AGROLAND: The Agricultural Sciences Journal
Vol. 8, No. 1 June (2021), 60 - 71
P-ISSN : 2407- 7585 & E-ISSN : 2407- 7593, Published by Tadulako University

Original Research **Open Access**

LAND SUITABILITY EVALUATION FOR BANANA IN JENAWI DISTRICT, KARANGANYAR, INDONESIA

Mujiyo[1)], Fitriana Romdhati[2)], Hery Widijanto[1)], Aktavia Herawati[1)]

[1)] Department of Soil Science, Faculty of Agriculture, Universitas Sebelas Maret, Ir. Sutami Street 36A, Jebres, Surakarta, 57126, Indonesia
[2)] Department of Agrotechnology, Faculty of Agriculture, Universitas Sebelas Maret, Ir. Sutami Street 36A, Jebres, Surakarta, 57126, Indonesia

Correspondence author's: Mujiyo
Email **:** mujiyo@staff.uns.ac.id

Submit: 28 April 2021, Revised: 15 June 2021, Accepted: June 2021
https://doi.org/10.22487/agroland.v8i1.903

ABSTRACT

The superior banana varieties in Karanganyar Regency, including Jenawi District, have the potential to be developed, but banana development is still constrained by the lack of information regarding land suitability. This study aims to to obtain the land suitability class for banana and its limiting factors, to arrange land management for its development. This research was a descriptive explorative study through a field survey approach, supported by laboratory analysis. Determination of land suitability classes is carried out by matching land characteristics with plant growth requirements. The actual land suitability class for banana plants is not suitable (N) and marginal suitable (S3). The inhibiting factors for banana suitability were low temperature, high rainfall, low P_2O_5 content, steep slopes, and high erosion hazards. Land improvement effort that can be done include elaborate drainage structure, liming and ameliorant adding, P-fertilizing, planting in line with contour and cover crop planting. Potential land suitability classes for banana are not suitable (N), marginal suitable (S3) and moderately suitable (S2). Jenawi District has sufficient land potential for banana development. Banana development can be carried out on land with moderately suitable potential land suitability by improving the land limiting factors.

Keywords: Banana, Jenawi, Land evaluation, Land suitability

INTRODUCTION

Bananas are the fourth most important food in developing countries (FAO 2014). Bananas are widely consumed by Indonesians because they contain minerals such as potassium, magnesium, phosphorus, iron, and calcium, and contain vitamins, such as vitamin C, vitamin B complex, vitamin B6, and serotonin (Balitbang Pertanian 2007). Apart from being highly nutritious, bananas have a high economic value that can increase farmers' income. Indonesia is the 6th largest banana producing country in the world. Banana production in Indonesia reached 7.3 million tons with a productivity of 77.64 tons ha^{-1} in 2015 (Pusdatin 2016). Banana production in Indonesia has met domestic requirements, but export requirements still need to be increased. Increased production can be done by expanding the banana cultivation area.

Banana plants can be used as conservation plants in dry and critical areas. The specialty of banana plants as conservation plants can be maximized to be cultivated in areas with low land capability, namely high slopes, prone to erosion, shallow soil depth and lots of gravel and rocks. According to Pusponegoro *et al*. (2018) land planted with bananas can reduce erosion hazard from medium to low, with good construction terraces as land management. Factor C (soil cover crop) in erosion management can be reduced by planting broadleaf plants (Pham *et al.* 2018). Broad-leaved plants such as bananas can protect the soil from raindrops. Banana development requires the availability of suitable land, especially in dry land areas which also makes bananas as a conservation plant.

Karanganyar Regency is one of the banana producers in Central Java Province. Jenawi District is one of the agricultural centers in Karanganyar Regency (Prihati 2013) which has the potential for banana plantation development. Banana plants have great potential in dry land such as yards, moor/garden, pasture land, state forests and plantations. The area of moor/garden that has the potential for banana development in Jenawi District is 1,992.00 ha (BPS Karanganyar, 2017). In addition, the Karanganyar Regency Government plans to develop superior varieties, and make Jenawi as a center for banana cultivation. Karanganyar Regency Government makes bananas as a main crop because bananas are relatively easy to care for and are not susceptible to pests and diseases. So far, many residents of Jenawi District have also planted bananas.

