Vol. 13, No. 2 (2024): 572 - 580 http://dx.doi.org/10.23960/jtep-l.v13i2.572-580

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Mapping of Land Suitability for Growing Tobacco (*Nicotiana tabacum* L.) Under Various Slope Using Geographic Information Systems

Mujiyo[1,✉], Daradinda Surya Irawaningsih[1], Slamet Minardi[1], Ongko Cahyono[1]

[1] Department of Soil Science, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, INDONESIA.

Article History:

Received : 28 November 2023
Revised : 02 February 2024
Accepted : 18 February 2024

Keywords:

Hilly land,
Land management,
Limiting factors,
Sustainable agriculture,
Tobacco growth potential.

Corresponding Author:
✉ mujiyo@staff.uns.ac.id
(Mujiyo Mujiyo)

ABSTRACT

The study aims to identify the classes and the determinant factors of land suitability of Tobacco in order to provide recommendations for land management as an effort in increasing the development of Tobacco in Eromoko District, Wonogiri Regency, Indonesia. This research used a descriptive-exploratory approach by field surveys, laboratory analysis, and matching the data with growth requirement characteristics for Tobacco crops. The field survey was carried out based on a working map, namely the Land Mapping Unit (LMU), overlaid maps of soil type, slope, and rainfall. Research results illustrated that 18 LMUs were included in the marginally suitable class (S3) (4,968.78 ha, about 51% of research area) with limiting factors wa*;* oa*;* nr*;* na*;* eh*, and 8 LMUs were included in the unsuitable class (N) (4,919.11 ha, about 49% of research area) with limiting factors* N *and* eh*. This study provide information about the land suitability class and the limiting factors each area to determine the potential success of Tobacco cultivation and make suitable improvement efforts.*

1. INTRODUCTION

Tobacco is a commodity with high selling value and benefits, such as the stems used as bioethanol (Handayani *et al.*, 2018). Tobacco plants are major commodity in Indonesia, but not all areas suitable for Tobacco plants. Eromoko District is the largest dry tobacco-producing area in Wonogiri Regency. Tobacco output remains uncertain year after year due to various factors, including climate (Munthe *et al.*, 2017), soil nutrients and water availability, and varieties (Hutapea *et al.*, 2014). Tobacco production in Eromoko District from 2015 to 2017 experienced a rapid increase in planting area and production yields. In 2018, the planting area decreased by 706.74 ha and a production yield of 1,134.48 tons, it was due to long dry season conditions. In 2019, the planting area increased to 1,222.05 ha, producing 1,728.82 tons. The decrease production yield affects the farmers' production yield and the farmers' difficulty in meeting high market demand.

Unstable production yields make it difficult for farmers to meet market demand, and the potential for losses is more significant. Therefore, it is necessary to research the class of land suitability of Tobacco plants to maximize Tobacco crop productivity using a Geographic Information System (GIS). Geographic Information System is a field of science that discusses the geographic field of the earth. The design of the GIS will provide location information on agricultural land, including the area of plantation, rice fields, and dry fields, then coordinate points and satellite imagery (Masykur, 2013). Mapping is a type of information for conveying, analyzing, and classifying the data concerned in map form, providing a clear and a proper layout (Novitasari *et al.*, 2015).

The information on whether the land has soil characteristics suitable for tobacco cultivation is not available. In contrast, dry land has sufficient area for tobacco cultivation and can be used by the surrounding community for tobacco production. The research used the necessary spatial analysis methods by using geographic information systems, in the form of maps is the main material in determining sample points for this research and was created using a GIS application. GIS modeling will provide actual and real images, explanations and conditions. This makes it easier for stakeholders to map and plan long-term land use more efficiently. The study aims to map the land suitability classes of tobacco in the area, find out the determinant factors of land suitability, and provide recommendations for land management efforts to increase and develop tobacco production in the area.

2. MATERIALS AND METHODS

The research conducted in the Eromoko District, Wonogiri Regency, Province of Central Java, Indonesia, at coordinates 110°46'34" - 110°53'37" East Longitude and 7°53'41"-7°55'28" South Latitude . The Eromoko District consists of mountains and hills, which are limestone areas. The Eromoko District is made up of folded hills, karst, and alluvial plains as a result of geomorphology (morphogenesis) (Nasrulloh, 2019). The average temperature in research area is 21.1°C to 26.4°C. Figure 1 presented the sampling location map of Eromoko District, Wonogiri Regency.

