




## Land Suitability Evaluation for Cardamom (*Elettaria cardamomum*) Cultivation in Sumber Rejo Village, Purwosari Subdistrict, Pasuruan Regency

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### ABSTRACT

Market demand for cardamom (*Elettaria cardamomum*) continues to rise, yet its cultivation remains limited to specific regions with suitable environmental conditions. Therefore, land suitability evaluation is essential as a basis for planning the development of this commodity. This study aims to assess land suitability for cardamom cultivation in Sumber Rejo Village, Purwosari Subdistrict, Pasuruan Regency. The evaluation was based on physical and chemical soil properties, including pH, organic carbon (C-organic), cation exchange capacity (CEC), base saturation, as well as soil texture and slope. Samples were collected from two types of land use: dry land (tegalan) and coffee plantations, with a total of six sampling points. The results showed that soil pH ranged from 5.70 to 5.92 (S1), C-organic ranged from 1.61% to 2.79% (S1), CEC from 23.93 to 33.07 cmol/kg (S1), and base saturation was in average < 35% (S2). Overall, the study area falls into the moderately suitable (S2) category for cardamom cultivation with potential improvement to S1 through manure and compost application. This evaluation, however, was based on only four parameters so that future research should continue with other parameters to have a more comprehensive results on land suitability for cardamom cultivation in Sumber Rejo village.

## 1. INTRODUCTION

Cardamom (*Elettaria cardamomum*), locally named *kapulaga*, is one of the commodities that is currently widely cultivated by farmers. According to [Suhartini et al. \(2021\)](#), Indonesia is competitive in the international market for cardamom, a spice commodity classified as HS 0908. Indonesia's exports of HS 0908 spices have a comparative advantage (rank number two after Guatemala), with an average ISP value of 0.983, an RCA value of 21.597, and a CEP value of 3.028. According to [BPS \(2023\)](#), the production level of cardamom in East Java reached 122,360.105 kg with a land area of approximately  $\pm 370.29$  hectares. The widespread cultivation of cardamom today is certainly based on the various advantages it offers, such as the benefits of cultivation and its relatively high selling price. This is in line with the opinion of [Mulyana \(2015\)](#), who stated that cardamom is one of the crops with a high market demand, which motivates farmers to cultivate it. Furthermore, research by [Selisiyah et al. \(2011\)](#) showed that cardamom cultivation has good market prospects because the demand for cardamom remains relatively high. From the several citations mentioned above, it can be concluded that cardamom has a relatively high level of demand.

The expansion of cardamom cultivation can be carried out through community empowerment programs that encourage people to plant cardamom under the canopy of plantation crops or mixed forests. Cardamom is a plant that requires specific growing conditions, including an altitude of 300–800 meters above sea level, light intensity of 30–70%, rainfall ranging from 2,500–4,000 mm, air temperature of 20–30 °C, and humidity between 40–75%. Cardamom should not be planted on land that has previously been cultivated with *Zingiberaceae* family plants and has been

affected by diseases, as there is a risk of soil-borne disease transmission. The preferred soil structure is fertile, crumbly, and highly porous. The suitable soil textures include sandy clay, clay loam, or sandy loam, with a high organic matter content, and a maximum land slope tolerance of 30% (Purwadi *et al.*, 2023).

The improvement of the village economy through cardamom cultivation is closely related to land preparation and optimization activities, one of which is land suitability evaluation. Land suitability refers to the degree of compatibility of a particular land area for a specific commodity, where the evaluation results in a suitability class determined by the lowest (most limiting) value. The suitability of the land can be assessed based on current conditions (actual land suitability) or after improvements are made (potential land suitability). The results of the land suitability evaluation serve as a basis for identifying factors that need to be improved to make the land more suitable for the cultivation of specific commodities, particularly cardamom. Therefore, this study also includes an analysis of farm business feasibility in relation to the limiting factors at the study site. The purpose of this research is to determine the land suitability in Sumber Rejo Village and to provide a general overview of the regional conditions of the village with respect to cardamom cultivation.

