Analysis of Potential Regeneration and Dispersal Patterns of Sago Palm (*Metroxylon Sagu Rott ver molat (Becc)*) in Natural Habitat, Bajo Barat District, Indonesia

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Abstract

Sago palm (*Metroxylon sagu*), a tropical plant that has functioned as a conservation plant. Sago can withstand rainwater with springs that appear around the sago stand. This plant is resistant to climate change because sago roots have a hydrological function to regulate the arrangement of water sources in the soil so that water quality is maintained and sago plants continue to produce. However, currently, the existence of sago in its natural habitat is under threat of extinction due to the clearing of sago forest which is converted into residential land, public facilities and infrastructure, rice fields, and over exploitation. The purpose of this study was to determine the regeneration potential and dispersal pattern of sago in Bajo Barat District, Luwu Regency. The method used in this research is a purposive sampling technique (nonrandom sampling). Starting from a field survey were to determine the point of sago land where data is taken, make a circular plot with a size of 20 meters with a total plot of 31 plots, taking the required data. The data were analyzed by calculating the number of individuals and density to determine the regeneration potential. But, the spatial distrubtion pattern used the Morisita Index and Dispersion Index. The results showed that the regeneration potential of sago plants in Sampean Village and Kadong-Kadong Village with density analysis experienced adequate regeneration growth (*fair category*). The dispersal pattern of sago palm in Sampean Village is dominated clumped by using the analysis of Morisita index and Dispersion index, while the seedling phase indicates a uniform distribution pattern. However, the dispersal pattern of sago shows the diffrent between Morisita index (*uniform*) and Dipersion index (*clumped*) in Kadong-kadong Village. To improve the existence of sago plant communities in their natural habitats, it is necessary to plant or cultivate using local types of sago plants, as well as conservation of sago from the village government and local communities.

Keywords
Sago palm, fair regenartion, clumped distribution, swamp area, conservation action

1. Introduction

Sago palm has function as a conservation plant. Sago can withstand rainwater, this can be seen by the presence of springs that appear around the sago stand. Sago plants can also store water for a long time, marked by the presence of waterlogging in the long dry season, and low erosion around land overgrown with sago. This plant is resistant to climate change because sago roots have a hydrological function to regulate the arrangement of water sources in the soil so that water quality is maintained and sago plants continue to produce, where other plants are difficult to grow (Karmila, et al 2015). Under these conditions, sago continues to grow normally and regenerate. Harianto and Pangloli (1992), stated that under these conditions, sago was able to cover the soil fairly quickly, thereby reducing the impact of erosion. The growth of sago regeneration is unique, where sago forms stem after 3 years of age. Then around the base of the stem, buds (shoots) grow and develop into sago saplings, then obtain nutrients from the parent tree, until the roots can absorb nutrients themselves and the leaves can carry out photosynthesis (Flach, 1997; Rostiwati et al., 2014).

The spread of sago in Indonesia includes Irian Jaya, Maluku, Sulawesi, Kalimantan and Sumatra. One of the wet tropical palms that have strong adaptations to grow on marginal lands such as freshwater and brackish water that does not allow optimal growth for food crops and other plantation crops is sago (Suryana 2007). South Sulawesi is one of the provinces in Indonesia where the distribution of sago (Metroxylon spp.) is quite large with an area of 4,012 ha and is spread over several districts and areas in South Sulawesi where sago trees (Metroxylon spp.) are still growing, such as Selayar Regency, Luwu Regency, North Luwu Regency, East Luwu Regency, Bone Regency, and Palopo City. The area of sago forest in Luwu Regency in 2014 was around 1,462 Ha. The survey results in 2016 stated that the area of sago forest in Luwu Regency was reduced where the remaining area was 1,382 hectares (BPS Kabupaten Luwu, 2016).

The area of this sago is getting less and less. This is due to human activities that affect the sago forest. Sampean Village and Kadong-Kadong Village are villages in West Bajo District, Luwu Regency which have sago potential. However, currently experiencing damage due to the reduced area and population of sago plants. This is due to the clearing of sago forest which is converted into residential land, public facilities and infrastructure, rice fields, excessive management, and lack of attention from the government and local communities (Yusuf, M., & Wekke, I. S. 2020).

