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Conservation and Economic Impact of Damar Trees in Damar Park on the Island of Sumatra, Indonesia

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ABSTRACT

Damar Park Krui is an agroforestry land managed by the Krui community on the West Coast, Lampung, with the dominance of damar trees (*Shorea javanica*). This research aims to analyze the vegetation and economic contribution of Damar Park. The research method includes making measuring plots and collecting vegetation data in Pekon Pahmungan and Pekon Gunung Kemala, and interviews with 100 respondents in June-July 2024. The tools used included Christen meters, tape measures, and GPS. Vegetation data analysis was carried out using the Importance Value Index (IVI). The results show that damar trees dominate with the largest number of trees, the largest base area, and the highest IVI. In Pekon Pahmungan, there are 17 species of trees with 196 trees, while Pekon Gunung Kemala has 12 species of trees with 194 trees. A comparison of data from 2021 to 2024 shows fluctuations in the number of damar trees, with a significant increase in 2023 and a decrease in 2024. Damar Park contributes significantly to the local economy through the export of damar resin. 100% of the community believes that Damar Park can help improve family economies. 59% of the community is aware that the price of damar can be increased through post-harvest technology, enhancing its economic value. However, challenges such as land conversion and lack of interest from the younger generation are a concern. This research highlights the importance of damar trees in the ecosystem and local economy as well as the need for conservation and community empowerment for the sustainability of Damar Park. Future research will focus on the repong ecosystem and aim to provide local communities with knowledge about post-harvest technologies that can increase prices and enhance the community's economy.

1. INTRODUCTION

Damar Park Krui features vegetation dominated by closely growing trees, giving it the appearance of a primary forest. Damar Park Krui is a garden managed by the Krui community on the West Coast using an agroforestry system, a mixed cultivation approach combining agricultural crops, plantations, and forestry, primarily featuring damar trees (*Shorea javanica*). The main product of this garden is damar, or the sap of the *Shorea javanica*, for which the local community still uses traditional techniques passed down from generation to generation [1].

Damar Park is a form of local wisdom in Lampung, especially in the Krui area. The agroforestry system applied to the Damar Park involves the local community in managing it. Damar Park is not only an example of success in natural resource management, but also a reflection of local wisdom that is able to integrate economic, ecological and social aspects [2].

Shorea javanica belongs to the *Dipterocarpaceae* family [3]. This is one of the types of plants that produces rare damar in the world and the only one found in Indonesia. Damar is widespread in West Coast Regency. According to data from the Lampung Provincial Forestry Department, the area of Damar Park in Krui spans approximately 29,000 hectares. Krui also has about 1,750,000 damar trees that are still productive [4].

Shorea javanica is known to be a mainstay commodity and icon in West Coast Regency. Damar plants grow well due to tropical rain forest with rainfall of 3300 mm/year [5]. Its existence was formed due to the local wisdom of the Krui people, resulting in quality damar. However, as the times progress, there are problems regarding the decline in popularity that threatens the existence of damar, including degradation and logging of damar [6]. This study fills the gap of existing research by routinely measuring and observing the dynamics of damar trees with routine and serial measurements every year, and examining how damar repong contributes positively to the economy of the West of Pesisir District's community. The novelty of this study is a time series study measuring the dynamics of tree growth in damar gardens and the significance of the study to measure the knowledge that damar contributes economically to the West of Pesisir District's community. For this reason, it is necessary to

conduct a study to find out the amount of damar that still exists in West of Pesisir District, Sumatera Island.

2. RESEARCH METHODS

2.1 Research time and location

This research was carried out from June to July 2024, in the Damar Park area. The research location includes two areas of Damar Park, which one area consist of one hectare. West Coast Regency has an area of 2,809.71 km² [7]. The research was carried out by making 20 plots of land with dimensions of 20m × 20m, 10m × 10m, 5m × 5m, and 2m × 2m. Administratively, the plot of this research is located in the area of Pekon Pahmungan and Pekon Gunung Kemala in Krui, West Coast. Details of the research location can be seen in Figures 1 and 2.

2.2 Research tools and materials

The tools used in this study include: (1) Christen meter to measure the height of trees; (2) Tape meter to caunt the diameter of the tree; (3) Stationery to record measurement data; (4) GPS to determine the direction and help create the measurement plot; (5) Raffia to make a plot measuring 20m × 20m or 400 m²; and (6) Plates or other markers to mark the tree that has been measured.

