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Vegetation Analysis of Tree Habitus at the Upstream of Tondano Watershed, Minahasa Regency, Sulawesi Utara Province

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ABSTRACT

Diversity of tree at a watershed was very influencial to health condition and invironment of the watershed mainly related to the hydrological condition. Therefore, it was important to observe variety of growth vegetation and its impact to hydrological condition. The aim of this study was to analyze vegetation of tree habitus at Tondano Sub-watershed. The methodology was consisted of measurement of density, frequency, domination, and the index of diversity, association, and distribution pattern for each vegetation. Result was used as consideration for making decision in covering vegetation at Tondano watershed.

Keywords: habitus, diversity, Tondano watershed

INTRODUCTION

Distributed parameter models were more suitable to estimate the hydrology effect of land use. It had the structure and physical estimation that allowed for improving the spatial variability [1] [2]. Many factors which would influence surface runoff was included time of rainfall duration, intensity, distribution of rainfall, the shape and area of watershed, topography, geology, and land use. In one side, vegetations and cropping system would decrease surface run off and in the other side, it was able to accelerate surface detention which would minimize surface run off [3]. Hydrological approaches in the watershed systems had granted great many contributions to hydraulic structured planning. The change of land cover from pervious area into impervious area would give an impact on the increasing of run off depth and it would increase surface run off and would diminish natural into groundwater storage that caused pond or flood and minimize infiltration [4].

The function of forest was very important due to the environmental ecosystem. Fast population growth would change any land use of forest to the others like agriculture or residential area. Therefore it had to be considered in making decision wisely for any changes of land use so that it did not damage the function of ecosystem. Based on the reason as above, research about hydrology cycle was very important, mainly in some watershed which recently had some changes.

MATERIALS AND METHODS

Location of study was in Tondano Sub-Watershed. It was located at North Sulawesi Province. Sedimentation, shallowing, and decreasing of both discharge and area number was happened in this sub-watershed. Local farmers had cropped any kinds tree habitus of clove, chocolate, palm, manggistan, champaca, and any kinds of natural plantations. Map of location was as in Figure 1 below.

The main river in Tondano Watershed was used for irrigation, fishery, dyke, transportation, and supplied water for 3 hydro electrical powers. Visual observation showed that little rivers at Tondan Sub-Watershed had discharge decreasing in dry season but there was flooded in rainy season. This condition indicated ecosystem damaged and it would impact other sub-system in Tondano Watershed.

This research had been conducted from October 2010 to May 2011. Field reasearch was carried out in Tondano Sub-Watershed on two agroecological zone namely upper and middle zone. Based on classification map of satelit citra TM, area number of Tondano Sub-Watershed was 54,785.5 ha and it was extended between 300 m dpl to 1,556 m dpl. The samples were observed based on the elevation of location at tropical zona and sub-montana zone. Ecological parametres measured in this research included density, frequency, domination, and index of diversity, association, and distribution pattern for each kind of trees.

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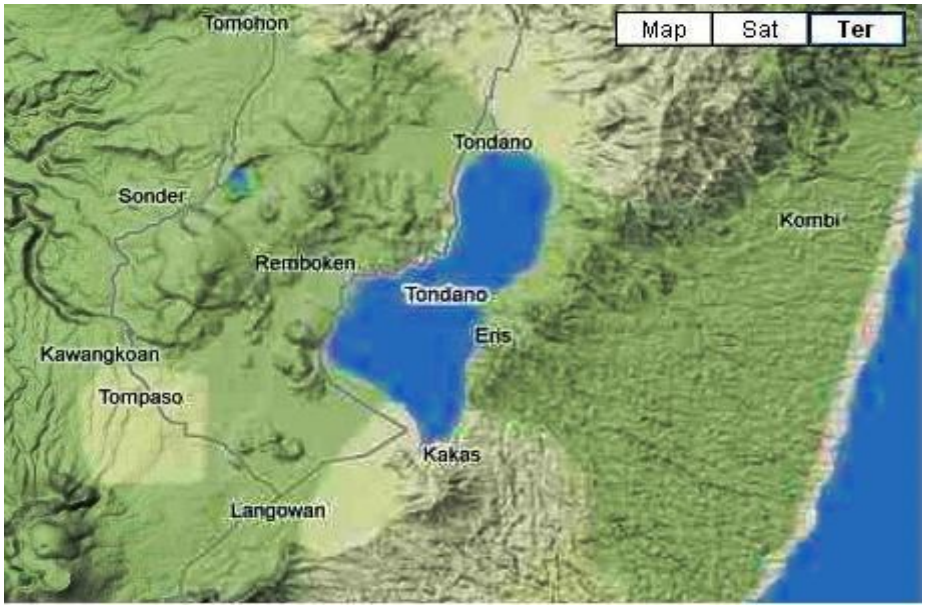

