Ecology of *Scaphium macropodum* in the production forest area of Sarolangun, Jambi

Sutan Sahala Muda Marpaung[1,6*], *Rizky Febriana Br* Lubis[2,7], *Dini Hardiani* Has[3,7], *Sahat Raja Marigo* Girsang[3,7], *Edgar* Octoyuda[4], *Yulizar Ihrami* Rahmila[1,5], *Nusrah* Rusadi[6], *Lora Septrianda* Putri[6], *Zhafran Fatih* Ananda[7], and *Septian Putra Adi* Nugroho[8]

[1]Natural Resources and Environmental Management Science, Graduate School, IPB University, Bogor 16129, Indonesia
[2]Forestry Study Program, Faculty of Agriculture, Syiah Kuala University, Aceh, Nanggroe Aceh Darussalam, Indonesia
[3]Forest Management Study Program, Faculty of Agriculture and Forestry, Universitas Satya Terra Bhinneka, Medan, 20128, Indonesia
[4]College of Management, Department of Business Administration, Chaoyang University of Taiwan, 413310 Taichung, Taiwan
[5]Ecology and Ethnobiology Research Center, National Research and Innovation Agency, Bogor, Indonesia.
[6]Forestry Department, Kupang State Agricultural Polytechnic, Kupang, East Nusa Tenggara, Indonesia
[7]Informatics Study Program, Faculty of Tecnology and Computer Science, Universitas Satya Terra Bhinneka, Medan, 20128, Indonesia
[8]Tropical Biodiversity Conservation Study Program, Department of Forest Resources Conservation and Ecotourism, Faculty of Forestry and Environment, IPB University, Bogor 16680, Indonesia

Abstract. The Pengulu Tribe in Limun District, Sarolangun Regency, Jambi, has long utilized *Scaphium macropodum*, locally known as "merpayang" or "mempayang," in traditional medicine. This species, belonging to the Sterculiaceae family, has a broader distribution than its seven subspecies. This study aimed to assess the population and ecological characteristics of *S. macropodum* within Sarolangun's production forest, providing baseline data for its sustainable use by indigenous communities. Specifically, this study estimated the population size and analyzed the key ecological factors influencing habitat suitability. Conducted from December 2023 to January 2024, the study employed observational methods, interviews, and literature review, with data analyzed descriptively and qualitatively. Ecological parameters were examined using the Importance Value Index (IVI), diversity and evenness indices, community similarity analysis (Ward's method), and Principal Component Analysis (PCA). The results identified 47 tree species from 18 families within the habitat of *S. macropodum*. In APL NM and HA DM, *Shorea parviflora* dominated, while *Shorea multiflora* and *Canarium* sp. were prevalent in HL DT and APL DM. Shannon-Wiener diversity indices indicated moderate diversity and evenness across sites, with the highest similarity (90.81%) observed between APL NM and HA DM, while APL DM had the lowest diversity. These findings provide crucial insights into *S. macropodum* conservation, emphasizing the need for habitat preservation and sustainable utilization to support indigenous practices while mitigating environmental pressures.

* Corresponding author: marpaungsutan@apps.ipb.ac.id

1 Introduction

Plants are essential natural resources that play a crucial role in human life by providing food, medicine, and contributing to biodiversity and ecosystem stability [1-2]. One species of ecological and economic importance is *Scaphium macropodum* (Sterculiaceae), which is widely utilized by local communities. The Pengulu Tribe in Limun District, Sarolangun Regency, Jambi Province, traditionally uses the fruit of S. macropodum, locally known as “merpayang” or “mempayang”, for medicinal purposes. This species belongs to the Sterculiaceae family, which comprises seven subspecies, three of which are found on Sumatra Island. Among these, *S. macropodum* has the widest distribution and is extensively utilized in traditional medicine and timber production [3-4].

Despite its ecological and economic importance, *S. macropodum* is increasingly threatened by habitat destruction and overexploitation. According to the IUCN Red List (1998), this species is classified as *Least Concern (LC)*, meaning it remains relatively abundant in nature, although its distribution is restricted to Sumatra and Kalimantan [4-6]. Additionally, it is not classified as a rare or protected species under Government Regulation No. 8 of 1999. However, in recent decades, concerns about the sustainability of *S. macropodum* have increased, particularly in the Sarolangun Production Forest, Jambi, which faces environmental pressures due to plantation expansion and logging. Excessive utilization without proper conservation efforts could lead to habitat degradation and a decline in the species population. Therefore, ecological studies on *S. macropodum* are essential to assess its current population status and to identify the key environmental factors influencing its habitat.

This study aimed to estimate the population structure, density, and spatial distribution of *S. macropodum* in the Sarolangun Production Forest, Jambi, and to analyze the ecological factors affecting its habitat suitability. The findings of this research were expected to contribute to the sustainable management of *S. macropodum*, particularly under the jurisdiction of KPHP Limau Unit VII Hulu. Furthermore, this study provided a deeper understanding of *S. macropodum's* adaptation to human altered ecosystems, offering insights for conservation and management efforts.

2 Materials and methods

2.1 Time and location of research

Study This was implemented from December 2023 to January 2024 in the production forest area of the Regional Office Technical Implementation Unit (UPTD) Production Forest Management Unit (KPHP) LIMAU Unit VII Hulu, Regency Sarolangun, Jambi Province. There are four research locations, namely in the Other Use Area of Nepal Melintang Village (APL NM), Meribung Village Customary Forest (HA DM), Temalang Village Protected Forest (HL DT), and Mersip Village Other Use Area (APL DM), with heights around 293–470m above sea level. The description of the research location is presented in Figure 1 as follows.