Karanganyar Regency, including Jenawi District has superior banana varieties that are in demand by the public because they have fast growth, sweet taste, and high vitamin A and C content (Herawati *et al*. 2018). However, it has not been developed optimally. Most of the banana cultivation is still carried out on a yard scale, is poorly maintained and has not paid attention to the suitability of the land, so the yield and quality are not good. Banana development is constrained by the lack of information regarding land suitability and information on land management for banana cultivation. Farmers need data bases and information on land conditions, so that land potentials can be found for sustainable crop production.

Improper use of agricultural land is a major obstacle to agricultural production. The continuous use of agricultural land, without regard to land suitability has led to more land degradation (FAO 2007). Land suitability evaluation aims to determine land potential and land management directions for commodity cultivation (Mujiyo, Sutarno, *et al*. 2020). The main objective of evaluating the suitability of agricultural land is to predict the potential and limitations of land for crop production (Pan and Pan 2012). The results of land suitability evaluation are in the form of information related to land limiting factors for agricultural production, which can be used by land users and governments in land use planning (Mardawilis *et al*. 2011; Abdelrahman *et al*. 2016).

Jenawi District based on geographical position and land potential has good prospects and opportunities for banana cultivation. Therefore, it is necessary to evaluate the land suitability so that the distribution of the location can be known. Evaluation of land suitability for bananas has been carried out, but only on the aspect of climatic conditions. There is no data regarding the suitability of soil conditions for bananas. The research objective was to obtain the land suitability class for banana in Jenawi District and its limiting factors, to arrange land management for banana development.

RESEARCH METHODS

This research was conducted in Jenawi District, Karanganyar Regency, Central Java, at coordinates 111°4'54.063" - 111°11'40.01" East Longitude and 7°37'14.103" - 7°31'39.311" South Latitude. This area based on geographical position and land potential has good prospects and opportunities for banana cultivation. This research was a descriptive explorative study through a field survey approach, supported by laboratory analysis. The research stages consisted of : (1) determining the Soil Map Unit (SMU) (2) field surveying (3) laboratory analysis; and (4) land suitability evaluation. The soil map unit was determined by conducting an initial soil survey at 23 observation points, which were spread out based on elevation and land use by the transect method. Soil map units are shown in Figure 1.

The field survey aims to find out information on land physiography and soil characteristics and to take soil samples for laboratory analysis. Each SMU was represented by a soil pedon. Laboratory analysis was carried out at the Laboratory of Physics and Soil Conservation and the Laboratory of Chemistry and Soil Fertility, Faculty of Agriculture, Universitas Sebelas Maret. The parameters observed included soil texture (pipette method), Organic-C (Walkey and Black), soil pH (pH meter with soil to water ratio 1: 5), Cation Exchange Capability (CEC) (NH4OAc 1N pH 7 extraction), base saturation (extraction NH4OAc 1N pH 7), total-P and total-K (25% HCl Extract method), total-N (Kjedahl method), salinity (electrical conductivity meter method) and alkalinity (exchangeable sodium percentage).

Evaluation of land suitability is carried out by matching the land characteristics with plant growth requirements. The terms of plant growth refer to Ritung et al. (2011) (Table 1). The land suitability classification refers to the Land Evaluation Framework according to FAO (1976), using three categories, namely order, class and sub-class. Land suitability classes consist of suitable (S1), moderate suitable (S2), marginal suitable (S3) and not suitable (N). The sub-class shows the land factors that limit the suitability of banana.