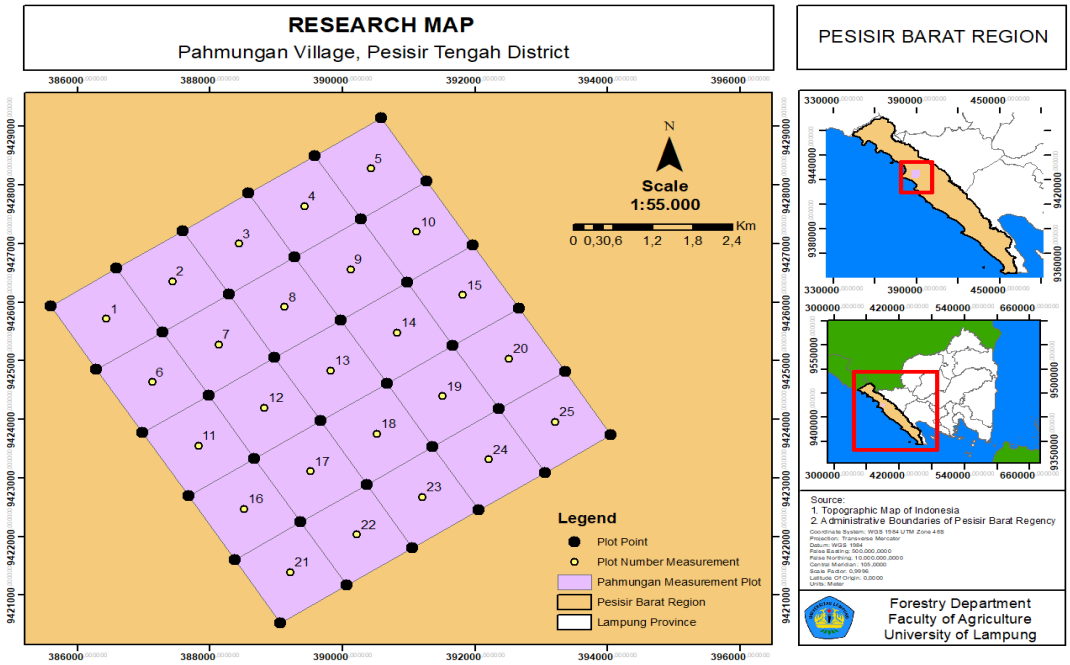

Figure 1. Research location of Damar Park vegetation dynamics in Pekon Pahmungan

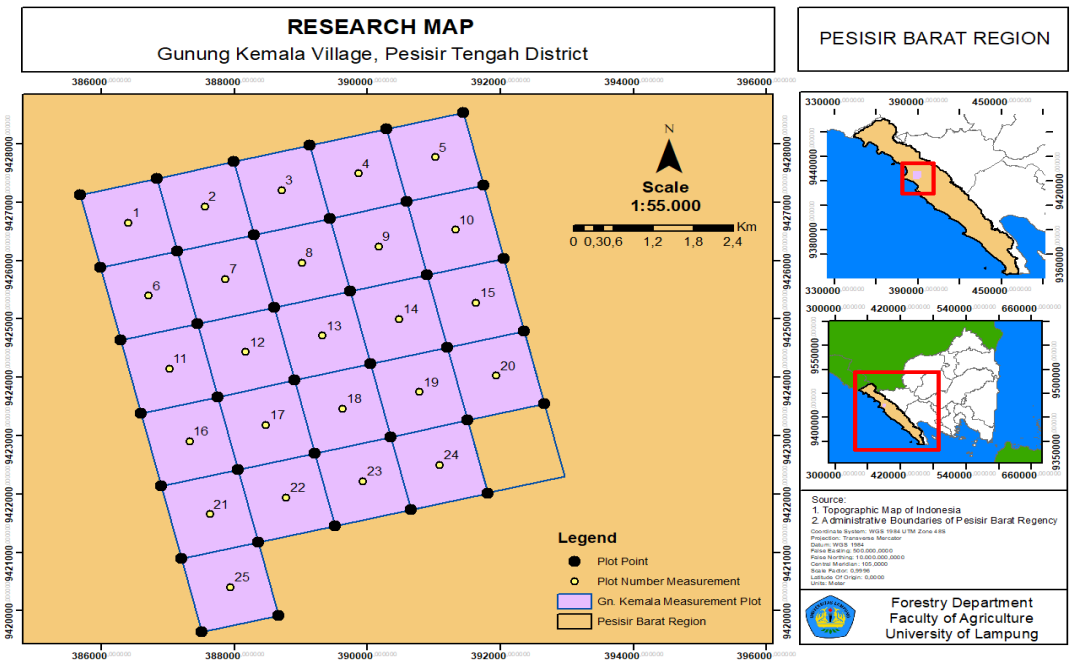

Figure 2. Research location of Damar Park vegetation dynamics in Pekon Gunung Kemala

2.3 Research methods

The creation of a measuring plot in the observation area allows vegetation studies to be carried out. The measurement location was chosen in Pekon Pahmungan and Pekon Gunung Kemala. In each of these two locations, a total of 25 plots were made.

