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# Relationship between Soil Conservation Techniques, Topsoil Depth and Vegetation Density Growing in Oil Palm Plantation Areas in Plantation IV, Regional II, Marihat

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**Abstract**

This study aimed to identify land conservation techniques and analyze the relationship between soil conservation techniques, topsoil depth, and weed density in coconut and palm oil plantations at PT Perkebunan Nusantara IV Marihat. The research was conducted in April–May 2026 using a descriptive method with a field survey approach. Samples were selected purposively based on the different conservation techniques applied to the land. Data were collected through field observations, measurements of topsoil depth, and analysis of weed vegetation using parameters such as density, frequency, dominance, important value, and the Summed Dominance Ratio (SDR). The results of the study show that the weed vegetation is dominated by Axonopus compressus, which has the highest SDR value of 0.55. Topsoil thickness ranges from 27 to 33 cm, with an average of 30 cm, indicating that the land is relatively suitable for coconut and palm oil growth. There is a relationship between vegetation density and topsoil thickness, where vegetation plays a role in covering the land, helping to reduce erosion and maintain land stability. Weed management should be selective, and sustainable land conservation practices are recommended to support productivity and ensure land sustainability.

**Keywords:** Coconut Palm Oil, Conservation, SDR, Soil, Topsoil, Vegetation, Weeds

## 1. Introduction

Coconut oil palm (Elaeis guineensis Jacq.) is one of the leading commodities in Indonesia's plantation sector because it produces vegetable oil that is highly needed both domestically and globally. Indonesia has become the world's largest producer of palm oil since 2006, surpassing Malaysia and other producing countries. In 2019, Indonesia's crude palm oil (CPO) production was recorded at 47.12 million tons, increasing to 48.29 million tons in 2020. However, production declined to 46.22 million tons in 2021. This fluctuation in production indicates a dynamic situation influenced by land management conditions and environmental factors that affect palm oil productivity (BPS, 2023). This shows that national palm oil productivity is not always stable, even as plantation area continues to increase.

Coconut and palm oil plantations in Indonesia are growing very rapidly. They span 22 provinces, with the main concentrations in Sumatra and Kalimantan, which contribute around 95% of national CPO production. This development is marked by a plantation expansion rate of up to 24% per year during the period 1990–2015, with the total area reaching 16 million hectares in 2017. Land ownership structure is dominated by smallholder plantations, accounting for 53%, followed by the private sector with 42%, and the government with 5%. This situation indicates that the palm oil sector plays a strategic role in the national economy, while also exerting increasing pressure on land use, which is becoming more land-intensive.

The productivity of coconut and palm oil is greatly influenced by environmental conditions, especially land characteristics such as topography, slope, and land surface shape. Sloping land has the potential to experience erosion, which can lead to the loss of the upper soil layers, organic matter content, and a decrease in nutrients and water availability for plants (Miskana et al., 2022). Topography also affects soil conditions and plant growth because it

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determines water flow and the distribution of nutrients in the land (Abdillah Fikri, Hastuti, & Firmansyah, 2023). These conditions show that land quality is an important factor in the successful cultivation of coconut and oil palm.

The main problem that appears in coconut and palm oil cultivation is land degradation, characterized by erosion, sedimentation, and increased land density due to runoff. These conditions cause a decline in land fertility, which directly impacts the production of fresh fruit bunches. Land that experiences damage requires conservation efforts to protect land structure, repair physical and chemical soil characteristics, and sustainably maintain productivity (Simangunsong, 2011). Without proper management, degraded land will continue to decline in quality, reducing ecosystem quality in the plantation.

The depth of the topsoil is an important factor in determining the land's ability to provide water and nutrients to plants. Soil with deep topsoil allows roots to develop more optimally, enabling more effective nutrient absorption, whereas shallow soil limits root growth and reduces nutrient availability (Wibawa, Sugianto, & Prasetyo, 2012). Land classification also serves as a basis for land management because each type of land has different characteristics and requires treatments suited to its nature (Hardjowigeno, 2010). These conditions show that variation in topsoil depth can directly influence plant productivity.

The presence of weeds is one of the biotic factors that influence the productivity of coconut palms. Weeds compete with the main plants for light, water, and nutrients, which can significantly reduce production (Zulhusni, Wijayani, & Suryanti, 2023). Several dominant weed species, such as Mikania micrantha, Asystasia cromandeliana, and Imperata cylindrica, can decrease production by up to 20% (Directorate General of Plantations, 2014). The diversity of weeds is also affected by environmental conditions such as light availability, land fertility, and the cultivation systems applied (Dibisono et al., 2022). These conditions suggest that weeds are important indicators of plantation ecosystem dynamics.