Considering the function and importance of sago plantation forest as a conservation plant and also as a food crop other than rice for future life, conservation efforts are needed to maintain and maintain the existence of sago forest. Specifically, the regeneration potential is used as the basis for the availability of tillers in their natural habitat that can support conservation activities. Therefore, it is necessary to study the regeneration potential and distribution pattern of sago in Sampean Village and Kadong-Kadong Village, Bajo Barat District, Luwu Regency.

2. Method

The study site was conducted at the high land sago palm area in the Sampean and Kadong-kadong Villages, Bajo Barat District, Luwu Regency, South Sulawesi Indonesia. Luwu Regency is located between 2°34'45" - 3°30'30" south latitude, 120°21'15" - 121°43'11" east longitude with area is 3.000,25 km². At the dry season (May – August), the average precipitation was 154 mm, with daily temperature about 32°C at altitude 90 – 500 meter above sea level . While at the rainy season (November – April), the precipitation was 1.067 – 3.768 mm, with temperature 15°C to 230°C. Especially, the Sampean and Kadong-kadong Villages have flat to hilly topography by claasified moderate (> 100 meter – 500 meter above sea level) to high land (> 500 meter above sea level) (BPS Kabupaten Luwu, 2016). The location for data collection in the study site was conducted in June – August 2017.

The method used in this study is a purvosive sampling technique (non random sampling). Starting from a field survey where to determine the point of sago land where data is taken, determine the coordinates of the plot (using GPS), make a circle plot with a diameter of 20 meters (each plot 314 m^2), where the number of plots in Sampean Village is 21 plots and Kadong-Kadong Village there are 10 plots. Determining the direction (using a compass) starting from the north tie point towards the south. Make observations and record into the prepared tally sheet. The parameters of the data collected were the growth phase of sago palm include seedling, sapling, pole and tree. The pole and tree were measured at breast height (1.30 m) above the trunk with the diameter roll. However, sapling and seedling were only counted the number of individuals.

The measurement data obtained in the field will be analyzed to calculate the density to explain potential regeneration and dispersal pattern (spatial distribution pattern). The potential regeneration is analyzed in the form of a graph, where this graph is the result of calculating the number of individuals for each growth phase and is supported by the regeneration status. The regeneration status based on Muhammad Hamid, et al. (2015) is 1) Good if the number of seedlings > saplings > poles > trees. 2) Adequate (Fair) if the number of seedlings > sapling > poles ≤ tree. 3) Low (Poor) if the species can live only on trees and seedlings. 4) There is no regeneration (None) if there are no species either at the pole, weaning, or seedling levels. 5) Only regenerate (New) if there are no trees but only at the level of growth of poles, sapling, and seedlings. The distribution pattern of sago palm can be calculated using the Morisita index and Dispersion index according to Rani (2013), with the criteria If ($I\delta = 1$), then the individual distribution plot is random. If ($I\delta > 1$), then the population has a clumped distribution pattern, and if $I(\delta < 1)$, the population has a uniform distribution pattern. Then, calculating standart of Morisita index (Ip) use 4 formulas and Ip value about between -1 to 1 with The standardized ex Morisita dispersion (Ip) ranged from –1 to 1, with 95% confidence limits at 0.5 and –0.5 Random dispersion. The Random pattern gives Ip value =0 , cluster pattern >0, and uniform pattern <0. Then, dispersion index use formula *(I)* = Variance (S^2)/ Abundant average (X), if (I =1) has random pattern, (1< 1) means the distribution of sago palm is uniform. If (1 > 1), the dispersal pattern is aggregat/clustered.

3. Result and Discussion

3.1. Regeneration Potential of Sago Palm

Plant regeneration is a natural phenomenon which is the process of replacing old plants by young plants. Sago plants that have a regeneration phase are those that have tillers at the seedling, sapling and pole phases. The success criteria for the regeneration process can be seen by calculating the number of growth rates and the highest density value in a growth structure. The regenartion potency of sago palm in Sampean and Kadong-kadong Villanges, is performed in Figure 1.

