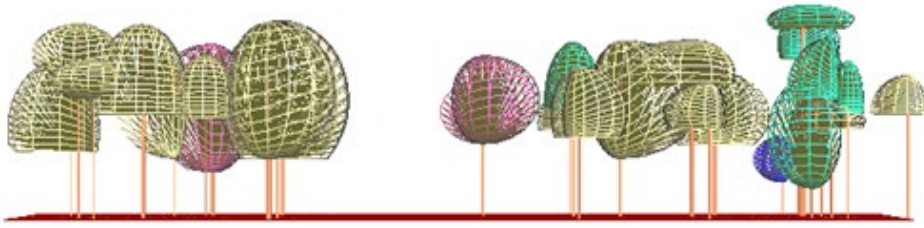
**Fig 3.** Sendang Tahunan Plot Vertical Projection

### 3.2 Sendang Mojo

The vegetation profile in Sendang Mojo, based on Figure 4, shows the width of the canopy in the plot measuring 60 meters x 8 meters. When compared with the plot area, the percentage of canopy cover in Sendang Mojo is 74.17%. Based on the classification of percentage canopy cover, this value is included in the good class. According to [16], this measure of canopy width characterizes the influence of tree growth in the radial direction. This is because canopy width describes stand density and individual tree competition.



**Fig 4.** Sendang Mojo Plot Horizontal Projection



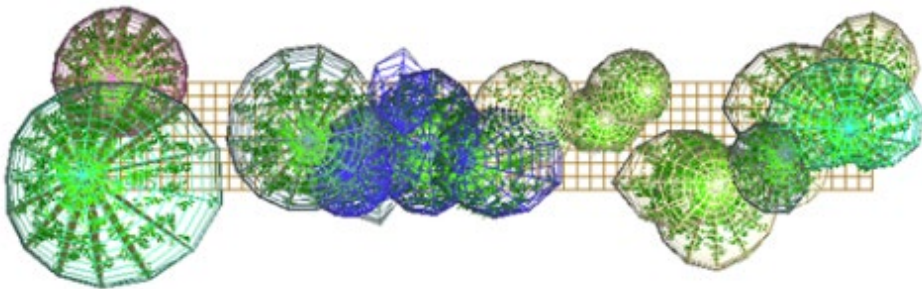
**Fig 5.** Sendang Mojo Plot Vertical Projection

The vegetation in Sendang Mojo is dominated by teak (*Tectona grandis*), with a total of 17 individuals in the measurement plot. Based on the vertical projection (Fig. 5), the vegetation in Sendang Mojo has almost the same tree height because the teak stands are mature stands. Teak generally grows at the pole and tree growth level with a trunk circumference of 32.5-113.5 cm and a height of 8-13.5 meters. Apart from teak, there are also other types such as three individuals of trembesi (*Samanea saman*), three individuals of mahogany (*Swietenia macrophylla*), one individual of water guava (*Syzygium aqueum*), and three individuals of white teak (*Gmelina arborea*). The vegetation with the shortest height is the water guava type, with a height of 5.5 meters, and the tallest is the white teak type, with a height of 14.5 meters. Based on canopy stratification, the vegetation in Sendang Mojo is included in stratum C.

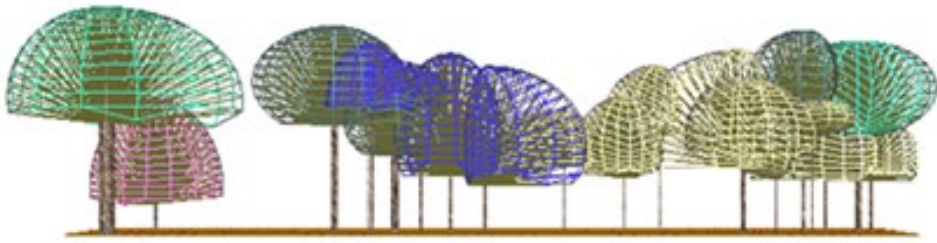
Around the Sendang Mojo spring, there are also banyan trees (*Ficus benjamina*). The wide crown makes the banyan tree very good at providing shade. Apart from that, banyans also have deep and numerous roots so that they can increase the number of springs as the tree ages. Banyan is a tree that can adapt to any region, including difficult places such as Gunungkidul, which is a limestone or karst mountain area. Banyan roots are able to penetrate rocks and limestone crevices [17].