Figure 1 Map of Location

1. Measurement of absolute and relative density for each tree

$$\text{Absolute density type- i (KMi)} = \frac{\text{The number of kind of trees}}{\text{Area plot number of sample}} \text{ (tree/ha)} \quad \ldots\ldots\ldots (1)$$

$$\text{Relative density type-i (KRi)} = \frac{\text{Absolute density of type}}{\text{Density number of type}} \times 100\% \quad \ldots\ldots\ldots\ldots (2)$$

2. Measurement of absolute and relative frequency for each tree

$$\text{Absolute frequency type i (FMi)} = \frac{\text{The number of plot type- i}}{\text{The number of total plot}} \times 100\ \% \ \ldots\ldots\ldots (3)$$

$$\text{Relative frequency type- i (FRi)} = \frac{\text{Absolute frequency type-i}}{\text{Total frequency of the whole type}} \times 100\% \ \ldots\ldots\ldots (4)$$

3. Measurement of absolute and relative domination for each tree:

$$\text{Absolute domination type-i (DMi)} = \frac{\text{Based area number of type}}{\text{Plot area number of sample}} \ (m^2/ha) \ \ldots(5)$$

$$\text{Relative domination type-i (DRi)} = \frac{\text{Absolute domination type-i}}{\text{Total DM of the whole type}} \times 100\% \ \ldots(6)$$

4. Analysis of INP

$$INP_a = KR_a + FR_a + DR_a \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Note:

INP =index of important value of certain type
KR = relative density of certain type
FR = relative frequency of certain type
DR = relative domination of certain type

5. Analysis of diversity index, the Shannon-Wienner formula was as follow:

$$H' = - \Sigma p_i \log p_i \quad \text{..... (8)}$$

6. Association among types, it was used contingency table for determining theoritical and observed of pair presence. X^2 was analysed first before determining pair association. The formula of X^2 was as follow:

$$\chi^2 = \frac{(\text{observed value} - \text{theoritical value})^2}{\text{theoritical value}} \quad \text{..... (9)}$$

Result of X^2 compared to X^2 from the table for determining association degree inter certain type of pairs

Distribution pattern of each type at location of study was carried out by comparing medium value of the type and its variate. If medium value was the same as varian, distribution pattern of the type was random, but if the two values were not the same, there were 2 possibilities. The probabilities were regular distributed (for the same values) or group distributed (for different values).

Analysis of vegetation was carried out by determining quadratic minimal value which was applicated in the location. The quadratic value was analysed using releve method with the scheme was as follow:

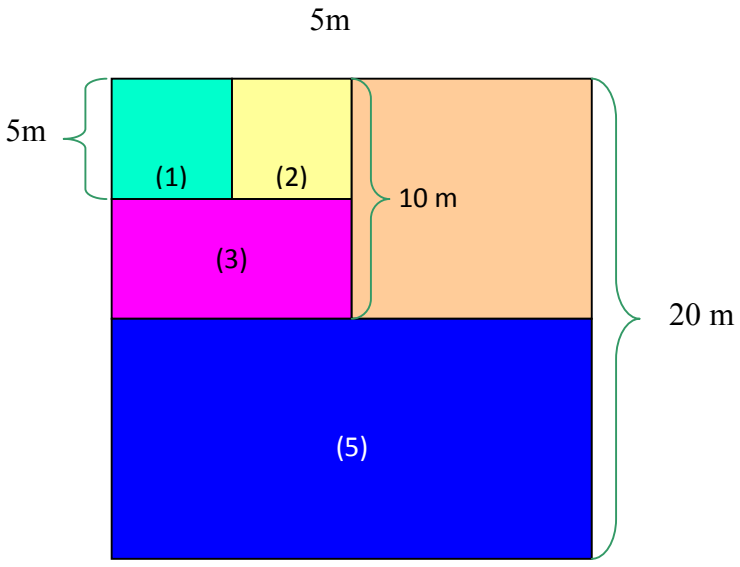

Figure 1 Scheme of application of releve scheme in the location of research

Inventarisation result of type of tree in each measured plot was recorded as in Table 1 below. Result was used to determine minimal measurement of plot in this research. The dimension of plot was 20 cm x 20 cm atau 400 m^2.

Table 1 Inventarisation of type of tree in each plot in application of releve method

No.	Dimension of plot	Type total	Note
1.	5 m x 5 m	3	Initial plot dimension
2.	5 m x 10 m	9	Number of type was increased 200%
3.	10 m x 10 m	14	Number of type was increased 55%
4.	10 m x 20 m	19	Number of type was increased 35,71%
5.	20 m x 20 m	20	Number of type was increased 5,26%

Determination of plot sample ecologically was better if it considered the condition of location of research. Therefore, sample used in this research was based on the elevation of location namely tropical zone (with elevation until 1000 m dpl). In general, the elevation in location of research was strech out between 650 m dpl and 820 m dpl. In each elevation of 100 dpl there was installed 30 random plots. It considered the increasing of elevation was 100 m dpl.

RESULTS AND DISCUSSION

In each plot, there was recorded type of vegetation with tree habitus and then it was carried out the analysis of vegetation Result showed that there was 42 species of trees in location of research. Analysis results of density, relative density, frequency, relative frequency, domination, relative domination, and important index value was presented as in Table 2 below. This data showed that the variation of composition and structure of vegetation was caused by the difference character of each tree. According to Krimmins [5], variation of structure and composition of vegetation in a community was influenced by different vertility and fecundity on each species so that there was different structure and composition of each species.

The value of density in Table 2 showed that there was variation of individual or tree number of 42 species. The total of this species was 574 trees with variation of measurement and architecture model. The highest absolute density was 65 and relative density was 11.32. It was found at the type of *Elmerrellia celebica.* Absolute and relative density was a parameter which could be the base for getting the image of tree position in the ecosystem. The relative value of 11.32 showed that approximate to 11% of total trees in this ecosystem were *Elmerrellia celebica*, so that the position of this type of tree in this ecosystem was so important.

Eugenia aromaticum was the type with second highest of density. The density of this type was 58 and its relative density was 10.1. This value indicated that *Eugenia aromaticum* had important value in the ecosystem of Tondano Watershed because there was 10 % of total type in this location. This type was planted by local society so that the process of growth was not natural. Where as *E.aromaticum* ecologically had to get attention because the position in ecosystem was high enough.

The other type with high enough of density and relative density for more than 5% was *Theobroma cocao, Garcinia mangostana,* and *Arenga pinnata*. Each of type had density 48, 41, and 39. These three types were important type too because the number of these types were so crowded and averaged distributed in all location. Where as these three types were as vegetations, but for the type of *G.mangostana* and *A. pinnata* were still found in the forest of Tondano Watershed.

Frequency value of *Elmerrellia celebica* was 80. It meaned that from 30 total plots observed, 24 plots (= 80 %) was as this type. Therefore, *E. celebica* had the highest density and frequency and it was assumed as crowded type and was distributed in almost all of the location. These 2 values was important because they were related among others. According to Greig-Smith, the value of frequency was directly influenced by density and distribution pattern. The value distribution still gave the information of the presence of certain veetation in one plot and it could not give illustration about the number of indivuduals in each plot.

In this research, the selection of quadratic method and its locating had been carried out with standard procedure so that the value of frequency was really hoped to illustrate the field condition. Analysis of quadratic was determined with applying method of area species curve [6] and it was fit with general standard. Therefore, the two species (kinston wood and wasian) which had highest value of density and frequency was included as species with best ability of adaptation to environment.