Suitable class (S1) means that the land factor do not inhibit plant growth and does not significantly affect land productivity. Moderate suitable class (S2) means that land characteristics can affect land productivity. Marginally suitable class (S3) means that land characteristics are difficult constraining factors and require large funds to overcome. Not suitable class (N) means that the characteristics of the land are a serious constraining factor and very difficult to overcome

Figure 1. Soil Map Unit of Jenawi District, Karanganyar Regency, Central Java.

RESULTS AND DISCUSSION

Land suitability evaluation is an assessment of a land to obtain information related to land potential for specific uses (Rahmawaty *et al*. 2016). The evaluation results consist of actual land suitability, and potential suitability. The actual suitability class is land suitability result based on the assessment of land under current conditions (Ulfa *et al*. 2014). Potential land suitability is based on estimated land conditions after land improvement is carried out.

Table 1. Land Requirement for Banana Cultivation

Land Characteristics	S1	S2	S3	N
Temperature (tc)				
Average temperature (°C)	25 - 27	27 - 30 22 - 25	30 - 35 18 - 22	> 35 < 18
Elevation (m asl)	< 1200	1200 - 1500	1500 - 2000	> 2000
Water availability (wa)				
Rainfall (mm year^{-1})	1500 - 2500	1250 - 1500 2500 - 3000	1000 - 1250 3000 - 4000	< 1000
Dry Month	0 - 3	3 - 4	4 - 6	> 6
Oxygen availability (oa)				
Drainage	good, quite obstructed	quite fast, medium	obstructed	very obstructed, fast
Rooting depth characteristic (rc)				
Texture	medium, quite fine, fine	medium, quite fine, fine	quite coarse, very fine	coarse
Coarse material (%)	< 15	15 - 35	35 - 55	> 55
Soil effective depth (cm)	> 75	> 75	50 - 75	< 50
Nutrient retention (nr)				
CEC (me 100 g^{-1})	> 16	5 - 16	< 5	
Base saturation (%)	> 50	35 -50	< 35	
pH H_2O	5.6 - 7.5	5.2 - 5.6 7.5 – 8.0	< 5.2 > 8.2	
C-Organic (%)	> 1.2	0.8 – 1.2	< 0.8	
Nutrient availability (na)				
N total (%)	0.21 - 0.50	0.10 - 0.20	< 0.10	
P_2O_5 (mg 100 g^{-1})	21- 40	15 - 20	< 15	
K_2O (cmol kg^{-1})	21- 40	10 - 20	< 10	
Toxicity (xc)				
Salinity (dS m^{-1})	< 2	2 - 4	4 - 6	> 6
Solidity (xn)				
Alkalinity /ESP (%)	< 4	4 - 8	8 - 12	> 12
Erosion Hazard (eh)				
Slope (%)	< 8	8 - 15	15 - 30	> 30
Erosion hazard	very low	low - medium	high	very high
Flood hazard/ inundation On planting period (fh)				
Height (cm)	-	-	25	> 25
Land preparation (lp)				
Surface rocks (%)	< 5	5 - 15	15 - 40	> 40
Rock outcrop (%)	< 5	5 - 15	15 - 25	> 25

Actual Land Suitability

Actual land suitability of bananas in Jenawi District is not suitable (N) and marginally suitable (S3). Actual land suitability class at SMU 1 is considered not suitable, while SMU 2, SMU 3, and SMU 4 are classified as marginally suitable (shows in Figure 2). The limiting factor for banana land suitability in research area is temperature, elevation, rainfall, base saturation, P_2O_5 content, slope and erosion hazard (Table 2).