The criteria for selecting sample plots are: 1) The plot used is a permanent plot created by Hubert-Deforesta in the 1970s which was handed over to Prof. Sugeng P. Harianto to be continued (He is a professor at the University of Lampung who handles the permanent plot of the French researcher), 2) The plot in Pahmungan village was determined as a permanent plot by Hubert-Deforesta form France and the plot in Gunung Kemala village was determined by Prof. Sugeng P. Harianto as a comparative plot for the growth and development of damar trees, 3) The selection of the plot in Gunung Kemala has a relatively low level of steepness or a flat area based on topography that is significantly different from the Pahmungan village plot which has a relatively high level of steepness, 4) The criteria that are quite different between the two villages are a strong basis for determining the sample plot.

The measurement was carried out using the census method. The sampling technique was carried out by: 1) Census namely by counting each tree in the measurement plot and grouping them based on the type and size of the tree, 2) Counting all trees in the 20 m x 20 m plot area and identifying tree types, tree diameters, tree heights to determine the Importance Value Index of each tree type, 3) Trees that have been identified in 25 plots in Pekon Pahmungan and 25 plots in Pekon Gunung Kemala were analyzed descriptively to see the total number of species and the total number of individual trees, and tree types, 4) Determination of tree height and diameter determines the results of KR or Relative density of type of plant, FR or relative frequency of a type of plant and DR or relative closure dominance of a plant type, 5) Using KR, FR, and DR data, the tree Importance Value Index is determined.

2.4 Field data collection

The stages of implementation are explained in detail as follows: The first stage is to repair the damaged plot boundary using plates or markers. All zinc plates are assigned a unique tree identification number according to the specified procedure: 1) Make 25 measuring squares in a 20m observation square, with raffia rope used as a measuring square boundary; 2) Measure the diameter and height of each tree in each plot, as well as count the number of individuals of each type of tree present; 3) To prevent repetition of measurements, symbols are painted on numbered and measured trees; 4) Determine the type and height of embroidery plants, as well as document the types of plants that die and their causes.

2.5 Data analysis

The approach to vegetative data analysis uses the Important Value Index (IVI) [8-10]. To calculate IVI, Relative Density (KR), Relative Frequency (FR), and Relative Domination are added.

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

$$KR = \frac{\text{Density of a species}}{\text{Density of all species}} \times 100 \quad (2)$$

$$FR = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100 \quad (3)$$

$$DR = \frac{\text{Dominansi sutau Jenis}}{\text{Dominansi seluruh jenis}} \times 100 \quad (4)$$

where, IVI: Index of important values of a type of plant; KR: Relative density of a type of plant; FR: Relative frequency of a type of plant; DR: Relative closure dominance of a plant type.

The research data were analyzed descriptively, with four repetitions in different years and using statistical analysis anova test.

3. RESULTS AND DISCUSSION

3.1 Analysis of variance of Damar Park location

The results of data processing with Anova for different locations (Pahmungan and Gunung Kemala) are presented in Table 1.

Different locations show significant differences in the Importance Value Index with a significance level of 0.05 (F Test = 30.248 with probability < 0.05). The Importance Value Index of Pahmungan is higher than Gunung Kemala due to the steepness of the location and the difficulty of access to Pahmungan, causing better preservation. IVI data from 2021 to 2024 are presented in Table 2.

Table 1. Anova test of the Importance Value Index at the Pahmungan and Gunung Kemala locations

Sources of Diversity	db	JK	Middle Square	F Calculate	
Group	3	4192.716	2096.358	1.04497441	ns
Treatment	1	60681.72	60681.72	30.2481007	**
Error rate	3	6018.400	2006.133		
Total	17	50470.6			

Table 2. Importance Value Index in Pahmungan and Gunung Kemala

	2021	2022	2023	2024
Pahmungan	131,11	136,85	111,60	104
Gunung Kemala	95,76	74,11	97,03	79,27

3.2 Dynamics of Damar Park in Pekon Pahmungan

Based on the results of vegetation analysis in Pekon Pahmungan on the permanent plot, 17 types of trees were obtained with a total of 196 trees. Form 17 types of trees obtained, 3 types of trees with the highest IVI values and tree diversity indices can be seen in Table 3.

