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Vegetation Analysis on the Upper Mahakam River Border

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Abstract. Vegetation analysis on the upper Mahakam river border. The Mahakam River Basin (DAS) is very wide, reaching 7.724.300 Ha. The condition of the vegetation in the Mahakam watershed continues to change due to the development of plantations, mining, and settlements. On the other hand, efforts to maintain biological resources from the diversity of vegetation are needed to protect against extinction. Remote sensing data can be used to differentiate between primary and secondary vegetation economically. However, it has limitations for detecting vegetation composition and the number of individuals per unit area. Therefore, field surveys in the context of conducting vegetation analysis are still needed to complement remote sensing data. This study aims to analyze the vegetation in each growth phase, namely the seedling, sapling, pole, and tree phases on the Mahakam riverbank. The method used is to make observation plots of 13 plots for each growth phase. Plots of 2 x 2 m^2 for seedling observation, 5 x 5 m^2 for sapling level, 10 x 10 m^2 for pole level, and 20 x 20 m^2 for tree level observation. Based on data analysis, the seedling stage consisted of 30 species, the average number of stems was 25576.9 per ha, the species diversity index was 1.371, and the highest important value index was 21.8% of Coffea robusta. There were 17 species of saplings, an average number of 4,092.3 stems per hectare, a diversity index of 1,118, and the highest important value index of 39.5% from Theobroma cacao. The pole level contained 16 species, the average number of stems was 1023.1 per hectare, the diversity index was 1.138, and the highest interest index was 23.7% for Paraserianthes falcataria. The tree level consists of 30 species. The average number of stems is 255.8 per hectare, the diversity index is 1.282, and the highest important value index is 54.9% of Durio zibethinus. From the results of the study, it can be concluded that most of the vegetation in the Mahakam riverbank area is former fields or agricultural activities.
***Keywords*:** Importance Value Index, Mahakam River, Succession, Vegetation Analysis

I. INTRODUCTION

The earth's surface condition is always changing time by time. Indonesia has several types of vegetation such as peat swamp forests (Astiani, 2021), mountains forest (Gunawan, 2011), and others. In general, the change of the earth's surface was caused by the transfer of land use functions in the context of development activities. Development that is not environmentally friendly can cause disasters in the future (Azizah, 2017). Mahakam River is one of the main rivers in East Kalimantan with a watershed area of *Daerah Aliran Sungai* (DAS) covered of 7,724,300 hectares. Spatially located at 113°49'51,6" E- 117°37'48" E and 1°51'39,6" N – 1°9'27" S (Suparjo et al 2019). This river consists of 37 tributaries that form several sub-DAS of Mahakam. Land cover change in the Mahakam River watershed run dynamically due to human activities, especially along the river border. Such as urban park can mitigate climate change by storing carbon (Muhlisin, 2021), and the river border is a big park with a bigger capacity for storing carbon. Land cover changing can be monitored periodically using remote sensing data. From these data, can be distinguished between primary and secondary vegetation that undergo a secondary succession process. However, remote sensing data has limitations, especially in detecting the diversity of plant species and the number of individuals per unit area. Therefore, terrestrial surveys of vegetation for the purposes of vegetation analysis are still needed to complement the results of remote sensing data analysis, especially along the Mahakam river bank. Santoso et al (2018) define the boundary of the river area and the river's benefit area is a river with embankments in the defined river boundary line three meters from the edge of the outer embankments is river border. The river border is an area that has the easiest accessibility to be reached using river vehicles, so that not a few people use the area as settlements, industrial activities, agricultural

cultivation land, and plantation cultivation. These activities have the potential to reduce the biodiversity of vegetation on the riverbanks. To find out how much the diversity of biodiversity in riparian rivers has decreased, a vegetation analysis can be carried out, namely taking an inventory of the number and types of vegetation at all growth phases, namely the level of seedlings, saplings, poles and trees. As we know one of the characteristics of land in East Kalimantan has low fertility (Mulyani and Sarwani, 2013). Therefore, land clearing for farming in general can only be done a few times the planting cycle and after that it is left to move to other land (Lay, 2015). However, before being left, generally people planted the perennials in the form of fruit trees as a sign of land cultivation.