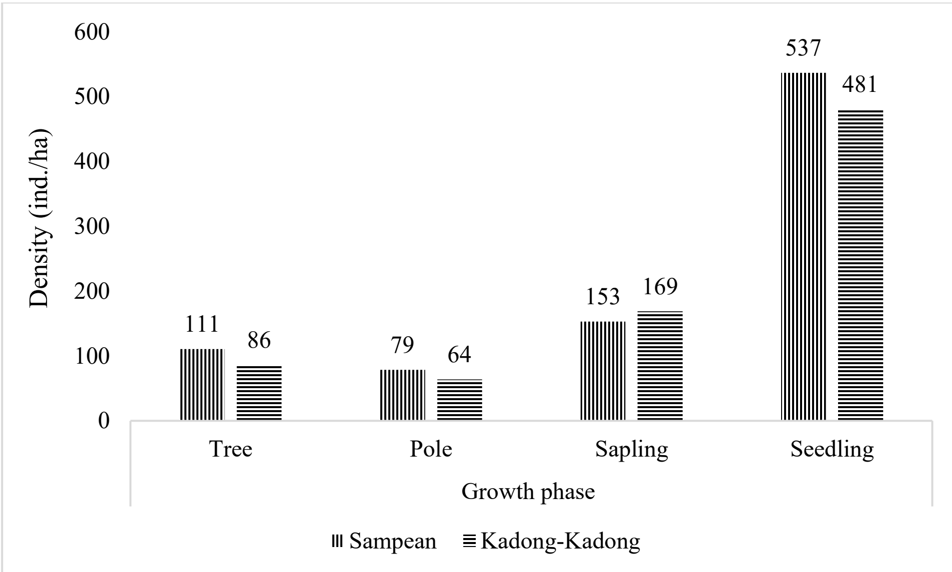

Figure 1. Regeneration potency of sago palm

Based on Figure 1, the higher density of growth phase is found in the Sampean Village than Kadong-Kadong Village. However, the most dominant density of growth phase shown in both villages is placed by seedling with value of 537 ind./ha In the Sampeang village and 481 ind/ha in Kadong-kadong vilage, then followed by sapling, tree and pole. On the other hand, the sapling phase is more dense in Kadong-Kadong Village with value 169 ind./ha than Sampean Village has density 153 ind./ha. In the general, the growth phase of sago palm majority was found in seedling and sapling, but not all of them grew to tree and pole level. This because competition for nutrients to grow, and is attacked by pests such as beetles. There is no silvicultural technique (thinning / pruning) and when the felling is finished, the cultivators of the sago do not clean the parts of the sago that suppress the saplings or seedling, thus them are difficult to grow. Tree density affects the existence of seedlings where there is less tree growth, the number of pole, sapling, and seedlings are also reduced, due to the growth process of the seedling comes from pneumetaphores (vegetative propagation) of the tree whose bases are old and have more fruit, compared to generative reproduction which derived from fruit to produce plants (seedlings) (Ismail, R., Wekke, I. S., Dinesh Kumar, A., Pandi Selvam, R., Shankar, K., & Nguyen, P. T. 2019).

The results study on the growth rate of sago form an inverted J curve. This shows that the regeneration conditions of the sago plants in Wewangriu Village are *fair category* (Hamid et al., 2015), where the number of individuals at the seedling level > sapling > poles ≤ trees and the density values of seedlings and sapling are also higher than the density values of poles and trees. This is because some people still maintain and preserve for their sago palms and the habitat conditions which sago grow well. So that the regeneration process can take place because there is sufficient regeneration available, and can guarantee the sustainability of the sago plant in the future. According to Widiyanti and Kusmana (2014), the horizontal structure of plants forming an inverted J curve will show a good secondary succession process over time. While, Mirmanto (2014) stated that growth regeneration is an inverted J curve. This curve explained that the smaller the growth phase, the greater the number of individuals. (Tukwain, S. M. F., Fatimah, F., & Wekke, I. S. 2018).