The table shows an analysis of different types of trees in an area, with metrics that include number of trees, base area, relative base area, frequency, relative frequency, density, relative density, and IVI. From the data, it can be seen that the damar species (*Shorea javanica*) dominates with the highest number of trees (76), the highest base area (1675), and the highest IVI (104). Based on the results of interviews with the community, it was found that damar trees dominate the damar repong because the community really wants more damar trees to grow in the damar garden. The existence of other trees is an effort by the community to get economic contributions other

than damar trees. Damar trees whose resin is harvested cannot be immediately taken and sold. The resin after being tapped by damar farmers will be left for half a month to a month, only then can the resin be sold to collectors. The existence of trees other than damar is an alternative harvest that generates money to survive the people of West of Pesisir District. The duku harvest, for example, is an intermediate harvest or fills the gap when the damar resin cannot be harvested, so duku becomes an alternative to harvest its fruit. When the mangosteen fruit harvest occurs, the mangosteen becomes an alternative source of income for the people of West of Pesisir District.The species exhibits a significant ecological presence, with high frequency (32.47%) and relative density (41.94%). Bayur (*Pterospermum javanicum*) also shows a fairly high dominance with a large base area (909) and IVI (56), as well as the highest density (1012.3). In contrast, species such as Acid kandis (*Garcinia xanthochymus*), Pepper (*Piper nigrum*), Sawfly (*Macaranga trichocarpa*), and Rub wood (*Cotylelobium melanoxylon*) have a very low presence with only one tree registered for each species and a very small IVI. With this, we can see the IVI value by measuring the diameter and height of the trees such as those in Figure 3 and Figure 4.

Table 3. Analysis of tree phase vegetation in Pekon Pahmungan

No.	Local Name	Latin Names	Number of Trees	K	KR	F	FR	D	DR	IVI
1	Duku	*Lansium domesticum*	19	500	9.69	9.0	12.22	1325	20.11	42
2	Melinjo	*Gnetum gnemon*	10	275	5.33	3.60	4.89	651.4	9.89	20
3	Pulai	*Alstonia scholaris*	13	350	6.78	6.64	9.02	677.0	10.28	26
4	Damar	*Shorea javanica*	76	1675	32.47	21.52	29.22	2763.0	41.94	104
5	Durian	*Durio zibethinus*	14	375	7.27	7.28	9.89	40.1	0.61	18
6	Kandis	*Garcinia xanthochymus*	1	25	0.48	0.04	0.05	1.3	0.02	1
7	Lada	*Piper nigrum*	1	225	4.36	1.68	2.28	11.7	0.18	7
8	Kayu Talas	*Colocasia esculenta*	15	225	4.36	1.68	2.28	31.6	0.48	7
9	Bayur	*Pterospermum javanicum*	27	909	17.62	16.00	21.73	1012.3	15.36	55
10	Kwao	*Pueraria mirifica*	1	75	1.45	1.04	1.41	4.1	0.06	3
11	Petai	*Parkia speciosa*	4	100	1.94	1.00	1.36	9.5	0.14	3
12	Jengkol	*Archidendron pauciflorum*	9	225	4.36	3.24	4.40	18.4	0.28	9
13	Manggis	*Garcinia mangostana*	4	75	1.45	0.64	0.87	37.5	0.57	3
14	Kayu sepat	*Macaranga trichocarpa*	1	25	0.48	0.04	0.05	1.3	0.02	1
15	Rarebu	*Macaranga trichocarpa*	1	25	0.48	0.04	0.05	1.0	0.01	1
16	Salam	*Syzygium polyantum*	2	50	0.97	0.16	0.22	2.5	0.04	1
17	Kayu Raru	*Cotyleloblum melanoxyloyn*	1	25	0.48	0.04	0.05	1.3	0.02	1
	Sum		196	5159	100	73.6	100	6588	100	300

Figure 3. Measure the diameter of the tree phase using a tape measure

The dominance of species such as damar can be caused by several factors such as better environmental adaptation, high rates of reproduction and growth, as well as positive interactions with other species or the lack of competitors and predators. In addition, natural disturbances or human activities that favor a particular species and physiological traits that are efficient in utilizing resources also contribute to this dominance. With a total of 196 trees identified, this table provides a clear picture of the diversity and distribution of tree species in the area, suggesting that some species play a more important role in the ecosystem than others [11].