Table 2 INP value otype of tree on tropica zone in upstream of Tondano Watershed

No	Scientific name	Location	KM	KR	F	FM	FR	DM	DR	INP
1	*Elmerellia celebica*	Wasian wood	65	11.32	24	80.00	7.89	2940.60	18.05	37.27
2	*Eugenia aromaticum*	Red pepper	58	10.10	20	66.67	6.58	913.50	5.67	22.29
3	*Theobroma cocao*	Cocoa	46	8.01	17	56.67	5.59	565.80	3.47	17.08
4	*Garcinia mangostana*	Mangosteen	41	7.14	16	53.33	5.26	1292.73	7.93	20.34
5	*Arenga pinnata*	Palm	39	6.79	14	46.67	4.60	1068.99	6.56	17.96
6	*Aegiceras floridum*	Wangurer wood	25	4.35	14	46.67	4.60	473.04	2.90	12.21
7	*Bruguiera gymnorrhiza*	Uhu wood	25	4.35	12	40.00	3.95	670.50	4.11	12.42
8	*Avicennia intermedia*	Canarium commune	24	4.18	15	50.00	4.93	754.80	4.63	13.75
9	*Pongemia pinnata*	Tuama wood	24	4.18	13	43.33	4.28	794.88	4.88	13.34
10	*Cananga odorata*	Fires wood	21	3.66	12	40.00	3.95	740.88	4.55	12.15
11	*Dillenia cerrata*	Fires wood	18	3.13	11	36.67	3.62	455.58	2.80	9.55
12	*Pometetia pinnata*	Baju wood	17	2.96	8	26.67	2.63	614.04	3.77	9.36
13	*Cananga odorata*	Bangko wood	17	2.96	10	33.33	3.29	418.37	2.57	8.82
14	*Dillenia ochreata*	Bualo wood	16	2.79	12	40.00	3.95	438.56	2.69	9.43
15	*Canarium balsamiferum*	Iron wood	16	2.79	10	33.33	3.29	557.12	3.42	9.50
16	*Hypobathrum frutescens*	Danoan wood	16	2.79	9	30.00	2.96	466.24	2.86	8.61
17	*Alstonia scholaris*	Dengilo wood	12	2.09	7	23.33	2.30	274.44	1.68	6.08
18	*Ficus erecta*	Amurang wood	10	1.74	8	26.67	2.63	326.10	2.00	6.37
19	*Engerhardia rigida*	Emporia wood	10	1.74	9	30.00	2.96	310.70	1.91	6.61
20	*Myristica celebica*	Duguan wood	10	1.74	5	16.67	1.64	293.50	1.80	5.19
21	*Litsea albayana*	Kenanga wood	9	1.57	5	16.67	1.64	258.39	1.58	4.80
22	*Pterospermum celebicum*	Ketena wood	9	1.57	5	16.67	1.64	237.96	1.46	4.67
23	*Turpinia sphaerocarpa*	Kelemur wood	9	1.57	6	20.00	1.97	211.59	1.30	4.84
24	*Aglaia elaeagnoidea*	Kase wood	9	1.57	4	13.33	1.31	226.71	1.39	4.27
25	*Evodia celebica*	Karikis wood	8	1.39	3	10.00	0.99	177.36	1.09	3.47
26	*Antidesma celebicum*	Kinton wood	7	1.22	3	10.00	0.99	137.41	0.84	3.05
27	*Fragrae fragrans*	Kutungga wood	6	1.04	2	6.67	0.66	160.26	0.98	2.67
28	*Premna tumentosa*	Komea wood	6	1.04	4	13.33	1.316	187.08	1.15	3.51
29	*Vibirnum sp*	Kulahi wood	6	1.04	3	10.00	0.99	164.88	1.01	3.04
30	*Toona celebica*	Usu wood	5	0.87	2	6.67	0.66	165.95	1.02	2.55
31	*Avicennia intermedia*	Waka wood	5	0.87	4	13.33	1.31	138.15	0.85	3.03
32	*Polyalthia celebica*	Lonu wood	4	0.70	2	6.67	0.66	103.24	0.63	1.99
33	*Eugenia therniana*	Waneran wood	4	0.70	2	6.67	0.66	120.64	0.74	2.09
34	*Manilkara celebica*	Moput wood	4	0.70	3	10.00	0.99	86.48	0.53	2.21
35	*Aglaea argentea*	Lai wood	3	0.52	2	6.67	0.66	104.04	0.64	1.82
36	*Pometia tomentosa*	Alas wood	3	0.52	1	3.33	0.33	88.53	0.54	1.39
37	*Pygeum rumphii*	Tongge wood	3	0.52	1	3.33	0.33	79.23	0.49	1.34
38	*Dracontomelon dao*	Yatako wood	3	0.52	1	3.33	0.33	67.74	0.41	1.27
39	*Mallotus ricinoides*	Owusel wood	3	0.52	2	6.67	0.66	85.29	0.52	1.70
40	*Mimusops elengi*	Uloto wood	2	0.35	1	3.33	0.33	62.54	0.38	1.06
41	*Litsea mappacea*	Wote wood	2	0.35	1	3.33	0.33	59.66	0.37	1.04
42	*Vitex cofassus*		1	0.17	1	3.33	0.33	18.62	0.11	0.62
	TOTAL		574	100	304	1013.33	100	16292.26	100	300