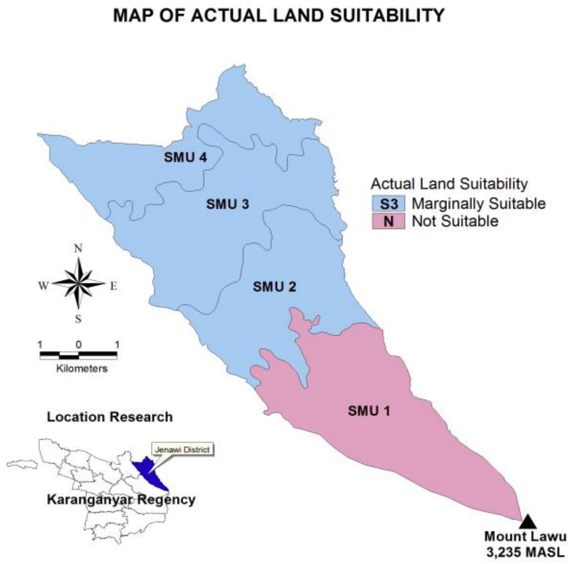

Figure 2. Map of Actual Land Suitability for Banana

Table 2. Actual Land Suitability of Banana

Land Characteristics	SMU 1		SMU 2		SMU 3		SMU 4	
	Value	Class	Value	Class	Value	Class	Value	Class
Temperature (tc)								
Average temperature (°C)	13.9	N	21.3	S3	22.7	S2	23.9	S2
Elevation (masl)	2056	N	837	S1	593	S1	399	S1
Water availability (wa)								
Rainfall (mm $year^{-1}$)	3750	S3	3750	S3	3250	S3	3000	S2
Dry Month	2.5	S1	2.5	S1	2.5	S1	2.5	S1
Oxygen availability (oa)								
Drainage	medium	S1	good	S1	good	S1	good	S2
Rooting depth characteristic (rc)								
Texture	quite fine	S2	quite fine	S2	medium	S2	quite fine	S2
Coarse material (%)	< 15	S1	< 15	S1	< 15	S1	< 15	S1
Soil effective depth (cm)	> 150	S1	50 - 100	S1	50 - 100	S1	> 150	S1
Nutrient retention (nr)								
CEC (me 100 g^{-1})	15.13	S2	12.85	S2	11.13	S2	8.58	S2
Base saturation (%)	29.62	S3	28.79	S3	42.62	S2	32.55	S1
pH H_2O	5.62	S1	5.66	S1	5.55	S2	5.62	S1
C-Organic (%)	3.49	S1	2.22	S1	1.99	S1	2.19	S1
Nutrient availability (na)								
N total (%)	0.56	S1	0.30	S1	0.28	S1	0.29	S1
P_2O_5 (mg 100 g^{-1})	2.61	S3	2.68	S3	3.22	S3	2.36	S3

Land Characteristics	SMU 1		SMU 2		SMU 3		SMU 4	
	Value	Class	Value	Class	Value	Class	Value	Class
K_2O (cmol kg^{-1})	72.8	S1	51.4	S1	80.6	S1	47.2	S1
Toxicity (xc)								
Salinity (dS m^{-1})	< 1	S1	< 1	S1	< 1	S1	< 1	S1
Solidity (xn)								
Alkalinity /ESP (%)	7.2	S2	5.62	S2	7.7	S2	7.4	S2
Erosion Hazard (eh)								
Slope (%)	15 - 25	S3	15 - 25	S3	25 - 35	S3	15 - 35	S3
Erosion hazard	high	S3	high	S3	high	S3	high	S3
Flood hazard/ inundation								
On planting period (fh)								
Height (cm)	< 25	S1	< 25	S1	< 25	S1	< 25	S1
Land preparation (lp)								
Surface rocks (%)	3 - 15	S1	3 - 15	S2	< 5	S1	< 5	S1
Rock outcrop (%)	< 5	S2	< 5	S1	< 5	S1	< 5	S1
Actual Land Suitability	N (tc1, tc2)		S3 (tc1, wa1, nr2, na2, eh1, eh2)		S3 (wa1, na2, eh1, eh2)		S3 (na2, eh1, eh2)	

Information: tc1 (temperature); tc2 (elevation); wa1 (rainfall); nr2 (base saturation); na2 (P_2O_5); eh1 (slope); eh2 (erosion hazard)