The local people of Sampean and Kadong-kadong Villages maintain the existence of their sago palms. For the community this is a source of staple food and some parts of the plant can be used, such as leaves, midribs, bark and pith. As wall as, some of the people of both village refused their sago land to convert the land functions, such as rice fields, development of facilities and infrastructure. The sago plam grows on flat plains, flooded , exposese to direct sunlight and contain the nutrients.

3.2. Dispersal Pattern of Sago Palm (Metroxylon spp.)

Dispersal pattern is an important aspect of population structure and is formed by the intrinsic factors of species and their habitat conditions. Quantitative descriptions of spatial patterns are not only important for knowing the dynamics of the distribution or spatial distribution of populations, but also for determining sampling techniques in population surveys. The spatial distribution of plants is an important character in an ecological community. This is usually the initial activity carried out to research a community and is a very basic thing in the life of an organism (Wahyuni et al., 2017). The Spatial distribution pattern of sago palm was determined by using Morisita Index and Dispersion Index. The Morisita index was used to calculate a total number of individual dan plot sampling in the both villages. However, dispersion index is the oldest and siplest analysis for detemining the dispersal pattern of species. According to Rani (2013), the results of the study prove that this index is the best method for measuring the distribution pattern of an individual because it does not depend on population density and sample size. The distribution pattern of sago plants in Sampean and Kadong-Kadong Village based on the Morisita Index value is presented in the Tabel 1.

Table 1. Dispersal Pattern of Sago Palm Based on Growth Phase in Sampean and Kadong-kadong Villages

Villages	**Growth Phase**	*Morisitas Index*			*Dispersion Index*		
		Iδ	**Ip**	**Dispersal Pattern**	***I***	**X² (Chi-square)**	**Dispersal Pattern**
Sampean	Seedling	0,967	-0,502	**Uniform**	0,423	8,458	**Uniform**
	Sapling	1,081	0,286	**Clumped**	1,406	28,119	**Random**
	Pole	1,362	0,502	**Clumped**	1,923	38,462	**Clumped**
	Tree	1,279	0,502	**Clumped**	2,003	40,055	**Clumped**
Kadong-Kadong	Seedling	0,963	-0,436	**Uniform**	0,389	3,503	**Clumped**
	Sapling	0,885	-0,473	**Uniform**	0,338	3,038	**Clumped**
	Pole	0,842	-0,238	**Uniform**	0,667	6,000	**Clumped**
	Tree	1,111	0,144	**Clumped**	1,321	11,889	**Uniform**

Iδ = Morisita index, Ip= Standard of Morisita index, *I*= Dispersion index

Based on Table 1, the result shows that the dispersal pattern of sago palm in Sampean Village is dominated clumped by using the analysis of Morisita index and Dispersion index. The growth phase of pole and tree, both the indices show a clumped distribution because the index value is greater than 1 ($I\delta$ and $I > 1$) . while the seedling phase indicates a uniform distribution pattern ($I\delta$ and $I < 1$). different at the sapling e phase where the value of the Morsita index and Ip ($I\delta > 1$, $Ip > 0$, α 5%) is assumed that the spatial distribution is clustered, but the dispersion index shows a random distribution (X^2chi-square between X^2 0,975 and X^2 0,025). On the other hand, the dispersal pattern of sago palm point out the diffrent between Morisita index and Dipersion index in Kadong-kadong Village. The growth phase of seedling, sapling and pole has uniform dispersion at Morisita index, but tree level indicates a clumped distrubution. Otherwise for Dispersion index, majority stages growth experince clumped, however tree phase has uniform spatial distribution pattern.

Spatial distribution pattern is related to the population characteristic of sago palm, and species density affect. Based on population structure (Figure 1), individu number of sago palm most dominant at seedling and sampling stages. The frequency of seedling presence and density are found than the sapling in the plots. The growth tendency of the seedlings near to the tree because it grows vegetatively, but more evenly grows due to generative growth through seeds. For the tree phase with diameter > 40 cm, the sago palm is used as staple food by community with slective cutting. This indicated the presence of trees increasingly clustered, as a result seedling and sapling around the tree wil be distubed during felling. The seedling and sapling which survive will grow to reach the pole stage and will live in clump dispersally.

