ЗЕМЛЕДЕЛИЕ И ЗАЩИТА РАСТЕНИЙ

SOIL FERTILITY AND PLANT PROTECTION

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ASSESSMENT OF LAND RESOURCES EVALUATION BASED ON LAND CAPACITY AND FERTILITY PERSPECTIVES FOR AGRICULTURAL COMMODITIES IN LESTI SUB-WATERSHED

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Land use that disregards the potential of the land, like is the case in watershed areas, not only increases the danger of disaster, but it can also lead to environmental damage. This study intends to assess the land capacity and soil fertility in the Lesti Sub-watershed in Malang Regency, East Java Province. GIS analysis, descriptive analysis, and laboratory tests were the data analytic techniques employed in this study. Four different land use types Moor, Coffee Plantation, Snakefruit Plantation, and Shrubs can be found in the area surrounding the watershed, according to field observations. The research findings imply that sloping and hilly plains have limiting factors for variable land capacities and limiting factors such as land slope and permeability. The study also provides an overview, namely that overall soil fertility is low and in all land use units, including the limiting factors on base saturation, C-organic, phosphate, and potassium. Overall, the research gives information or instructions for accurately analyzing land resources to measure agricultural commodity output based on the physiography of watershed areas experiencing land degradation.

Keywords: *Land Capability; Soil Fertility; Watershed*

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Introduction

The watershed is a dynamic ecosystem that connects upstream and downstream, where a river unit and its tributaries naturally collect, store, and distribute water originating from rainfall to lakes or the sea. Land boundaries separate topography and sea boundaries from water areas that are still affected by land activities. Experts, researchers, policymakers, and natural resource managers have all recognized over the last few decades that the watershed is one of the most important land management units [1]. Watershed management, according to [2], is a type of regional development that uses watersheds as a management unit, and is basically efforts to use natural resources rationally to achieve profitable agricultural production goals [3].

Meanwhile, [4] assert that it is important to be aware of the existence of human and natural variables, which are elements that cause watershed damage. Natural causes are those brought on by nature and can take the shape of disasters like landslides and volcanic eruptions, whereas human factors are those brought on by people and have a significant impact on the watershed ecology. Human use of watershed land frequently goes over the allowed amount. This phenomena may be observed in Indonesia's watersheds, which are dispersed over numerous regions and have suffered significant harm that has led to land degradation. In accordance with the Ministry of Environment and Forestry's statistics data from 2013, Indonesia had 19.57 million hectares of critical land and 4.74 million hectares of very critical land, for a total critical land area of 44.30 million hectares [5]. The Lesti sub-watershed in Malang Regency is one of those with a large enough critical area. This sub-watershed covers the upstream portion of the Brantas watershed, which receives priority treatment. The Lesti sub-watershed encompasses 58,384 hectares and comprises 21,928 hectares of important land that must be repaired urgently. The occurrence of landslides, floods, and other natural disasters linked to land usage within the watershed are additional issues unique to the Lesti sub-watershed. In reality, these three processes typically emerge from land farming in steeply sloping places without any further attempts to conserve soil and water. Even research studies [6] have shown that the condition of the Lesti sub-watershed has been harmed owing to reduced land cover, therefore it has the potential to endure a water shortfall. In 2017, there was a 2,141,057m^3 water shortage during the dry season.

Environmental damage can result from land use that ignores the potential of the land in addition to posing a danger of disaster. Therefore, it is necessary to provide input based on conservative measures so that it can evolve into a different approach in an effort to progress agriculture in the Lesti Sub-watershed area while also giving guidance for the development of superior commodities that can be decided. Analyzing land resources is one way to accomplish this, paying close attention to their fertility and capability already in place. [7] stated that 'capacity' is used to refer to the potential of land to be used in a given way or with certain management methods, which essentially means that capability is an assessment of the relative suitability of land for certain uses. [8] stated that in order to restore degraded land, land capability analysis is critical in order to create a database that includes hydrological and soil parameters. Furthermore, knowledge of land capability and suitability allows for the planning of land use and the development of land management capable of enhancing agricultural productivity [9]. Soil fertility is positioned in another context as a reliable method for assessing land resources. According to [10] and [11], soil fertility is the state of a soil that indicates its ability to provide necessary nutrients in adequate amounts for plant growth.