A few years later he returned to his former land for replanting. In East Kalimantan this system is known as the rotational cultivation system (Babikir, 1981). During left, there was a natural succession on land. After the rotation, how is the plant succession going on the ex-swidden land taking place, what types are able to grow and what are the individual densities in each growth phase? With the limitations of remote sensing in identifying vegetation types at various stages of forest growth in areas where natural succession takes place, a terrestrial survey is required. Based on this, it is necessary to conduct a study on the analysis of vegetation along the Mahakam River, especially in the upper and middle parts with the consideration that the ecology of this area has high conservation value. Similar things have been studied by (Siregar et al. 2019; Siregar et al. 2018; Hidayat et al. 2018 and Helmanto et al. 2020) in several parts of the forest in North Sulawesi, in the Bali Botanical Garden, and in the Sampit Botanical Garden area. However, their habitat is different from the riverbanks.

This study aims to analyze the vegetation in the upper and middle Mahakam River basin areas, identify the successional processes that occur and identify the important values of species and species diversity. From this research, it is known the diversity of vegetation types, vegetation density, and the important value index of each type. This study is limited by the following scope:

1) The study area is not more than 100 meters from the river bank
2) The growth phase includes seedlings, saplings, poles, and trees
3) Parameters studied include vegetation type, diameter at breast height, number of individuals per unit area

From the results of the study it can be suggested not to open new land, but to return to the original land that was left and carry out enrichment planting, especially with local vegetation types.

II. MATERIALS AND METHODS

Study area was located at along Mahakam river border of Mahakam Ulu and West Kutai Regency, East Kalimantan. Vegetation observation plots were placed in 5 consecutive locations from upstream to downstream, namely the villages of Liu Mulang, Batumajang, Long Merah, Muara Ratah and Minta. The plot's location was not more than five hundred meters from the river border. The average distance between plot locations is 59.5 Km. Map of the research location is shown in Figure 1. The object of research consisted of all vegetation species with seedling, sapling, pole, and tree levels at the field.

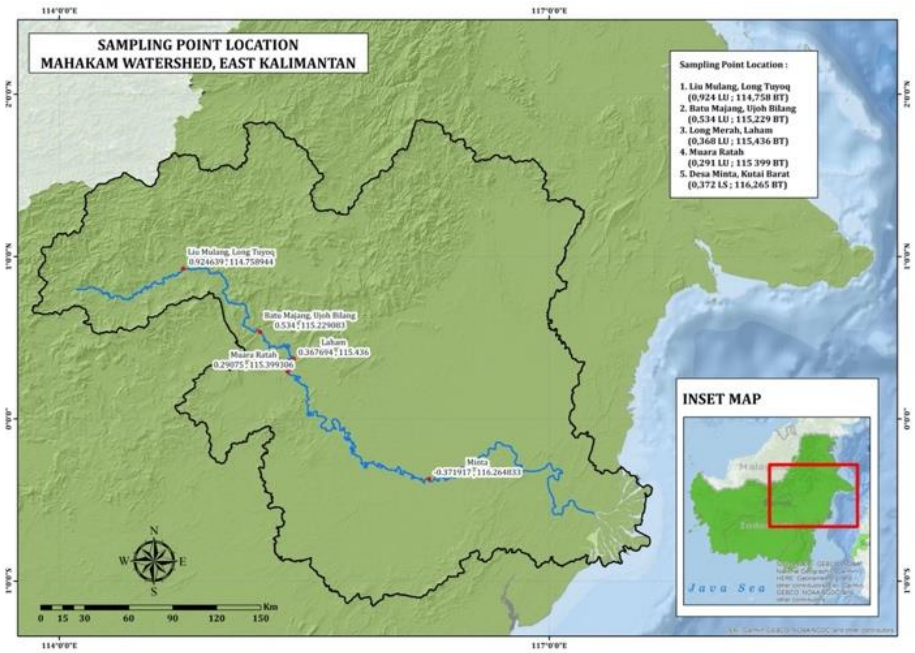

Figure 1. Plot Locations Along Mahakam Watershed.