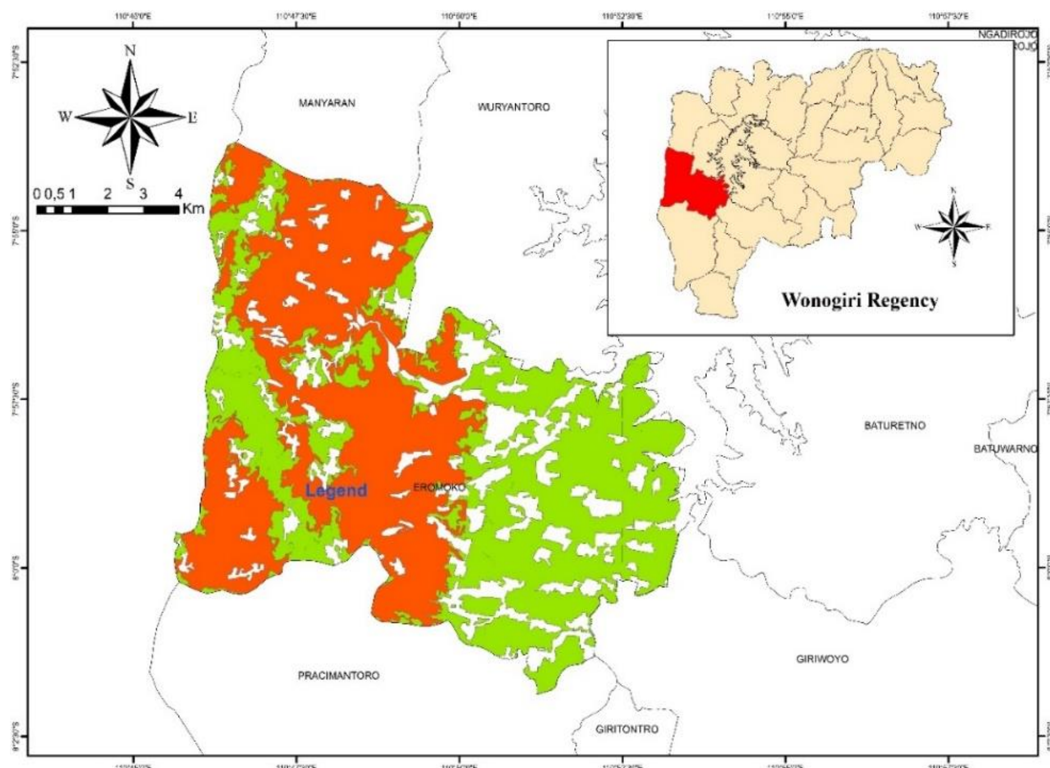

Figure 1. Map of site sampling location (Remark: the green color for Eromoko District; the orange color for Tobacco plantation area in Eromoko District).

The research is a descriptive exploratory indicator approach carried out through field surveys and supported by data from soil analysis in the laboratory. The exploratory descriptive method aims to analyze and present data systematically so that it is easy to understand and discover something new by grouping facts (Diniyah *et al*., 2018). The indicators observed include land suitability and limiting factors for tobacco plants in Eromoko District. Field surveys are carried out by observing land conditions based on work maps. Work maps are created from overlaying thematic maps (administrative maps, soil type maps, slope maps, rainfall maps), namely land mapping unit (LMU). In the land mapping unit (LMU), the distribution of sampling points is carried out using purposive sampling, provided that the selected points represent the uniformity of land and environmental characteristics (soil type, slope, rainfall). Land map units consist of thematic maps at a scale of 1: 25000.

Table 1. The growth requirements for tobacco (*Nicotiana tabacum* L.)