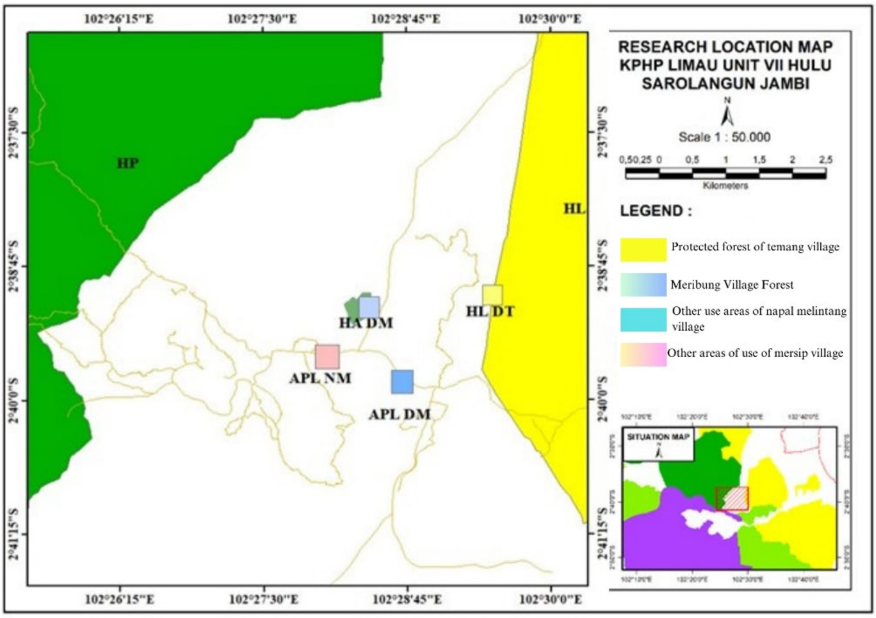

Fig.1. Study Location Map

2.2 Research tools and materials

Tools used in the data collection were thermometer air, lux meter, price meter, earth drill, meter, GPS, compass, binoculars, digital camera, tools write, and tally sheet. The object used was a questionnaire for interviews—the software used to help manage data in Microsoft Excel, Minitab 18, and ArcGis 10.5.

2.3 Procedure study

2.3.1 Population structure & density analysis

The population structure and density of *S. macropodum* were assessed using the single plot method, which is widely applied in vegetation studies [7]. The plot used is a square of 100 mx 100 m, further divided into 2–5 subplots of 20 m × 20 m (Fig.2). Vegetation analysis was conducted at different growth stages, including seedlings, saplings, poles, and mature trees. The collected data included the number of individuals at each growth stage, stem diameter and height measurements for saplings, poles, and trees, as well as ecological indices such as the Importance Value Index (IVI) to determine species dominance and the Shannon Wiener Index (H') to assess species diversity. The classification of tree growth stages followed:

1. Seedlings were defined as individuals with heights ≤1.5 m
2. Saplings had heights >1.5 m and diameters <10 cm
3. Poles had diameters between 10–20 cm
4. Mature trees had diameters >20 cm.

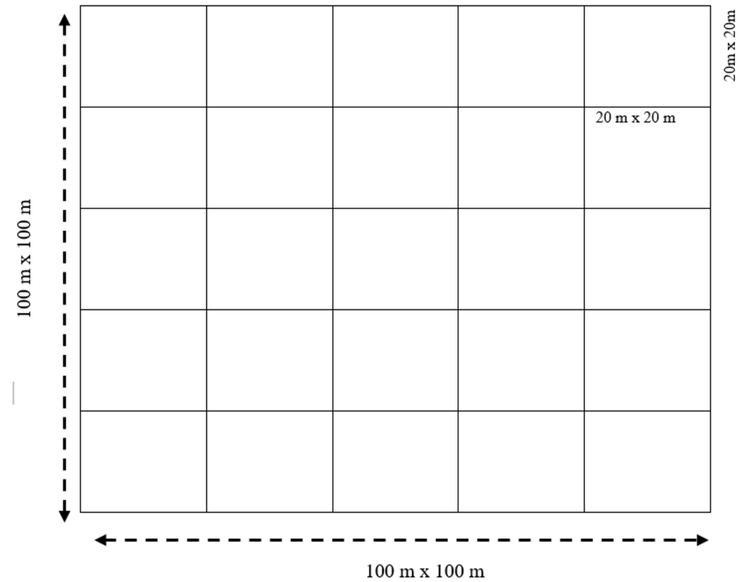

Figure 2. Illustration of single plot observation plot and measurement plot size at each growth level

2.3.2 Spatial distribution analysis

The spatial distribution of *S. macropodum* was analyzed to determine whether the species exhibits a random, uniform, or clumped distribution pattern. Data collection was conducted using 20 m × 20 m sample plots in each study location. The GPS coordinates of individual *S. macropodum* trees were recorded, and their distribution was analyzed using the Morisita Index (Id), which quantifies species aggregation levels.
To visualize the spatial distribution, ArcGIS 10.5 software was used to generate distribution maps of *S. macropodum* in the study area. The analysis results indicate the Morisita Index values and spatial distribution patterns, reflecting the species' distribution characteristics.
The spatial distribution pattern was determined based on the following criteria:
1. If Id ≥ Mc > 1.0, the distribution is clumped.
2. If Mc > Id ≥ 1.0, the distribution is random.
3. If 1.0 > Id > Mu, the distribution is uniform.

2.3.3 Ecological factor analysis

The ecological factors influencing *S. macropodum* were examined through an analysis of biotic and abiotic factors. Biotic factors included the density and composition of tree vegetation in the habitat of *S. macropodum* as well as seed dispersal mechanisms, particularly the role of wind and animals (e.g., monkeys and birds) in seed distribution. Abiotic factors measured in the field included temperature, humidity, light intensity, altitude, and slope, which were recorded using thermometers, lux meters, and GPS devices. Additionally, soil properties such as pH, nitrogen (N), phosphorus (P), and potassium (K) were analyzed from soil samples collected at 10 random points within each 100 m × 100 m plot, with testing conducted at IPB Soil Laboratory.

Samples were obtained using 10 soil drills weighing approximately 1.5 kg, composited following. The collected data were then compiled and statistically processed to identify patterns and key ecological variables. To determine the key ecological drivers affecting *S.*

macropodum, Principal Component Analysis (PCA) was used to reduce dimensionality and identify the most significant environmental variables. Additionally, multiple regression analysis was performed to assess the relationship between ecological factors and population density.

2.4 Data analysis

2.4.1 Importance value index (IVI)

Analysis of the structure and composition of vegetation was utilized to understand the composition and structure of a standing area forest. Vegetation analysis was conducted using the important value index (IVI) analysis. This analysis explains species dominance in an area by considering density, frequency, and dominance. The formula used is as follows:

$$\text{Density (De)} = \frac{\text{Individual number of a species}}{\text{Plot area (Ha)}} \quad (1)$$

$$\text{Relative density (RDe)} = \frac{\text{Density value of a species}}{\text{Density value of all species}} \times 100\% \quad (2)$$

$$\text{Frequency (Fr)} = \frac{\text{Number of plots where species were found}}{\text{Total number of plot}} \quad (3)$$

$$\text{Relative frequency (RFr)} = \frac{\text{Frequency value of a species}}{\text{Frequency value of all species}} \times 100\% \quad (4)$$

$$\text{Dominance a species (D)} = \frac{\text{Basal area of a species}}{\text{Plot area (Ha)}} \quad (5)$$

$$\text{Basal area} = \frac{1}{4}\pi d^2 \quad (6)$$

$$\text{Relative dominance (RDo)} = \frac{\text{Dominance value of a species}}{\text{Dominance value of all species}} \times 100\% \quad (7)$$

$$\text{Importance Value Index (IVI)} = RDe + RFr + RDo \text{ (stage of pole and tree)} \quad (8)$$

$$\text{Importance Value Index (IVI)} = RDe + RFr \text{ (stage of seedling and sapling)} \quad (9)$$

2.4.2 Shannon-wiener index (h´)

Diversity was analyzed using the Shannon-Wiener index. The Shannon-Wiener index is sensitive to the number of species found. The equation Shannon-Wiener Index is as follows:

$$H' = -\sum \quad pi\ ln\ ln\ pi \quad (10)$$

Description: H´ = Shannon-Wiener index; Pi = proportion individuals within a species ke-i (Σ n i / N); ni = number of individuals of the i-th species; and N = total number of individuals of all species found.