## 2. RESEARCH METHOD

This research was conducted from June to July 2025 and consisted of three stages, namely pre-survey, survey, and post-survey activities. The pre-survey stage, which included site reconnaissance and determination of sampling points, was carried out in June 2025, followed by the survey stage, involving sample collection, in July 2025. The post-survey stage, consisting of laboratory analysis, was also conducted in July 2025. The pre-survey and survey activities were carried out on two land-use units, namely dryland fields (*tegalan*) and coffee plantation areas, located in Sumber Rejo Village, Purwosari Subdistrict, Pasuruan Regency, at an altitude of approximately 840 meters above sea level. This elevation is slightly above the optimal range for cardamom cultivation (300–800 m above sea level), but still within a tolerable limit. The soil sample analyses were performed at the Land Resources Laboratory I and II, Faculty of Agriculture, Universitas Pembangunan Nasional “Veteran” East Java.

Sumber Rejo Village, located in Purwosari Subdistrict, Pasuruan Regency, East Java Province, lies at the foothills of Mount Arjuno and is one of the areas with potential for the development of cardamom (*Elettaria cardamomum*) cultivation. Purwosari District itself has a topography ranging from lowlands to highlands (with altitudes from 0 meters to over 1,000 meters above sea level) and a land surface that slopes slightly toward the east and north. From the perspective of the local community, the residents of Sumber Rejo Village predominantly work as plantation farmers, with coffee being the main commodity. In addition, some residents are also engaged in the cardamom seedling business. Based on visual observations conducted in Sumber Rejo Village, the area is dominated by mixed forests with various canopy covers, which provides favorable conditions for cardamom growth. However, the main issue is that farmers have not yet fully recognized the potential of cardamom cultivation as part of their farming enterprises. The increasing demand for cardamom presents an opportunity to generate additional income apart from coffee production.

### 2.1. Research Procedure

This research was conducted using the visual observation method on cardamom cultivation areas in Sumber Rejo Village. There were two Land Mapping Units (LMU), namely KT (*tegalan* or dryland) and KP (plantation), which were used as observation references. Each LMU consisted of three sampling points as replications, resulting in a total of six observation points. Soil samplings were determined randomly, and measurements were performed in the depth 0–30 cm.

### 2.2. Determination of Sampling Points

The determination of sampling points was carried out in accordance with the work plan and the predefined sample plots. The field survey focused on determining the boundaries of the study area, which served as a reference during soil sampling. These boundaries were established based on land slope, soil type maps, and land use maps. The selection of the study area boundaries was based on several factors, including the types of agricultural landforms (such as rice fields and seasonal crop areas) and plantation lands (such as forests and perennial crops) present at the research site. In this study, the sampling points were determined in dryland fields (*tegalan*) and coffee plantation areas.