Land suitability class for banana at SMU 1 is not suitable with limiting factors, namely temperature and elevation. SMU 1 is located at 2,056 masl with average air temperatures 13.9 °C. Area with high elevation will have low temperatures. Banana growth is not optimal at low temperatures. Low air temperature can interfere with growth and affect crop production. Prayoga and Ismail (2020) state that the elevation of the land is affecting the ability of plants to adapt to the environment. Air temperature plays an important role in the growth of new leaves and fruit (Ravi and Vaganan, 2016). The emergence of new leaves stops at temperatures below 16 °C and banana growth stops at temperatures below 14 °C (Robinson and Saúco 2010). Banana growth is good at 25-30 °C, and will experience a slow maturation process at lower temperatures, even to the point of damaging plants if the temperature is below the freezing point (Rizal and Sasmita 2014).

SMU 2 has a marginal land suitability class (S3) with limiting factors such as temperature, rainfall, base saturation, P_2O_5 content, slope and erosion hazard. The temperature at SMU 2 is also too low for banana growth. Although not as low as in SMU 1, the low temperature will affect the process of fruit formation and ripening, so it will affect the quality of bananas. The climatic factor that is also a limiting factor is rainfall. Rainfall in Jenawi District is higher than the optimum requirement for bananas, which can interfere with their growth. High rainfall can have direct and indirect effects on growth and yield quality. The direct effect of rainfall on plants is that it can damage plants and can trigger the development of diseases. High rainfall accompanied by high humidity can cause the emergence of Black Sigatoka disease (*Mycosphaerella fijiensis*) which causes damage to banana leaves (Robinson and Saúco 2010). The low temperature at SMU 2 indicates the humidity is quite high, so with high rainfall, disease development can occur.

The indirect effect is that high rainfall can cause soil nutrient leaching and cause erosion. High rainfall can lead to the leaching of soil nutrients (Robinson and Saúco 2010). High rainfall also affects run-off and the rate of erosion (Sutapa 2010). SMU 2 has a slope of 15-25% which is categorized as rather steep. Steep slope with high rainfall (3250 mm $year^{-1}$) will increase erosion hazards and nutrient leaching in this area. Nutrient leaching which is quite intensive, may be one of the factors causing the low base saturation and availability of soil phosphorus. Base saturation symbolizes the availability of several essential nutrients such as Ca, Mg, K and Na. Low base saturation results in reduced nutrient availability and deficiency of phosphorus reduce nutrients for plant growth. In this area phosphorus content is low about 2.68 mg 100 g^{-1} which categorized as suitable marginal for banana growth, it might decrease metabolic processes on plant including cell division, cell expansion, plant respiration, and photosynthesis (da Silva *et al*. 2014).

Land suitability for Banana at SMU 3 and SMU 4 is classified as marginally suitable (S3) with limiting factors, including rainfall (only in SMU 3), P_2O_5 content, slope and erosion hazard.

Rainfall at SMU 3 also exceeds the requirement for bananas, thus affecting growth and fruit quality. Bananas grow well in flat topography, and be able to grow in the elevation of more than 500 masl with a normal temperatures 17-30 ^oC (Batubuaya *et al*. 2019). Steep slope causing high erosion potential. High erosion hazards will lead to banana production failure because the soil depth will become thinner and cannot support the plants properly. The steep slope is also an obstacle for farmers in land management. The research results of Nainggolan's (2018) show that the use of fertilizers for banana cultivation will be greater on steep slope, so that in addition to the danger of erosion during the rainy season, land on a steep slope (25-35%) will incur higher production costs in farming.

Several characteristics of the land in all SMU have met the needs of banana growth so that it is very suitable. Rooting depth characteristic in all observation points has very suitable conditions (S1) for banana growth. Although the land is on a steep slope, the soil depth is >150 cm. Depth soil condition is allow roots to develop properly (Patompo *et al*. 2018). All SMU do not have a flood hazard, so crop damage due to flooding can be avoided. Organic-C in all SMU is moderate, so it is sufficient for banana growth. In addition, soil fertility conditions including Total-N and K_2O content at all points are classified as very suitable (S1) so it can supply essential macronutrient needs for banana plant growth. Nitrogen nutrients play a role in stimulating plants during the vegetative phase so that it will affect the growth of banana plant height (Martono *et al*. 2017). The salinity condition of the soil did not inhibit the absorption of soil nutrients, nor causing toxicity for the growth of banana plants, classified as very suitable (S1). It shows that the soil fertility conditions in the research area have the potential to be used as banana development land.

