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Biophysical Characteristics of the Mount Hamiding Protected Forest Area and Forest Engineering for Sustainability

(Karakteristik Biofisik Kawasan Hutan Lindung Gunung Hamiding dan Rekayasa Hutan Untuk Keberlanjutan)

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Abstract

The protected forest of Mount Hamiding serves as a water management system, preventing erosion and flooding, while also acting as an ecosystem buffer. However, it has been damaged due to social pressure from the increasing population, which has led to the need to meet the community's needs around the forest. The purpose of this study was to determine the biophysical conditions of the protected forest area of Mount Hamiding: soil, slope, climate and sustainable management strategies. The method used in this study is a descriptive method with a qualitative-quantitative approach. Data collection techniques were carried out using observation, interview and literature study techniques. The results of the study showed that the biophysical conditions of the protected forest area of Mount Hamiding have slopes from flat to steep, entisol soil types which are newly formed soils with physical and chemical soil properties, while the climate type in the protected forest area is based on climate A and B. Forest and soil damage caused by anthropogenic activities, namely clearing forests to expand agricultural and plantation areas, and illegal logging. Based on this phenomenon, the strategic efforts made to manage forests sustainably, namely to improve the physical and chemical conditions of the soil, are through forest rehabilitation activities with an agroforestry model that aims to improve ecological functions and community welfare because this pattern is a form of product diversification and provides ecological functions for the environment.

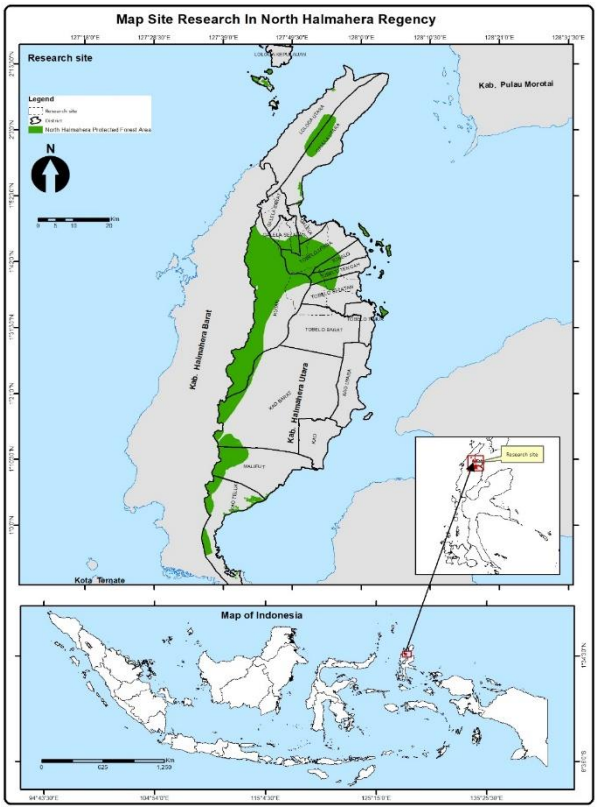
I. INTRODUCTION

Protected forests are buffer areas (Kailola et al., 2019; Kailola, 2023; Latupapua & Kailola, 2023) that function as protected areas that provide environmental services and are a place to live (Dudley, 2020; Truong, 2022; Maneewong et al., 202). The existence of protected forests is greatly influenced by soil conditions, slopes and climate (Wade et al., 2020). Soil is one of the factors that determines plant growth. For plants, soil functions as: a place for plants to grow, a place for air supply for plant root respiration and microorganism life, a place for nutrient supply for plant growth, both in the form of organic and inorganic substances and a place for water supply to dissolve nutrients so that they can be absorbed by plants. The success or