Note : KM = absolute density KR = relative density
F = frequency FM = absolute frequency
FR = relative frequency
DM = absolute domination DR = relative domination
INP = important value of index

The success of each type to occupate an area was influenced by its ability to adapt optimally to the whole factors of physical environment (they were included temperature, sun shine, soil structure, humidity, etc), biotic factors (they were included interaction among species, competition, parasitism, etc), and chemical factors (they were included water supply, oxygen, pH, nutrision in soil, etc) which was interaction among each other.

Domination value of type was analysed by considering the diametre of stem and the number of certain type in its ecosystem. Result showed that *E.celebica* had the highest domination value of 2940.6 and relative domination value of 18.05%. The other type that had high enough domination value was 1) *E.aromatic* (the domination value was 913.5 and the relative domination was 5.61%); 2) *T. cacao* (the domination value was 565.8 and relative domination was 3,47%); 3) *G. mangostana* (the domination value was 1292.73 and relative domination was 7.93%); and 4) s*A.pinnata* (the domination value was 1068.99 and relative domination was 6.56%). The variety of domination value was determined by the dimension of each stem for the same type of tree. Bigger dimension of stem and higher density would cause higher domination value. If domination value was more than 15, it indicated that these five types had different domination.

Important value of index (INP) indicated the type position at location of research. Types of *E.celebica, E.aromaticum, T.cacao, G.mangostana*, and *A. pinnata* had the highest INP. The total number INP of these five types were 114.94 or about 38% of total INP of the whole types found in location of research. This result showed that the five types were dominant in the ecosystem of Tondano Watershed. It indicated that these types had ability to adapt in the whole location of research. Type of *E.celebica* which had bigger diametre of stem, was predicted formerly growing where as this type was frequently disturb because of cutting as source of wood for furniture.

Based on the INP value of the whole types, it was analysed diversity index (H') due to Shannon-Wiener. Result showed that diversity index of species at the whole plot was 2.29. Diversity index of 2.29 was in the category of medium. This value indicated the property of trees species in the location of research. Because of diversity index only analysed tree habitus, the variety of species in the location was really higher than this value. This condition indicated that ecosystem in the location of research was not so stabil because there was high human interfering in this ecosystem. The structure and composition of forest was very influenced with disturbance naturally as well as anthropogenically.

Based on the variety of value as above, for the next it could determine average value of species in the community. The average value was 1.68. High averaged of type in the location of research caused higher average value.