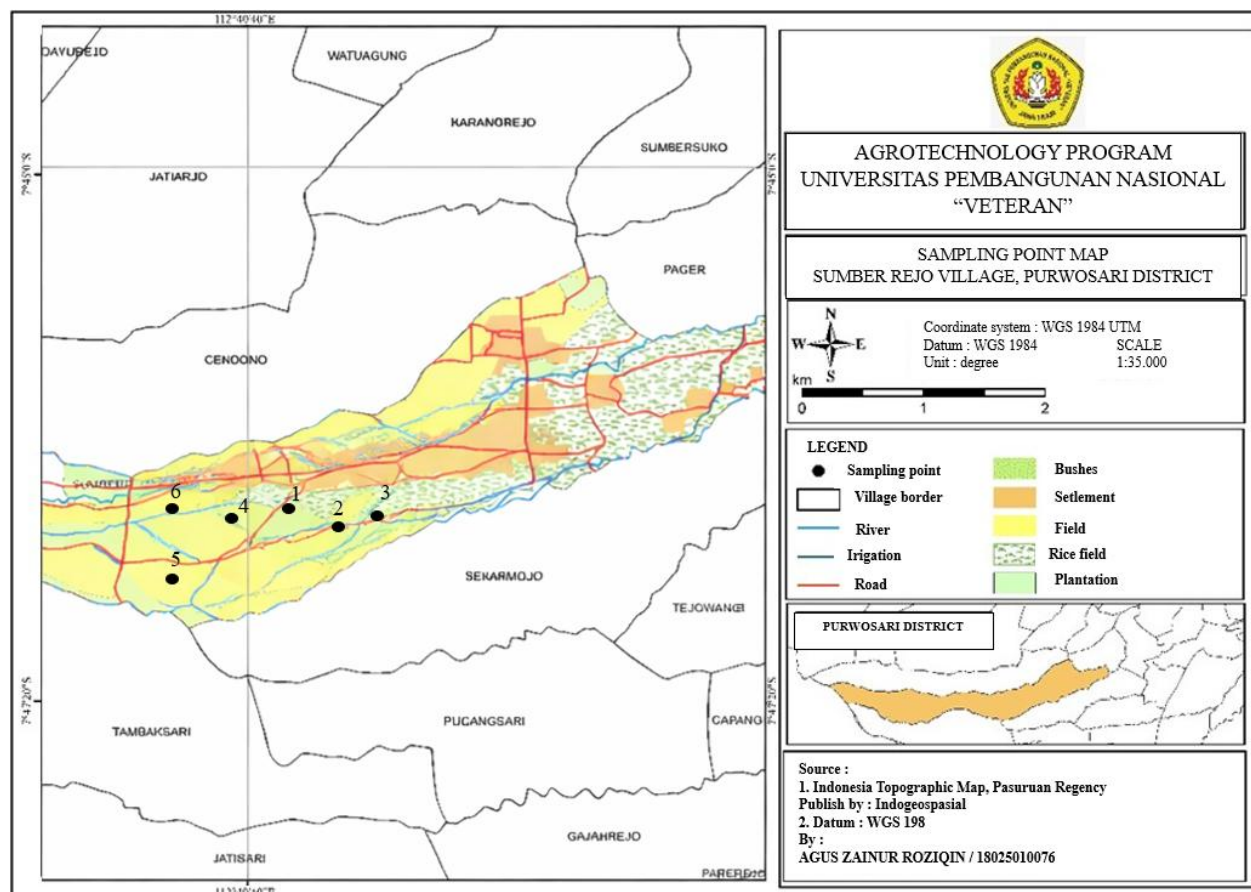


Figure 1. Map of LMU in Sumber Rejo Village and sampling point

### 2.3. Soil Sampling

Soil sampling was carried out based on the sampling point map. Samples were taken at a single soil depth (0–30 cm) in two observation sites, namely coffee plantation land and bare land, with three sampling points in each location. The soil sampling procedure referred to SNI 03-4148.1 (2000), involving the collection of both undisturbed and disturbed soil samples using tools such as iron rings (6 cm in diameter), hand trowels, and crowbars (BSN, 2000). The undisturbed soil samples were taken from specific soil layers in their natural, intact condition, closely resembling their in-situ state. In contrast, disturbed soil samples did not retain their original structure, as they were altered during collection.

All soil samples were transported following the fundamental principle that each sample must remain separate and unchanged throughout the transportation process. The disturbed soil samples were air-dried in a drying room, while the undisturbed soil samples were soaked in containers filled with water up to three-quarters of their volume.

### 2.4. Evaluation Criteria

Land suitability evaluation for cardamom was based on the *Technical Guidelines for Land Suitability Evaluation for Agricultural Commodities* published by Balai Besar Litbang Sumberdaya Lahan Pertanian, Badan Litbang Pertanian (Djaenuddin *et al.*, 2011). The guidelines classifies land characteristics into four categories, namely S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), N (currently unsuitable), and N1 (permanently unsuitable). Table 1 details the characteristics evaluated to determine land suitability for cardamom cultivation. For this study, evaluation was based on four parameters, namely cation exchange capacity (CEC), base saturation (BS), soil pH (H<sub>2</sub>O), and organic carbon (C-organic).