failure of RHL activities is due to soil conditions. One way to accelerate the development of good plants for forest plants is to look at soil conditions. This is because soil conditions are one of the factors that greatly affect plants. Soil fertility is a condition of the soil where the water, air and nutrient systems are in a fairly balanced state and are available according to plant needs, both physically, chemically and biologically (Rofita et al., 2021). Fertile soil is soil that has a deep profile (very deep) exceeding 150 cm, a loose crumbly structure, pH 6-6.5, and has high microbial activity (maximum) (Kailola, 2023b). The darker the soil colour, the higher the level of fertility, because the darker it is, the more humus is contained in the soil. Etisol Soil Type is a type of young soil that has not developed significantly and shows little or no evidence of pedogenic horizon development. This soil is often found in areas with volcanic activity, sandy areas, or areas that have recently experienced erosion. Some examples of entisol soil types include regosol, lithosol, and alluvial. Land slope or land slope is the ratio between the height difference (vertical distance) of a land and the horizontal distance. Land slope is usually expressed in per cent (%), indicating how many meters of height difference for every 100 meters of horizontal distance. Topographic conditions in the Soakonora Village forest area are flat, sloping, slightly steep, steep and very steep (Kailola, 2024). Climate is the average atmospheric condition, which is the result of calculating weather parameters over a long period. Climate elements are parameters that are difficult to control in forest management activities. The weather parameters used in forestry are rainfall and temperature. The Mount Hamiding protected forest is an ecosystem buffer forest area, but has recently experienced degradation due to social pressure from the community to meet their living needs (Kailola, 2025). Based on this phenomenon, it is important to conduct a study to determine the biophysical conditions and efforts to overcome damage for sustainable management.

II. MATERIAL AND METHOD

This research was conducted in the protected forest area of Mount Hamiding from January to April 2024. The research method used in this study was descriptive, while the approach used was descriptive-qualitative (Kailola et al., 2023). Data collection techniques were carried out by observation, interviews and literature studies. Primary data were obtained from the results of observations and interviews, and secondary data from literature studies. Qualitative research data analysis was carried out interactively and continued continuously until completion through three elements: data reduction, data presentation, and conclusion. Data reduction is classifying data so that conclusions can be drawn in the end. Data reduction can make it easier for researchers to find the data obtained if needed, and helps in coding certain aspects. Data presentation involves collecting information in an organised manner so that it can provide the possibility of conclusions. Data verification is producing an accurate conclusion. To get an accurate conclusion, it can be reviewed again by verifying the records during the research activities and looking for patterns, themes, models, relationships and similarities in order to decide on a conclusion.



Picture 1. Map Research

III. RESULT AND DISCUSSION

3.1. Biophysical conditions

The protected forest area of Mount Hamiding has a slope level ranging from flat to steep. The type of soil is entisol, with rainfall (Kailola, 2024). Based on the results of observations and interviews, this forest area has been damaged by human activities

(anthropogenic). The physical and chemical properties of the soil can be seen in Table 1.

From the data on soil chemical conditions in protected forest areas, it shows that the highest percentage of available nitrogen nutrients is in Soakonora village 0.34% in the medium category, followed by Roko village in the medium category (25%), Efi-Efi in the medium category (0.25%), Togawa in the low category (0.14%), Mamuya in the low category (0.11%), and Wangongira in the low category 0.04%, while the average result is 0.20% in the low category. The highest percentage of phosphorus elements is in Togawa village 0.09% in the very high category, followed by Sokonora village (0.09%) in the very high category, Efi_Efi (0.07%) in the very high category, Mamuya (0.05) in the very high category, Roko (0.03%), in the medium category, and Wangongira village 0.02% in the medium category, while the average is 0.06% in the high category.

The highest organic carbon element in Roko village is 17.59% in the very high category, and very low only in 2 villages, namely Wangongira village (0.33%) and Mamuya village (0.14%). The average organic carbon element is 5.49% in the very high category.