Procedures

1. Sampling location determination
   The sampling locations were determined based on the coordinates that have been previously determined in accordance with the sampling location map. The sampling locations were determined purposively at the river border with a maximum distance of 100 meters from the river bank. The total observation plots for each growth phase were 13 plots. The plot sizes were 20 m x 20 m for tree observation, 10 m x 10 m for poles, 5 m x 5 m for saplings, and 2 m x 2 m for seedlings. Parameters observed in each plot were plant species, number of individuals, and diameter at breast height specifically for trees. Data collected was calculated by the species significance index or called *Indeks Nilai Penting* (INP) and the Shanon Winer species diversity index (H').
2. Data collection
   Data collection is one of the most important in the research procedure. It can be held by remote sensing data. According to Sing et al (2020) relationship between the object of interest and sensor-specific resolution characteristics such as spatial, spectral, radiometric, and temporal resolutions. However, field data is still needed for specific purposes. The field data collected collection procedure consisted of:
   a) on a 20 m x 20 m plot size, data recorded consist of diameter breast height for all trees, tree species identification, and the number of trees.
   b) on the 10 m x 10 m plot, the species and number of trees at the pole level were recorded.
   c) on the 5 m x 5 m plot, the number and species of trees at the sapling level are recorded.
   d) on a 2 m x 2 m plot, seedlings and species were recorded.
3. Data analysis
   The calculated parameters include Dr, KR, Fr, INP, and H' as indicated respectively in equations (1), (2), (3), (4), and (5).

$$Dr = \frac{ba}{Ba} \qquad \text{eq.(1)}$$

$$Kr = \frac{ni}{Ni} \qquad \text{eq.(2)}$$

$$Fr = \frac{\sum n}{\sum N} \qquad \text{eq. (3)}$$

$$INP = Dr + Fr + Kr \qquad \text{eq. (4)}$$

$$H' = -\sum \frac{ni}{N} \log \frac{ni}{N} \qquad \text{eq. (5)}$$

Where: Dr is relative dominance,
Kr is relative density,
Fr is relative frequency,
Ba is the total basal area of a species,
Ba is the total basal area of all species,
Ni is total number of certain species and
Ni is total number of all species,
n is the total plot which attended by a species and
N is the total plot attended by all species.

Summed Dominance Ratio (SDR) index was used to analyze the plant species dominance and frequency (Muhlisin 2021, Magguran,1988), it was calculated by formula (5) (Iskandar and Iskandar 2016).

III. Results and Discussion

The results of vegetation analysis data for all growth levels of seedlings, saplings, poles, and trees are summarized into a table as presented in Table 1.

Table 1. Vegetation Analysis Result.

#	Growth level	Number of Species	Average number/ hectare	H'	Maximum					Species
					n	Dr (%)	Kr (%)	Fr (%)	INP (%)	
1.	Seedling	30	25576.9	1.371	36	-	13.3	8.5	21,8	*Coffea robusta*
2.	Sapling	17	4092.3	1.118	10	-	14.5	25.0	39.5	*Theobroma cacao*
3.	Pole	16	1023.1	1.138	7	-	16.3	7.4	23.7	*P. falcataria*
4.	Tree	30	255.8	1.282	25	25.2	18.8	10.9	54.9	*Durio zibethinus*

1. Seedling phase

From Table 1. it is known that in the growth phase of the seedling level, there were 30 speciose that were successfully observed. The average number of seedlings was 25576.9 stems per hectare. According to the environmental quality scale, tree density (Bambang, 2011) was very dense. Shanon Winer's diversity index (H') is 1.37. According to the environmental quality scale criteria, species diversity (Bambang, 2011) was categorized as less diverse. The highest importance value index or *Indek Nilai Penting* (INP) at the seedling level was owned by species of Coffee (*Coffea robusta*) with a value of 21.8%. Coffee is a type of cultivated plant. Thus, based on the type of vegetation, the Mahakam River border is an area of former cultivation gardens, although natural succession took place. The complete data of seedlings was indicated in Table 2.