### 3.3 Salak Spring

Horizontally, the distribution of vegetation in Salak is shown in Figure 6. The vegetation in the Salak Spring area has relatively dense canopy cover and is almost completely covered by the canopy. This is supported by a large percentage of canopy cover of 87.71%, which is included in the very good class. Based on the horizontal projection of the Salak plot, only a few gaps in the profile diagram plot are open without canopy cover.



**Fig 6.** Salak Plot Horizontal Projection



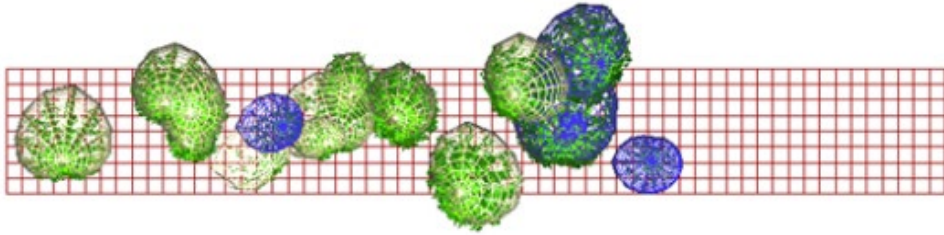
**Fig 7.** Salak Plot Vertical Projection

The vegetation profile in the Salak plot consists of one stratum (Fig. 7), which is included in stratum C. This is indicated by the height of the trees, which ranges from 9 to 14.6 meters. This height is still included in stratum C, with a height criterion of 4-20 meters. The vegetation types that dominate the Salak plot are Gamal (*Gliricidia sepium*), with a total of nine individuals found, and Johar (*Cassia siamea*), with a total of five individuals. Other species that are also found in the Salak Plot are Bipa (*Adenantha pavonina*), Pine (*Casuarina* sp.), Damar (*Agathis dammara*), and Banyan (*Ficus* sp.). This shows that the vegetation around the Salak Spring is quite diverse, with a total of six different tree species found.

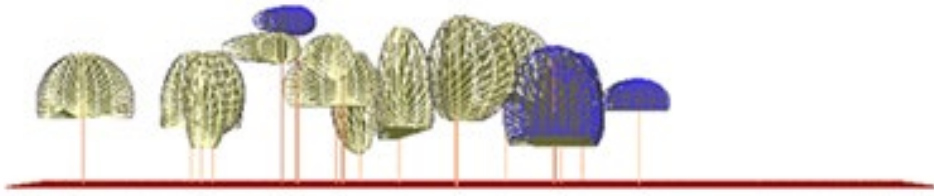
Banyan is the largest tree around the Salak Spring. The circumference of the trunk reaches 3.5 meters. This banyan is 16 meters high with a relatively short branch-free trunk height of 3.5 meters. The size of the crown is very wide, namely with a north south crown diameter reaching 16 meters and an east west diameter reaching 14.5 meters. The shape of the banyan tree's canopy is wide and thick, with a deep and spreading root system. This characteristic causes the roots of the banyan tree to be able to grip the surrounding soil well, because the roots are able to reach quite deep areas of the ground, even to underground river areas. This ability of the banyan tree causes the soil around the banyan tree to be relatively sturdy and has high resistance to landslides. Banyan trees have the ability to store large amounts of water so that water sources around banyan trees can be maintained [18].

### 3.4 Sendang Ayu

Based on Figure 8 below, we can see the horizontal distribution of trees in Sendang Ayu. Horizontally, you can see the condition of the canopy cover in a plot measuring 60 meters x 8 meters. The percentage of canopy cover in Sendang Ayu reached 42.08% so it is included in the medium class. Sendang Ayu has relatively dense canopy cover on the lower slopes and becomes increasingly sparse and even has no canopy cover on the upper slopes. The upper slopes of Sendang Ayu have more vegetation at the weaning growth stage, so it is not included in the profile diagram projection. However, on the upper slopes of Sendang Ayu, you can find bamboo groves. Even though bamboo is not a type of tree, it plays an important role in the presence of water. Bamboo has a direct function, namely as a land cover to reduce erosion and, at the same time, as a rainwater catchment area. Bamboo has rhizome roots, very dense, broad, and strong, and plants with fairly wide fronds, if planted in hilly areas or next to slopes, will help bind the soil structure and avoid the danger of landslides [19]. The characteristics of bamboo roots allow this plant to maintain the hydrological system by binding soil and water so it can be used as a conservation plant.