### 2.5. Laboratory Analysis

Laboratory analyses were carried out to determine the characteristics of the selected land. Prior to analysis, the disturbed soil samples were air-dried and sieved to a size of 0.5 mm. The sieved samples were then composited to obtain representative samples for each Land Mapping Unit (LMU). The analyses focused on identifying both physical and chemical soil properties. The physical property analyzed was soil texture, while the chemical properties included soil pH (H<sub>2</sub>O), base saturation (BS), cation exchange capacity (CEC), and organic carbon (C-organic). The analysis of these soil properties was conducted using various chemical reagents such as HCl, H<sub>2</sub>O<sub>2</sub>, NH<sub>4</sub>OAc (ammonium acetate), 70% ethanol, NaOH, distilled H<sub>2</sub>O, ammonium molybdate, and carbonic acid, all of which were Merck KGaA products from Germany. The analytical procedures followed the Soil Analysis Manual published by the Indonesian Soil Research Institute (Sulaeman *et al.*, 2009; Eviati *et al.*, 2023).

Table 1. Land requirements for cardamom cultivation

Land Characteristic	S1	S2	S3	N
Average daily temperature (°C)	22 – 28	28 – 34 / 18 – 22	34 – 40 / 15 – 18	> 40 / < 15
Rainfall (mm)	1000 – 2000	500 – 1000 / 2000 – 3000	250 – 500 / 3000 – 4000	< 250 / > 4000
Drainage	Good to moderate	Slightly impeded	Impeded, somewhat rapid	Very impeded, rapid
Texture	Fine, moderately fine, medium	-	Very fine, moderately coarse	Coarse
Coarse material (%)	< 15	15 – 35	35 – 55	> 55
Soil depth (cm)	> 50	> 50	30 – 50	< 30
Peat thickness (cm)	< 60	60 – 140	140 – 200	> 200
Peat thickness with mineral enrichment (cm)	< 140	140 – 200	200 – 400	> 400
Decomposition stage	Sapric +	Sapric, hemic +	Hemic, fibric +	Fibric
Clay CEC (cmol)	> 16	< 16	-	-
Base saturation (%)	> 35	20 – 35	< 20	-
pH H <sub>2</sub> O	5.0 – 6.0	4.5 – 5.0	< 4.5	-
Organic C (%)	> 1.2	0.8 – 1.2	< 0.8	-
Salinity (dS/m)	< 4	4 – 6	6 – 8	> 8
Alkalinity/ESP (%)	< 15	15 – 20	20 – 25	> 25
Slope (%)	< 8	8 – 16	16 – 30	> 30
Erosion hazard	Very low	Low – moderate	Severe	Very severe
Inundation	F0	F1	F2	> F2
Surface rock (%)	< 5	5 – 15	15 – 40	> 40
Rock outcrop (%)	< 5	5 – 15	15 – 25	> 25

Source: Technical Guidelines for Land Suitability Evaluation for Agricultural Commodities (Djaenuddin *et al.*, 2011).

### 2.6. Observation Parameter

The observed parameters included soil chemical analyses based on the collected soil samples, namely cation exchange capacity (CEC), base saturation (BS), soil pH (H<sub>2</sub>O), and organic carbon (C-organic). These parameters were selected due to the limited availability of information regarding the soil nutrient retention capacity in Sumber Rejo Village, which is essential for cardamom cultivation. The following table presents the analysis parameters, units, and testing methods used in this study.

Table 2. Evaluation parameters used in this study

No	Analysis Type	Unit	Method	Reference
1	CEC	cmol/kg	Distillation	Eviati <i>et al.</i> (2023)
2	Base saturation	%	NH <sub>4</sub> OAc	
3	pH (H <sub>2</sub> O)	-	Electrometry	
4	C-organic	%	Walkey and Black	

### 3. RESULT AND DISCUSSION

#### 3.1. pH H<sub>2</sub>O

The results of laboratory analysis for soil pH showed that the pH values at all sampling locations ranged from 5.70 to 5.92, which falls within the slightly acidic to weakly neutral range. According to the land suitability classification standard by [Djaenuddin \*et al.\* \(2011\)](#), soil pH values between 5.5 and 6.8 are categorized as highly suitable (S1) for most crops, including cardamom (*Elettaria cardamomum*), which generally grows well at a pH range of 5.5–6.5. Therefore, all samples were classified as S1, indicating that the soil pH conditions are already optimal for cardamom growth and no acidity correction is required.