The criteria for the Shannon-Wiener index value (H´) are defined as follows;

a) An H´ value > 3 indicates that species diversity in an area is high
b) The value of H´ < H´ < 3 indicates moderate species diversity in an area
c) The value of H´ < 1 indicates that the species diversity in an area is small or low.

2.4.3 Index evenness

Degrees equality abundance was measured for each individual species using an index based on evenness, as outlined with equality:

$$E = \frac{H'}{Ln\,(S)} \tag{11}$$

Description : E = evenness value ; H´ = Shannon-Winner index ; Ln (S) = natural logarithm of the total number of individuals. The E value ranges from 0 – 1, where The E value approaching zero (0) indicates low evenness. On the contrary, if the E value approaches one (1), it indicates high evenness.

2.4.4 Community similarity index

Ward's method determines plant communities' similarity levels in four locations. This method is a clustering method that, in its stages, combines two clusters based on the minor level of variance. The Ward method equation used is:

$$E_m = \sum_{i=l}^{n_m} \quad \sum_{k=l}^{Pk} \quad (X_{ml,k} - \underline{X}_{m,k})^2 \tag{12}$$

Information :
Em = sum of squares of cluster errors m on k variables
XML,k = score owned on variable *k* (*k* = *1* ,..., *p*) for object *l* (1=1,...., n $_m$) in *cluster m* (m=1,.....,g)

Furthermore, dendrograms from other tree species communities were used to identify similarities in plant communities across research locations. This dendrogram can describe the connection between location studies based on the existence of other tree species. The dendrogram was made using the Minitab 18 software.

2.4.5 Index morisita (Id)

Distribution data *S. macropodum* processed with ArcGIS 10.5 software. Moreover, it is displayed in a form map and analyzed in a descriptive way. D nature was determined from its distribution using Index Morisita (Id). Researchers often use the Morisita (Id) index because it has a sample distribution with a derivative index that can be used to determine the distribution pattern, namely the standardized Morisita dispersion index denoted by I_p. The Index Morisita (Id) can be calculated in several stages, as follows:

$$Id = n\left[\frac{\Sigma x^2 - \Sigma x}{(\Sigma x)^2 - \Sigma x}\right] \tag{13}$$

$$Mu = \frac{\chi^2_{0.975} - n + \Sigma x}{(\Sigma x) - 1} \tag{14}$$

$$Mc = \frac{\chi^2_{0.025} - n + \Sigma x}{(\Sigma x) - 1} \tag{15}$$

Description: *Id* = Morisita index; n = number of plots; Σx = total of the number of individuals in the plot, Σx^2 = total of the squares of the number of individuals in the plot, *Mu* = uniform distribution pattern index; *Mc* = Clustered distribution pattern index; x^2 0.975 = value from the chi-square table with df (n-1) that has 97.5% of the area to the right of the curve, and x^2 0.025 = value from the chi-square table with df (n-1) that has 2.5% of the area to the right of the curve.

The decision rule for determining the form of the distribution pattern is as follows:

a) If the value $Id \geq Mc > 1.0$, then I_p is calculated using the equation:

$$Ip = 0.5 + 0.5\left(\frac{Id - Mc}{n - Mc}\right) \tag{16}$$

b) If the value $Mc > Id \geq 1.0$, then I_p is calculated by the equation:

$$Ip = 0.5\left(\frac{Id - 1}{Mc - 1}\right) \tag{17}$$

c) If the Value is 1.0 > Id > Mu, then I_p is calculated by the equation:

$$Ip = -0.5\left(\frac{Id - 1}{Mu - 1}\right) \tag{18}$$

d) If the Value is 1.0 > Mu > Id, then I_p is calculated by the equation

$$Ip = -0.5 + 0.5\left(\frac{Id - Mu}{Mu}\right) \tag{19}$$

The decision-making rules are as follows:
a. If *Ip* = 0, then the distribution pattern is random.
b. If Ip > 0, then the distribution is clumped.
c. If Ip < 0, then the distribution is uniform.

2.4.6 Ecological factor analysis of s. macropodum

Ecological factor analysis was conducted at the four *S. macropodum* research locations. The ecological factors in this study consisted of biotic factors (total density of tree vegetation) and abiotic factors (light intensity, temperature, humidity, height, slope, N, P, K, and pH) in the observation plot for the presence of *S. macropodum*. These factors were then analyzed using PCA (Principal Component Analysis). PCA analysis is a method for dividing similar variables into components [9]. PCA was employed to convert correlated variables into a set of new variables by reducing the number of dimensions while retaining the variability within the dataset. This analysis was conducted utilizing the Minitab 18 software.

The next multiple regression analysis was carried out using a stepwise procedure. This analysis was carried out to determine the independent variables (ecological factors) that influence the dependent variable (density of *S. macropodum*) with the following equation model:

$$Y_i = B_0 + B_1X1 + B_2X2 + B_3X3 + \cdots + B_{10}X10 + \varepsilon \tag{20}$$

Description: Y = density of *S. macropodum*, X1 = density of tree vegetation, X2 = temperature, X3 = light intensity, X4 = humidity, X5 = slope, X6 = altitude, X7 = Ph, X8 = N, X9 = P, X10 = K, ε = standard error value, B0 = intercept value, B1...B6 = coefficient of each regression.

3 Results and discussion

3.1 Population structure & density analysis

The population structure and density of *S. macropodum* were analyzed based on the number of individuals at different growth stages (seedlings, saplings, poles, and trees). The highest population density was recorded HA DM (215 ind/ha), followed by APL NM (114 ind/ha), HL DT (108 ind/ha), and APL DM (83 ind/ha). The relationship between diameter, height, and population condition of *S. macropodum* is illustrated in Figures 3 and 4.