**Fig 8.** Sendang Ayu Plot Horizontal

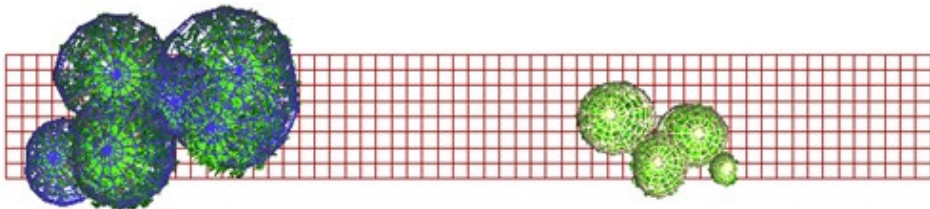


**Fig 9.** Sendang Ayu Plot Vertical Projection

The condition of the canopy strata in Sendang Ayu can be determined based on Fig. 9 above. Based on observations, it was found that Sendang Ayu has one canopy layer, namely in stratum C, with tree height criteria of 4-20 meters. This is because the tree height is in the range of 7-12 meters. The composition of the vegetation in Sendang Ayu is relatively uniform, as evidenced by the fact that only two types of trees were found. The tree consists of five individuals of the *Tabebuia* sp. and 11 individuals of the Gamal type (*Gliricidia sepium*). This makes the level of species diversity in Sendang Ayu quite low. According to [20], a community is considered to have high species diversity if the community is composed of many species.

### 3.5 Tuk Umbul

Fig. 10 below shows the percent canopy cover in the Tuk Umbul Plot is 33.13% so it is included in the bad class. This cover is the rarest when compared to the other four water source plots. This is because Tuk Umbul is a water source only recently managed by Wanagama. One of the management efforts is through planting so that the vegetation found is still not at the level of tree growth. The location of Tuk Umbul, which is directly adjacent to the Panggal Buaya vegetated land use, also means that there are fewer trees to be found. This is influenced by the type of Panggal Buaya, which has a certain planting distance, and many do not include tree growth levels.



**Fig 10.** Tuk Umbul Plot Horizontal



**Fig 11.** Tuk Umbul Plot Vertical Projection

The strata in Tuk Umbul are depicted from a vertical projection, as in Figure 11 above. The vegetation in Tuk Umbul consists of 6 individuals of Jabon (*Neolamarckia cadamba*) and 4 Panggal Buaya (*Zanthoxylum rhetsa*) species. The size of this Jabon tree is relatively large, with a trunk circumference of 64-150 cm and a tree height of 10.5-15 meters. The size of the crocodile's pelvis is relatively the same because this type is a perennial plant. The circumference of the panggal buaya trunk is between 38-50 cm, and the tree's height is 7 meters. Based on the height of the tree, it can be seen that Tuk Umbul has one stratum like other water source locations, which is included in stratum C. Just like Sendang Ayu, Tuk Umbul also has a quite a low level of diversity because it only consists of two types of trees.

### 3.6 INP

The INP calculation is shown in Table 1. Table 1 shows that the tree species with the highest Importance Value Index (INP) is the *Tectona grandis* species, with a value of 41.33. The INP of a species is a value that describes the role of a species in a community. The greater the INP of a species, the greater its role. Conversely, the smaller the INP of a species, the smaller the role of that species in the community [21]. The high INP value for this teak species is partly influenced by the highest relative density value among the other 14 species, namely 22.22%. Relative density is the comparison between the number of individuals per measuring plot and the total number of individuals in all measuring plots [22]. There were 13 individual teak trees found at the Sendang Mojo point growing on community land because they were planted.