Table 2. Vegetation analysis of seedling level growth.

#	Local Name	Botanical Title	Number of Seedlings (N)	Attended Plots (F)	Kr (%)	Fr (%)	NPJ (%)
1	Kopi	*Coffea robusta*	36	5	13.3	8.5	21.8
2	Medang	*Litsea firma Hook*	40	1	14.8	1.7	16.5
3	Kapur	*Dryobalanops aromatica*	37	1	13.7	1.7	15.4
4	Jambu-jambuan	*Eugenia sp*	24	3	8.9	5.1	14.0
5	Kopi2an	*Leea indica*	14	4	5.2	6.8	12.0
6	Jingalon	*Baccaurea lanceolata*	6	5	2.2	8.5	10.7
7	Mindi-mindian	*meliaceae*	18	2	6.7	3.4	10.1
8	Durian	*Durio zibethinus*	13	3	4.8	5.1	9.9
9	Terap	*Artocarpus odoratissima*	10	3	3.7	5.1	8.8
10	Aren	*Arenga pinnata*	4	4	1.5	6.8	8.3
11	Laban	*Vitex pubescens*	12	1	4.4	1.7	6.1
12	Pisang	*Musa sp*	10	1	3.7	1.7	5.4
13	Jengkol	*Archidendron pauciflorum*	5	2	1.9	3.4	5.2
14	Waru	*Hibiscus tiliaceus*	4	2	1.5	3.4	4.9
15	Rambutan	*Nephelium lapacium*	3	2	1.1	3.4	4.5
16	simpur	*Dillenia indica*	3	2	1.1	3.4	4.5
17	Kakao	*Theobroma cacao*	3	2	1.1	3.4	4.5
18	Kapas-kapasan	*Malvaceae*	7	1	2.6	1.7	4.3
19	Makaranga	*Macaranga gigantea*	2	2	0.7	3.4	4.1
20	Makaranga	*Macaranga triloba*	2	2	0.7	3.4	4.1
21	Keruing	*Dipterocarpus cornutus*	2	2	0.7	3.4	4.1
22	Jambu air	*Syzygium aqueum*	4	1	1.5	1.7	3.2
23	Lengkeng	*Dimocarpus longan*	2	1	0.7	1.7	2.4
24	Makaranga	*Macaranga lowii*	2	1	0.7	1.7	2.4
25	Sirih hutan	*Piper aduncum*	2	1	0.7	1.7	2.4
26	Manggis hutan	*Garcinia bancana*	1	1	0.4	1.7	2.1
27	Gempol	*Nauclea orientalis*	1	1	0.4	1.7	2.1
28	Asam-asaman	*Baccaurea sp*	1	1	0.4	1.7	2.1
29	Kedondong htn	*Spondias pinnata*	1	1	0.4	1.7	2.1
30	Langsat	*Lansium domesticum*	1	1	0.4	1.7	2.1
	Total:		270	59	100.0	100.0	200.0

2. Stake phase

At the sapling level, there were 17 identified plant species. The average number of individual saplings was 4292.3 stems per hectare. According to the environmental quality scale, tree density was very dense. The Shanon Winer (H') diversity index was 1.118. According to the environmental quality scale criteria, species diversity was categorized as less diverse. The highest importance value index of species at the sapling level was 39.5%, owned by *Theobroma cacao*. Is a type of cultivated plant. Based on the type of vegetation, the Mahakam river border is an area of former cultivation gardens. The complete data of stake level was indicated in Table 3.

Table 3. Vegetation analysis of sapling level.

