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# SOIL FERTILITY STATUS IN MANDALA COSTUMARY FOREST BASED ON TOPOGRAPHY LEVELS

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**ABSTRACT**

***Abstract:*** *The level of soil fertility based on nutrients is influenced by the topography of a region. The purpose of this study was to determine the status of soil fertility at a topography of 300-350 masl in the Mandala customary forest based on C, N, P and K content. , 320-330 masl, 330-340 masl and 340-350 masl. Soil analysis uses chemical laboratory tests to determine the content of C, N, P and K. Elements C, N, P and K are associated with soil fertility criteria. Then determining the status of soil fertility is done by looking for the scoring of the element criteria. The results showed that the status of soil fertility in the Mandala customary forest was very high. At 330-350 masl topography, soil fertility is classified as very high, while soil fertility is very high at 300-330 masl topography. The higher a place, the chemical properties of the soil will increase, so that soil fertility will increase. The altitude limit that affects soil fertility starts from 0 masl <-> 3000 masl. Soil fertility status can be used as a guide in making decisions in managing forests to maintain the availability of nutrients.*

***Keywords:*** *Soil Fertility; Topography; Soil Organic Matter; Forest*

**Abstrak**:Tingkat kesuburan tanah berdasarkan unsur hara dipengaruhi oleh topography suatu wialyah. Tujuan penelitian ini adalah untuk mengetahui status kesuburan tanah pada topografi 300-350 mdpl di hutan adat Mandala berdasarkan kandungan C, N, P dan K. Sampel tanah diambil dari 5 titik topografi yang berbeda yaitu pada ketinggian 300-310 mdpl, 310-320 mdpl, 320-330 mdpl, 330-340 mdpl dan 340-350 mdpl. Analisis tanah menggunakan uji laboratorium kimia untuk mengetahui kandungan C, N, P dan K. Unsur C, N, P dan K dikaitkan dengan kriteria kesuburan tanah. Kemudian penentuan status kesuburan tanah dilakukan dengan mencari skoring dari kriteria elemen. Hasil penelitian menunjukkan bahwa status kesuburan tanah di hutan adat Mandala sangat tinggi. Pada topografi 330-350 mdpl, kesuburan tanah tergolong sangat tinggi, sedangkan kesuburan tanah sangat tinggi pada topografi 300-330 mdpl. Semakin tinggi suatu tempat maka sifat kimiawi tanah semakin meningkat, pada ketinggian sehingga kesuburan tanah semakin meningkat. Batas ketinggian yang mempengaruhi kesuburan tanah mulai dari 0mdpl<->3000mdpl. Status kesuburan tanah dapat dijadikan pedoman dalam mengambil keputusan dalam mengelola hutan untuk menjaga ketersediaan unsur hara.

**Kata Kunci:** *Kesuburan Tanah; Topography; Bahan Organik Tanah; Forest*

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## A. INTRODUCTION

Land is a natural resource as a medium for growing plants. The function of land is as a life supporter and planting media for plants because of the land is on which the living creatures stand on it (Arsyad, 2010). The nature of the soil affects its fertility (Darmawijaya, 1990) which has an impact on living things on it. Soil fertility is identified from the availability of sufficient and balanced nutrients to guarantee its growth. Thus, fertile or infertile land is associated with both physical and chemical properties, because these two properties influence each other. The physical properties of the soil include texture, structure and permeability, while the chemical properties include pH, the nutrient content consists of nitrogen, phosphorus, potassium and other organic materials. The number of species and number of plants can also contribute to soil fertility either physically or chemically (Sumarni et al., 2010)such as leaf and stem avalanches and rotting fruit can help in the supply of nutrients. Soil nutrients especially N are correlated with microbial biomass and plant litter microbes (Cotrufo et al., 2013; Sumarni et al., 2010)

Soil fertility varies in one place depending on its forming factors that parent material, topography, climate, organism, and time affect the formation of soil and its development. These factors do not work alone, but cooperate in producing land. Certain conditions of one of the soil forming factors are more dominant than others, so that heterogeneous soil properties are formed (Priyono & Priyana, 2016). The heterogeneous nature of soil causes different fertility, (Foth & Turk, 1972) and (Birkeland, 1984) suggest that the rate of development or soil fertility can be assessed based on color, depth, texture, structure, and nutrients. Therefore, soil fertility or development is not the same for different topography. The level of soil fertility can be done through an elemental diagnosis (Prabowo & Subantoro, 2018).