Observing characteristics of land capability and fertility can serve as a guideline for more optimal land usage in accordance with expectations, while not overlooking the importance of nutrient content in supporting plant growth. This is done because the two aspects will offer an accurate assessment in accordance with the dynamics of living, in which food must constantly be fulfilled, as well as efforts to construct functional regional spatial design. The research conducted allows for updating in areas where the scope of the notion of land capability and fertility in the Lesti sub-watershed has never been thoroughly studied. Empirical study focuses on the research issue, such as the analysis of surface runoff dispersion [12]. [6] which focuses on the availability of water resources. [13] who used GIS to conduct a land use analysis in the Lesti watershed. Furthermore, there is study on the analysis of the sedimentation of the Lesti Das with changes in land use [14]. The study is set to become a benchmark for watershed performance by including conservation concepts while also recommending superior agricultural goods. The purpose of this study is to assess land capabilities and soil fertility in the Lesti Sub-watershed in Malang Regency, East Java Province.

Research method

a. Location

The study was carried out in the Lesti sub-watershed, which is part of the larger Brantas watershed upstream. The Lesti sub-watershed is administratively located in Malang Regency and covers an area of 64,740.84 acres. The research area is bounded by Sukodono Village, which is one of the communities in

Dampit District. Sukodono Village was chosen because the area has substantial land degradation, including flood and landslide indicators. Sukodono Village is located at an elevation of 300 meters above sea level and has an average temperature of 20-27 degrees Celsius. Sukodono Village contains four land use units based on field observations: Moorland, Coffee Plantations, Snakefruits Gardens, and Shrubs.

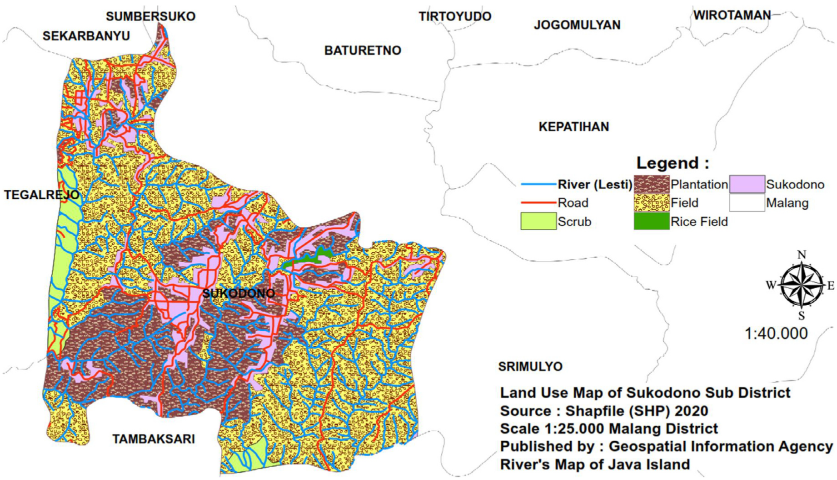

Figure 1. Land Use in Sukodono Village as a Water Catchment Area Lesti sub-watershed

b. Sampling

The parameters of the observations that will be studied are adjusted by soil sampling. Disturbed soil samples collect aggregate soil. Soil rings were used to collect undisturbed soil samples, and sterile soil samples were collected for biological analysis. Collecting sterile soil samples with an alcohol-sprayed soil drill. Slope, erosion sensitivity, solum depth, drainage, soil texture, permeability, hazard of flooding, and rock/gravel are the observed land capacity parameters. Soil fertility metrics include CEC, Base Saturation, C-Organic, P_2O_5, and K_2O. Land capability parameters are assessed using [15] assessments, whereas land fertility parameters are calculated using the Technical Guidelines for Soil Fertility Evaluation [16]. The sampling was done at 15 sites, with three repetitions for each land use. Furthermore, soil samples were collected at the following depths: 0-20 cm, 20-40 cm, and 40-60 cm. 45 soil samples were collected in total.

c. Data analysis

Data analysis techniques used in this study are:

1. GIS analysis using overlay
   This technique is used to determine the suitability of changes in land use with land capabilities. The data study included administrative maps of the research area, soil type maps, slope maps, land use maps, which were then carried out using an overlay technique. GIS analysis was performed using Arc View Software version 3.3.2.
2. Descriptive Analysis
   Descriptive analysis is used to explain the findings in the field. The findings from this study include the extent of changes in land use and the degree of suitability of changes in land use with land capabilities.
3. Laboratory Test
   The collected soil samples were then taken to the Laboratory of Land Resources and Plant Health, Faculty of Agriculture UPN "Veteran" East Java, to be tested for soil samples in the form of Acidity Level (pH), Cation Exchange Capacity (CEC), Base Saturation (KB), levels C-Organic, total N, Ptotal, and K-total content. The soil samples that have been taken are analyzed qualitatively to obtain data on the chemical properties of the soil. Data on soil chemical properties obtained were then analyzed for suitability with the soil fertility suitability table based on soil analysis assessment criteria and plant growth requirements. Soil color analysis was carried out by matching the soil samples with the Munsell Soil Color Chart book.

Results and Discussion

a. Land Capability Assessment

Land capability is an assessment of land capability for certain applications based on each restricting factor. Land use that is not in accordance with its capabilities and is not accompanied by adequate soil conservation initiatives will exacerbate erosion. Land capacity class is a set of land uses in an area based on the land's potential to be used efficiently and ideally with particular treatments so that it can be used sustainably. Soil sampling data were evaluated, and land capability classes were developed based on land usage. The five land uses at the research site are as follows:

Table 1 shows that the value of land capability class IV with a limit on the slope level results in a variety of restricting factors when assessing upland land use units. Despite a slope of 25.8%, dry ground is used for salak plants. In addition to snakefruit land, upland land is capable of being classified as class IV land. Although considerable land management is required, the area can be used for growing food crops. Additionally, there are fewer attempts made to determine plant options than for classes I to III, and difficult slopes have the greatest influence on land use units on dry land.

Table 1.

Land Capability Class

Parameters	Land Use				
	Moor	Dry land	Snakefruit	Coffee	Shrubs
Slope	D	C	D	E	E
Erosion Sensitivity	KE3	KE3	KE3	KE4	KE4
Solum Depth	k0	k1	k1	k1	k0
Drainage	d2	d2	d1	d2	d3
Soil Texture	t2	t2	t2	t1	t1
Permeability	P3	P4	P3	P3	P2
Flood Threat	O0	O0	O0	O0	O0
Gravel/Rock	b0	b0	b0	b0	b0
Salinity	g0	g0	g1	g0	g1
Limitation	Slope	Permeability	Slope	Slope	Slope
Land Capability Class	IV	III	IV	VI	VI

Source: Data Analysis (2023).

Seasonal crops, agricultural crops, shrubs or grass, protected forests, production forests, and nature reserves are typically employed on Class IV property. The soil has a deep solum in the moor area. The characteristics of the plants planted have an impact on the land's condition in dry locations with a cropping strategy utilizing polyculture and annual coffee plants. Utilizing salak plants, for instance, on upland with sloping or mountainous slopes, is particularly beneficial for lowering erosion rates. Dry land is often neutral to slightly acidic, according to laboratory test results. Although the roots of snakefruits plants are fibrous, they are also fairly powerful. As a result, the loss of soil in this location can maintain the thickness of the soil. Surface runoff's volume and speed will be impacted by the slope's relative height. The topsoil is affected by the runoff by losing soil. As a result, the soil's solum is declining, which lowers its productivity and makes it impossible to make other types of land improvements. The rate of surface runoff will increase as the slope of the ground increases. Due to this, there is a greater amount of soil erosion. Land in class IV should be utilized for a variety of land capacities

[17]. Given the comparatively high value of land potential, agricultural land should be used as efficiently as possible.

The evaluation of resources at the research site revealed that land use units, particularly dry land paddy fields, had land capability class III. When compared to other land uses, the utilization of dry land rice fields has the highest land capability class. The characteristics of rainfed lowland land have a different class of land capabilities than the moor. This result is consistent with [18] that the average land capability for paddy fields in class 3 is near to class 4, while dry land capability in class 4 is close to class 5. Class III is a type of land that is excellent for growing annual crops, particularly paddy plant. As a result, the land use of rice has a relatively steady value in comparison to other uses. The permeability value, 6.5 cm/hour on average, entering the rather fast permeability class, and the criteria for group P4 are the limiting considerations for the usage of paddy fields. This value is uncommon when compared to other land uses. The shown conditions should be moderately loamy soil with a high unit weight. In actuality, paddy fields have water availability depends on rainfall, except in places near river streams. This is because the land has a rainfed water management system. According to [15], the classification in class III to class IV land capability has a slope in the range of 8% -30%. The key limiting factor is very high permeability, as well as a relatively shallow solum due to frequent erosion. The magnitude of the permeability value influences the capacity of the land to hold water. These criteria suggest consistency between field observations and laboratory analysis.