Figure 4. Measure the height of the tree with a Christian Hipsometer

3.3 Dynamics of Damar Park in Pekon Gunung Kemala

Based on the results of vegetation analysis in Pekon Pahmungan on the permanent plot, 12 types of trees were obtained with a total of 194 trees. Form 13 types of trees obtained, 3 types of trees with the highest IVI values and tree diversity indices can be seen in Table 4.

Table 4 shows that damar trees are very dominating in Pekon Gunung Kemala. This happened because the local community has realized the importance of damar trees in the Krui area. Damar trees that are difficult to grow in other areas make people continue to cultivate them and utilize damar sap, which has high economic value [12].

Table 4. Diversity of tree species in Pekon Gunung Kemala

No.	Local Name	Latin Name	Number of Trees	K	KR	F	FR	D	DR	IVI
1	Duku	*Lansium domesticum*	18	475	9.79	12.66	10.27	11875	9.69	29.75
2	Damar	*Shorea javanica*	61	1500	30.92	21.85	17.73	37500	30.61	79.27
3	Tupak	*Baccaurea racemosa*	22	550	11.34	16.90	13.70	14375	11.73	36.78
4	Haneban	*Vitex pinnata*	22	550	11.34	18.28	14.28	15000	12.24	38.42
5	Durian	*Durio zubethinus*	24	625	12.88	18.28	14.28	15000	12.24	39.96
6	Petai	*Pakia speciosa*	2	50	1.03	2	2	1250	1.02	3.67
7	Bayur	*Pterospermum acerifolium*	4	100	2.06	3.97	3.97	2500	2.04	7.32
8	Jengkol	*Archidendron pauciflorum*	5	125	2.57	4.89	4.89	3125	2.55	9.09
9	Lamtoro	*Leucaena leucocephala*	10	250	5.15	8.87	8.78	5625	4.59	16.87
10	Cempedak	*Artocarpus integer*	1	25	0.51	1	1	625	0.51	1.83
11	Angsor	*Ficus callosa*	19	450	9.27	8.76	8.76	11250	9.18	25.57
12	Manggis	*Garcinia mangostana*	6	150	3.09	5.86	5.86	4375	3.57	11.42
	Sum		194	4850	100	123.28	100	122	100	300

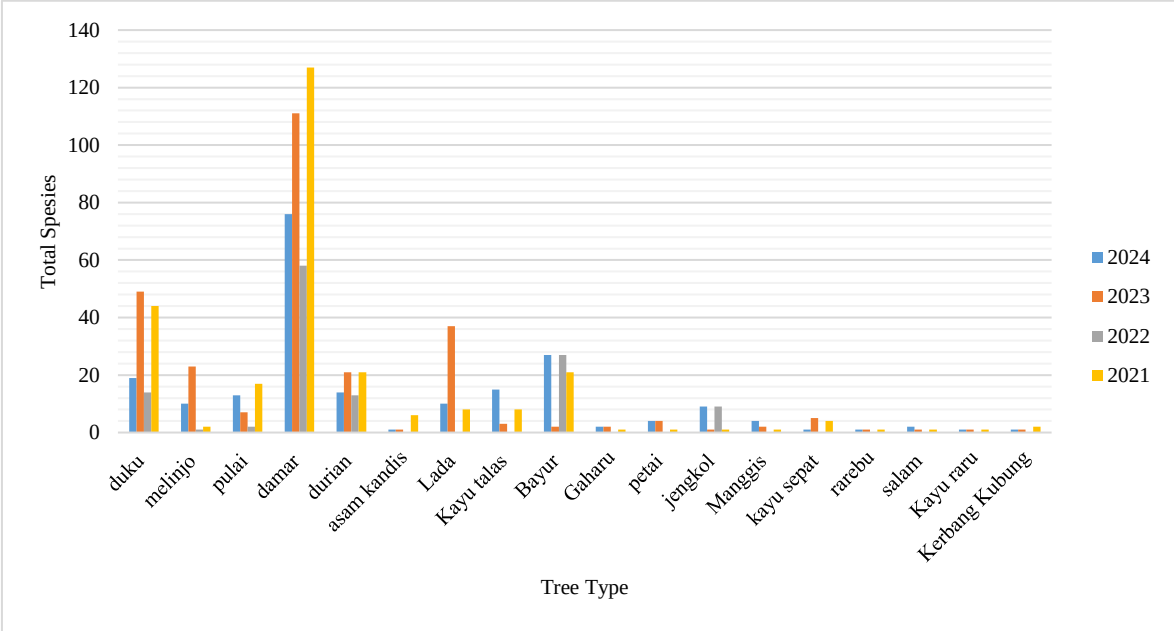

Figure 5. Comparison of various types of trees in Pekon Pahmungan from 2021 to 2024