Soil fertility levels can decrease if available nutrients are reduced. Reduced nutrient concentrations in the soil such as organic matter and soil cation exchange capacity and changes in pH are called decreases in chemical fertility (Hartemink, n.d.). This decrease in fertility usually occurs through erosion by runoff which causes the loss of the upper layer. Topography affects soil fertility through its influence on drainage, surface runoff, soil erosion, and microclimate, which is the exposure of the soil surface to the sun and wind (Hadayanto, Muddarisma, & Fiqri, 2017). The higher the place, the lower the air temperature and the higher the rainfall and the more fertile the land (Puspita Sari et al., 2013). Soil fertility affects the condition of living things on it, for example vegetation that grows on fertile soil can grow well. The forest area as the lungs of the world, in order to keep carrying out its functions, the land in the forest must provide sufficient nutrients for the growth and development of vegetation.

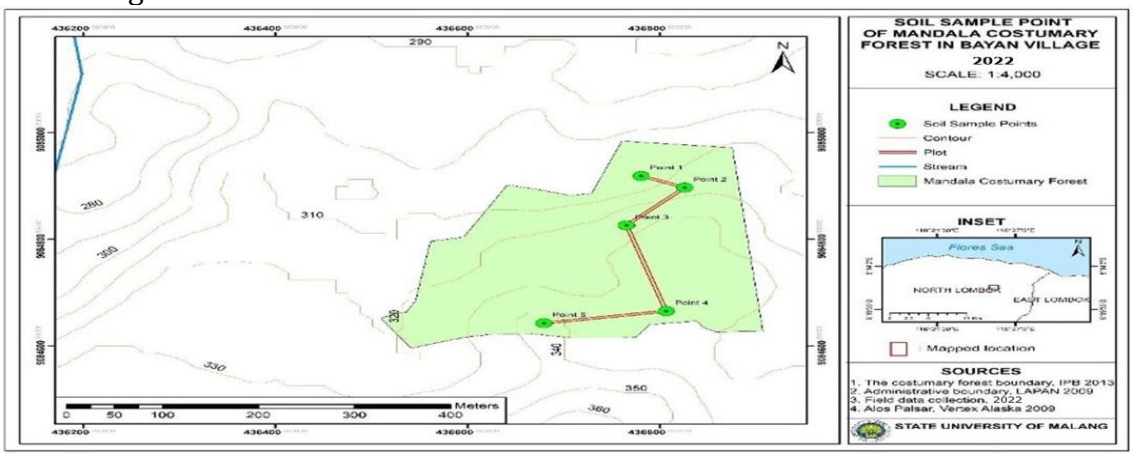
Forest areas with nutrient availability require wise management by paying attention to ecological balance. One example in the Bayan community is that they manage forests with traditional ecological knowledge, Awiq-awiq that contributes to fertile vegetation. This is supported by traditional ecological knowledge in the community in Lae Hole II North Sumatra able to maintain vegetation growth in Sicike-Cike Nature Tourist Park (NTP) (Odorolina, Situmorang, & Simanjuntak, 2015). Traditional techniques in the system sustainable agriculture (Ahmed et al., 2020; Bedoya Garland et al., 2017; Bogunovic et al., n.d.). The bayan community is very obedient to awiq-awiq because of the function of the forest for them, namely to maintain the availability of water as a factor in supporting their livelihoods in

agriculture, so conservation efforts in this area need to be supported by their fertility. The quantity and quality of plant species and their litter (Augusto et al., 2015; Casals et al., 2014; Hoosbeek et al., 2018), can affect soil organic matter (SOM). Mechanical Tillage can change the chemical composition and quality soil organic matter (SOM) (Angers & Eriksen-Hamel, 2008; Paulino, 2014).

Based on this description, a study of the soil fertility level in customary forests in the Bayan community is needed. Several studies that have been carried out regarding soil fertility have concluded that nutrients are factors that influence soil fertility (Kharal et al., 2018; Sari et al., 2022). However, not many studies have examined soil fertility rates based on topography. This study aims to determine the level of soil fertility in different topography in the Mandala customary forest. It is expected that the results of the study will provide information on soil conditions as a consideration in efforts to conserve land by various interested parties.

## B. METHODS

The study was conducted in the Mandala customary forest of Bayan village in North Lombok Regency, West Nusa Tenggara, Indonesia. The height of the study site was between 310-350 mdpl. The study design used a field survey to identify and select research locations based on topography. The research sample can be seen in Figure 1.