Potential Land Suitability

Potential land suitability is based on estimated land conditions after land improvement is carried out. The formulation of recommendations for land management is compiled based on land characteristics which become the limiting factor for land suitability in Jenawi District. The potential land suitability after land improvement is unsuitable (N) at SMU 1, marginally suitable (S3) at SMU 2, and moderately suitable (S2) at SMU 3 and 4. Recommendations for land management are listed in Table 3. Map of potential land suitability for banana is shown in Figure 3.

SMU 1 has a limiting factor that is difficult to overcome because it is related to climatic factors. Air temperature at SMU 1 is directly affected by elevation. Higher elevation causes lower temperature. The temperature at SMU 1 may cause disruption of banana growth, starting from leaf formation, flowering, fruit formation and fruit ripening. Low temperatures affect almost all phases of plant growth. Improvement efforts are not able to be made, so the potential land suitability at SMU 1 is not suitable (N). Banana cultivation in SMU 1 is not recommended. Climatic conditions are difficult and require large capital to overcome. A high level of management is required to make climatic conditions suitable for crops (Mujiyo *et al*., 2017).

Rainfall at SMU 2 and SMU 3 exceeds the optimal requirement for bananas. High rainfall can increase the risk of nutrient loss due to leaching and increase the erosion hazard. Excess rainfall can also cause waterlogging which can inhibit oxygen supply to plant roots. The land management effort that can be done is the elaborate drainage structure. Elaborate drainage structures have to installed to disperse excess rainfall and prevent waterlogging (Robinson and Saúco, 2010). Another effort that can be done is to install biopori on the land, so that water can be stored in the soil. The application of biopores can absorb surface runoff, so that erosion and nutrients loss are reduced (Devianti *et al*., 2019). Improvement of the drainage structure along with the application of biopori can be used as a solution to overcome excess water due to high rainfall.

Base saturation in SMU 1 and SMU 2 is low. Nutrient leaching is one of the causes of low base saturation. Yao *et al*., (2021) stated that high rainfall intensity causes surface runoff and nutrient loss during rainy season on sloping agricultural land. Base saturation needs to be increased with the addition of dolomite. Dolomite contains several nutrients such as Ca and Mg which can increase base saturation. Application of dolomite as much as 1.4 ton ha^{-1} significantly increases base saturation (Syaputra *et al*., 2015). Another effort that can be done is the addition of ameliorants such as biochar. The addition of biochar can increase soil pH (Liu *et al*., 2017), so that base saturation also increases.

Table 3. Improvement Effort and Potential Land Suitability for each SMU

SMU	Inhibiting Factor	Improvement Effort	Potential Land Suitability
SMU 1	Temperature	-	Not suitable (N)
	Elevation	-	
SMU 2	Temperature	-	Marginally suitable (S3)
	Rainfall	Elaborate drainage structure	
	Base saturation	Liming; amelioration	
	P_2O_5 content	P fertilization (organic and inorganic)	
	Slope	Planting in line with contour; cover crop planting	
	Erosion hazard	Planting in line with contour; cover crop planting	
SMU 3	Rainfall	Elaborate drainage structure	Moderately suitable (S2)
	P_2O_5 content	P fertilization (organic and inorganic)	
	Slope	Planting in line with contour; cover crop planting	
	Erosion hazard	Planting in line with contour; cover crop planting	
SMU 4	P_2O_5 content	P fertilization (organic and inorganic)	Moderately suitable (S2)
	Slope	Planting in line with contour; cover crop planting	
	Erosion hazard	Planting in line with contour; cover crop planting	