Land characteristic requirements	Land suitability class			
	S1	S2	S3	N
Temperature (*tr*)				
Average temperature (°C) during the growth period	24-30	22-24 30-32	21-22 32– 34	< 21 > 34
Water availability (*wa*)				
Annual rainfall (mm/year)	600 -1200	1.200 – 1.400 500 – 600	> 1.400 400 – 600	< 400
Humidity (%)	24 – 75	20 – 24 75 – 90	< 20 > 90	
Oxygen availability (*oa*)				
Drainage	Good, medium	Somewhat low	low, excessively fast	very low, fast
Rooting cause (*rc*)				
Texture	Medium, rather fine, fine	rather rough, very fine	Rough	Rough
Coarse material (%)	<15	15-35	35-55	>55
Soil depth (cm)	>75	50-75	30-50	<35
Peat				
Thickness (cm)	<100	100-200	200-300	>300
Maturity level	sapric	sapric, hemic	hemic	fibric
Nutrient retention (*nr*)				
Land CEC (cmol)	>16	5-16	<5	
Base saturation (%)	>35	20-35	<20	-
pH H_2O	5.5-7.5	5.0-5.5 7.5-8.0	<5.0 >8.0	
C-Organic (%)	>1.2	0.8-1.2	<0.8	
Nutrient availability (*na*)				
N total (%)	High	Medium	Low-very low	
P_2O_5 (mg/100 g)	Medium	Low	Very low	
K_2O (mg/100 g)	Medium	Low	Very low	
Toxicity (*tc*)				
Salinity (ds/m)	< 2	2 – 4	4 - 6	> 6
Xodicity (*xn*)				
Alkalinity/esp (%)	< 10	10 – 15	15 – 20	> 20
Sulfidic hazard (*xs*)				
Sulfidic depth (cm)	> 100	75 – 100	40 - 75	< 40
Erosion hazard (*eh*)				
Slope (%)	<8	8-16	16-30	>30
Erosion hazard	Very light	Light-medium	Heavy	Very heavy
Flood hazard (*fh*) (Flooding during planting)	F0	-	F1	>F1
Heigh / depth(cm)	-	-	-	25
Period (day)	-	-	-	<7
Land preparation (*lp*)				
Rock surface (%)	<5	5-15	15-40	>40
Outcrop rock (%)	<5	5-15	15-25	>25

Source: Ritung *et al.* (2011)

2.1. Soil sampling and analysis

Making work maps using the overlay method, namely combining soil type maps, land use maps, slope maps, rainfall maps in Eromoko District. Work map was made using a GIS application. GIS software combines mathematical models and algorithms to analyze spatial data and explain land conditions and the surrounding environment. The use and design of GIS will offer information on a location or area that has agricultural land,including plantation areas, rice fields, and moorland, as well as coordinate points and satellite figures (Masykur, 2014). Advances in mapping (visualization) technology are currently experiencing very rapid development (Shofiyanti, 2011), potential suitability map and land use area suitability class map (Rofizar *et al.*, 2017).

This research was carried out in a descriptive exploratory approach. The indicator approach was carried out through field surveys and data supported by soil laboratory analysis. Laboratory analysis was conducted at the Chemistry and Soil Fertility Laboratory and the Physics and Soil Conservation Laboratory, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta. The field survey was carried out by observing the condition of the land based on sampling points in land mapping unit of the work maps.

Land suitability indicators for tobacco plants that have been determined include rainfall, drainage conditions, texture, pH, C-organic, CEC, slope, altitude, and erosion conditions. Field data collection includes annual temperature observations (results of calculations from altitude), rainfall (rainfall data for the last 10 years in Eromoko District), drainage, the effective depth of soil, slope, surface rock, rock outcrops, landslide hazard, erosion hazard, and flooding/inundation. Laboratory analysis parameters and methods included soil texture analysis (pipette method), CEC (extraction method), base saturation (1N Ammonium acetate pH 7 saturation method), pH, organic C (Walkley & Black method), N Total (Kjeldahl method), P2O5 (Olsen method), K2O (Spectrometry method), Salinity, and Electric conductivity (EC) (Electro Conductivity meter).

2.2. Data analysis

The land's characteristics match to the criteria for the requirements for plant growth. This will result in land suitability classes, as well as their limiting considerations. Land evaluation results are described as a map as a basis for rational land use planning (Andrean *et al.*, 2017). Table 1 shows the requirements for tobacco (*Nicotiana tabacum* L.) growth of land used as a reference for land suitability matching (Ritung *et al.*, 2011).

3. RESULTS AND DISCUSSION

3.1. Land Suitability

The results of matching the soil characteristics value (Table 2) as parameters obtained about the conditions for land use of tobacco plants produce actual land suitability classes as presented in the Table 3. Actual land suitability is an assessment of land characteristics during a survey, and there have been no attempts to improve land conditions (Hidayat *et al*., 2021). The analysis results show that tobacco plants' actual land suitability class in Eromoko District shows two categories: suitable marginal (S3) in 4.968, 78 ha area and unsuitable (N) in 4.919,11 ha area. (S3) suitability class of 18 LMU, include LMU 1 to 18, each with different limiting factors, as presented in Table 1. Class of N suitability of 8 LMUs, include LMU 19 to 26. The limiting factors in general of the research is rainfall (*wa*), nutrient retention (*nr*), base saturation (*nr*), and available nutrients (*na*), consist of total N and available K, drainage (*oa*), and slope (*eh*).