#	Local Name	Botanical Title	Number of Trees (N)	Attended Plots (F)	Kr (%)	Fr (%)	NPJ (%)
1	Kakao	*Theobroma cacao*	10	6	14.5	25.0	39.5
2	Laban	*Vitex pubescens*	16	1	23.2	4.2	27.4
3	Terap	*Artocarpus integra*	11	1	15.9	4.2	20.1
4	Kapur	*Dryobalanops aromatica*	9	1	13.0	4.2	17.2
5	Sengon	*Paraserianthes falcataria*	5	2	7.2	8.3	15.6
6	Durian	*Durio zibethinus*	3	2	4.3	8.3	12.7
7	Terentang	*Campnosperma auriculata*	5	1	7.2	4.2	11.4
8	Mindi2an	*Meliaceae*	1	1	1.4	4.2	5.6
9	Simpur	*Dillenia indica*	1	1	1.4	4.2	5.6
10	Pinang	*Areca catecu*	1	1	1.4	4.2	5.6
11	Kayu hitam	*Diospyros bornensis*	1	1	1.4	4.2	5.6
12	Asam-asaman	*Baccaurea sp*	1	1	1.4	4.2	5.6
13	Meranti merah	*Shorea leprosula*	1	1	1.4	4.2	5.6
14	Langsat	*Lansium domesticum*	1	1	1.4	4.2	5.6
15	Jambu air	*Syzygium aqueum*	1	1	1.4	4.2	5.6
16	Kopi	*Coffea robusta*	1	1	1.4	4.2	5.6
17	Pinang	*Areca catechu*	1	1	1.4	4.2	5.6
	Total :		69	24	100.0	100.0	200.0

3. Pole phase

In the phase of pole level, 16 species of plants were identified. The average number of individual pole levels is 1023.1 stems per hectare. According to the environmental quality scale, tree density was very dense. Shanon Winer's diversity index (H') was 1.138. According to the environmental quality scale criteria, species diversity was categorized as less diverse. The highest importance value index of species at the pole level 23.7 % belonged to *Paraserianthes falcataria* with the local name Sengon. Sengon is a pioneer type of cultivated vegetation. Based on the type of vegetation, the Mahakam River border is a cultivation area. The complete data of the pole level was indicated in Table 4.

Table 4. Vegetation analysis of pole level.

#	Local Name	Botanical Name	Number of Trees (N)	Number of Attended Plots (F)	Kr (%)	Fr (%)	NPJ (%)
1	Sengon	*Paraserianthes falcataria*	7	2	16.3	7.4	23.7
2	Pinang	*Areca catechu*	5	3	11.6	11.1	22.7
3	Kakao	*Theobroma cacao*	5	3	11.6	11.1	22.7
4	Durian	*Durio zibethinus*	6	2	14.0	7.4	21.4
5	Asam-asaman	*Baccaurea sp*	5	2	11.6	7.4	19.0
6	Laban	*Vitex pubescens*	1	4	2.3	14.8	17.1
7	Rambutan	*Nephelium lapacium*	2	2	4.7	7.4	12.1
8	Ihau	*Dimocarpus longan*	2	1	4.7	3.7	8.4
9	Kapur	*Dryobalanops armatica*	2	1	4.7	3.7	8.4
10	Ara	*Ficus carica*	2	1	4.7	3.7	8.4
11	Simpur	*Dillenia indica*	1	1	2.3	3.7	6.0
12	Langsat	*Lansium domesticum*	1	1	2.3	3.7	6.0
13	Terentang	*Camnosperma*	1	1	2.3	3.7	6.0
14	Meranti Merah	*Shorea pinanga*	1	1	2.3	3.7	6.0
15	Merawan	*Hopea pierrei*	1	1	2.3	3.7	6.0
16	Belimbing	*Averrhoa carambola*	1	1	2.3	3.7	6.0
	Total:		43	27	100.0	100.0	200.0