The second largest INP value is found in the Jabon species (*Neolamarckia cadamba*) at 38.72. One of the reasons for the high INP of Jabon is that this species has the second-highest relative density percentage after the teak species. This is because the Jabon species is only found at the Tuk Umbul water source location in 6 individuals and grows to form homogeneous stands. Apart from that, Jabon also has the second-highest relative dominance after *Ficus* sp., with a stem diameter that is quite large compared to other species. The diameter range of this species ranges from 12.10 cm-47.77 cm. The diameter is directly proportional to the basal area (lbs) value of the tree, so as the tree's diameter increases, the lbs value will also increase. The greater the lbs of a species, the higher the dominance of that species in the area.

From the relative dominance calculations that have been carried out, it can be seen that the species *Ficus* sp. has the highest relative dominance percentage compared to other species, namely 25.77%. *Ficus* sp. One individual was found at the Tuk Salak water source with a stem diameter of 111.46 cm. This large diameter makes this species have an lbs value of 9.75 cm<sup>2</sup>. The existence of this species plays a role in storing large amounts of water so that water sources around the banyan tree can be maintained [18].

**Table 1.** Quantitative Community Structure Tree Growth Levels at Wanagama Springs

Species	Density (individu/ha)	KR	Dominancy (cm <sup>2</sup> /ha)	DR	Frekuensi	FR	INP	Rank
<i>Gliricidia sepium</i>	16.667	11.111	1909.169	7.554	0.1333	13.333	31.998	4
<i>Hibiscus tiliaceus</i>	4.167	2.778	1916.136	1.215	0.0667	6.667	10.660	13
<i>Malaleuca leucadendra</i>	4.167	2.778	6455.762	4.095	0.0667	6.667	13.539	8
<i>Syzygium sp.</i>	4.167	2.778	4087.381	2.593	0.0667	6.667	12.037	10
<i>Tectona grandis</i>	33.333	22.222	19628.367	12.450	0.0667	6.667	41.339	1
<i>Samanea saman</i>	4.167	2.778	1841.245	1.168	0.0667	6.667	10.612	14
<i>Sweetenia sp.</i>	4.167	2.778	2869.228	1.820	0.0667	6.667	11.264	11
<i>Gmelina sp.</i>	12.5	8	7273.504	4.613	0.0667	6.667	19.613	7
<i>Casuarina sp.</i>	4.167	2.778	6181.081	3.920	0.0667	6.667	13.365	9
<i>Adenanthera pavonina</i>	12.5	8	20779.425	13.180	0.0667	6.667	28.180	5
<i>Cassia siamea</i>	16.667	11.111	7792.202	4.942	0.0667	6.667	22.720	6
<i>Ficus sp.</i>	4.167	3	40638.270	25.776	0.0667	6.667	35.220	3
<i>Agathis dammara</i>	4.167	2.778	2018.312	1.280	0.0667	6.667	10.725	12
<i>Neolamarckia cadamba</i>	25	17	24271.580	15.395	0.0667	6.667	38.728	2
<b>Total</b>	<b>125.000</b>	<b>100</b>	<b>157661.662</b>	<b>100</b>	<b>1</b>	<b>100</b>	<b>300</b>	

Vegetation analysis was also carried out on the frequency of each species in a measuring plot [23]. Frequency is the presence of a species in the measurement plot. Information regarding frequency in an ecology is used to state the proportion of samples consisting of a particular species to the total number of species [22]. The results of relative frequency calculations show that all species in each water source have a value of 6.67%, except for one species which has a value of 13.33%, namely the gamal (*Gliricidiasepium*). This species was found more frequently in the five plots than other species. Based on the data obtained, the gamal species were found at the Tuk Salak and Sendang Tahunan water source points, while the other 13 species were only found at one of the water source points.

## 4 Conclusions

The research results showed that the percentage of canopy cover varied from 33.13% in Tuk Umbul, followed by Sendang Tahunan and Sendang Ayu at 46.87% and 42.08%, then Sendang Mojo (74.17%) and the best is at the Salak Spring area (87.71%). Teak (*Tectona grandis*) has the highest important index value, followed by Jabon (*Neolamarckia cadamba*), and Beringin (*Ficus* sp.).

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