3.2. Limiting Factors

3.2.1. Water Availability (*wa*)

Based on the research area, the average temperature was 21.10 °C to 26.4 °C with rainfall of 1750 mm/year. Temperature is influenced by altitude, the higher the research location, the lower the temperature, and vice versa, if the research location's altitude is low, the temperature will be higher. Sitorus *et al.*, (2014) stated that the area will experience a decrease of around 0.6 °C for every 100 meter increase in elevation.

Table 2. Land suitability characteristics

Characteristic requirements	Range value
Temperature (*tr*)	
Average temperature (°C) during the growth period	21.1 – 26.4
Water availability (*wa*)	
Rainfall during the growth period (mm)	1750
Oxygen availability (*oa*)	
Drainage	Good – excessively fast
Rooting cause (*rc*)	
Texture	Slightly fine – rough
Coarse material (%)	<15
Soil depth (cm)	25 – 125
Nutrient retention (*nr*)	
Land CEC (cmol)	20.58 – 54.56
Base saturation (%)	4.28 – 18.63
pH H2O	5.52 – 6.08
C-Organic (%)	4.12 – 15.28
Nutrient availability (*na*)	
N total (%)	0.067 – 0.342
P2O5 (mg / 100 g)	22.44 – 110.95
K2O (mg / 100 g)	1.86 – 8.38
Toxicity (*tc*)	
Salinity (ds/m)	0.03 - 0.12
Erosion hazard (*eh*)	
Slope (%)	3 – 45
Erosion hazard	
Flood hazard / flooding during planting (*fh*)	
Height / depth (cm)	<1
Period (day)	<1
Land preparation (*lp*)	
Rock on the surface	1
Outcrop rock	–

Table 3. The land suitability class of tobacco crops.

Land Map Unit (LMU)	Actual Land Suitability Class for Tobacco	Limiting Factor	Area (ha)
1, 2, 3, 4, 5, 6, 8, 9, 10	S3; *wa*, *nr*, *na*	Rainfall, base saturation, Total N, K_2O available	4,175.59
7	S3; *wa*, *oa*, *nr*, *na*	Rainfall, drainage, alkaline saturation, K_2O available	45.43
13, 14, 15, 17, 18	S3; *wa*, *nr*, *na*, *eh*	Rainfall, base saturation, total N, available K_2O, slope, erosion hazard	577.29
11, 12, 16	S3; *wa*, *oa*, *nr*, *na*, *eh*	Rainfall, drainage, base saturation, total N, available K_2O, slope, erosion hazard	170.46
19, 20, 21, 22, 23, 24, 25, 26	N; *eh*	Slope, erosion hazard	4,919.11

Remark: *wa* = water availability, *oa* = oxygen availability, *nr* = nutrient retention, *na* = available nutrient, *eh* = slope hazard

3.2.2. Oxygen Availability (*oa*)

Soil drainage is a water channel on the surface or underground formed naturally or artificially, and drainage shows the availability of oxygen in the soil. The faster the water infiltrates, the more water fill the soil pores, increasing oxygen availability. Based on the research results, 26 LMUs were divided into 3 classes, namely good drainage, somewhat low, and excessively fast. LMU of 1, 3, 4, 5, 6, 8, 9, 10, 13, 14, 15, 17, 21, 22, 24, 25, and 26 showed a good drainage value , which the water has flowed through the soil surface without any obstacles, even though the rainfall is high the soil can absorb water well and there are no puddles so that plants can grow well. The similar statement of Anshori *et al.*, (2023) water availability and groundwater conditions are influenced by soil structure and pores. Land units of 7, 11, 12, 16, 19, 20, and 23 have rather fast drainage and with the exception of land unit 2, which has somewhat low drainage, limited water holding capacity and is dominated mostly by the clay component.

3.2.3. Nutrient Retention (*nr*)

Based on the soil analysis results in the research location laboratory, 26 LMUs had high CEC, ranging from 20.58 to 68.74 cmol/kg. The value of CEC was influenced by several factors, namely pH, organic matter, and texture. Suryani, (2014) explains that the CEC is directly proportional to the clay fraction. The greater the number of clay fractions, the greater the CEC. Base saturation are the ratio between the number of base cations and acid cations in the soil adsorption complex. Husni *et al.*, (2016) stated that base saturation is directly proportional to the CEC value because base saturation is a reflection of the large number of complex cations in soil colloids.