4. Tree phase

Tree growth phase level was known that there were 30 species of plants identified. The average number of tree-level individuals were 255.8 stems per hectare. According to the environmental quality scale, the tree density was very dense. Shanon Winer's diversity index (H') 1.282. According to the environmental quality scale criteria, species diversity was categorized as less diverse. The highest species importance value index of tree level 54.9% was owned by durian or *Durio zibethinus*. Durian is a type of vegetation that is widely cultivated by community. In the observation plot there were 25 durian trees. The relative dominance of the durian tree was 25.2%. The average diameter breast height of durian tree at the study area was 38.275 cm. From the diameter of the stem, it was estimated that the age of durian has reached tens of years. The complete data of tree level was indicated in Table 5.

Table 5. Vegetation analysis of tree level growth.

#	Local Name	Botanical Title	Base Area (m^2)	Number o Trees (N)	Attended Plots (F)	Dr (%)	Kr (%)	Fr (%)	INP (%)
1	Durian	*Durio zibethinus*	16.5717	25	6	25.2	18.8	10.9	54.9
2	Sengon	*Paraserianthes falcataria*	13.2043	32	3	20.1	24.1	5.5	49.6
3	Kapur	*Drybalanops lanceolata*	4.356	7	4	6.6	5.3	7.3	19.2
4	Rambutan	*Nephelium lapacium*	2.0730	6	4	3.1	4.5	7.3	14.9
5	Keruing	*Dipterocarpus conutus*	3.3556	4	3	5.1	3.0	5.5	13.6
6	Ihau	*Dimocarpus longan*	2.2803	5	3	3.5	3.8	5.5	12.7
7	Binuang	*Octomelas sumatrana*	4.0691	3	2	6.2	2.3	3.6	12.1
8	Asam-asaman	*Baccaurea sp*	1.3517	4	3	2.1	3.0	5.5	10.5
9	Laban	*Vitex pubescens*	0.3118	9	1	0.5	6.8	1.8	9.1
10	Meranti merah	*Shorea pinanga*	2.0530	3	2	3.1	2.3	3.6	9.0
11	Langsat	*Lansium domesticum*	1.3735	4	2	2.1	3.0	3.6	8.7
12	Cempedak	*Artocarpus integer*	0.4812	3	3	0.7	2.3	5.5	8.4
13	Meranti kuning	*Shorea multiflora*	1.3429	2	2	2.0	1.5	3.6	7.2
14	Kedondong	*Spondias pinnata*	1.3417	3	1	2.0	2.3	1.8	6.1
15	Terap	*Artocarpus integra*	1.9864	1	1	3.0	0.8	1.8	5.6
16	Merawan	*Hopea pierrei*	1.4206	2	1	2.2	1.5	1.8	5.5
17	Meranti putih	*Shorea bracteolata Dyer*	1.2874	2	1	2.0	1.5	1.8	5.3
18	Karet	*Hevea brasilliensis*	1.2169	2	1	1.8	1.5	1.8	5.2
19	Angsana	*Pterocarpus indica*	0.5212	3	1	0.8	2.3	1.8	4.9
20	Aren	*Arenga pinnata*	0.7857	2	1	1.2	1.5	1.8	4.5
21	Medang	*Litsea firma Hook*	1.1075	1	1	1.7	0.8	1.8	4.3
22	Lai	*Durio Kutejensis*	0.4739	2	1	0.7	1.5	1.8	4.0
23	Duku	*Lansium domesticum*	0.6066	1	1	0.9	0.8	1.8	3.5
24	Mangga	*Mangifera indica*	0.5155	1	1	0.8	0.8	1.8	3.4
25	Matoa	*Pommetia pinnata*	0.5283	1	1	0.8	0.8	1.8	3.4
26	Nangka	*Artocarpus heterophyllus*	0.3350	1	1	0.5	0.8	1.8	3.1
27	Mahang	*Macaranga gigantea*	0.2643	1	1	0.4	0.8	1.8	3.0
28	Rambutan Hutan	*Castanopsis argentea*	0.3020	1	1	0.5	0.8	1.8	3.0
29	Asam Payang	*Mangifera pajang*	0.1662	1	1	0.3	0.8	1.8	2.8
30	Jambu2an	*Eugenia sp*	0.1386	1	1	0.2	0.8	1.8	2.8
	Total		65.822	133	55	100	100	100	300