Source: Reseacher, 2022

**Figure 1.** Map of the Mandala Customary Forest Land Sample Plot

Soil samples were measured by chemical laboratory tests to determine soil fertility based on c-organic content, N, P, and K. Furthermore, data analysis to determine the status of soil fertility at each point representing different topography was then concluded to determine the fertility rate land in the Mandala customary forest. Several recent studies have shown soil organic matter to be a good indicator of soil quality (Audette et al., 2021), Determination based on the technical guidelines for evaluating soil fertility, (the Soil Research Center and Agro-climate, 1983) and (Arsyad, 2010) can be seen in table 1. Then a map of soil fertility status in various topography in the Mandala customary forest in Bayan village with a scale of 1: 50,000 based on measured soil fertility parameter data and soil fertility status obtained. Making maps using Geographic Information Systems

**Table 1.** Key to Determine Soil Fertility Status Based on Parameters C, N, P and K

| Parameter | Very low | Low | Medium | High | Very High |
|---|---|---|---|---|---|
| C-organic (%) | <1,00 | 1-2 | 2,01-3 | 3,01-5 | >5 |

| | | | | | |
|---|---|---|---|---|---|
| N-Total (%) | <0,10 | 0,1-0,2 | 0,21-0,5 | 0,51-0,75 | >0,75 |
| P2O5 Bray-I (ppm) | <10 | 10-15 | 16-25 | 26-35 | >35 |
| K2O (me/100g) | <0,10 | 0,1-0,2 | 0,3-0,5 | 0,6-1 | >1 |

(the Soil Research Center and Agro-climate, 1983) and (Arsyad, 2010)

Based on table 1, information is obtained about the soil fertility status at each point with different topography, namely I (300-310 masl), II (310-320 masl), III (320-330 masl), IV (330-340 masl) and V (340-350 masl). Then, the scoring was used to conclude the soil fertility status in the Mandala customary forest. The score classification criteria are:

$$\text{Interval} = \frac{\text{maximum score} - \text{minimum score}}{4} \quad (1)$$

$$\text{Interval} = \frac{20-4}{4} = 4$$

**Table 2.** Criteria of Soil Fertility Status Score

| No | Score | Classification |
|---|---|---|
| 1 | 4-7 | Low |
| 2 | 8-11 | Medium |
| 3 | 12-15 | High |
| 4 | 16-20 | Very High |

## C. RESULT AND DISCUSSION

### 1. Result

#### C-Organic

C-organic shows the amount of organic available in the soil and serves to determine soil fertility. The organic C content in Mandala customary forests varies at each point due to differences in topography. Criteria for C-organic can be seen in table 3.

**Table 3.** Criteria for C-Organic in Mandala Customary Forest

| Point | C-Organic (%) | Criteria |
|---|---|---|
| I | 1,66 | Low |
| II | 1,91 | Low |
| III | 2,36 | Medium |
| IV | 3,53 | High |
| V | 3,35 | High |
| Average | 2,562 | High |

The highest C-organic content is at an altitude of 340-350 masl, while the lowest is at an altitude of 300-310 masl (table 3).

#### N-Total

N element (nitrogen) in the soil is often used as a barrier in soil fertility, because this element is needed in a very large number of plants. Based on laboratory data analysis, the average N-total content of land in the Mandala customary forest, which is 0.136%, is categorized as low. This situation states that the soil does not get a lot of nutrients, because the soil at the research site has rough texture with sandy clay classes. N element becomes problem in all types of soil, especially rough texture (Syekhfani, 2010). The content value of N-total for each topography in the study location can be seen in table 4 below.

**Table 4.** N-Total Criteria in Mandala Customary Forests

| Point | N-Total (%) | Criteria |
|---|---|---|

| | | |
|---|---|---|
| I | 0,09 | Very Low |
| II | 0,13 | Low |
| III | 0,13 | Low |
| IV | 0,16 | Low |
| V | 0,17 | Low |
| Average | 0,136 | Low |

The total N-content based on table 4 tends to increase with increasing altitude.

**P (P2O5)**

The P value (P2O5) at all heights is classified as a very high category, besides that the average P value is also very high. The very high P2O5 content available on andosol soils reaches 32-131 ppm with an average of 152 ppm (Sukarman & Dariah, 2014). High temperatures can stimulate microbial activity and the content of P2O5 in the soil and increase microbial mineralization and P2O5 uptake by plants so that P2O5 cyclic acceleration increases and the available P2O5 content tends to be high (Rui et al., 2012), this statement is in accordance with the air temperature conditions in the Bayan village. P criteria in Mandala customary forest can be seen in table 5.