Soil pH at the research location ranges from 5.52 to 6.18 and it is very suitable to meet the soil pH requirements for growing tobacco plants. Soil pH suitable for growing tobacco plants ranges from 5.5 to 6.2. Karamina *et al.*, (2018) explained that plants will generally easily absorb soil nutrients at pH 6-7 because the nutrients will dissolve easily. The higher soil pH, the more difficult of plants to absorb nutrients contained in the soil and vice versa. Meanwhile, the lower soil pH (too acidic), the content of nutrients and microorganisms in the soil is rare, which can disrupt plant growth. Organics can influence soil properties that support plant growth by supplying energy sources for soil organisms and triggering plant growth. Sipahutar *et al.*, (2014) Based on the results of C-Organic analysis, there are 26 land units with relatively high C-Organic content, ranging from 3.77% to 15.28%. The optimum nutrient retention for C-Organic in tobacco plants is more than 1.2%, and the 26 LMUs have C-Organic levels above 1.2%.

3.2.4 Erosion Hazard (*eh*)

The erosion hazard is determined by the degrees of slope, which observed in the field using a clinometer. Based on the results of field observation, the slope at the research location was divided into 3 categories, namely gentle slope <3% (LMUs 1, 2, 3, 4), moderately sloping 3-8% (LMUs 5, 6, 7, 8, 9, and 10), hilly 8-15% (LMUs 11, 12, 13, 14, 15, 16, 17, and 18), and moderately steep slope >15% (LMUs 19, 20, 21, 22, 23, 24, 25, and 26). The erosion hazard can be seen from the slope, which has the potential for erosion in the severe to very heavy category on slopes >15%. Still, at the research location, the level of erosion hazard was light. The slope and length greatly influence the hazard of erosion. Herawati (2010) explained that the erosion hazard level is the maximum quantity of soil lost of land when plant management and soil conservation remain not change.

The water availability factor for tobacco plants is similar with the average rainfall (rainwaters), which are 1750 mm. The ideal average amount for tobacco plants should be around 600-1200 mm. The factor of oxygen availability as limiting factor are drainage because they were included in the category of slightly obstructed and relatively fast drainage. Nutrient retentions are limiting factor due to low base saturation. The available nutrient factor is an inhibitor since the results show that total N and K_2O are poor available in soil, which does not support the tobacco plant growth. The others were erosion hazards caused by the steep slope, which is prone to erosion and unsuitable for tobacco growing. The land suitability class for the Eromoko District presented in Figure 2.

3.3. The determinants factor of land suitability

Based on the results of the One Way ANOVA test with a significance level of 5% (*F*-count= 626.059); *p*-value= 0.000), the difference in slope in Eromoko District affects the land suitability class. The ANOVA test (Table 4) results showed very significant (*P*-value = 0.000 <0.01), means that the slope significantly affects the land suitability class. The determining factors, in this research, are land and soil characteristics that affect land suitability classes. The following land characteristics contribute to environmental diversity: soil type, land use, rainfall, and slope. Therefore,

Table 4. The effect of source of land diversity on land suitability classes

Land Characteristics	p-value	Significance
Soil Type	1.000	Not significant
Land Use	0.051	Not significant
Slope	**0.000**	Significant