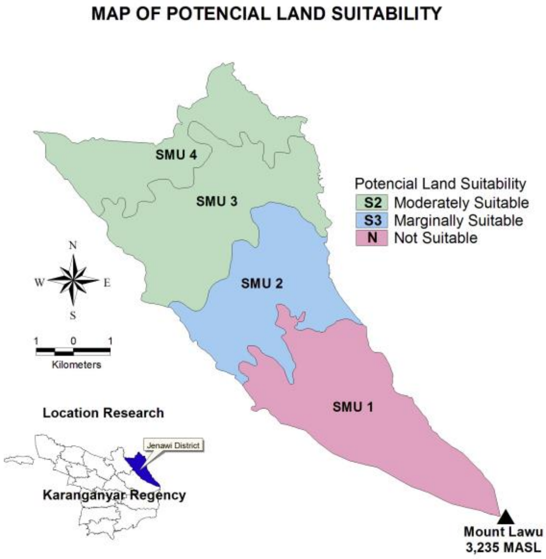

Figure 3. Map of Potential Land Suitability for Banana

SMU 1 to SMU 4 have a limiting factor of very low P_2O_5 content. The need for banana plants for macronutrients, especially NPK, reaches 10 kg of manure or in the range of 650 to 900 kg of NPK fertilizer per hectare in 1 year for growth and banana production (Rodinah *et al*., 2017). This shows that the soil in Jenawi District requires additional nutrients with proper fertilization. Fertilization can be done with organic or inorganic fertilizers. Tufaila *et al*. (2014) stated that giving chicken manure with a dose of 20-25 tons ha^{-1} can increase soil P_2O_5 from low to high levels. Inorganic P supply by TSP or ash positively effecting the uptake of P in soil, research of (Schiemenz & Eichler-Löbermann, 2010) showed the average of crops yields has increased by P supply.

SMU 2, SMU 3 and SMU 4 have limiting factors, namely the steep slope and high erosion hazard. Land management efforts that can be done are planting in line with contour and cover crop planting. Lenka *et al*. (2017) stated that planting in line with contour and cover crop planting can reduce erosion hazards in areas with steep slopes. Cover crop planting such as grass is effective in reducing soil loss due to erosion, especially in mountainous areas with steep slopes (Biddoccu *et al*., 2016).

CONCLUSION AND SUGGESTION

Bananas have sufficient potential to be developed in Jenawi District by implementing several land improvements. Banana plantation development can be carried out on land with sufficient potential land suitability, at SMU 3 and SMU 4. The location selection is based on land limiting factors that can still be resolved. Recommendations for land management that can be carried out are elaborate drainage structure, the addition of lime and ameliorant, P fertilization, planting in line with contour and cover crop planting. It is hoped that the development of bananas in Jenawi District can increase farmers' income as well as reduce the potential of erosion hazards.

REFERENCES

Abdelrahman, M. A. E., Natarajan, A., and Hegde, R., 2016. Assessment of land suitability and capability by integrating remote sensing and GIS for agriculture in Chamarajanagar district, Karnataka, India. *Egyptian Journal of Remote Sensing and Space Science*, 19(1): 125–141.

Balitbang Pertanian. 2007. *Prospek Dan Arah Pengembangan Agribisnis Pisang*. Badan Penelitian dan Pengembangan Pertanian, Departemen Pertanian, Jakarta.

Batubuaya, R., Kamagi, Y. E. B., & Joseph, B. R. V. (2019). Kajian Sifat Fisik Tanah untuk Tanaman Pisang Abaka (Musa textilis NEE) di Perkebunan PT. Viola Fiber Internasional Kabupaten Minahasa Tenggara. *E-Journal Unsrat*, *1*(2).

Biddoccu, M., Ferraris, S., Opsi, F., and Cavallo, E., 2016. Long-term monitoring of soil management effects on runoff and soil erosion in sloping vineyards in Alto Monferrato (North-West Italy). *Soil and Tillage Research*, 155: 176–189.