Land use for the growth of coffee plants and shrubs has the potential of class VI land, with the limiting element of the land's slope, specifically a slope of 33-34%. [15] claimed that in class VI land capability, it is very unlikely to be cultivated and the land is in current conditions where grass or shrubs flourish. On the other hand, in the field, it is known that coffee plantations have altered a lot of crops or land conversion with snakefruits plants. The land usage of shrubs has not been used optimally, thus land conservation efforts are still not optimal; the majority of plant commodities are kriyu plants and horrible shards of shrubs or grass. This means that the land is not productive, so it is used for snakefruits plants by intercropping with annual crops and creating terraces to reduce the rate of erosion. The scrub land was formerly a tea garden, but it was abandoned and overgrown with plants. The soil of Class VI land capability rating is prone to erosion. Even if the area has been transformed into a producing forest, the management must be accurate and in compliance with conservation principles. Some class VI terrain have deep solums. Because coffee is an annual plant, this area has a deep solum, just like coffee fields. However, most farmers do not manage their land in accordance with conservation principles. As a result, actions to enhance the ground carried out by farmers on this land are required to prevent landslides in the area around the coffee plantations and for shrub.

A limiting constraint for land usage in the Lesti sub-watershed, particularly in mountainous places, is the land's slope, which can be up to very steep. This is especially true for class IV and VI property. One of the causes of land erosion is slopes. The quantity of surface runoff and the energy of water on soil particles are both impacted by steep slopes. The more soil particles that are splashed down by raindrop contact, the higher the slope of the slope. There is little slope on upland land where saladk, coffee, and shrubs are grown. Due to the slope of the slope, which slows down surface runoff, decreasing infiltration rates might result in an increase in the volume of surface runoff and soil erosion [19][18].

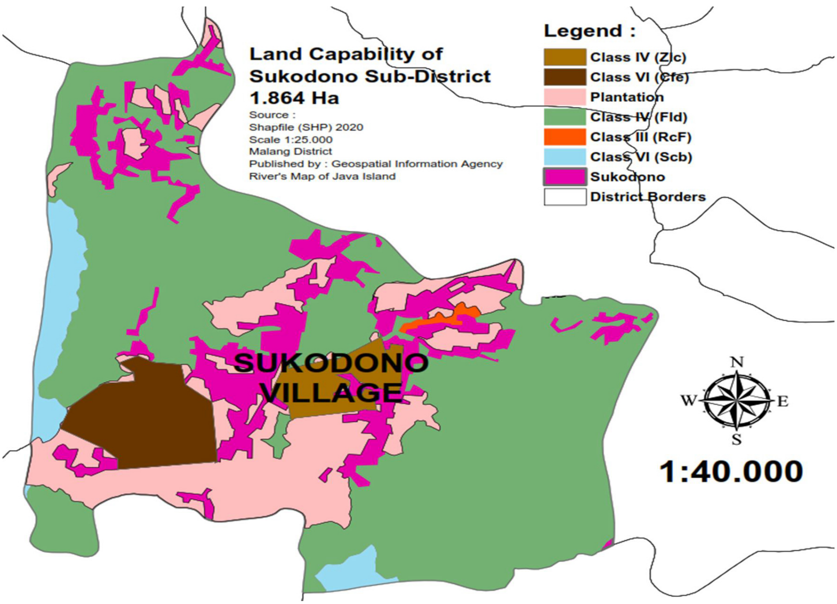

Figure 2. Land Capability Map

b. Soil Fertility Assessment

The capacity of the soil to offer nutrients in adequate and balanced amounts for plant growth and yield is known as soil fertility. The availability of sufficient and balanced nutrients, ideal soil water and air conditions, and favorable soil microbial conditions all contribute to soil fertility. However, the Lesti sub-watersheed has a low class of fertility status for all land uses. various class assignment values. The results of the study show that the high rate of erosion is to blame for the low soil fertility class. The slope of the slope affects whether erosion values are high or low. The slope is what prevents the bulk of land utilization, according to data on land capability. high rainfall levels, which increase the risk of erosion. As a result of the raindrops' size splashing on the ground, the precipitation causes the soil aggregates it hits to break apart into individual soil particles. Additionally, it will be swept away by water currents from high to low areas, causing silt to accumulate. Low soil fertility can be seen in areas with steep slopes [20].