Table 1. Soil chemistry in the Mount Hamiding Protected Forest Area

Number	Village	Altitude of the place	pH	Temperature	C_Org (%)	N_ttl (%)	Phosphorus (%)	P2O5 (%)
1	Soakonora	175,3	6,57N	29,68	5,71**	0,34SR	0,09**	0,20**
2	Togawa	83,3	6,49A	30,05	4,83*	0,14R	0,09**	0,21**
3	Mamuya	230,7	6,67N	28,28	0,14SR	0,11R	0,05*	0,11**
4	Efi efi	637,5	7,54B	28,43	4,31*	0,25S	0,07**	0,16**
5	Wangongira	470,4	6,18N	28,47	0,33SR	0,04SR	0,02s	0,05*
6	Roko	146,8	7,64B	29,88	17,59**	0,32S	0,03S	0,08**
	Average	290,67	6,848N	29,13	5,49**	0,20R	0,06*	0,13**

*Information : N = neutral, A = acids, B =bases, R = low, SR = very low, S = middle, * =high, ** = very high.*
Data Source: *Kailola, 2024*

This illustrates that the availability of organic carbon elements in the four villages (Roko, Soakonora, Togawa, Efi-Efi) is quite high, while the other two villages, namely Wangongira, have very low. The highest P2O5 element in Togawa village is 0.21% in the very high category, the lowest in Wangongira village is 0.05% in the high category, and overall, the average is 0.13% in the very high category. This illustrates that the availability of P2O5 elements is very high at the research location. According to Rofita (2022), North Halmahera Regency has an area with very complex landscape conditions, where in the north there are karst and structural hilly landscapes, while the central part has active volcanic mountains, and the southern part has volcanic landscapes. The complex and varied landscape conditions cause unique general and specific topographies, where both topographies have different functions in influencing land and forest damage. Topographic conditions with general slopes have abundant soil resources and thick soil solum and function as reservoirs and controls against flood threats, so that they can be conservative areas for protected forest areas. The impacts caused by forest damage on volcanic landscapes are lower than structural landscapes.

Volcanic landscapes have characteristics of mountainous to hilly relief, relatively thick and abundant soil sources, and the soil in this landscape is generally andosol, which is physically and chemically fertile. Volcanic landscapes are not easily eroded if there is no human interference. The highest land damage occurs in structural landscapes, because they have steep relief with rough surface topography, steep slopes are caused by resistant rocks, so that they are difficult to weather and high erosion, so that the weathered material that becomes soil is relatively thin.

Most of North Halmahera Regency is a mountainous area dominated by volcanic rock formations (andesite and basaltic igneous rocks). Based on the soil type map from (Balai Besar Sumberdaya Lahan Pertanian, 2014), the types of soil found in North Halmahera Regency include: inceptisol, afisol, molisol, utisol, entisol and andosol. According to Rofita, (2022) that the type of soil in the Tobelo sub-district is mostly andosol, while North Galela (Mamuya is andosol), Galela and West Galela are entisol. this is also in line with Watimena (2011) that the soil in the Galela

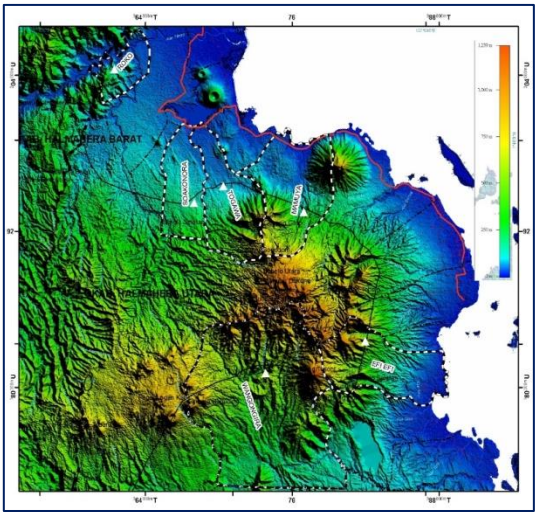
area is an entisol. The results of this study indicate that the type of soil in North Halmahera is actually varied because it consists of mountain plates, whereas in South Galela (Sokonora and Togawa), it is entisol. While in the North Galela sub-district, it is andosol. Therefore, it is necessary to avoid in forest management to change the landscape into agriculture because it will have an impact on damage and the danger of flooding and erosion. Based on the data above, it shows that the HLGH area has a topography from hilly to steep with various types of soil, namely entisol, andosol and regosol.