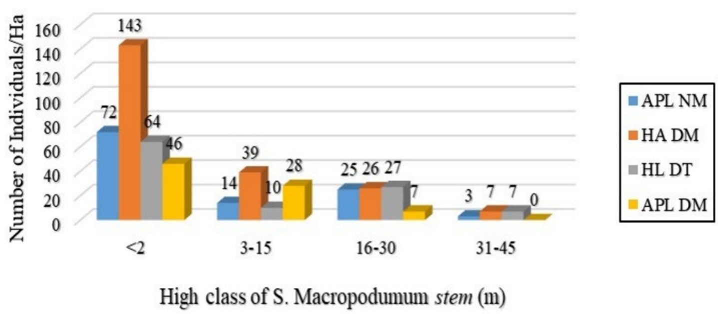

Fig.3 Class Distribution of *S. macropodum* in Sarolangun.

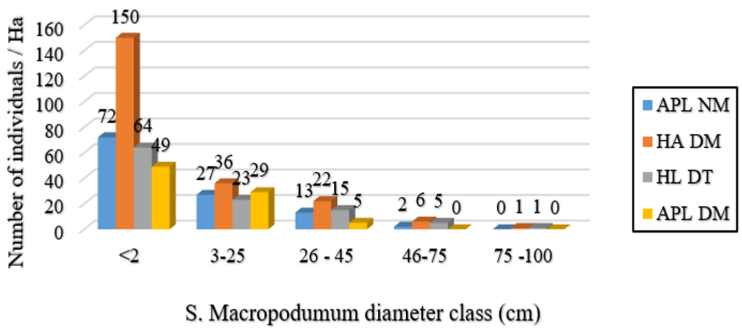

Figure 4. Diameter Distribution of *S. macropodum* in Sarolangun. Size

Fig.3 and 4 demonstrated that the diameter and height classes of the *S. macropodum* stem in HA DM exhibit the best population condition, as evidenced by the significantly larger potential of *S. macropodum* compared to the other three research locations. The high potential of *S. macropodum* in HA DM can be attributed to the sufficient availability of environmental factors necessary for its development in HA DM. According to [10], plant density is influenced by environmental factors, such as sunlight, humidity, and soil fertility. In addition, the HA DM research location was included in the limbo prohibition area of ten, referred to as customary forest. Accessing this area was more challenging than entering other research locations. The Pengulu Tribe has strict customary regulations and norms that must not be violated. One of the regulations was that people may not carelessly entered this customary forest area or carry out any activities in it. If violated, the community will be subject to sanctions from customary regulations and violations of norms from the Pengulu Tribe.

Fig.3 and 4 also showed that the APL DM location had the least potential for *S. Macropodum*, further demonstrating the location's unfavorable growth conditions. The status of the APL DM area was the same as that of the APL NM location. However, APL DM has the potential for a smaller number of *S. Macropodum*. This happens because the APL DM location was close to residential areas, so the land was opened to formation land. In addition, the APL DM location was sloping with low canopy cover, so it has the highest temperature of the four other research locations. [11] stated that humidity and temperature are components of climate micro, which greatly influence the growth of plants and are related to realizing conditions in an optimal environment for plants. According to [12] plant growth exhibits an increasing trend with rising temperatures and decreasing humidity levels; conversely, growth declines when temperature decreases and humidity increases. Figure 5 presented the density of *S. Macropodum*, based on its growth rate at the four research locations.

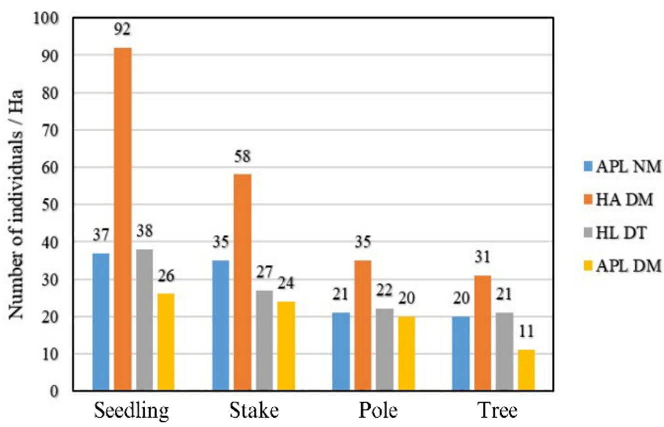

Fig. 5. The density of *S. macropodum* in the four research locations based on growth rate

As seen in Figure 5 above, the *S. macropodum* standed in the four research locations and has a similar distribution as an inverted J graph. The number of *S. Macropodum,* which was the largest at the seedling growth stage, demonstrated this. As the diameter and height of the *S. Macropodum* trunk increase, the number decreased proportionally, resulting in the smallest number of *S. macropodums*. According to [4] young phase trees have a more significant number, and then the number of trees in the older phase decreases in proportion to increasing age or increasing growth phase. [4] also stated that natural forest stands whose regeneration process is going well can be seen from young individuals who have a more significant number compared to old individuals; the population condition shows a normal distribution. This showed that *S. Macropodum's* regeneration was going quite well in the four research locations.

Despite the abundance of seedlings, the number that made it to the next growth stage, which includes stakes, poles, and trees, declined. This was because, in the seedling phase, *S. Macropodum* required shade to survive. In general, each type of plant has a different effect on the light it receives. One of the environmental factors that affects growth is the light intensity factor; some plants are tolerant or intolerant; however, some plants are semi-tolerant, such as *S. Macropodum* at the growth stage of *S. Macropodum* seedlings, which require shade but will change following changes in growth rate. [11] stated that shade is needed to reduce evaporation and transpiration so that humidity can be maintained and plants can grow well. The inability of seedlings to survive in open canopy cover locations without shade leads to a decline in the number of *S. macropodum* seedlings, preventing them from reaching the next growth stage.

Figure 5 showed that in APL NM, the density of *S. Macropodum* was relatively not much different at each growth level. This was because the location of APL NM was quite steep, and the vegetation cover was still quite dense, so at this location, many *S. Macropodum* were found at all growth levels. In addition, there were few threats because the location was also quite far from residential areas, so people rarely entered this location.

3.2 Spatial distribution analysis

The spatial distribution pattern of *S. macropodum* in the four research locations tended to be clustered. It can be seen that the distribution pattern of *S. macropodum* was clumped in three research locations, namely APL NM, HA DM, and HL DT. Meanwhile, in the APL DM location, the distribution pattern of *S. macropodum* was uniform. Based on the calculation of the Morisita dispersion index (Id) in the three research locations which had values of Id = 1.19, 1.72 and 1.43 and Mc = 1.77, 1.51 and 1.77 so that Id ≥ Mc > 1.0, the results of the following calculation showed the values of Ip = 0.16, 0.01 and 0.28 or Ip > 0 so that it can be concluded that the distribution pattern of *S. macropodum* in the three locations was clumped. At the research location in APL, DM has an Id value of 0.45 and Mu = -0.16 so that 1> Id ≥ Mu, the results of the following calculation showed the value of Ip = -0.24 or Ip < 0, so it can be concluded that the distribution pattern of *S. macropodum* was uniform. The distribution pattern of *S. macropodum* at the four research locations was presented in Table 1.