The four levels of fertility are high (T), moderate (S), low (R), and very low (SR). In order to determine what efforts can be made to increase soil productivity, which will also have an impact on increasing crop yields and the standard of living in farming communities, classification of soil fertility capability looks at the field-based factors that affect the level of soil fertility. Loss of topsoil or topsoil results in the loss of nutrients and can have an impact on the soil's physical characteristics, one of which is harm to the soil structure. A variety of soil-forming elements, such as parent material, climate, relief, organisms, or time, can influence the soil fertility at a given area. As illustrated in Table 2, the classification of soil fertility capacity for different land uses comprises fields, rice fields, salak gardens, and coffee plantations. 1,500–2,500 mm of rain fall each year falls on the ground near Sukodono Village. This is consistent with earlier claims that high rainfall rates generate high rates of soil erosion because they force the soil to undergo a lot of sedimentation processes in places with low slope levels.

Each soil fertility measure has a distinct value in different land uses. The salak plantations, coffee plantations, and shrubs have a reasonably steep slope, making erosion a serious to extremely severe concern. According to [21], permeability is one of the causes of high and low levels of soil erodibility (erosion sensitivity). The higher the sand concentration of the soil, the greater its ability for infiltration. As a result, the ability to hold water is limited. Paddy fields, on average, have a higher clay content than other land uses. However, the terrain in Sukodono village has a significant sand component. This is due to the rainfed rice field management approach used in Sukodono Village.

Cation exchange capacity allows land to absorb and provide nutrients more effectively than low CEC land. According to the study's findings, a high CEC on scrubland was not matched by increased base saturation but had a low CEC (R) of 5.61%, and other spl CECs such as coffee plantations, salak plantations, fields, and rice fields as a whole showed CEC high (T) but all also had low base saturation ranging from 4.47% to 6.34%. As a result, all land in the village area of Sukodono Village that is flowed by the Lesti sub-watershed has experienced a lot of alkaline cations leaching in the soil, so that it is dominated by acid cations, Al, H, and water movement occurs, causing erosion, which will cause loss of nutrients and reduce the level of soil fertility.

Table 2.

Land Fertility Class

Land Use	Parameters					Justification
	KTK	KB	%C-org	P2O5	K2O	
Field	T	R	S	SR	SR	Low
Ricefield	T	R	R	SR	SR	Low
Salak Garden	ST	R	R	R	SR	Low
Coffee Garden	T	R	R	S	SR	Low
Shrubs	ST	R	R	T	SR	Low

Source: Data Analysis (2023).

Explanation:
T = Height R = Low
ST = Very High SR = Very Low
S = Moderate

The C-organic content in all land use units ranged from moderate to low, ranging from 2.17% to 1.03%. The field land use unit's moderate organic matter content (S), which was 2.17%, was heavily influenced by the multiple organic matter sources. Low organic matter content (R) is highly influenced by the slope of the ground in other regions such as paddy fields, gardens, and bushes, and most of the soil on the surface is lost by water to the land below or taken away by rivers.

Phosphate concentration ranges from 0.87 me/100g to 42.34 me/100g, and it is included in the criterion ranging from extremely low (SR) to high (T) for high land in shrubs, namely 42.34 me/100g and very low (SR). Due to land experiencing a lot of leaching, especially basic cations, the Al and Fe factors are very influential in paddy fields and fields because they have a very strong ability to bind P in soil conditions with a pH below 6, as well as very low potassium (SR) from 0.02 me/100g to 0.16 me/100g for all land uses. As a result, the land has a low soil fertility status for all land use units, with limiting characteristics such as base saturation, C-organic, phosphate, and potassium.

Rainwater carries soil particles away, resulting in the majority of namyak nutrients being deposited in low or sloping areas, causing sedimentation processes, which can cause a decrease in soil productivity or even become critical land and cannot be used to increase production, and damage occurring in conservation areas

[22]. According to [23], rainwater that falls to the earth causes erosion of the soil in its route, resulting in erosion on particular slopes. Indonesia is a tropical country with a rainy climate and annual rainfall of 2,500 mm. These lands are highly susceptible to runoff and erosion due to relatively high rainfall and relatively steep slopes.

