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Evaluation of Land Capabilities for Coffee and Durian Crops to Sustainable Agriculture

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ABSTRACT

The utilization of land that is not corresponding to its capabilities will accelerate land degradation. Therefore, in this study, the land capability was assessed to determine land capability classes and land use directions for applying sustainable agricultural systems in coffee and durian cultivation areas in the Wonosalam region, Jombang, East Java. The procedures included field observations, soil sampling, and laboratory analysis. Soil samples were taken at two depths, 0-30 cm and 30-60 cm, carried out by taking samples at two different points, then analyzed in a composite manner. The results showed that the class of land capability for planting coffee and durian was in class VII, which had a limiting factor in the form of slopes. Limited grazing and nature reserves are the focus of class VII land-use guidelines so that the land use direction follows the characteristics of the nature reserve and the principles of sustainable agriculture. Concerning long-term agriculture, we need to use conservation strategies both vegetatively and mechanically. Thus, the land that is the research site will be able to maintain its carrying capacity and minimize the decline in land quality and quantity on land use in the Wonosalam, Jombang area.

Keywords: *Land Capability, Land Use Direction, Sustainable Agriculture System.*

1. INTRODUCTION

Land is a valuable natural resource for agricultural businesses, and as the world's population grows, the demand for agricultural land increases. However, there is a limited amount of land suitable for agricultural activities (Ritung et al., 2015). According to Sumarno's research (2018), even if the degradation reaches an irreversible stage, the damage cannot be repaired and shows a decline in land quality due to improper use and exceeding capacity. In order to get around this problem, one solution is to manage the land according to what the land can do (Abdelrahman et al., 2016). The land can be used for a certain purpose by considering all the elements that can become obstacles. Improper land use and poor soil conservation measures will lead to increased erosion, a serious problem. Land production will be disrupted if the land is degraded (Hantarto, 2017).

Land use not following its capabilities will accelerate land degradation. Land use according to its ability is the goal of land classification, to direct land-use based on its ability (Choudhury & Das, 2015).

For agricultural land to be used for generations, it must be managed following sustainable agriculture principles, namely through optimal, sustainable, and profitable use of natural resources. According to the notion of sustainable agriculture, this is in line with the demands of the present generation without compromising the ability of future generations to meet their own needs (Ippolito et al., 2021). Sustainable land management can be achieved in several ways, one of which is by concentrating the land according to its capabilities. In order to detect environmental constraints in land use planning, land capacity evaluation is an important agricultural planning method (Choudhury & Das, 2015).

The direction of land use following the principles of sustainable agriculture is to use the land according to the land capability class.

This study examines land capability to identify land capacity classes and directions for sustainable agriculture in line with land capability classes in the Wonosalam area, Jombang, especially at PT Fructi Agri Sejati.

2. MATERIAL AND METHOD

PT. Fructi Agri Sejati, Wonosalam Jombang was used for soil survey and sampling. The land area of 85 ha is utilized by a polyculture planting system of various cultivated plants, such as cocoa and cocoa beans as well as jackfruit and jackfruit trees as well as teak and mahogany trees. PT Fructi Agri Sejati has a land use map (Figure 1) showing the main agricultural commodities grown there. The research area is in 7˚42'14"– 7˚43'55" LS and 112˚20'19" - 112˚21'32" BT.