Research previously shows that weed composition can vary under different land conditions, such as flat and hilly areas, with different dominant species (Zulhusni et al., 2023). These differences indicate that environmental factors and land management influence the structure of weed vegetation. Identifying weed types and their density levels is an important first step in effective vegetation management to support the productivity of the main crops. This demonstrates that soil and weed vegetation are complex and interconnected, influencing each other.

Based on these conditions, it is necessary to understand the relationship between soil conservation techniques, topsoil depth, and weed vegetation density in the coconut palm oil plantation system. This research is formulated as several questions: How are soil conservation techniques applied in the Marihat IV Nusantara Plantation? What are the conditions of topsoil depth? What is the level of vegetation density? Additionally, what is the relationship between soil conservation techniques and topsoil depth, as well as between topsoil depth and vegetation density?

The purpose of this study is to identify the soil conservation techniques used, analyze the relationship between soil conservation techniques and topsoil depth, analyze the relationship between topsoil depth and vegetation density, and examine the relationship between soil conservation techniques and vegetation density.

This research is expected to contribute to the scientific understanding of sustainable land management in coconut plantations.

## 2. Material and Methods

This study was carried out at PT Perkebunan Nusantara IV Marihat in April–May 2026. The method used is a descriptive study with a survey approach, aiming to describe the relationship between soil conservation techniques, topsoil depth, and vegetation density in coconut oil plantation areas. The study population covers the entire Marihat garden area, which has varied topography, land types, and vegetation. The researchers used purposive sampling based on the different soil conservation techniques applied, with several observation plots established for each conservation type.

The object of the study area is a coconut and palm oil plantation, with observed variables including soil conservation techniques, topsoil depth, and vegetation density. Data collection involved field observations to identify land conservation methods, measure topsoil depth using a land drill or simple digging tools, and analyze vegetation density using parameters such as absolute and relative density, absolute and relative dominance, absolute and relative frequency, and important value. Additionally, we used the SDR (Structural Diversity Index) to describe vegetation structure quantitatively.

We used descriptive statistics to characterize each variable, presented in tables, graphs, average values, standard deviations, and frequency distributions. Correlation analysis examined relationships among soil conservation techniques, topsoil depth, and vegetation density. Regression analysis was also performed to determine the influence of these variables. The results are expected to provide a comprehensive understanding of the field conditions and the interrelationships among physical and environmental factors within the coconut and palm oil plantation system.

## 3. Results and Discussion

### 3.1. Research Location Description

This study was conducted in a plantation area of coconut and palm oil plantation at PT Perkebunan Nusantara IV Marihat Plantation Business Unit in Marihat.

The geographical coordinates are approximately 2°52' N and 99°05' E, in Simalungun Regency, North Sumatra. The location encompasses several sub-districts, including Siantar, Jorlang Hataran, Dolok Thousands, and the Land of Java, with an approximate distance of 135 km from Medan City and about 10 km from Pematang Siantar City. The topography of the area is undulating, with slopes ranging from 0 to 15%, and sits at an altitude of 367–378 meters above sea level.

Climatologically, the research area is classified as a wet zone with annual rainfall between 3,000 and 3,330 mm, relatively evenly distributed throughout the year, with approximately 184 rainy days per year. The air temperature ranges from 20°C to 29°C, with sunlight exposure lasting about 5–7 hours per day. The dominant soil type is Podzolic, with a pH of 5.0–6.0, sandy clay texture, good drainage, and classified as very suitable (S1) for the cultivation of coconut and palm oil. The environmental conditions support plant growth and influence the soil and vegetation dynamics at the study site.

### 3.2. Observation result Field

#### 3.2.1. Identification Results: Vegetation Weeds in Marihat

Based on the data, the weeds found in the area fall into three main groups: broadleaf weeds, narrowleaf weeds, and enigmatic weeds. Broadleaf weeds dominate in terms of species variety, with three main species identified: Ageratum conyzoides, Desmodium tricolorum, and Scoparia dulcis. These species tend to thrive in the environmental conditions of the study area's environmental conditions, especially in locations with sufficient light intensity, adequate height, and good humidity.

Weeds from the Poaceae family are also prominent, particularly Axonopus compressus and Oplismenus hirtellus ssp., which have strong adaptive abilities, tall growth potential, and the capacity to rapidly become dominant weeds in the coconut and palm oil plantation.