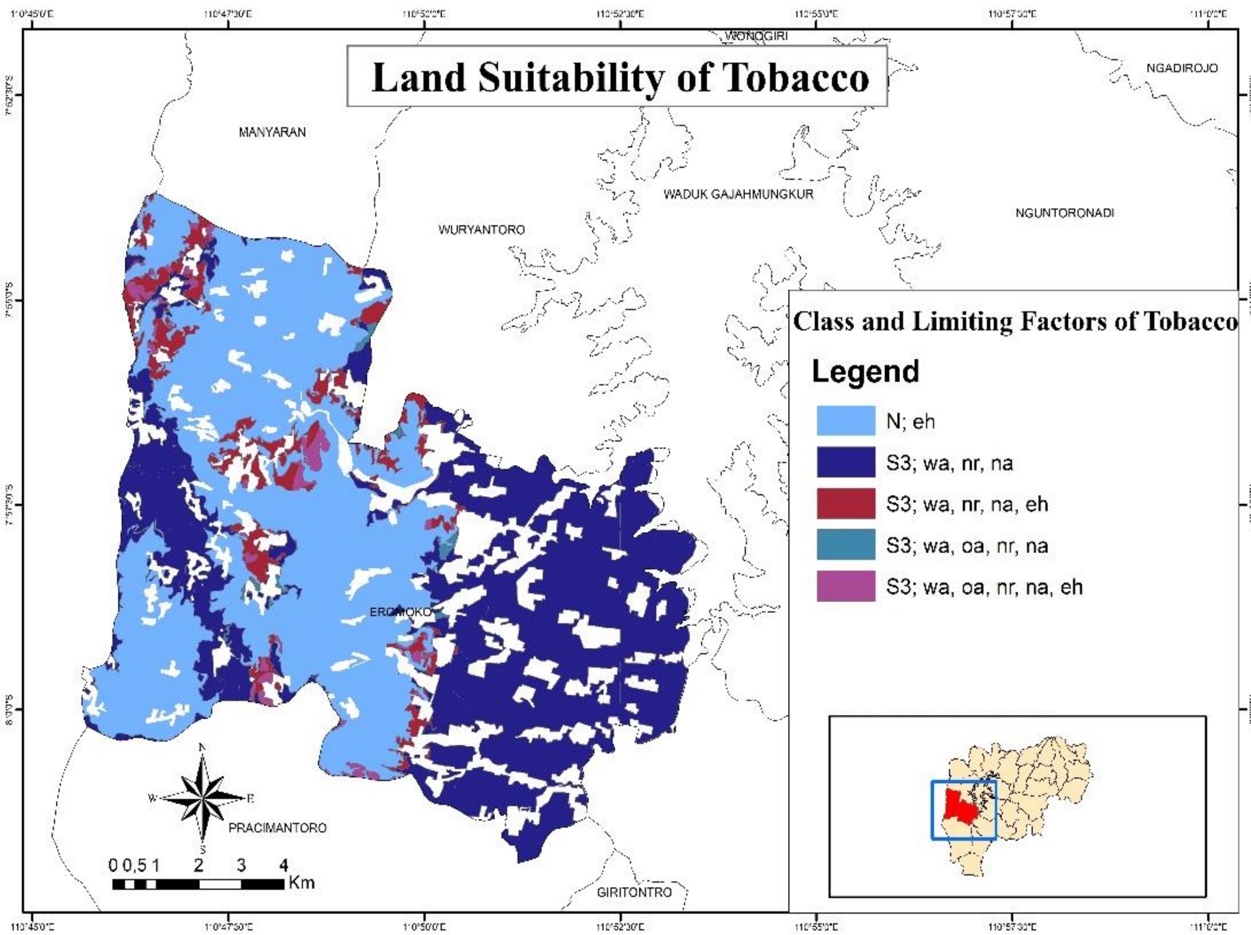

Figure 2. Actual land suitability map for tobacco plants.

rainfall cannot be examined because the value is the same at each LMU. Based on Table 4, the slope is the most significant source of land diversity, influencing the differences in land suitability classes at each LMU. The determining factor is calculated using the parameter that is most closely correlated to the land suitability class. The land suitability class will also change when the parameter value increases or lowers. The environmental factors (land characteristics) of the slope as well as determinant parameter will influence the condition of land suitability classes and value.

Based on the DMRT test (Figure 3), the moderately steep slope (> 15%), with an average value of 5.00 compared to other slopes. Slope of 8-15% has an average value of 3.62, slope 3-8% has an average value of 1.16, and the most suitable is a slope < 3% with an average value of 1.00. The smaller the average value obtained, the more appropriate the land suitability class. Likewise, the greater the average value of the slope, the land suitability class will be lower meaning that the land is less suitable for tobacco.

The determinants of texture show a real correlation (*P*-value <0.01), and the determinants of erosion hazard show a strong correlation (*P*-value <0.05) (Table 5). The erosion hazard determinants significantly correlate to land suitability class (r = 0.944, *P*-value = 0.000). The erosion hazard shows that the greater the erosion hazard value, the less suitable the land suitability, and vice versa, the smaller the erosion hazard value, the more suitable the land suitability. The determining factor in texture has a considerable correlation to the land suitability class (r = 0.241, *P*-value = 0.034). The results of the correlation test on texture show that the greater the texture value, the less suitable the land suitability, and the smaller the texture value, the more suitable the land suitability.