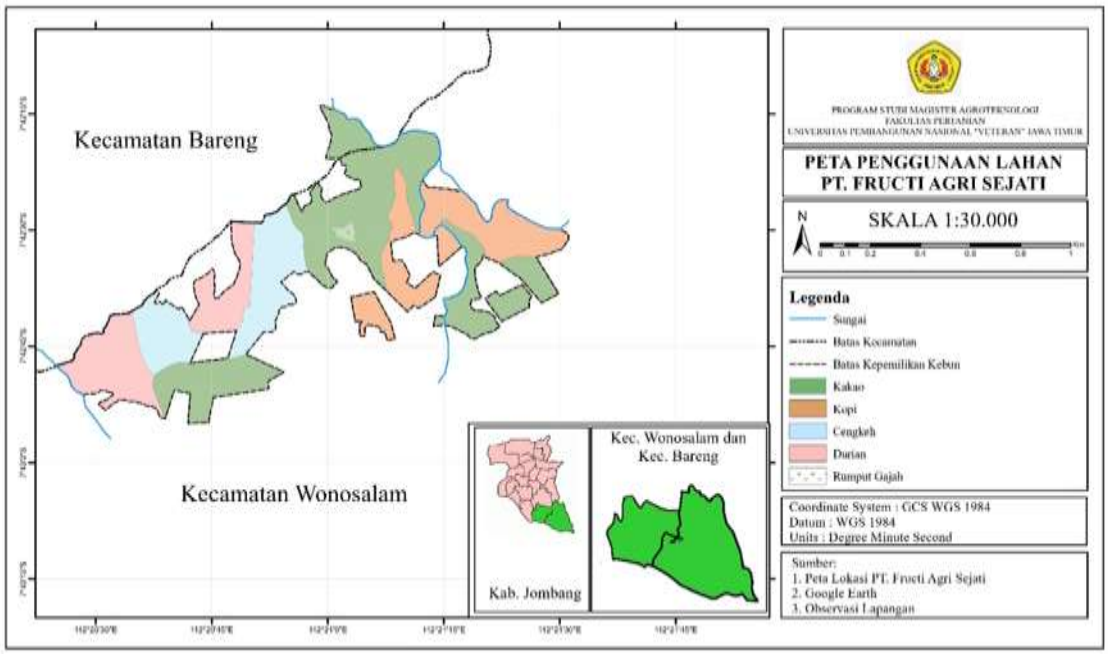

Figure 1. Land Use Map of PT. True Fructi Agri

The alfisol soil type and slope conditions of about 50 percent contributed to the severe erosion rate at this site. Landowners use mechanical and biological methods to protect their land. This is done mechanically by making terraces and gutters to slow down the flow of rainwater, thereby reducing surface erosion. At the biological level, this is done by planting grass on the terraces and planting teak and mahogany on the property's slopes.

Soil sampling is the first step in establishing soil capability. Undisturbed and disturbed soil samples were collected for research purposes. Soil samples were taken at two depths, 0-30 cm and 30-60 cm, carried out by taking samples at two different points and then analyzed compositely.

The results of field observations and laboratory analysis results are then used to determine the land capability class. Matching analysis is used to analyze land capability. Land unit values and conversion tables were compared to find a suitable match for the constraining factors (Table 1).

Land capability class grouping requires benchmarks. Benchmarking is done to help classify land capability classes. This chart lists each type of inhibiting factor and the worst-tolerable state in each class (Table 1).

Table 1. Land Capability Class Criteria

No	Limiting Factor	Land Ability Class							
		I	II	III	IV	V	VI	VII	VIII
1.	Texture (t)								
	Upper layer	t2/t3	t1/t4	t1/t4	*	*	*	*	*
	Bottom Layer	t2/t3	t1/t4	t1/t4	*	*	*	*	*
2.	Slope (l)	l0	l1	l2	l3	*	l4	l5	l6
3.	Drainage (d)	d0/d1	d2	d3	d4	**	*	*	*
4.	Jeluk works (k)	k0	k0	k1	k2	*	k3	*	*
5.	Erosion rate (e)	e0	e1	e1	e2	*	e3	e4	*
6.	Rock/gravel (b)	b0	b0	b0	b1	b2	*	*	b3
7.	Flood Danger (o)	o0	o1	o2	o3	o4	*	*	*

Source: Arsyad (2010)

Note:

* can have inhibitory factor values from lower classes

** ground surface is always flooded

Table 2. Classification of Soil Texture

Class	Criteria	Description
t1	Smooth	Dusty Clay and Clay
t2	Slightly smooth	Sandy clay, dusty clay loam, loamy loam, sandy clay loam
t3	Medium	Dust, dusty clay, clay
t4	Slightly Rough	Sandy Clay
t5	Rough	Loamy sand and sand

Source: Arsyad (2010)

Table 3. Slope Classification

Class	Criteria	tilt (%)
l0	Flat	0-3
l1	Sloping/Choppy	3-8
l2	Slightly slanted/wavy	8-15
l3	Sloping Hilly	15-30
l4	Slightly Steep	30-45
l5	Steep	45-65
l6	Very Steep	>65

Source: Arsyad (2010)

Table 4. Effective Depth Criteria

Class	Criteria	Description (cm)
k0	Deep	>90
k1	Medium	50-90
k2	Shallow	25-50
k3	Very shallow	<25