Table 1. Distribution pattern of *S. macropodum*

Research Location	Id	Your	Mc	Ip	Distribution
APL NM	1.19	0.42	1.77	0.16	Clumped
HA DM	1.72	0.61	1.51	0.01	Clumped
HL DT	1.43	0.42	1.77	0.28	Clumped
DM APP	0.45	-0.16	2.53	0.24	Uniform

Table 1 showed that most of the distribution of *S. macropodum* in the field is in groups. The distribution of *S. macropodum* in groups is determined by the statement [8] which states that most plants in nature have a grouped distribution. Grouping occurs as a result of interactions between plants and their habitat, as well as their tendency to seek environmental conditions that best support their survival and growth. The distribution pattern of living things in nature is influenced by competition for nutrients, food, light, weather changes, differences in local habitat conditions, reproductive processes, and social attraction.

The APL DM location showed a uniform distribution pattern of *S. Macropodum*. According to [8] the pattern of plant distribution in nature is rarely found to be uniform (regular). The uniform distribution pattern of *S. macropodum* at the APL DM research location was thought to have occurred because the research location was a forest area of other use area or called "*Area Penggunaan Lain* (*APL*)" where the community was free to do activities, a reasonably open location so that it has a relatively high temperature and low humidity when compared to other research locations. In addition, the uniform distribution pattern was also thought to have occurred because of community intervention in moving *S. macropodum* seedlings.

3.3 Ecological factors of *s. macropodum* (biotic factors)

3.3.1 Tree vegetation composition

The vegetation composition measured in this study was only tree vegetation. Vegetation analysis found 47 species from 18 vegetation families in the four *S. macropodum* habitat research locations (APL NM, HA DM, HL DT, and APL DM) in the KPHP LIMAU Unit VII Hulu area. The HA DM research location has the best *S. macropodum* potential of the three other research locations. However, data from the tree vegetation composition showed that only 47 individual trees were found in HA DM. The most significant composition of *S. macropodum* vegetation was found in the APL NM location, with 71 individual trees and 50 individual trees in the HL DT location. The APL DM location had the least composition of *S. macropodum* vegetation, namely 40 individual trees. The highest IVI values were for the three tree species in the four *S. macropodum* habitats presented in Table 2.

Table 2. The highest IVI values of three tree species in four habitats of *S. macropodum*

Research Location	Local Name	De (Ind/Ha)	RDe (%)	RFr (%)	RDo (%)	IVI (%)
APL NM	*Scaphium macropodum*	24	25.26	15.38	4.16	44.81
	Shorea parviflora	20	21.05	18.46	4.46	43.97
	Litsea firm	10	10.53	12.31	4.72	27.56
HA DM	*Scaphium macropodum*	31	39.74	28.85	5.30	73.89
	Shorea parviflora	14	17.95	19.23	6.00	43.18
	Shorea multiflora	4	5.1 3	5.77	6.14	17.03
HL DT	*Scaphium macropodum*	27	35.14	20.69	5.31	61.07
	Shorea multiflora	8	10.42	10.34	6.29	27.02
	Shorea parviflora	7	9.13	13.04	3.91	23.35
DM APP	*Scaphium macropodum*	11	21.06	21.28	5.87	48.72
	Canarium Sp.	7	13.72	12.77	6.92	33.41
	Coompassia malaccencis	6	11.80	12.77	8.60	33.13

The Importance Value Index (IVI) is a numerical parameter that quantifies the dominance and ecological significance of a species within a plant community [14]. The results of the IVI calculation for tree growth rates presented in Table 2 showed that *S. macropodum* has the highest IVI value in the four research locations, namely 44.81%, 73.89%, 61.07% and 48.72%. The IVI value of *S. macropodum* was complete at all growth levels at all four research locations. Dipterocarpaceae was the dominant family in the four research locations. The number of species found was four species. Meranti (*Shorea parviflora*) was the dominant tree species found in two research locations of *S. macropodum habitat*: APL NM and HA DM. Each plant species generally influences its environmental conditions differently. The research locations of APL NM and HA DM have similar habitat environmental conditions. This can be seen from the dense canopy cover, low temperature, and high humidity in both locations, which were the criteria for the growth place of *S. Macropodum*. In addition, in HL DT and APL DM, the dominant species were squirrel coconut (*Shorea multiflora*) and mosquito legs (*Canarium Sp*). At the APL NM location, the second highest IVI value after *S. macropodum* was the shorea species (*Shorea parviflora*) (43.97%) and the lowest was cassava wood (*Connarus semidecandrus*) (5.71%). Similarly, in the APL NM location, the second highest IVI value after *S. macropodum* at the HA DM location was shorea (*Shorea parviflora*) (43.18%), and the lowest was mempening (*Quercus lucida*), which was 6.41%. At the HL DT location, the second highest IVI value after *S. macropodum* was the squirrel coconut (*Shorea multiflora*), 27.02%, and the lowest, 5.82%, was tempest (*Fragraea fragran*ce). At the APL DM location, the second highest INP value after *S. macropodum* was 33.41%, namely the mosquito's foot species (*Canarium Sp*), and the lowest 8.91% was the taye imbo species (*Barringtonia macrostachya*). IVI data for other tree species in the four *S. macropodum* habitats.

Shannon-Wienner diversity and evenness showed that the APL NM location has an H´ value = 2.38, indicating that the diversity of tree vegetation at the APL NM location was moderate. The E value = 0.52, indicating that the evenness of other tree vegetation at the APL NM location was moderate. The HA DM location has an H´ value = 2.18, indicating that the diversity of tree vegetation at the APL NM location was moderate. The E value = 0.5, indicating that the evenness of other tree vegetation at the HA DM location was moderate. The HL DT location has an H` Value = 2.42, indicating that the diversity of tree vegetation at the HL DT location was moderate. The E value = 0.56, indicating that the evenness of other tree vegetation at the HL DT location was moderate. The APL DM site exhibited a diversity index (H´) of 2.37, signifying a moderate level of tree vegetation diversity, adequate productivity, a relatively balanced ecosystem, and moderate ecological pressure. Additionally, the evenness index (E) of 0.6 suggested a moderate distribution of tree vegetation across the APL DM site.

3.3..2 Community similarities

Community similarity index analysis using the Ward method formed three clusters (Fig. 6). The first cluster consisted of APL NM and HA DM with a similarity index value reaching 90.81%; the second cluster consisted of HL DT againsted the first cluster with a similarity index value of 73.74%, and the third cluster of APL DM againsted the first and second clusters with a similarity index value of 49.02%. The high index indicated that both locations have almost the same tree species. The higher the diversity between communities, the lower the similarity index value produced, and vice versa. The community similarity dendrogram at the four research locations was presented in Fig. 6.