The results of the analysis of physical and chemical properties of the soil in the HLGH area show that the nitrogen nutrient is available in the moderate category in the villages of Soakonora, Roko and Efi-Efi in the moderate category. While the villages of Togawa, Mamuya and Wangongira are in the low category. These results indicate that the availability of nitrogen nutrients is low to moderate. This condition illustrates that the availability of N elements needs to be increased for the growth of forest vegetation through fertilisation with compost and choosing to plant local plant species that can bind oxygen. The percentage of phosphorus elements in the villages of Togawa, Sokonora, Efi-Efi is very high, in the village of Mamuya it is high while in the villages of Wangongira and Roko it is in the moderate category. This illustrates that the phosphorus element is sufficiently available for the villages of Togawa, Soakonora, Efi-Efi and Mamuya, while for the villages of Wangongira and Roko, it needs to be increased. The availability of organic carbon elements in the villages of Roko, Soakonora, Togawa and Efi-Efi is quite high, while in the villages of Wangongira and Mamuya, it is very low. In villages that experience carbon deficiency, treatment needs to be given to increase carbon. The soil pH conditions in Wangongira and Togawa villages show acidic conditions, while the other 4 villages are neutral. This shows that the average soil pH condition shows neutral conditions, which are very good for plant growth because neutral pH conditions cause the nutrient metabolism cycle in plants to run well. Climate conditions with rainfall of 1500 - 2000 mm per year for the southern Tobelo area (Efi-Efi) and Wangongira, while rainfall of 2000-2500 mm/year covers North Halmahera as a whole (including the villages of Mamuya, Sokonora, Togawa and Roko). The results of the slope analysis in Table 2 illustrate that the HLGH area has a slope percentage with flat conditions of 33.75%, sloping 38.82%, slightly steep 18.17%, steep 6.79% and very steep 2.4%, so that the management of the HLGH area needs to consider the biophysical conditions mentioned above.

Table 2. Slope of the Hamiding Mountain Protected Forest area

Number	Slope	Category	Wide (ha)	Percentage
1	Flat	0-8%	9.273,16	33,75%
2	Sloping	8-15%	10.665,14	38,82%
3	A bit steep	15-25 %	4.990,69	18,17%
4	Steep	25-30%	1.864,43	6,79%
5	Very Steep	30-40%	678,59	2,47%

Data source: (K*ailola Jacob, 2024)*



Picture. 2. Location of soil sampling for research

Based on the slope and soil profile data in Figure 2. The protected forest area of Mount Hamiding has an entisol soil type that is easily fragile because it is a type of soil that is still easy because the new soil in the formation process does not have a deep solum, with a slope level from flat to very steep. The slope data shows that it is very dangerous if the forest area is opened for plantation activities, illegal logging and others.

3.2. Forest engineering

Therefore, by looking at the phenomenon of the condition of the protected forest area of Mount Hamiding, the efforts needed to restore soil fertility include:

Forest Engineering is empirical facts from the results of research on the biophysical conditions of HLGH show that protected forests are damaged due to anthropogenic activities and minimal access by the community and stakeholders, so the approach used is to apply forest engineering activities. According to Simon, (2008) in Dako, (2020), forest engineering aims to provide a new model in forest management so that forest management can help meet the needs of people living around forest areas and indirectly help improve community welfare. In forest management engineering, the main activities that must be carried out are: 1). Determination of Location. Forest location for planting or rehabilitation activities and protected forests. 2). Selection of plant types: in making forest management engineering, it is necessary to pay attention to the types of plants to be used and one of them is the type of plant that is suitable for growing in the area and in accordance with government regulations. According to Manan in Kailola 2023, the selection of plant types for rehabilitation activities needs to consider ecological factors and social factors of the surrounding population. 3) Planting patterns; the forest engineering technique used is forest management with an agroforestry pattern. According to Suryani and Dariah (2012), the ultimate goal of agroforestry is to improve the welfare of farmers, especially those around the forest, namely by increasing active community participation in improving and maintaining the environment. This goal can be achieved by optimizing positive interactions between the various components (trees, agricultural crops, livestock/animals) or interactions between these components and their environment. There are several advantages of agroforestry compared to other land use systems. First) Productivity. Various research results show that the total product of mixed systems in agroforestry is higher than the monoculture system (planting one type of plant). The failure of one component/type of plant in a mixed crop system can be covered by the success of other components/types of gardens, second) Diversity. The combination of more than two components in the agroforestry system produces high diversity, both in terms of products and services. Therefore, from an economic perspective, it can reduce the risk of losses due to market price fluctuations. While from an ecological aspect, crop failure can be avoided if only one type is planted, third) Independence. High diversification in agroforestry can meet the basic needs of the community, while releasing dependence on external products. The independence of the agroforestry system does not require many inputs such as fertilisers and pesticides when compared to the monoculture system, fourth. Agroforestry practices have optimal diversity and productivity (Supriyanto, 2024; Murniati, 2024), which can provide balanced results throughout the land management, thus ensuring the stability and sustainability of farmers' income.

The form of protected forest management by involving the community in a participatory manner and by the regulations and policies for managing protected forests by Permenhut P.83/2016 concerning the social forestry scheme concerning the forms of social forestry programs that are by the conditions at the HLGH site level, namely community forests and village forests with agroforestry patterns without reducing the ecological function of the forest in sustainable management.

Based on research data on biophysical conditions, both regarding soil types, physical properties, soil chemistry, slope, climate and local vegetation types, agroforestry patterns can be applied.

According to Dako (2020) that forest management based on land slope classes is divided into several categories, namely: 1) Slope class 15 - 30%, 2) Slope class 30 - 45% and 3) Slope class more than 45%.

• HLGH management on a slope class of 15-30%

Forest management on a slope of 15-30% aims to improve the welfare of local communities by continuing to maintain forest sustainability. The types of plants to be planted in protected forest

areas are 50% types of medicinal plants, honey bee cultivation, and animal feed, and 50% are perennial plants. Perennial plants in the form of forestry plants, as much as 25% and plantation plants, as much as 25%. The types of forestry plants planted are local plant types: iron liver (Homalium foetidum), matoa (Pometia Spp), nyatoh (Palaquium Spp). plantation plants are nutmeg (Myristica fragrans), candlenut (Aleurites molluccanus), cloves (Zyzygium aromaticum) and chocolate (Theobroma cacao L).

• Management with a slope of 30 - 45%

Management of protected forests with a slope of 30 - 45% in which there are already gardens, because their function has changed. This is because before being designated as a protected forest area, the community had made gardens, then there was forest encroachment to open new land to be used as gardens. Therefore, its management must pay attention to ecological, economic and socio-cultural aspects. The composition of the types of plants that must be planted is 25% types of medicinal plants, animal feed, honey bee cultivation and 35% types of forestry plants; matoa (Pometia Spp), iron liver (Homalium foetidum), nyato (Palaquium Spp), sengon (Albizia falcataria) are native types for protecting biodiversity and function to fertilize the soil where the results of the study showed that the nitrogen content varies low -medium, and 35% of plantation crops; candlenut (Aleurites molluccanus), nutmeg (Myristica fragrans), cloves (Zyzygium aromaticum) and chocolate (Theobroma cacao L).

IV. CONCLUSION AND SUGGESTIONS

The condition of the protected forest area of Mount Hamiding is damaged due to anthropogenic damage due to forest encroachment to be used as agricultural land and illegal logging, this has an impact on forest and land damage where the type of entisol soil is the formation of new soil, so it is prone to flooding and erosion. Efforts that need to be made to overcome this problem are forest engineering, namely by carrying out land rehabilitation activities that have been damaged due to anthropogenic activities with an agroforestry pattern, namely by selecting types according to the characteristics of the growing place that can restore nutrients and plants that provide economic value, namely types of wood and multi-purpose trees species (MPTs).

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