Table 3. Laboratory result pH H<sub>2</sub>O

LMU	Replication			Average	Land Suitability Level				Class
	1	2	3		S1	S2	S3	N	
KT1	5.83	5.76	5.85	5.81	5.0 – 6.0	4.5 – 5.0	< 4.5	-	S1
KT2	5.72	5.68	5.69	5.70					S1
KT3	5.87	5.78	5.89	5.85					S1
KP1	5.86	5.83	5.9	5.86					S1
KP2	5.72	5.76	5.78	5.75					S1
KP3	5.93	5.87	5.96	5.92					S1

Note: KT : dryland; KP : plantation

The soil pH value can be adjusted through liming when it indicates a high level of acidity. Farmers in Sumber Rejo Village commonly use manure as the primary fertilizer, which is mixed with chemical fertilizers to enhance soil fertility. According to [Yuniarti \*et al.\* \(2018\)](#), the application of manure is a common method to stabilize soil pH and has been proven to be effective and environmentally friendly when applied continuously over the long term.

Soil pH is one of the main factors determining the availability of nutrients in the soil and the growth health of cardamom plants. Cardamom ideally grows in soil with a pH range of 5.5–6.8, which is classified as slightly acidic to neutral. Within this range, macronutrients such as nitrogen (N), phosphorus (P), and potassium (K) are in their most available and absorbable forms for plants. When the soil pH is too low (extremely acidic, <5), nutrients such as phosphorus tend to bind with aluminum (Al) and iron (Fe), making them unavailable for plant uptake. Conversely, when the pH is too high (>7), micronutrients such as zinc (Zn), copper (Cu), and manganese (Mn) become less available, potentially leading to nutrient deficiencies in cultivated plants ([Yuniarti \*et al.\*, 2020](#)).

In addition, a suitable soil pH also supports the activity of soil microorganisms, particularly decomposer bacteria that break down organic matter and produce nitrogen in forms that can be absorbed by plants ([Sefano \*et al.\*, 2023](#)). These microorganisms are most active in soils with a pH close to neutral. In cardamom cultivation, maintaining the soil pH within the optimal range helps to enhance root development, stimulate tiller formation, and support the generative phase, including the formation of high-quality flowers and fruits. Therefore, regular monitoring and adjustment of soil pH—such as through liming in overly acidic soils or the addition of organic matter to stabilize pH—are essential components of a sustainable cardamom cultivation management system ([Nopriani \*et al.\*, 2023](#)).

#### 3.2. C-Organic

The results of the laboratory analysis of organic carbon content (% C-organic) showed relatively good values, ranging from 1.61% to 2.79%. Based on the soil fertility classification by [Djaenuddin \*et al.\* \(2011\)](#), organic matter content above 1.5% falls into the moderate to high category, which still supports optimal plant growth. The organic carbon content plays a crucial role in improving soil structure, enhancing cation exchange capacity (CEC), and maintaining soil moisture, all of which are essential for cardamom growth. All sampling locations were classified as S1 (highly suitable), indicating a high level of suitability in terms of organic matter content.

Organic carbon (C-organic) has a close relationship with soil pH and can be maintained through regular application of manure, as well as utilizing crop residues from surrounding areas. A study by [Kesumaningwati \(2016\)](#)

Table 4. Laboratory result for C-organic (%)

LMU	Replication			Average	Land Suitability Level				Class
	1	2	3		S1	S2	S3	N	
KT1	1.63	1.71	1.5	1.61	> 1.2	0.8 – 1.2	< 0.8	-	S1
KT2	2.34	2.47	2.3	2.37					S1
KT3	1.88	1.8	1.96	1.88					S1
KP1	1.84	2.01	1.75	1.87					S1
KP2	2.26	2.13	2.38	2.26					S1
KP3	2.76	2.97	2.63	2.79					S1

Note: KT : dryland; KP : plantation

demonstrated that the use of bokashi made from rice husk residues significantly increased the organic carbon content in the soil.