Source: Arsyad (2010)

Table 5. Drainage Criteria

Class	Criteria	Description
d0	Good	Good air circulation, the entire soil profile is uniformly light in color, and there are no spots
d1	Somewhat Good	Good air circulation, no yellow, gray, or brown spots on the top or bottom soil layers.
d2	Somewhat Poor	Good air circulation in the topsoil (no yellow, gray, or brown spots). On the other hand, there is poor air circulation in the lower layers (yellow, gray, or brown spots).
d3	Poor	There are yellow, brown, or gray spots on the lower top soil and along the bottom layer.
d4	Extremely Poor	The entire soil surface layer is gray, or there are gray, yellow, or brown spots.

Source: Arsyad (2010)

Table 6. Soil Erosion Criteria

Class	Criteria	Description
e0	No Erosion	No top layer is missing
e1	Light	<25% topsoil lost
e2	Medium	25-75% of topsoil is lost
e3	Heavy	▪ 75% of topsoil is lost ▪ < 25% of subsoil lost
e4	Extra Heavy	> 25% of subsoil lost

Source: Arsyad (2010)

3. RESULT AND DISCUSSION

3.1 Land Capability Class Evaluation

Environmental conditions, such as topography and soil conditions, as well as hydrological and climatic conditions and the dynamics that occur (e.g., erosion and flooding), are factors in land capability. Land capacity at the class level seems to have the same magnitude as the inhibiting variable (Mulya et al., 2019). As you advance to a higher social class, the land quality decreases further, increasing the danger of property damage and the size of the variables limiting your ability to make effective use of the land.

According to observations and analysis, coffee and durian plantations have seven limiting criteria with different classes on each limiting variable (Table 7). Coffee plants have a sandy loam texture with a slightly fine texture category and are included in ability class I, for durian plants have a dusty clay texture (0-30 cm depth) with criteria for fine texture and dusty soil texture (30-60 cm depth) with a medium texture category. So it belongs to ability classes I and II (Table 7). If the soil texture is coarse, macro pores will develop, resulting in rapid porosity, preventing water build-up. (Isra et al., 2019) concluded this. Capability class I (one) includes drainage, effective depth, surface rock, and flood hazard, among others (Table 7). Overall, drainage may significantly impact soil aeration, moisture transport, and nutrient efficacy in the soil (Wawan, 2017). To qualify for ability class I (one), both fields (Coffee and Durian) must have an effective depth of more than 90 cm (Table 7).

Observative observation of erosion at the study site showed that the level of erosion on coffee and durian plantations was low. This is due to the presence of litter covering the soil surface to minimize erosion.

In order to maximize nutrient uptake, roots must be able to move

freely in the soil to a depth of more than 90 centimeters, allowing roots to search for water and nutrients in the subsoil.

Table 7. Results of Land Capability Evaluation of Coffee and Durian Plants

No	Limiting Factor	Coffee				Durian			
		Result	Value	Criteria	Class	Result	Value	Criteria	Class
1.	Texture								
	Upper layer	Dusty Clay	t2	Slightly Smooth	I	Dusty Clay	t1	Fine	II
	Bottom Layer	Dusty Clay	t2	Slightly Smooth	I	Dust	t3	Currently	I
2.	Slope	51.1%	l5	Steep	VII	48%	l5	Steep	VII
3.	Drainage	Well	d0	Well	I	Well	d0	Well	I
4.	Effective Depth	>90 cm	k0	In	I	>90 cm	k0	In	I
5.	Erosion Rate	<25% top layer is gone	e2	Light	IV	<25% top layer is gone	e2	Light	IV
6.	Rock/	None	b0	Never any	I	None	b0	Never any	I
7.	Gravel	None	o0	In 1 year flooded for 24 hours	I	None	o0	In 1 year flooded for 24 hours	I
Ability Class				VII				VII	
Limiting Factor				Slope				Slope	

Source: Data Analyzed

3.2 Land Use Directions Based on Land Capability Class

The obstacle that limits coffee and durian plantations is the slope, which is included in the VII (seven) ability class in the land classification system. Both areas are steep because they have a slope of 51% and 48%, respectively. Land capacity classes are then used together with land use directions to determine the best allocation for coffee and durian plantations (Figure 2).