Based on the distribution of dominant species of vegetation that composed the stand, it could be seen that the Mahakam River border area was generally former community land, both abandoned and still being managed by the community. The river border area is the area with the most accessible by the community. The community clears the fields for several years. In general, the soil in East Kalimantan has low fertility, it was abandoned within a certain time if its productivity has decreased. However, as a sign that the land had been worked on before it was abandoned, fruit trees were planted as a sign of land ownership. Such land by the local people of East Kalimantan is called *lembo*, and in Sanggau West Kalimantan is called Tembawang (Astiani and Ripin 2016). From remote sensing data, the vegetation structure of the Mahakam River border indicates a secondary vegetation type. Vegetation composition become an important thing because it gives several benefits and provides goods for people (Astiani and Ripin 2016). Although the distance between plot locations is spatially quite far, on average 59.5 km, the tendency of vegetation types tends to be similar. The main cause is traces of human intervention.

The succession process that takes place on the Mahakam River border occurs naturally. This can be proven by the average number of individuals per hectare at each stand growth phase. In the seedling phase, the number is abundant. But the number decreases with the increasing age of the tree and the size of the trunk diameter. From the 53 species found in the field, there are 4 species that

have each growth phase. They are *Baccaurea sp*, *Durio zibethinus*, *Dryobalanops aromatica and Vitex pubescens.* The succession process goes on naturally which is marked by the abundance of seedlings and decreases gradually with increasing age and plant size as indicated in Figure 2.

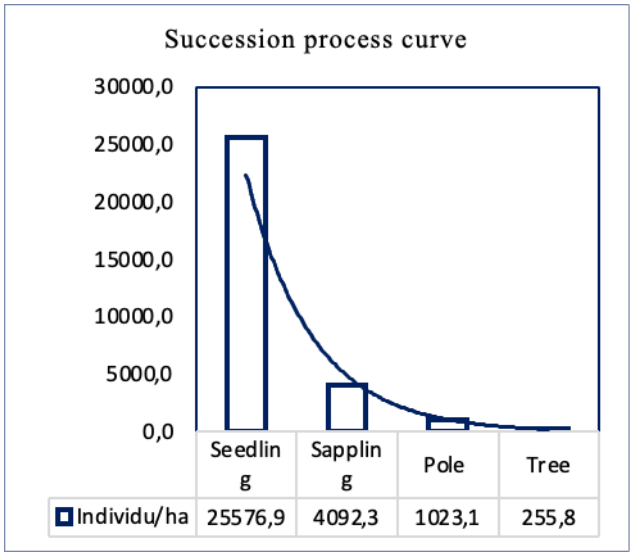

Figure 2. Succession process curve.

Base on Figure 2 it can be clearly seen that the development of vegetation occurs naturally, starting from the seedling level with abundance and decreasing along with the process of plant growth. As the age of the vegetation increases, the number decreases due to natural death. However, judging from the type of vegetation that grows, it shows that the study area is a former human cultivation area. To increase the growth of stand in the river border Suryanto et al (2018) recommend the using of Multi System Silviculture (MSS). It is suitable to be implemented in the upper river border of Mahakam.

IV. Conclusion

Based on the discussion above, it can be concluded that the type of vegetation in Mahakam watershed which is located on the river border is secondary vegetation. The majority of which are composed of plant species commonly cultivated by the community. The succession process runs naturally which is marked by the abundance of seedlings and decreases gradually with increasing age and plant size. This needs to be maintained in the future and increase the diversity of species on the banks of the river. The local species such as *Dryobalanops aromatica* existed in all phases of growth. *Durio zibethinus* has the highest species importance index among the others.

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