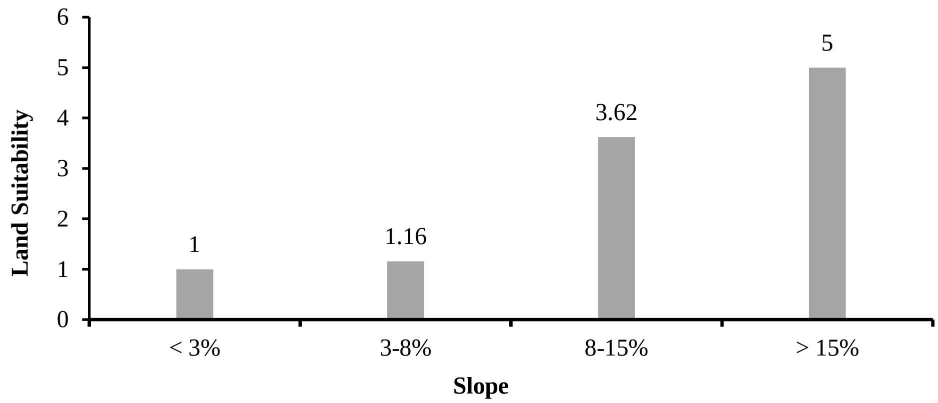

Figure 3. The distribution of land suitability class on various slope

Table 5. Factors determining the actual condition of the land regarding the land suitability class

Soil Parameters	r	Significance
Texture	0.241*	Significant
Erosion Hazard	0.944**	Significant

The analysis of variance and correlation tests shows that the determining factor, which is very closely related to determining land suitability class, is the erosion hazard. Texture is significantly related or correlated to the land suitability class, but texture has no real effect on the characteristics of the land.

3.4. The Recommendation Strategies

Limiting factors in the form of air availability, nutrient retention, available nutrients can be improved by creating drainage channels (Kholifah & Sampoerno, 2016), and adding organic material ameliorant litter (Alibasyah, 2016), and organic fertilizer (Andrean *et al.*, 2017), texture and erosion hazard. If the texture is similar to erosion, use terraces to control surface flow. Erosion can be reduced by building terraces, growing ground cover crops, and planting parallel to contours (Pasaribu *et al.*, 2018). The existing limiting factors can be corrected with various efforts. By considering the stakeholders, improvement efforts can be made with low, medium, and high efforts.

4. CONCLUSIONS

The actual land suitability class for tobacco plants in Eromoko District is divided into 2 classes, namely the marginal suitability class (S3) of 4,968.78 ha or about 51% area with the limiting factors of water availability (*wa*), oxygen availability (*oa*), nutrient retention (*nr*), available nutrients (*na*), and erosion hazards (*eh*), and the unsuitable class (N) in 4,919.11 ha or about 49% area with erosion hazard (*eh*) were the limiting factors. The research findings provide valuable information for farmers and stakeholders to maximize tobacco crop productivity and meet market demand.

REFERENCES

Alibasyah, M.R. (2016). Perubahan beberapa sifat fisika dan kimia ultisol akibat pemberian pupuk kompos dan kapur dolomit pada lahan berteras. *Jurnal Floratek*, ***11***(1), 75–87.

Andrean, V.E., Monde, A., & Nursalam. (2017). Pemetaan kesesuaian lahan untuk tanaman pangan di Kecamatan Soyo Jaya Kabupaten Morowali Utara. *Agrotekbis : Jurnal Ilmu Pertanian*, ***5***(3), 344–350.

Anshori, A., Srihartanto, E., Fibrianty, F., Suswatiningsih, T.E., Budiarti, S. W., Riyanto, D., Cahyaningrum, H., & Suradal, S. (2023). Increase of cropping index in dryland supported by groundwater irrigation. *Caraka Tani: Journal of Sustainable Agriculture*, ***38***(1), 1-13. http://dx.doi.org/10.20961/carakatani.v38i1.58029

Diniyah, A.N., Akbar, G.A.M., Akbar, P., Nurjaman, A., & Bernard, M. (2018). Analisis kemampuan kemampuan penalaran dan *self confidence* siswa SMA dalam materi peluang. *Journal on Education*, ***1***(1), 14–21.

Handayani, S.S., Amrullah, Tarnanda, R., & Anita, R. (2018). Proses degradasi lignin pada limbah batang tembakau sebagai persiapan produksi bioetanol. *Jurnal Pijar MIPA*, ***10***(1), 279–288.

Herawati, T. (2010). Analisis spasial tingkat bahaya erosi di wilayah DAS Cisadane Kabupaten Bogor (Spatial analysis of erosion danger level at cisadane watershed area Bogor District). *Jurnal Penelitian Hutan dan Konservasi Alam*, ***7***(4), 413–424. https://doi.org/10.20886/jphka.2010.7.4.413-424

Hidayat, M.Y., Fauzi, R., & Siregar, C.A. (2021). Kesesuaian lahan beberapa jenis tanaman untuk perbaikan kualitas lahan di hutan lindung Sekaroh. *Jurnal Penelitian Hutan dan Konservasi Alam*, ***18***(1), 13-27.