**Table 1.** Types of Weeds at Marihat Location

| No | Type Weeds | Regional Name | Family | Group |
|---|---|---|---|---|
| **1** | *desmodium tricolorum* | scales betok | *Fabaceae* | Leaf wide |
| **2** | *Kylinga nominalis* | shave pendul | *Cyperaceae* | Puzzle tekian |
| **3** | *Axonopus compressus* | Grass mini elephant | *Poaceae* | Leaf narrow |
| **4** | *ageratum conyzoides* | bandotan | *Asteraceae* | Leaf wide |
| **5** | *Scorpiaria dulcis* | broom sweet | *Plantaginaceae* | Leaf wide |
| **6** | *Oplismenus hirtellus ssp* | basket wavy | *Poaceae* | Leaf narrow |

#### 3.2.2. Topsoil Thickness in Marihat

The data show that the thickness of the topsoil in each plot varies between 27 cm and 33 cm, with the lowest value found in Plot 3 (27 cm) and the highest in Plot 1 and Plot 7 (33 cm). This variation reflects differences in the physical condition of the land in each plot, influenced by factors such as erosion, land management, and organic material accumulation. The average topsoil thickness of 30 cm indicates that the soil layer in the study site is generally classified as good to quite suitable for supporting plant growth, as it can still provide nutrients, water, and sufficient space for root development.

**Table 2.** Topsoil Thickness in Marihat

| No | Plot | Thickness (cm) |
|---|---|---|
| **1** | Plot 1 | 33 |
| **2** | Plot 2 | 31 |
| **3** | Plot 3 | 27 |
| **4** | Plot 4 | 31 |
| **5** | Plot 5 | 29 |
| **6** | Plot 6 | 28 |
| **7** | Plot 7 | 33 |
| **8** | Plot 8 | 29 |
| **9** | Plot 9 | 28 |
| **10** | Plot 10 | 31 |
| **Average** | - | 30 |

#### 3.2.3. Vegetation Weeds In the garden Marihat

**a. Density Weeds**

The analysis results show that Oplismenus hirtellus ssp. has the highest absolute density, with 776 individuals and a relative density of 0.24. This indicates that this species is the most dominant in terms of the number of individuals at the research site. On the other hand, Kyllinga nemoralis and Scoparia dulcis have very low densities, which suggests that these species are limited in number and are only found in a few observation plots.

**b. Dominance Weeds**

The absolute dominance value (DM) is the same for all weed types, namely 100. However, the highest relative dominance (DN) is found in Oplismenus hirtellus ssp., with a value of 1.29, indicating that this species not only has a high number of individuals but also tends to grow larger compared to other species. The lowest dominance is

observed in Kyllinga nemoralis, with a DN value of 0.15, suggesting that its influence on the plant community is relatively small.

**c. Frequency Presence (FM and FN)**

The highest absolute frequency value (FM) is in Axonopus compressus, with a value of 10 and a relative frequency (FN) of 0.29, indicating that this weed has a widespread distribution and occurs in almost all observation plots. In contrast, Oplismenus hirtellus ssp. and Desmodium tricolor have low frequency values, indicating that their distribution is limited to specific locations within the study area.

**d. Important Values and SDR**

Important values that combine density, dominance, and frequency show that Axonopus compressus has the highest combined score of 1.65 with an SDR of 0.55, indicating that this species is the most dominant and influential in the plant community at the research location. On the other hand, Kyllinga nemoralis has the lowest SDR value of 0.10, suggesting that its role in the plant community is relatively small.

**Table 3.** Vegetation weeds garden Marihat

| Type Weeds | KM | KN | DM | DN | FM | FN | Important Values | SDR |
|---|---|---|---|---|---|---|---|---|
| *desmodium tricolorum* | 753 | 0.23 | 100 | 1.26 | 4 | 0.11 | 1.60 | 0.53 |
| *kylinga nominalist* | 87 | 0.03 | 100 | 0.15 | 5 | 0.14 | 0.31 | 0.10 |
| *axonopus compressus* | 691 | 0.21 | 100 | 1.15 | 10 | 0.29 | 1.65 | 0.55 |
| *ageratum conyzoides* | 545 | 0.17 | 100 | 0.91 | 8 | 0.23 | 1.31 | 0.44 |
| *scoparia dulcis* | 386 | 0.12 | 100 | 0.64 | 6 | 0.17 | 0.93 | 0.31 |
| *oplismenus hirtellus ssp* | 776 | 0.24 | 100 | 1.29 | 2 | 0.06 | 1.59 | 0.53 |
| Total | 3,238 | | 600 | | 35 | | | |

### 3.2.4. Analysis Results: Soil Organic C Content in Gardens Marihat

Laboratory analysis shows that organic C content in the study area varies from 2.02% to 4.26%, with the lowest value in Plot 1 (2.02%) and the highest in Plot 9 (4.26%). Generally, large partial plots have organic C content in the highest category, indicating that the land in the Marihat garden still contains sufficient organic material. This supports the growth of coconut palms.

Plots 1 and 2 have organic carbon (C) content classified as moderate, with values of 2.02% and 2.17%, respectively. These indicate the availability of organic material, but the levels are not optimal. This condition may be influenced by low organic material input, high decomposition rates, and nutrient leaching due to heavy rainfall at the study location.