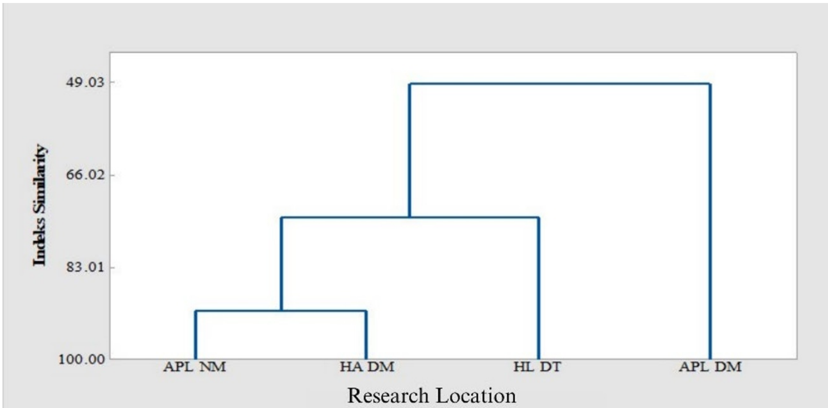

Fig. 6. Dendrogram of community similarity in four *S. macropodum research locations.*

The first cluster explained that around 9.29% of tree species in APL NM were not owned by HA DM. In the second cluster, it can be interpreted that HL DT did not own 26.26% of tree species from the entire community from the first cluster. In the third cluster, it can also be interpreted that APL DM did not own 50.48% of tree species from the entire community from the first and second clusters. The difference in community similarity values was influenced by the number of individuals and different tree species. APL DM generally has a lower diversity index than APL NM, HA DM, and HL DT. According to [13], the condition of climate micro tends to be the same; it will be occupied by individuals of the same type because species that experience have developed mechanisms and tolerance to habitat. According to [4], the height of a place remains relatively constant, and the characteristics of the species tend to be similar. The height of different places will show the characteristics of species of different compilers. The altitude at the APL NM and HA DM locations was not significantly different, whereas the altitude at the APL DM location was significantly different from the other two locations, but not significantly different from the HL DT location, indicating a greater degree of community similarity compared to the other two locations.

Environmental conditions affected the species similarity index. Few tree species living in APL DM were species that can survive existing disturbances. The proximity of this area to community settlements led to the opening of a significant amount of land for plantations, resulting in a more open canopy cover and a higher temperature than in the other three research locations. Consequently, many plants, including *S. Macropodum*, struggle to thrive. Furthermore, the other three research locations have more vegetation due to their favorable environmental conditions and minimal disturbance.

3.3.3 Seed scatterer

When this research was conducted, *S. macropodum* was not in the flowering or fruiting period, so no animals were found directly eating the seeds of *S. macropodum* and based on the results of an interview with one of the respondents of the Pengulu Tribe, namely Mr. Mahmud (80 years old), who is also an elder of the Pengulu Tribe, stated that the fruit of *S. macropodum* is liked by simply (*Presbytis mellophones*) as one of its foods. This can indicate that simpai (*Presbytis melalophos*) is an animal that plays a role in seed dispersal from *S. Macropodum*. Seed dispersal is one of the plants' adaptation efforts to maintain their species' existence from the danger of extinction. Animals like birds, monkeys, squirrels, and bats, through their droppings, disperse certain plant seeds. Animals significantly contribute to natural forest regeneration by ingesting seeds and dispersing them through their droppings. These animals influence the spread of seeds, which will then grow into new individuals [14]. In addition to seed dispersal from animals, it can also occur with the help of wind. According to data from BMKG (2018), the average wind direction in Limun District over the last 5 years (2014-2015) has been towards the north. The leaves of *S. macropodum* fruit are shaped like a boat, which, if it falls, will fly away with the wind up to 50 m from the parent tree. This is evident from the study results, which showed a relatively large distance between the *S. macropodum* tree and its offspring.

3.4 Ecological factors of *s. macropod* (abiotic factors)

3.4.1 Environmental factors

The average temperature and humidity in the Limau Unit VII Hulu KPHP Area at the four research locations were 26°C and 79% (APL NM), 24°C and 92% (HA DM), 27°C and 75% (HL DT), and 29°C and 66% (APL DM). Temperature and humidity measurements were carried out 3 times, namely in the morning, afternoon, and evening, with different measurement times, and it was stated that one of the factors that influenced the growth and composition of species was the physical condition of the environment. Data on environmental conditions in the field were presented in Table 3.

Table 3. Average environmental factors

Research Location	Temperature °C	Humidity (%)	Intensity Light (Lux)	Slope (°)	Height m above Sea Level
APL NM	26	79	1155	60	470
HA DM	24	92	1092	61	401
HL DT	27	75	1343	29	357
DM APP	29	66	1652	53	350

The results of temperature and humidity measurements at the four habitat research locations of *S. macropodum* in the Limau Unit VII Hulu KPHP area described the temperature and humidity conditions that were necessary for *S. Macropodum*'s growth. *S. macropodum* requires suitable temperature and humidity conditions to grow and adapt to its environment. According to [12] plant growth tends to increase with rising temperatures and decreasing humidity levels, whereas a decline in temperature accompanied by an increase in humidity results in reduced growth. The APL DM research location boasted the highest air temperature (27-31°C), the highest humidity of 61-72%, an altitude of 350 meters above sea level (m.asl), an average slope of 53°C, and light intensity of 1652 lux, all of which disrupt the growth of *S. Macropodum*. Figure 5 demonstrated that the density of *S. macropodum* at the APL DM location was smaller compared to the other three research locations. We found the least amount of *S. macropodum* at the APL DM research location, likely due to its more open habitat. According to [12] the factors affecting temperature and humidity are height, place, and closing title. At the HA DM location, the light intensity is lower (1392 lux), with an average low temperature, high humidity, an altitude of around 401 m.asl, and an average slope of 61°, but these environmental conditions were preferred by *S. Macropodum*. This can be seen from the potential of *S. Macropodum*, which was most often found in this location. The environmental characteristics at the APL NM and HL DT locations were similar to those of HA DM; this was evident from the environmental factor values, which did not differ significantly from those of HA DM. [11] stated that intensity acceptance of different suns on each plant will cause differences in plant growth parameters. *S. macropodum* exhibits a semi-tolerant response to light, but during the seedling phase, it necessitates a humid environment and avoids direct sunlight. Temperature and rainfall influence humidity. Therefore, both temperature and rainfall are impacted by the success of humidity growth. Figure 7 presented the rainfall data for Sarolangun Regency in 2018.