Husni, M.R., Sufardi, S., & Khalil, M. (2016). Evaluasi status kesuburan pada beberapa jenis tanah di lahan kering Kabupaten Pidie Provinsi Aceh. *Jurnal Ilmiah Mahasiswa Pertanian,* ***1***(1), 147–154.

Hutapea, A.S., Hadiastono, T., & Martosudiro, M. (2014). Pengaruh pemberian pupuk kalium (KNO_3) terhadap infeksi tobacco mosaik virus (TMV) pada beberapa varietas tembakau virginia (*Nicotiana tabacum* L.). *Jurnal HPT (Hama Penyakit Tumbuhan),* ***2***(1), 102–109.

Karamina, H., Fikrinda, W., & Murti, A.T. (2018). Kompleksitas pengaruh temperatur dan kelembaban tanah terhadap nilai pH tanah di perkebunan jambu biji varietas kristal (*Psidium guajava* l.) Bumiaji, Kota Batu. *Jurnal Kultivasi*, ***16***(3), 430–434. https://doi.org/10.24198/kultivasi.v16i3.13225

Kholifah, M., & Sampoerno. (2016). Pemberian amelioran pada bibit kelapa sawit (*Elaeis Guieneensis Jacq*.) di pembibitan awal. *Jurnal Online Mahasiswa Fakultas Pertanian Universitas Riau*, ***3***(2), 1-8.

Masykur, F. (2014). Implementasi sistem informasi geografis menggunakan google maps API dalam pemetaan asal mahasiswa. *Simetris: Jurnal Teknik Mesin, Elektro dan Ilmu Komputer*, ***5***(2), 181-186.

Munthe, R.R., Marbun, P., & Marpaung, P. (2017). Evaluasi kesesuaian lahan untuk tanaman kelapa sawit (*Elaeis guinensis Jack*) dan Kelengkeng (*Euphoria longan Lamk*.) di Kecamatan NA IX-X Kabupaten Labuhan Batu Utara. *Jurnal Agroekoteknologi Universitas Sumatera Utara,* ***5***(1), 144–151.

Nasrulloh, M. (2019). Geologi daerah sindukarto dan sekitarnya Kecamatan Eromoko Kabupaten Wonogiri Jawa Tengah. *Jurnal Online Mahasiswa (JOM) Bidang Teknik Geologi,* ***1***(1).

Novitasari, N.W., Nugraha, A.L., & Suprayogi, A. (2015). Pemetaan multi hazards berbasis sistem informasi geografis di Kabupaten Demak Jawa Tengah. *Jurnal Geodesi Undip*, ***4***(4), 181–190.

Pasaribu, P.H.P., Rauf, A., & Slamet, B. (2018). Kajian tingkat bahaya erosi pada berbagai tipe penggunaan lahan di Kecamatan Merdeka Kabupaten Karo. *Jurnal Serambi Engineering*, ***3***(1), 279–284. https://doi.org/10.32672/jse.v3i1.357

Ritung, S., Nugroho, K., Mulyani, A., & Suryani, E. (2011). *Petunjuk Teknis Evaluasi Lahan untuk Komoditas Pertanian (Edisi Revisi)*. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian, Badan Penelitian dan Pengembangan Pertanian, Bogor.

Rofizar, Jaya, Y.V., & Irawan, H. (2017). Aplikasi SIG untuk pemetaan kesesuaian kawasan budididaya ikan kerapu menggunakan keramba di perairan laut Desa Genting Pulur Kabupaten Kepulauan Anambas. *Jurnal Intek Akuakultur*, ***1***(1), 37–50.

Shofiyanti, R. (2011). Teknologi pesawat tanpa awak untuk pemetaan dan pemantauan tanaman dan lahan pertanian. *Jurnal Informatika Pertanian*, ***20***(2), 58 – 64.

Sipahutar, A., Marbun, P., & Fauzi, F. (2014). Kajian C-organik, N dan P humitropepts pada ketinggian tempat yang berbeda di Kecamatan Lintong Nihuta. *Jurnal Agroekoteknologi Universitas Sumatera Utara*, ***2***(4).

Sitorus, T.B., Napitupulu, F.H., & Ambarita, H. (2014). Korelasi temperatur udara dan intensitas radiasi matahari terhadap performansi mesin pendingin siklus adsorpsi tenaga matahari. *Jurnal Ilmiah Teknik Mesin Cylinder*, ***1***(1), 8–17.

Suryani, I. (2014). Kapasitas tukar kation (KTK) berbagai kedalaman tanah pada areal konversi lahan hutan. *Jurnal Agrisistem*, ***10***(2), 99–106.