Plots 3 to 6 show higher organic C content, ranging from approximately 3.25% to 4.04%, influenced by litter accumulation from plants and the accumulation of leaf stalks from oil palm trees in the field. Plot 9 has the highest content, amounting to 4.26%, which falls into the very high category and indicates good soil fertility. This suggests increased cation-exchange capacity, improved soil structure, and of greater ability to store water and nutrients.

**Table 4.** Organic C content garden Marihat

| NO | Observation Plot | C- Organic ( %) | Criteria |
|---|---|---|---|
| 1. | Plot 1 | 2.02 | Currently |
| 2. | Plot 2 | 2.17 | Currently |
| 3. | Plot 3 | 3.25 | Tall |
| 4. | Plot 4 | 3.68 | Tall |
| 5. | Plot 5 | 3.83 | Tall |
| 6. | Plot 6 | 4.04 | Tall |
| 7. | Plot 7 | 2.53 | Currently |
| 8. | Plot 8 | 2.74 | Currently |
| 9. | Plot 9 | 4.26 | Very high |
| 10. | Plot 10 | 3.61 | Tall |

### 3.2.5. Connection Vegetation Weeds With Topsoil in Marihat

Based on the analysis of weed vegetation and topsoil thickness measurements in the plantation area of coconut and oil palm plantation area at PT Perkebunan Nusantara IV Marihat Unit, there is a relationship between weed presence and land condition. The topsoil thickness ranges from 27 cm to 33 cm, with an average of 30 cm, indicating that the land condition is relatively good.

Meanwhile, weed vegetation is dominated by Axonopus compressus, which has the highest SDR value of 1.65, followed by Desmodium tricolor with an SDR of 1.62. Other weed types have lower SDR values.

From an ecological perspective, vegetation weeds are connected to topsoil thickness because they function as ground cover that reduces the impact of direct rainfall on

the soil surface. The presence of sufficient weeds in an area can help slow the rate of erosion, resulting in greater topsoil thickness. This condition demonstrates that weeds play a role in maintaining the stability of the land surface at the study site.

The dominance of Axonopus compressus, with high density and frequency, indicates that this species primarily competes with the main plants rather than protecting the land. However, its presence still helps reduce surface erosion, especially on open land. Meanwhile, Kyllinga nemoralis, with a low SDR value of 0.10, may contribute to land conservation because its creeping growth habit allows it to evenly cover the surface of the land surface.

In plots with greater topsoil thickness, such as Plot 1 and Plot 7, it is suspected that the land has better vegetation cover or experiences lower disturbance, which helps suppress erosion. Conversely, in plots with lower topsoil thickness, such as Plot 3, the vegetation cover may be less than optimal, or surface disturbances may occur, leading to land erosion. This suggests a correlation between variation in weed vegetation and the stability of topsoil thickness at the study locations.

### 3.2.6. Implications for Land Management

Research on weeds and topsoil thickness in the coconut oil palm plantation area of PT Perkebunan Nusantara IV, Marihat Unit, reveals several important implications for land management. The dominance of Axonopus compressus, with the highest SDR value, indicates that the land is sufficiently open and supports aggressive weed growth. This condition highlights the need for intensive weed control in crop areas that have not yet produced or are in the early stages of production, to prevent high competition with oil palm trees for nutrients, water, and light.

The presence of vegetation weeds does not always have a negative impact, because various types—such as those with narrow leaves, wide leaves, or specific growth patterns—play a role in covering the land, which can reduce erosion, maintain soil humidity, and help preserve topsoil stability. Therefore, weed management should be selective to retain useful species for land conservation and control dominant weeds that may harm the main plants.

## 4. Conclusion

The study shows that the composition of vegetation weeds at the site includes species with wide leaves, narrow leaves, and rhizomes, with Axonopus compressus as the dominant species. This species is characterized by high density, frequency, dominance, and importance, as well as the highest SDR (0.55). The topsoil thickness ranges from 27 to 33 cm, with an average of 30 cm, indicating that the land is relatively good and still supports the growth of oil palm trees.

Furthermore, there is a connection between vegetation weeds and topsoil thickness; weeds can play a role in covering the land, helping to reduce erosion and maintain land stability.

Inappropriate weed management can increase competition with main plants and accelerate land degradation. Conversely, selective management can benefit land conservation. Therefore, it is recommended to control weeds selectively, especially dominant species such as Ageratum conyzoides, while maintaining weeds that cover the land from groups with wide leaves, narrow leaves, and riddles. Additionally, apply sustainable land conservation techniques such as organic mulching, cover cropping, vegetation to prevent erosion, and proper drainage systems, particularly in areas with low topsoil thickness.

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