According to Mohfar (2012) competition or competition affects the ability of individuals to survive and reproduce, and can be indicated by changes in population sizes at a time. With increasing time, these individuals experience growth that requires a lot of energy so that there is competition, whether it is competition between individuals of one species or between various species in order to survive and grow. This competition can be in the form of competition for sunlight, mineral nutrients and defense against external disturbances such as pests and diseases. This competition will continue until there is a process of natural selection. This competition causes the death of individuals who are not able to survive and also results in a reduction in the number of individuals in each class and its growth rate structure (Irwanto et al., 2018; and Luhulima et al., 2015).

Habitat of sago palm is located at an altitude of 400 - 700 meters above sea level with a flat to hilly topography in the Sampean and Kadong-kadong villages. Especially, sago palm are found predominantly waterlogged due to its proximity to the main river, but at certain spots it is not inundated the conditions are still wet and humid. Sago plants need adequate water, but permanent flooding can interfere with sago growth. Sago grows in swamp areas with fresh water swamp areas and in areas along streams, around water sources, or in swamp forests. This indicates that the dispersal pattern of sago palm is also influenced by habitat condition (Botanri, 2011; Vita, 2017).

The result of data analysis using Morisita index and Dispersion index, pointed out that the dispersal pattern is dominated by clumped and uniform. Clustere ddistribution occurs because it is affected by environmental factors. The pattern of clumped dispersion is a distribution that often experience in the nature (Indrayanto, 2010). According to Metananda (2015), socio-ecologically, the clumped dispersal pattern indicates that te presence of nutrient is cocentrated in certain location. In addition, the socio-biological distribution of cluster also shows thre is social interaction or association between growth phase. (Wekke, I. S., Aghsari, D., Evizariza, E., Junaidi, J., & Harun, N. (2018). Plant live with a high sensitivity to environment in the early stages. On the other hand, The uniform dispersion pattern is the distribution in which individuals are found in certain places in the community, individuals who are more or less equidistant from each other. This uniform distribution pattern is due to the uniform growing location, and competition for nutrients, growing space, loging treatment, and migration. In addition, it is also influenced by physical factors such as abnormal water conditions, sandy and muddy soil, unstable sunlight, and low-temperature humidity (Fitriani dkk., 2019). According to Ludwig and Reynolds (1988), a uniform distribution pattern occurs when the conditions in which the growth is relatively uniform, and compete for space, for nutrients. Climatic conditions and the availability of nutrients or nutrients are environmental factors that play a very important role in distribution. However, if a community provides sufficient nutrients for the growth of a plant species, it will tend to form a clustered distribution pattern. In addition to external disturbances such as logging and changes in area designation, this uniform distribution pattern is also due to the instincts of these individuals or species to seek a suitable or decent living environment. These individuals will be able to live and grow if the environment where they grow is supportive. If the environment is not supportive, these individuals will certainly die.

4. Conclusion

The growth of sago regeneration in Sampean Village and Kadong-Kadong Village based on the number of growth rates has form an inverted J curve. This shows that the regeneration conditions of the sago plants in Wewangriu Village are *fair category*, where the number of individuals at the seedling level > sapling > poles ≤ trees and the density values of seedlings and sapling are also higher than the density values of poles and trees.

The dispersal pattern of sago palm in Sampean Village is dominated clumped by using the analysis of Morisita index and Dispersion index, while the seedling phase indicates a uniform distribution pattern. However, the dispersal pattern of sago shows the diffrent between Morisita index and Dipersion index in Kadong-kadong Village. The growth phase of seedling, sapling and pole has uniform dispersion at Morisita index, but tree level indicates a clumped distrubution. Otherwise for Dispersion index, majority stages growth experince clumped, however tree phase has uniform spatial distribution pattern

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Biography

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