Table 3 Distribution pattern type of tree on tropica zone in upstream of Tondano Watershed

No	Scientific name	∑X	∑X²	SD	Average	Standard deviation	Distribution
1	*Elmerellia celebica*	65	369	4.07	3.03	1.34	Group
2	*Eugenia aromaticum*	58	267	2.37	2.43	1.30	Regular
3	*Theobroma cocao*	46	138	1.58	1.67	1.04	Regular
4	*Garcinia mangostana*	41	151	2.01	1.63	1.23	Group
5	*Arenga pinnata*	39	134	1.91	1.40	1.36	Regular
6	*Aegiceras floridum*	25	91	1.29	1.17	1.10	Group
7	*Bruguiera gymnorrhiza*	25	72	1.04	1.00	1.04	Regular
8	*Avicennia intermedia*	24	71	1.05	0.97	1.08	Group
9	*Pongemia pinnata*	24	64	0.97	0.87	1.12	Group
10	*Cananga odorata*	21	56	0.82	0.87	0.95	Regular
11	*Dillenia cerrata*	18	68	1.05	0.87	1.21	Group
12	*Pometetia pinnata*	17	68	1.08	0.80	1.35	Group
13	*Cananga odorata*	17	47	0.73	0.70	1.05	Group
14	*Dillenia ochreata*	16	42	0.68	0.60	1.13	Group
15	*Canarium balsamiferum*	16	29	0.45	0.57	0.79	Regular
16	*Hypobathrum frutescens*	16	27	0.41	0.57	0.72	Regular
17	*Alstonia scholaris*	12	37	0.59	0.57	1.05	Group
18	*Ficus erecta*	10	32	0.51	0.53	0.96	Regular
19	*Engerhardia rigida*	10	52	0.89	0.53	1.67	Group
20	*Myristica celebica*	10	31	0.51	0.50	1.01	Group
21	*Litsea albayana*	9	33	0.54	0.50	1.09	Group
22	*Pterospermum celebicum*	9	28	0.46	0.47	0.98	Regular
23	*Turpinia sphaerocarpa*	9	32	0.54	0.47	1.15	Group
24	*Aglaia elaeagnoidea*	9	23	0.39	0.37	1.07	Group
25	*Evodia celebica*	8	23	0.39	0.37	1.07	Group
26	*Antidesma celebicum*	7	16	0.27	0.33	0.80	Regular
27	*Fragrae fragrans*	6	15	0.27	0.23	1.14	Group
28	*Premna tumentosa*	6	14	0.25	0.20	1.26	Group
29	*Vibirnum sp*	6	12	0.21	0.20	1.07	Group
30	*Toona celebica*	5	14	0.25	0.20	1.26	Group
31	*Avicennia intermedia*	5	9	0.16	0.17	0.97	Regular
32	*Polyalthia celebica*	4	9	0.16	0.17	0.97	Regular
33	*Eugenia therniana*	4	6	0.11	0.13	0.81	Regular
34	*Manilkara celebica*	4	10	0.18	0.13	1.37	Group
35	*Aglaea argentea*	3	6	0.11	0.13	0.81	Regular
36	*Pometia tomentosa*	3	4	0.07	0.13	0.52	Regular
37	*Pygeum rumphii*	3	5	0.09	0.10	0.91	Regular
38	*Dracontomelon dao*	3	3	0.05	0.10	0.53	Regular
39	*Mallotus ricinoides*	3	3	0.05	0.10	0.53	Regular
40	*Mimusops elengi*	2	3	0.05	0.10	0.53	Regular
41	*Litsea mappacea*	2	3	0.05	0.10	0.53	Regular
42	*Vitex cofassus*	1	3	0.05	0.10	0.53	Regular

Certain type with group distribution was caused by general seed or propagule of each vegetation would fall surround the mother of vegetation. Therefore if there was supported by other condition, regeneration was occured surround the mother of vegetation. This type was generally supported by wind so if the seed was relative big, it could not distribute in big radius. Type of tree with regular spatial distribution was generally distributed by zoochori or anthropochori, so that this type could distribute with regular pattern at location of research.

CONCLUSION

Based on the results as above, it was concluded that vegetation in the upstream of Tondano Watershed had diversity index of medium category. Result showed that there were 5 types of species which had highest important value of index. These 5 species were *E. celebica, E. aromaticum, G. mangostana, A. pinnata* and *T. cocao*.

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