The majority of the Lesti Sub-watershed, including Sukodono Village, features Alfisol soil types, a mountainous and limestone hilly physiography, and limestone parent material. Snakefruits and coffee plants are the most common types of plantation crops grown. Most of the Lesti Sub-watershed with the specific location of Sukodono Village has Alfisol soil types, mountainous and limestone hilly physiography, and limestone parent material. Factually the types of plantation crops cultivated are dominated by salak and coffee plants. The productivity of alfisols that is not optimal is strongly influenced by: (1) parent material which is dominated by limestone, (2) soil solum that is deep and shallow enough so that the root zone is affected, (3) soil horizons which are dominated by clay texture so that they often experience the process of eluviation in the upper layers and illuviation or deposition occurs in the sub horizon so that nutrients settle in the lower layers and some are also carried away by surface runoff due to the rate of movement of water in the rainy season, (4) water is also an obstacle in the dry season for areas far from River flow.

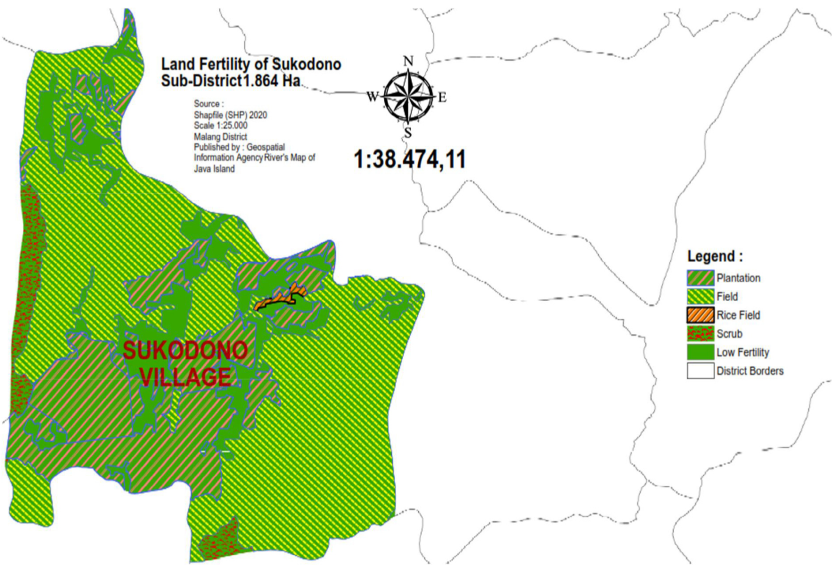

Figure 2. Land Fertility Map

Land in shrubs has a high rate of erosion because there are no annual plants in that location and the slope is steep. This is consistent with studies [24] that revealed higher rainfall intensity on open forest land and overgrazing on medium to steep slopes worsened substantial soil loss in water catchments. [25] also stated that when slopes are steep (25%), soil erosion increases dramatically because the dense protective cover of annual plants reduces and the cover of shrubs grows, and when slopes are very steep (40%), soil erosion remains constant. After planting is completed, the height remains the same. Other research findings include the fact that the slope on dry ground is likewise moderate, and the soil texture is sandy, allowing surface runoff containing nutrients to be taken away by the water flow. In comparison to other land uses, paddy fields have the lowest slope.

Conclusion

Land evaluation is a method of assessing the potential of land resources. Land evaluation results give the necessary information or guidance for land usage and can finally appraise the production of agricultural commodities to be gained. Furthermore, the class of land capability is primarily a collection of land uses in a region based on the land's ability to be used efficiently and ideally with particular treatments so that it can be used sustainably. The study's findings conclude that the sloping and mountainous plains in the Sukodono Village area have limiting elements for land capability ranging from class III to IV, with limiting criteria including land slope and sufficient permeability. Conversely, evaluating nutrient issues in the soil and offering fertilization advice are both steps in the soil fertility evaluation process. Different fertility levels exist on the land used for agriculture. It's critical to evaluate soil fertility in order to determine which minerals present challenges for plant growth. The addition of nutrients to the soil by fertilization is crucial to achieving profitable agricultural production since declining soil fertility can be a significant factor affecting soil productivity. Considering the findings, it can be concluded that base saturation, C-organic, phosphate, and potassium limitations as well as overall soil fertility are all in a bad state. Additionally, intense land cultivation has an impact on low soil fertility and contributes to erosion.

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