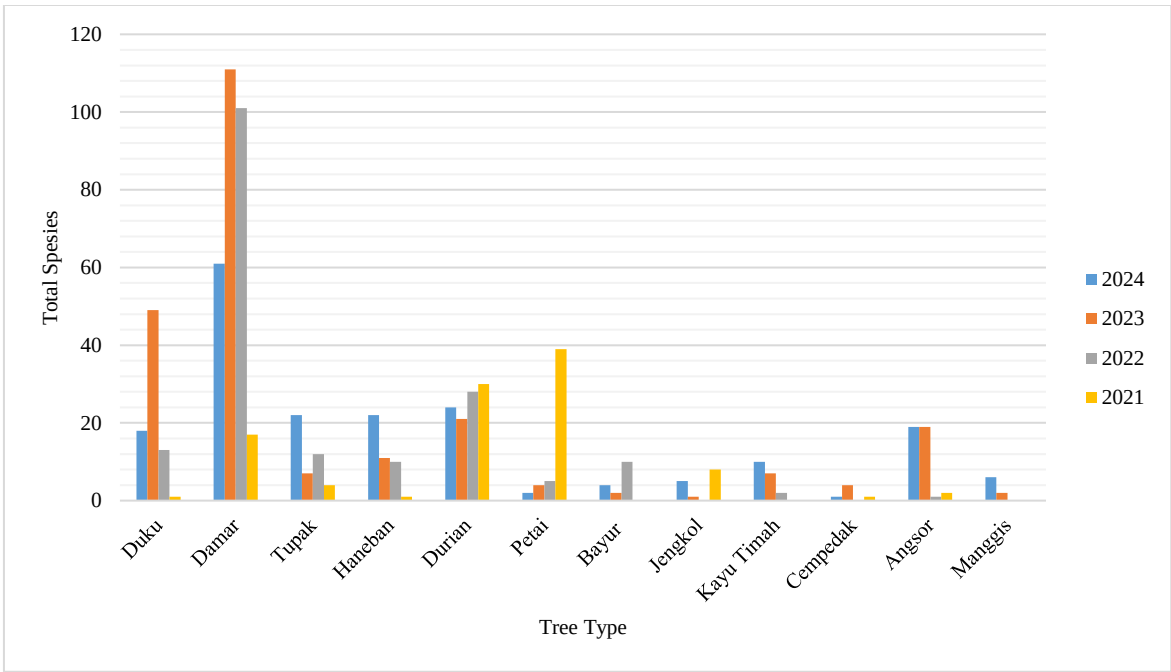

Figure 6. Comparison of various types of trees in Pekon Gunung Kemala from 2021 to 2024