Figure 2. Land use directions based on land capability class
Source: Arsyad (2010)

The more capable the land, the less land is available for other uses or, the more limited it is. Based on the land use direction (Figure 2.), there appears to be a preference for nature reserves, natural forests, and limited use of grasslands for ability class VII (seven).

3.3 Directions for Application of Sustainable Agricultural Systems According to Soil Capability Class

The ability class for coffee and durian plantations is class VII (seven), which has a limiting constraint in the form of steep slopes. Land use should be used following sustainable agricultural systems in these circumstances. (a) agricultural resources are used according to their intended use, with conservation measures in the form of biological recycling and enrichment of soil nutrients; (b) environmental quality, including the ecological balance of agricultural, water, and air resources, is maintained and sustainable; and (c) farming can generate sufficient income to support themselves (Sudaryanto et al., 2018).

Land use and conservation activities must be balanced to maintain the ecosystem and the physical condition of the land. For coffee and durian plantations, the best use for ability class VII (seven) is as a nature reserve. This shows the land use for coffee and durian cultivation at PT. True Agri Fructi does not match the land capability class (Figure 2). For sustainable farming systems, land use directions must match the characteristics of the nature reserve.

The characteristics that determine the nature reserve area are (a) it has a diversity of wild flora and fauna species

that are incorporated in an ecosystem type, and (b) it has natural conditions, both wild plants and animals that are physically pristine and undisturbed; (c) there are plant and animal communities and their ecosystems that are rare and whose existence is threatened with extinction; (d) have certain biota formations and compositional units; (e) has a sufficient area and a certain shape that can support effective management and ensure the natural ecological process; (f) has the characteristics of potential and can be an example of an ecosystem whose existence requires conservation (Government Regulation No. 28 of 2011). The right direction for using land for nature reserves or protected forests is to make efforts to reforest, enrich and rehabilitate forests.

The establishment of a conservation system is the next step toward sustainable agriculture. With a slope of over 45 percent, this property is in dire need of conservation action. There are several ways to ensure that soil damage does not occur, such as ensuring that each piece of land is used according to its capabilities and treating it accordingly.

Preventing soil erosion, rehabilitating damaged soil, and conserving and increasing soil production are the main objectives of soil conservation initiatives (Hantarto, 2017). PT Fructi Agri Sejati, Wonosalam, Jombang using vegetative and mechanical conservation techniques on coffee and durian plantations in Wonosalam and Jombang.

A. Vegetative Conservation

Cover crops and planting along contour lines are two methods of vegetative conservation.

a) Ground Cover Plants

Plants or plants specifically produced to protect the soil from erosion and improve the soil's chemical and physical properties are known as cover crops or ground cover crops (Ariyanti et al., 2016). Raindrops that fall and water flow can be restrained or reduced by cover crops, which provide organic matter to the soil by shedding dead branches, twigs, and leaves (Erfandi, 2016). Improved soil structure resistance, increased ability to absorb and hold rainwater that falls, and addition of nutrients are all benefits of organic matter. It also reduces the dispersion force of rainwater and slows down runoff, reducing erosion and increasing groundwater infiltration (Ginting, 2019).

Low, medium, and tall ground cover crops are categorized as *Centrosema pubescens, Mimosa invisa, Pueraria phaseoloides, Indigofera endecaphylla, Ageratum conyzoidesc, Oxalis latifolia, Althenanthera amoena, and Calliandra callothyrsus; and 3) High ground cover plants such as Leucaena glauca, Leucaena leucocephala, Albizz, and Clibadium pallessens. Acacias melanoxylon, Erythrina sp., and Grevilles robusta*.

b) Planting According to Contour Lines

This cropping technique does not propose a slope direction from top to bottom but plants in a direction that is parallel to or across contour lines. As a result of planting along the contour lines, the area should be equipped with drains to prevent water from spilling. It was protecting the local topsoil by planting on a plot of land that is sloped with a contour system (Erfandi, 2016).

Planting along contour lines is used on sloping soil to prevent erosion and runoff. It is an imaginary line that connects places of equal height and intersects perpendicularly to the slope of the ground. Usually, buildings and factories are built to a length corresponding to the contour lines of the terrain. Cropping along contour lines

reduces runoff, erosion, and nutrient loss, benefiting the environment. In order to avoid soil erosion at PT. Fructi Agri, which has a steep slope, is recommended to plant according to the contour line.