### 3.3. CEC

The results of the laboratory analysis of cation exchange capacity (CEC) showed varying values ranging from 23.93 cmol/kg to 33.07 cmol/kg, which fall into the high category (generally, soils with CEC > 20 cmol/kg are considered suitable for agriculture). A high cation exchange capacity indicates the soil’s strong ability to retain and supply essential nutrients required for plant growth.

Table 5. Laboratory result CEC (cmol)

LMU	Replication			Average	Land Suitability Level				Class
	1	2	3		S1	S2	S3	N	
KT1	23.6	23.2	25.0	23.93	> 16	< 16	-	-	S1
KT2	29.6	30.3	27.8	29.23					S1
KT3	25.7	24.6	26.7	25.67					S1
KP1	26.4	24.6	25.7	25.57					S1
KP2	32.7	34.1	32.4	33.07					S1
KP3	28.5	28.9	27.1	28.17					S1

Note: KT : dryland; KP : plantation

Cation Exchange Capacity (CEC) refers to the soil’s ability to retain and release cationic nutrients essential for plant growth, such as calcium (Ca<sup>2+</sup>), magnesium (Mg<sup>2+</sup>), potassium (K<sup>+</sup>), and sodium (Na<sup>+</sup>). Soils with high CEC can hold greater amounts of nutrients and gradually release them according to plant needs (Sarah *et al.*, 2024). In cardamom cultivation, a high CEC is particularly important to maintain a stable nutrient supply, as cardamom is a perennial crop that requires a long-term and consistent availability of nutrients to support both its vegetative and generative growth.

Soils with good Cation Exchange Capacity (CEC) help support strong root development, dense leaf growth, and optimal flower and fruit formation. High-CEC soils are also better able to maintain stable pH and soil moisture, as soil particles (such as clay and organic matter) with negative charges can bind water and nutrients more effectively. Conversely, soils with low CEC tend to lose nutrients quickly due to leaching caused by rainfall, which can lead to nutrient deficiencies and stunted growth in cardamom plants (Harefa *et al.*, 2024). Therefore, increasing CEC through the addition of organic materials (such as compost or manure) and maintaining good soil structure are essential steps in cardamom land management to achieve optimal productivity (Hilwa *et al.*, 2020).

### 3.4. Base Saturation

The results of the laboratory analysis of base saturation showed that the soils in locations KT and KP contain high levels of calcium (Ca), magnesium (Mg), and potassium (K), which strongly support cardamom growth. The Ca content ranged from 38.87 to 43.27 cmol/kg, Mg ranged from 13.62 to 16.19 cmol/kg, and K ranged from 23.53 to 25.6 cmol/kg. These three elements are essential macronutrients that play vital roles in plant growth and development

(Feronica & Setiawan, 2023). Calcium strengthens cell walls and root structures, magnesium is a key component of chlorophyll that supports photosynthesis, and potassium contributes to fruit formation and enhances plant resistance to environmental stress (Rika, 2022).

In average, the base saturation value is 31.12 for dry land and 32.34 for plantation area. Both are less than 35 and therefore included in the S2 category (moderately suitable). In addition, the sodium (Na) content at both locations was found to be relatively high, measuring 45.89 cmol/kg in KT and 46.87 cmol/kg in KP. Sodium is not an essential nutrient for cardamom, and excessive amounts can lead to soil salinity issues, potentially disrupting the absorption of other nutrients and reducing plant productivity. Nevertheless, the high levels of Ca, Mg, and K help to balance the cation composition in the soil, thereby minimizing the negative effects of sodium. Consequently, the land is still classified as moderately suitable (S2) for cardamom cultivation. Specific management practices such as improving drainage and regular monitoring of soil salinity are recommended to maintain nutrient balance in the long term.