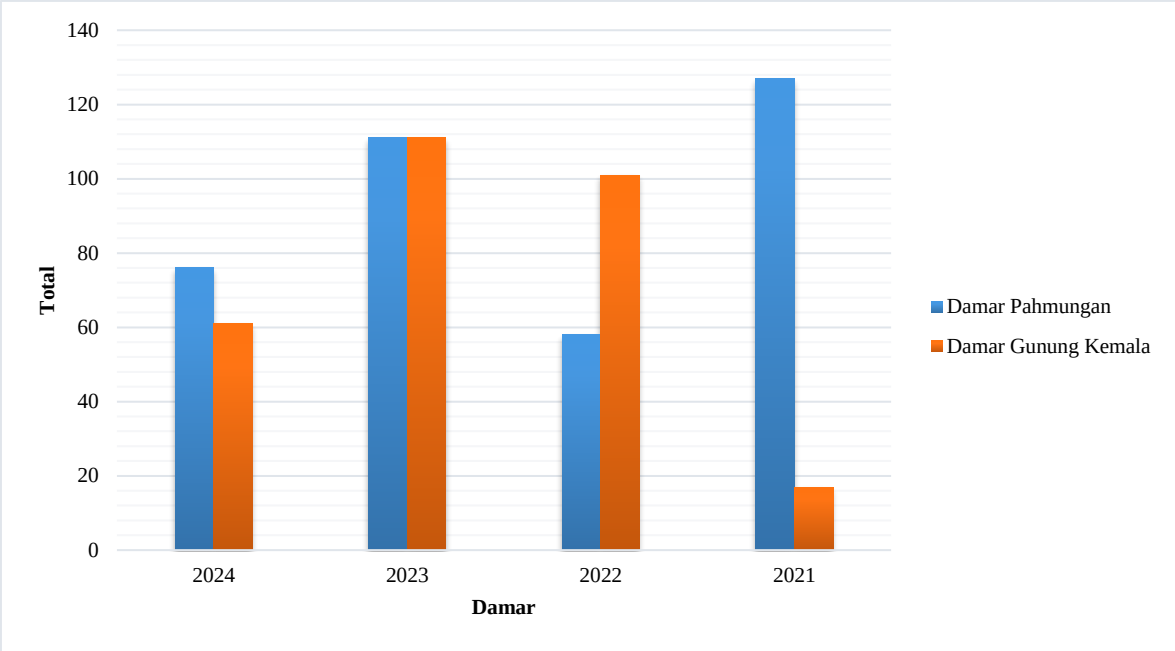

Figure 7. Comparison of damar in Pekon Pahmungan and Pekon Gunung Kemala from 2021 to 2024

3.4 Comparasion of damar in Pekon Pahmungan and Pekon Gunung Kemala as part of community conservation efforts

A comparison of various types of trees in Pekon Pahmungan and Pekon Gunung Kemala from 2021 to 2024 can be seen in Figure 5 and Figure 6. The comparison of the types of *Shorea Javanica* species found in Pekon Pahmungan and Pekon Gunung Kemala from 2021, 2022, 2023 and 2024 can be seen in Figure 7.

Figure 6 depicts the number of different types of plants over three years in 2021, 2022, 2023, and 2024. The most dominating plant is "damar," which peaked in 2023 with a number 120. However, in 2024, the number of "damar" plants has a drastic decrease, it almost reached the number recorded in 2021. In addition to "damar", the "duku" plant also stands out with a significant number and is relatively stable throughout the three years. The sharp decline in the number of "damar" crops from 2023 to 2024 could be caused by various factors such as climate change, different land uses, pest or disease attacks, or changes in agricultural practices. To understand this decline further, additional research is needed so that appropriate steps can be taken to manage these crops. This graph provides insight into changes in the number of specific crops over three years, with special attention paid to significant fluctuations in "damar" plants.

Figure 7 shows quantitative data for different types of objects (most likely plant or fruit types) from 2021 to 2024. From this diagram, it can be seen that several types of objects have undergone significant changes from year to year. Some interesting trends can be observed from this chart. For example, the number of damar peaked in 2023 with more than 100 trees, but experienced a sharp decline in 2024. In contrast, the number of Duku is quite consistent from year to year, although there is a slight decrease in 2024 compared to 2023. Petai shows a significant decline from 2021 to 2023, but no data is shown for 2024. Bayur had the highest number in 2021 with a drastic decline in the following years. Some objects such as Durian and Tin Wood only have data in 2024, suggesting that data for previous years may not be available or the number is very small. Jengkol showed a decrease from 2023 to 2024, while Cempedak and Angsor remained stable during the period shown. Mangosteen has limited data but appears to be consistent between 2021 and 2024. Overall, this chart provides a comprehensive overview of the fluctuations in the number of specific objects over the past four years. This variation may be due to various factors such as changes in the environment, policies, or market conditions. Further analysis can help identify the reasons behind these trends and provide insights for management and planning ahead. This increase can be attributed to the factor of farmers' preference for damar production. These farmers' favourability factors may include various aspects, such as better cultivation techniques, increased interest in growing and caring for damar plants, and support from the government or related institutions that facilitate the growth and management of damar plants more effectively. The existence of these factors has contributed significantly to the increase in the amount of damar in 2024 [13]. Based on the results of this study, the impact of damar tree conservation is the maintenance of damar trees from year to year with various ways for the community to maintain damar repong. The measurements carried out in this study as serial data to see the consistency of the implementation of conservation efforts carried out by the West of Pesisir District's community towards damar trees.

Similar research [11] describes Pekon Pahmungan obtained the Important Value Index in the tree phase of 136.41 and Pekon Negara Ratu Tenumbang that the Important Value Index in the tree phase was 89.25 in 2023. The research describes data on tree phase diversity. According to study [12], describing damar trees and Durian trees including the diversity recorded in the research.