B. **Mechanical Conservation**

The term mechanical engineering refers to the mechanical, physical treatment of soil and structural construction to prevent runoff and erosion and increase the usable capacity of the soil. Mechanical techniques in soil conservation have several objectives, including 1) slowing runoff; 2) accommodating and directing surface runoff using non-destructive force; 3) increasing water infiltration into the soil and improving soil aeration; and 4) providing water for plants (Kunarso et al., 2018). Techniques that rely on mechanical means include: Soil and building construction can be defined as a mechanical approach if physically treated to minimize runoff and erosion, as well as improve the usability of the soil.

Mechanical soil conservation methods include 1) slowing runoff; 2) accommodating and directing surface runoff using non-destructive force; 3) increasing water infiltration into the soil and improving soil aeration; 4) providing irrigation for plants (Kunarso et al., 2018). Strategies for soil and water conservation rely heavily on mechanical processes, such as:

a) Soil Tillage System Setting

Tillage is the practice of mechanically manipulating soil to improve the environment in which plants can thrive (Jambak et al., 2017). Tillage is beneficial for loosening and reshaping soil structure, reducing soil strength, and creating a healthy structure and aeration system so plants can develop effectively and provide nutrients to the soil. Soil damage can be minimized by: Cultivating the soil as needed to avoid soil damage due to tillage (minimum tillage). When the soil has reached the proper moisture level, tillage can be carried out. In accordance/parallel to the contour line, tillage is carried out (Sarminah & Karyati, 2018).

b) Terrace Making

The bench terrace is the first step in creating a decent terrace (Bench Terrace). Bench terraces are usually built to protect the soil layer from being eroded. Cutting the slopes and leveling the soil at the bottom creates a series of bench shapes; that is how bench terraces are built. As a first stage, the core and flow limits are determined.

Bench terraces consist of a row of flat or nearly flat surfaces that slope inward about 3%. In order to prevent surface water from flowing towards the edge of the terrace, the fields are separated by a perpendicular plane with a 2:1 slope. Lamtoro gung, calliandra, or grass for animal feed were planted in the handler on the edge of the terrace with a width of approximately 20 cm and 30 cm. A channel 15 centimeters wide and 25 centimeters deep has been carved from the core processing plane. There is a 0.1 percent slope in the processing area and the channel towards the river (waterway). One hundred meters is the distance limit between waterways (Wahyudie, 2020).

c) Construction of a water drain

This sewer's construction aims to build a water channel to keep runoff water from accumulating anywhere. Waste is beneficial because it diverts water from ravines and into the soil, preventing it from eroding. Surface drainage canals are constructed according to the slope to divert rainwater and other runoff from terraced areas (Sarminah & Karyati, 2018).

Water from the surface will be channeled into the sewer through a diversion channel. The goal is to protect certain areas, such as agricultural land, from criminal activity. The depth of this channel depends on the typical runoff volume, although the slope is usually 0.3 percent medium width. Reinforcing plants or grass on channel cliffs is something we encourage.

Typically, the cross-section of the drain will be triangular, trapezoidal, or parabolic. The recommendation is to plant grasses, such as elephant grass, along channel bottoms and cliffs to prevent water from eating away at certain parts of the channel quickly. A drop structure and wood in the drain may need to be installed to accommodate very steep marbles (Wahyudie, 2020).

4. CONCLUSION

The ability class on coffee and durian plantations in the PT Fructi Agri Sejati area is class VII with a limiting element in the form of a slope with a slope condition of >45 percent. Class VII land capacity includes the direction of utilization in nature reserves, natural forests, and limited grazing.

The direction of sustainable agricultural systems is the implementation of conservation strategies. Conservation activities that can be carried out are mechanically (conducted by tillage, terracing, and installation of sewerage) and vegetatively (planting cover crops and planting according to contours) (planting cover crops and planting according to contours). With these two methods, it is intended that the quality of the environment and the ecological balance of agricultural resources will be maintained and maintained, as well as maintaining and increasing soil productivity so that the land can be used sustainably. Thus, land use at PT Fructi Agri Sejati is expected to meet sustainable agriculture principles.

SUGGESTION

Land management at the PT Fructi Agri Sejati location still needs to be improved to reduce land damage and produce an environmental condition comparable to the nature reserve following land-use regulations.

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