Table 6. Laboratory result for base saturation

Base saturation (%)	LMU		Land Suitability Level					
	Dry land (KT)	Plantation (KP)	S1	S2	S3	N	Class KT	Class KP
Ca	38.87	43.27						
Mg	16.19	13.62						
K	23.53	25.6						
Na	45.89	46.87						
Average	31.12	32.34	> 35	20 – 35	< 20	-	S2	S2

### 3.5. Improvement Suggestions

The sampling points KP1, KP2, and KP3 exhibited slope gradients ranging from 9.5% to 14.5%, indicating the need for soil conservation measures such as terracing, bench terraces, planting of cover crops, and the construction of contour drainage channels to reduce the potential for erosion and improve land stability (Setiawan *et al.*, 2018). These measures are crucial because cardamom (*Elettaria cardamomum*) has a shallow root system that is easily disturbed by the loss of the topsoil layer.

The contents of essential nutrients such as calcium (Ca), magnesium (Mg), and potassium (K) were relatively high across all sampling locations, while the elevated sodium (Na) levels require proper mitigation. Therefore, it is recommended to conduct regular monitoring of soil salinity and to apply organic materials, such as manure and compost, on a routine basis to help balance soil cations (Mulyadi *et al.*, 2021). The application of dolomite lime can also be used to maintain pH stability and enhance the availability of essential nutrients. With a combination of soil conservation strategies and sustainable nutrient management, the existing land shows strong potential to become a productive area for intensive and environmentally friendly cardamom cultivation.

The results of laboratory analysis on soil chemical properties showed that all Land Mapping Units (LMUs) were classified as S1 (highly suitable), indicating that no major improvement measures are required. However, land conservation efforts remain necessary. Land conservation should not only focus on physical aspects such as erosion control and slope stability, but also on maintaining and improving soil chemical properties to ensure sustained crop productivity. The conservation of soil chemical characteristics aims to maintain soil pH stability, enhance organic matter content, and preserve cation exchange capacity (CEC) to keep essential nutrients available for plants. Conservative measures that can be implemented include the regular application of organic fertilizers (such as compost or manure), liming of acidic soils, and crop rotation or intercropping systems that help improve soil quality (Sulistyaningrum *et al.*, 2014). These efforts are crucial to prevent fertility decline caused by nutrient leaching, sodium accumulation, or cation imbalance. Therefore, the conservation of soil chemical properties plays a significant role in maintaining the long-term sustainability of cardamom cultivation systems.

#### 4. CONCLUSION

Based on the results of the land evaluation conducted in Sumber Rejo Village, it can be concluded that the physical and chemical conditions of the soil at the study site are highly supportive of cardamom (*Elettaria cardamomum*) cultivation. Major parameters, including soil pH, organic carbon content, cation exchange capacity (CEC) have values within highly suitable (S1) category, but base saturation (BS) fall within the moderately suitable (S2) category. The dominant sandy clay texture, good drainage, and deep effective soil depth provide optimal support for root development and nutrient absorption. Although the sodium (Na) content was found to be relatively high, this issue can be mitigated through proper drainage management. Overall, the land in Sumber Rejo Village possesses a high potential for development as a cardamom cultivation area, both technically and economically, provided that sustainable soil quality management is maintained. This evaluation, however, is based on only four parameters (pH, CEC, C-organic, and base saturation). Future research should build on this research by evaluating other parameters to obtain a more comprehensive assessment of land suitability for cardamom cultivation in Sumber Rejo village.

#### AUTHOR CONTRIBUTION STATEMENT

Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
AZR	✓	✓	✓		✓	✓	✓	✓	✓					
Pur				✓						✓		✓		
PES				✓						✓		✓		

C: Conceptualization	Fo: Formal Analysis	O: Writing - Original Draft	Fu: Funding Acquisition
M: Methodology	I: Investigation	E: Writing - Review & Editing	P: Project Administration
So: Software	D: Data Curation	Vi: Visualization	
Va: Validation	R: Resources	Su: Supervision	

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