3.5 Conservation and economic impact of damar trees in Damar Park

Based on the research results from the researcher (Figure 8), it was found that Damar Park is land planted with various plants such as forestry plants and fruit plants. So, the West of Pesisir District people can use various plants to increase their

economy. This describes that agroforestry has been carried out by the West of Pesisir District community since ancient times. Based on the results of the study, it was found that Damar Park plays an important role in economy- contibution. 100% of the community believes that Damar Park can help the community improve the family economy. 59% of the community knows that the price of damar can be increased with post-harvest technology to increase economic value. However, even though the community knows that post-harvest technology can increase the economic value of damar, they do not carry out the post-harvest technology. Therefore, local universities such as the University of Lampung are required to provide additional post-harvest knowledge so that the value of damar resin increases significantly and of course will provide a significant economic contribution to the income of the West of Pesisir District community. The damar tree (*Shorea javanica*) produces sap that is exported to national and international markets, including to Japan, for use in industries such as perfumes, paints, and cosmetics [14]. This income from damar sap allows many families in the West of Pesisir District to improve their standard of living, including sending their children to higher education [15]. The increase in income of the Pahmungan and Gunung Kemala communities was also caused by the presence of Damar Park. This can be seen in Table 5.

Figure 8. Damar Park research team

Table 5. Income increase in Pahmungan and Gunung Kemala communities

	2021	2022	2023	2024
Pahmungan	811,600	830,534	892,000	1,600,000
Gunung Kemala	580,150	451,908	672,720	1,160,000

The Pahmungan community increased their income from 2021 to 2024. The same thing happened in Gunung Kemala. The income increased significantly in 2024 (the Pahmungan location increased by IDR 1,600,000 and Gunung Kemala IDR 1,160,000). This is because the basic price of damar resin on the market has doubled from the previous price.

According to a study, the damar sector has become a basic economic activity that contributes positively to economic growth in the West of Pesisir District Lampung. Based on the analysis, it is shown that the distribution of income from the damar sector is quite evenly distributed in some districts, although there is still variation between regions [16].

However, Damar Park faces challenges from various sides, including pressure to convert land use into oil palm plantations that are more economically profitable in the short term [17]. In addition, the younger generation tends to be less interested in continuing this tradition because it is considered less modern and not financially promising than other jobs [18]. Efforts to preserve Damar Park require collaboration between indigenous peoples, the government, and various other stakeholders [19]. Modern approaches and training programs involving information technology and IT-based promotions can attract the interest of the younger generation to continue to preserve this tradition [20]. Support from the government in the form of empowerment and training programs is also very important to ensure the sustainability of Damar Park [21].

4. CONCLUSIONS

Based on the analysis of vegetation in Pesisisr Barat, it can be seen that damar trees (*Shorea javanica*) dominate the research area with the largest number of trees, the largest base area, and the highest IVI with score 136,85. The Anova results show that location has an effect on the Importance Value index with $\alpha_{0,05}$. The steep Pahmungan location has a higher IVI than the flat and easily accessible Gunung Kemala. Location does not affect diversity. This can be seen in the Pahmungan location with 17 species and 196 trees, not much different from Gunung Kemala with 12 species and 194 trees.

The dominance of damar trees is due to good environmental adaptation, high reproduction and growth rates, and the lack of competitors and predators. Damar trees are also very important for the local community because their sap has high economic value. Analysis of vegetation in Pekon Pahmungan and Pekon Gunung Kemala shows that damar trees are very dominating in the region. In 2024, there will be a significant increase in the amount of damar compared to 2023, which is due to farmers' interest in damar cultivation and support from the government or related institutions. However, in 2024 there will also be a decrease in the amount of damar which is most likely caused by weather changes, pest attacks, and plant diseases.

Damar Park makes an important contribution to the regional economy, with damar sap being exported to national and international markets. Income from damar sap allows many families on the West of Pesisir District to improve their standard of living. Local wisdom in the local community in Pahmungan and Gunung Kemala has a positive impact on the income of the local community. This is shown from year to year the income of the West Coast community has increased. In 2024 there was a two-fold increase in income from IDR 811,600 to IDR 1,600,000 (Pahmungan), IDR 580,150 to IDR 1,160,000 (Gunung Kemala). To increase conservation efforts in the West Coast, it is necessary collaboration effort between indigenous community, governments, university and various other stakeholders, as well as modern approaches and training programs that appeal to the younger generation. Overall, the study provides a clear picture of the diversity and distribution of tree species in the area, as well as the importance of damar trees in the local ecosystem and economy. To ensure the sustainability of Damar Park, conservation and empowerment measures involving various parties are needed.

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