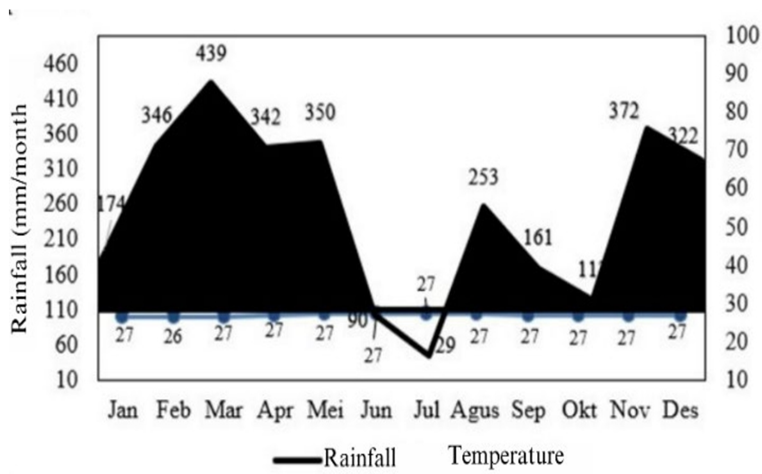

Fig.7. 2023 rainfall data in Sarolangun Regency

Based on Figure 7, it can be seen that the temperature in Sarolangun has been relatively stable at 27°C for several months, with the highest temperature at 27°C. Rainfall during the study in the Limau Unit VII Hulu KPHP area was classified. The average monthly rainfall throughout 2018 was 249 mm/month. The highest rainfall occurred in March, and the lowest in July (Fig.7). [11] stated that the category of rainfall properties based on Oldeman is divided into three: rainfall > 200 mm was classified as a wet month, rainfall between 100-200 mm was classified as a humid month, and rainfall <100 mm was classified as a dry month. According to the 2018 rainfall data, the dry months included June and July due to their low rainfall intensity of less than 100 mm/month. January, September, and October were classified as humid months because the rainfall was between 100-200 mm. Other months, with rainfall intensities exceeding 400 mm/month, fall under the category of wet months. Data on rainfall and air temperature spans five years in Sarolangun Regency, Jambi.

3.5 Factors affecting the habitat *of s. macropodum*

The results of biotic and abiotic factor measurements were combined to determine the factors that influenced the existence of *S. Macropodum*. The combination of variables that made up these factors was analyzed using PCA (Principal Component Analysis). The results of the PCA analysis of factors that influenced the habitat of *S. macropodum* were presented in Table 4.

Table 4. Eigenvalues and principal components (KU) of *S. macropodum* habitat

Variables	**KU1**	**KU2**
Eigenvalue	5.85	2.52
Proportion	0.59	0.25
Cumulative	0.59	0.84
X1	-0.26	0.32
X2	0.16	0.53
X3	-0.33	0.13
X4	-0.13	-0.54
X5	-0.38	0.14
X6	-0.36	-0.26
X7	0.29	-0.30
X8	0.41	0.06
X9	0.34	-0.30
X10	0.38	-0.19

Note: X1= Tree vegetation density, X2= temperature, X3= light intensity, X4= humidity, X5= slope, X6= altitude, X7= Ph, X8= N, X9= P, X10= K.

The analysis results revealed that the factors affecting the habitat of *S. macropodum* reduce to two main components (KU) when the eigenvalue was greater than 1. According to [4], species distribution was considered even againsted the gradient of its environmental variables if it has an eigenvalue > 0.5. KU only reaches KU 2 because KU 2 already has a cumulative value of 83.70%, and this value already described the influence of the variables on the research location. Each component has its proportion, namely KU1 of 58.52% and KU2 of 25.18%. KU1 was a linear combination of variables with the largest proportion of variant values from one other main component, so this main component has a variable composition with better information than the other main component variables. Each component has a variable value; sociables that have a value above 0.35 result in the reduction of the main component components. The results of the arrangement of variables for each component were as follows: KU1 = 0.41 X8 (N) - 0.38 X5 (slope) + 0.38 X10 (K) - 0.36 X6 (altitude). KU2 = -0.54 X4 (humidity) + 0.53 X2 (temperature).

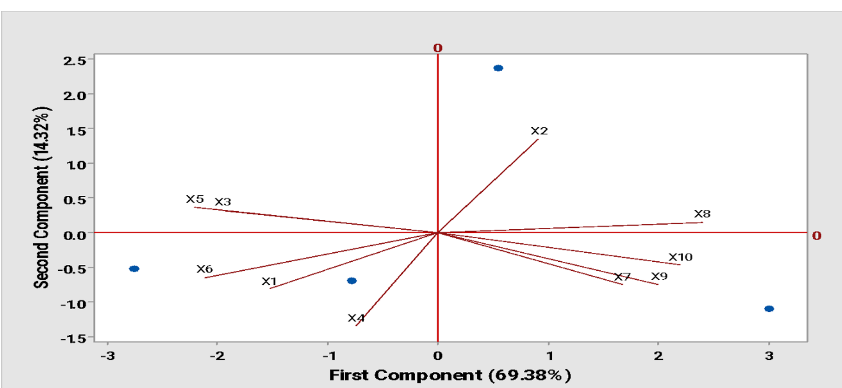

Fig.8. Factor biplot results in ecology *S. macropodum* in to form component main

The biplot (Figure 8) revealed that the four research locations were far apart, indicating distinct characteristics among them. Based on the location between the research locations, APL NM and HA DM were close together. This demonstrates that while these two locations shared similar characteristics, they differed from APL DM and HL DT, as evident from their distant locations. The research locations, HL DT and HA DM, were relatively close to each other, but not too close; this indicates that their characteristics differed from those of NPL DM and NPL NM, which were visible from their distant locations.

Based on the vector length, it showed that X5 (slope) and X9 (N) have large diversity. X3 (light intensity) and X10 (K) have large diversity. X1 (density) has a small diversity value. The closeness between variables showed that the properties given by the variables were increasingly similar. If the correlation formed a perpendicular, it was not significant. X2 (temperature) and X1 (density) have a slight positive correlation (0.26). X5 (slope) and X6 (altitude) have a slight angle with a positive correlation and a significant value (0.62). X7 (pH) and X8 (N) have a negative correlation with a significant value (-0.92). At the APL NM location, the light intensity, slope, and altitude values were higher than the other three research locations. The highest temperature was at the NPL DM location. The highest air density and humidity were at the HA DM location. The highest N, P, K, and pH values were at the HL DT location.