**Table 5.** P Criteria (P2O5) in Customary Forest Mandala

| Point | P (P2O5) (ppm) | Criteria |
|---|---|---|
| I | 73,43 | Very High |
| II | 92,64 | Very High |
| III | 136,93 | Very High |
| IV | 40,30 | Very High |
| V | 84,06 | Very High |
| Average | 85,472 | Very High |

**K (K2O)**

The results of analysis of potassium (K / K2O) in a laboratory with a very high category at all heights in the Mandala customary forest. The available K content is around 5.88-7.32 me / 100 grams, for more details can be seen in table 6.

**Table 6.** Criteria K (K2O) in Customary Forest Mandala

| Point | K(K2O)(me/100) | Criteria |
|---|---|---|
| I | 6,70 | Very High |
| II | 5,93 | Very High |
| III | 6,07 | Very High |
| IV | 7,32 | Very High |
| V | 5,88 | Very High |
| Average | 6,38 | Very High |

Based on table 6, it can be concluded that the average land in the Mandala customary forest has a very high K element, so that this area gets an adequate supply of nutrients for plant growth.

## 2. Discussion

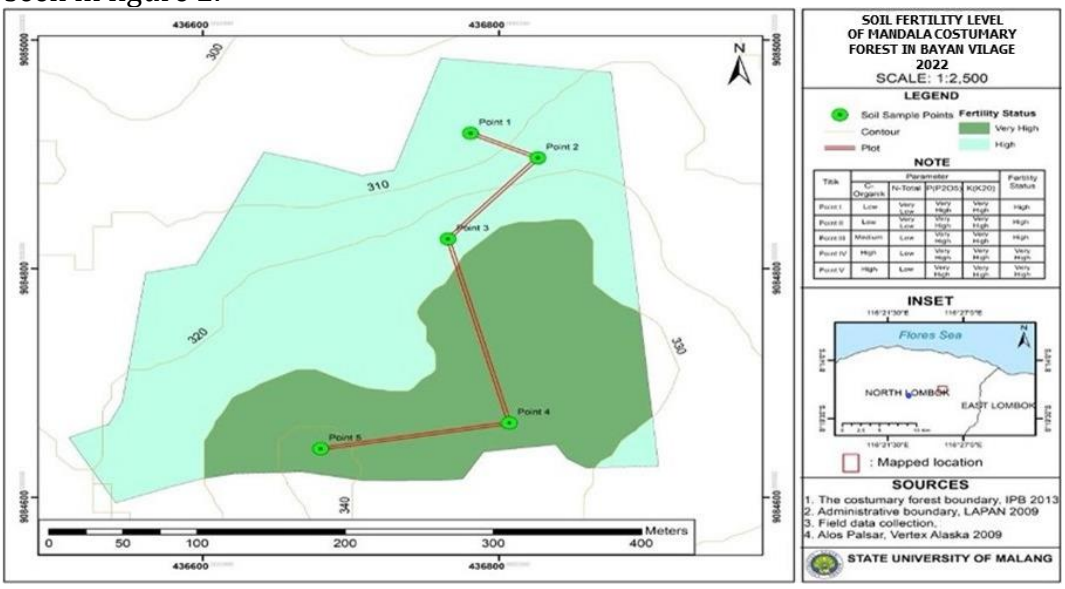
The highest C-organic content is at an altitude of 340-350 masl, while the lowest is at an altitude of 300-310 masl (table 2). The data concludes that the C-organic content increases as the higher the place. High areas such as mountains have higher rainfall and lower temperatures that can increase the amount of brown waste/humus. It causes the litter decomposition process runs slowly that results the accumulation of C-organic in the soil which is the main source of

organic matter (Kidanemariam et al., 2012; Ping & Stiles, n.d.; Puspita Sari et al., 2013), which plays an important role in increasing soil nutrients (Hanafiah, 2007). This is supported by the results of a study by (Supriadi, Randriani , & Towaha, 2016)that pointed out the C-organic has significant positive correlation with the height of the place.

The average C-organic content in Mandala customary forests is high. Such C-organic content does not have complex problems in chemical processes in the soil (Hardiwogino, 2003), because it is very sufficient to support the various processes. In addition, the high C-organic content shows the high production of organic matter because the vegetation in Mandala customary forests is quite high.. N content in the soil besides being determined by total N-availability is also influenced by soil organic matter (Rusdiana et al., n.d.).