The existence of *S. macropodum* cannot be separated from the influence of the surrounding environment, namely biotic and abiotic factors. The existence of tree species vegetation (biotic) can have an influence, such as competition to utilize growing space to support a better life. Abiotic factors, including light intensity, temperature, humidity, altitude, and soil chemical properties (pH, N, P, and K), played a significant role in influencing plant growth and development. To identify the factors affecting the growth of *S. macropodum* across the four research sites, multiple linear regression analysis was performed. Additionally, multiple linear regression analysis of the principal component variables was conducted to assess their influence on the primary components. The regression analysis, using a stepwise procedure with an alpha of 0.15, yielded a significant r-square adj value of 73.94%, indicating the presence of only one significant variable, humidity (X4). The equation Y = -502 + 7.38 X4 indicated the presence of *S. macropodum* trees. This showed that humidity was the most influential factor in the habitat of *S. macropodum* growth. The field revealed that *S. macropodum* seedlings needed shade and a humid environment to thrive. This can be seen from HA DT, which has higher humidity. Hence, the density of *S. macropodum* was greater than the APL DM location, which has low humidity, and the density of *S. macropodum* found at that location is also less.

4 Conclusion

The Meribung Village Customary Forest exhibited the highest density of *Scaphium macropodum*, reaching 216 individuals per hectare, whereas the Mersip Village other use area recorded the lowest density at 81 individuals per hectare. All four research sites demonstrated a similar distribution pattern, resembling an inverted J-shaped curve, indicative of a normal distribution, where the seedling population surpassed the number of mature trees. Among the ecological factors influencing *S. macropodum* habitat, humidity played a significant role. The optimal humidity level for this species, as observed in the Meribung Village Customary Forest, was 92%.

Acknowledgement

The author expresses heartfelt gratitude to the inhabitants of the production forest area under the Regional Office Technical Implementation Unit (UPTD) of the Production Forest Management Unit (KPHP) LIMAU Unit VII Hulu, Regency Sarolangun, Jambi Province, for their invaluable cooperation and support during this study. Special appreciation is extended to Sutan Sahala Muda Marpaung for his significant contributions, both morally and materially, which greatly enhanced the quality and success of this research. The author acknowledges and thanks everyone involved for their efforts and assistance, which were instrumental in achieving the objectives of this study.

Reference

1. N. D. H. Sitanggang, E. A. M. Zuhud, B. Masy'ud, And R. Soekmad, Ethnobotany of the Toba Batak Ethnic Community in Samosir District, North Sumatra, Indonesia. *Biodiversitas Journal of Biological Diversity*, **23**(12) (2022). https://doi.org/10.13057/biodiv/d231204.
2. S. S. M. Marpaung, Y. I. Rahmila, D. H. Has, T. Setiawan, and S. P. A. Nugroho, Ethnographic and plant utilization: A case study of the Penguluh Tribe, Jambi Province, Indonesia. *IOP Conference Series: Earth and Environmental Science*, **1359**(1), 012104 (2024). https://doi.org/10.1088/1755-1315/1359/1/012104
3. A. Handayani, E. A. M. Zuhud, and D. I. Junaedi, Naturalized Alien Plant as Traditional Medicine Resources: A Study from Cibodas Biosphere Reserve, West Java. *Jurnal Sylva Lestari*, **11**(2), 298-319 (2023). https://doi.org/10.23960/jsl.v11i2.715.
4. P. Wilkie, A revision of *Scaphium* (*Sterculioideae, Malvaceae/Sterculiaceae*). *Edinburgh Journal of Botany*, **66**(2), 283–328 (2009).
5. T. Yamada and E. Suzuki, Ontogenic change in leaf shape and crown form of a tropical tree, *Scaphium macropodum* (*Sterculiaceae*) in Borneo. *Journal of Plant Research*, **109**, 211–217 (1996). https://doi.org/10.1007/BF02344547.
6. T. Yamada, A. Itoh, M. Kanzaki, T. Yamakura, E. Suzuki, and P. S. Ashton, Local and geographical distributions for a tropical tree genus, *Scaphium* (*Sterculiaceae*) in the Far East. *Plant Ecology*, **148**, 23–30 (2000). https://doi.org/10.1023/A:1009879221679.
7. H. D. Has, S.S.M Marpaung, E.D Jati, B.R. Hartati, I. Fitrianto, I. Yulianti. I, S.P.A Nugroho, Y.I. Rahmila, F.D. Rahmayanti and R Fadilah, Ethnobotany of Food Plants in The Penghulu Tribe Community in Sarolangun, Jambi. *Jurnal Penelitian Pendidikan IPA*, **9**(9), 7705–7712 (2023). https://doi.org/10.29303/jppipa.v9i9.4972.
8. A. Susilowati, D. Elfiati, H. H. Rachmat, K. S. Yulita, A. N. Hadi, Y. S. Kusuma & S. A. L. Batu, Vegetation structure and floristic composition of tree species in the habitat of Scaphium macropodum in Gunung Leuser National Park, Sumatra, Indonesia. *Biodiversitas Journal of Biological Diversity*, ***21***(7) (2020). doi.org/10.13057/biodiv/d210720
9. M. Yulianti, C. Kusmana, Y. Setiawan, L.B. Prasetyo, Y.I. Rahmila, B. Pranoto, R. Rahmania, I Yeny, N. Sari and W. Halwany, Land cover change analysis in Sagara Anakan Cilacap, Central Java, using principal component analysis (PCA). *IOP Conference Series: Earth and Environmental Science*, **1315**(1), 012046 (2024). https://doi.org/10.1088/1755-1315/1315/1/012046.
10. F. P. Gardner, R. B. Pearce, and R. L. Mitchell, *Physiology of Crop Plants* (Scientific Publishers, 2017).

11. R. R. Shamshiri, J. W. Jones, K. R. Thorp, D. Ahmad, H. C. Man, and S. Taheri, Review of optimum temperature, humidity, and vapour pressure deficit for microclimate evaluation and control in greenhouse cultivation of tomato: a review. *International agrophysics*, ***32***(2), 287-302 (2018). doi: 10.1515/intag-2017-0005
12. J. L. Hatfield, and J. H. Prueger, Temperature extremes: Effect on plant growth and development. *Weather and climate extremes*, ***10***(Part A), 4-10 (2015). doi.org/10.1016/j.wace.2015.08.001
13. M. G. Barbour, J. H. Burk, and W. D, *Terrestrial Plant Ecology (1980).*
14. A. P. P. Hartoyo, A. Sunkar, R. Ramadani, S. Faluthi, and S. Hidayati, Normalized difference vegetation index (NDVI) analysis for vegetation cover in Leuser Ecosystem Area, Sumatra, Indonesia. *Biodiversitas Journal of Biological Diversity*, **22**(3) (2021). https://doi.org/10.13057/biodiv/d220311.