The P content in the soil affects plant growth and production. P plays a role in cell division, formation of fruit flowers and seeds, accelerates maturation, robustness of the stem so as not to collapse and development of roots (Hardiwogino, 2003). valuable source of nutrients from N and P can increase the cycle of nutrients and their availability long-term land (Kharel et al., 2021; Sauer et al., 2015). Therefore, if the plant lacks phosphorus, its growth will be disrupted that results in non-optimal production. The results of analysis of potassium (K / K2O) in a laboratory with a very high category at all heights in the Mandala customary forest. This element is very much needed by plants with almost the same amount as nitrogen. Potassium (K / K2O) is essential for the formation and transfer of carbohydrates in plants and photosynthesis (Hardiwogino, 2003), so as to strengthen plant stems. Low potassium nutrients are bad for plants that can cause production decrease.

The status of soil fertility is a condition of the soil with the availability of plant needs both physically, chemically and biologically balanced. The status of soil fertility in the Mandala customary forest is classified as very high category as can be seen in figure 2.




Source: Reseacher, 2022

**Figure 2.** Status of Soil Fertility in the Mandala Customary Forest

High fertility status in the Mandala customary forest in Bayan Village is spread at point I (300-310 masl), point II (310-320 masl) and point III (320-330 masl), while at point IV (330-340 masl) and point V (340-350 masl) with a very high category. It can be concluded that the higher a place, the higher the soil fertility

status. The results of similar studies that have been conducted reveal the higher the place, the better the chemical properties of the soil so that nutrients in the soil are higher (Kidanemariam et al., 2012).

Based on the analysis of several soil properties in figure 2, the soil fertility status was mainly determined by the content of P and K. However, the inhibiting factors of soil fertility in the study sites were low and very low N content. Low C-organic values are found in two locations with a topography of 300-320 masl, while the high is in the topography of 330-350 masl. The percentage of organic C and the percentage of total higher in the upper than lower slope, respectively (Liu et al., 2007). Organic matter can affect the physical, chemical and biological properties of the soil. The role of organic matter on soil is to increase the availability of nutrients from the results of its decomposition (Stevenson, 1982), so that soil fertility increases. The low carbon in the soil due to tree felling, causes changes in forest vegetation that have an impact on the composition of reduced soil organic matter. Soil carbon content (C) is an indicator of soil quality (Bhattacharyya et al., 2009), which can increase carbon sequestration and reducing carbon emissions as conservation (Johnson , Franzluebbers , Weyers , & Reicosky, 2007), thereby impacting vegetation such as climate change and global food security intrinsic (Huang , Xu , & Chen , 2008).

Very high P and K values supply sufficient nutrients for plant growth in Mandala customary forests. P element has some functions for plants in the process of cell division, fruit formation, flowers and seeds, carbohydrate metabolism, strengthening stems, and root development, so that the lack of P content can inhibit plant growth and development (Sari et al., 2022). High soil fertility in the Mandala customary forest cannot be separated from forest management with awiq-awiq. When someone cuts trees without the permission of the customary institution, sanctions are imposed. Based on this rule, the community safeguards the forest by not cutting down trees, because the forest trees affect the composition of organic matter. The level of soil fertility in the forest can be used as a consideration or reference in the conservation of natural resources. So that, to improve soil health and to aid in climate change mitigation, the quantity of soil organic matter (SOM) should be maintained or increased over the long run (Audette et al., 2021).

## D. CONCLUSION AND SUGGESTION

The results showed that soil fertility in the Mandala customary forest was very high. This is evidenced by the results of chemical laboratory test analysis related to C, N, P and K soil elements. The results of the C-organic analysis show a low-high soil fertility category with a low distribution (300-320 masl), medium (320-330 masl), and high (330-350 masl). Soil fertility based on the N content is classified as very low category at an altitude of 300-310 masl and low at 310-350 masl. On the other hand, the P and K content shows very high soil fertility at all points or topography in Mandala customary forests. Based on the results of the fertility status determination from the C, N, P and K values at an altitude of 300-350, it can be concluded that soil fertility in the Mandala customary forest ranges from high to very high. The higher the place, the chemical properties of the soil also increase, so that soil fertility increases. The soil fertility status provides important information that can be used as a reference in making forest management policy decisions.

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