BPS Kabupaten Karanganyar, 2017. *Statistik Daerah Kecamatan Jenawi 2017*. Badan Pusat Statistik Kabupaten Karanganyar, Karanganyar.

da Silva, D. A., Esteves, J. A. de F., Messias, U., Teixeira, A., Gonçalves, J. G. R., Chiorato, A. F., and Carbonell, S. A. M., 2014. Efficiency in the use of phosphorus by common bean genotypes. *Scientia Agricola*, 71(3): 232–239.

Devianti, Jayanti, D. S., Mulia, I., & Sitorus, A. 2019. Model of surface runoff estimation on oil palm plantation with or without biopore infiltration hole using SCS-CN and ANN methods. In *IOP Conference Series: Earth and Environmental Science* (Vol. 365, No. 1, p. 012065). IOP Publishing

FAO. 1976. A framework for land evaluation. FAO Soils Bulletin No. 32. In *A framework for land evaluation*.

FAO. 2007. Land Evaluation Towards a Revised Framework. *Food and Agriculture Organization of the United Nations, Rome, Italy*.

FAO. 2014. FAO urges countries to step up action against destructive banana disease. *Food and Agriculture Organization of the United Nation*.

Herawati, A., Mujiyo, Widijanto, H., Isnaini, & Romdhati, F. 2018. Land conservation on banana cultivation based on erosion risks level at Jenawi District-Karanganyar, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *200* (1).

Lenka, N. K., Satapathy, K. K., Lal, R., Singh, R. K., Singh, N. A. K., Agrawal, P. K., Choudhury, P., and Rathore, A., 2017. Weed strip management for minimizing soil erosion and enhancing productivity in the sloping lands of north-eastern India. *Soil and Tillage Research*, 170: 104–113.

Liu, S., Meng, J., Jiang, L., Yang, X., Lan, Y., Cheng, X., and Chen, W., 2017. Rice husk biochar impacts soil phosphorous availability, phosphatase activities and bacterial community characteristics in three different soil types. *Applied Soil Ecology*, 116: 12–22.

Mardawilis, M., Sudira, P., Sunarminto, B., and Shiddiq, D., 2011. Analisis Neraca Air Untuk Pengembangan Tanaman Pangan Pada Kondisi Iklim Yang Berbeda. *Agritech: Jurnal Fakultas Teknologi Pertanian UGM*, 31(2): 109–115.

Martono, T., Purwati, & Arsensi, I. 2017. Pengaruh Pemberian Pupuk NPK Phoska dan Pupuk Organik Cair terhadap Pertumbuhan dan Produksi Tanaman Pisang Rutai (Musa sp). *Agrifarm*, *6*(2).

Mujiyo, M., Widijanto, H., Herawati, A., Rochman, F., and Rafirman, R., 2017. Potensi Lahan Untuk Budidaya Pisang Di Kecamatan Jenawi Karanganyar. *Caraka Tani: Journal of Sustainable Agriculture*, 32(2): 142.

Mujiyo, Sutarno, Suwarto, Budiono, R., and Sutopo, N. R., 2020. Inhibiting Factors of Land Suitability for Piper nigrum L . In a Hilly Area of Tirtomoyo District , Central Java. *J Trop Soils*, 25(1): 29–37.

Nainggolan, L. P., 2018. Pengaruh Kemiringan Lahan Garapan terhadap Curahan Tenaga Kerja dan Penggunaan Pupuk pada Petani Pisang yang Bertumpangsarikan Jagung – Jahe. *Jurnal Ilmiah Skylandsea*, 2(1): 27–30.

Nuarsa, I. W., Dibia, I. N., Wikantika, K., Suwardhi, D., and Rai, I. N., 2018. GIS based analysis of agroclimate land suitability for Banana plants in Bali Province, Indonesia. *HAYATI Journal of Biosciences*, 25(1): 11–17.

Pan, G., & Pan, J. (2011, October). Research in crop land suitability analysis based on GIS. In *International Conference on Computer and Computing Technologies in Agriculture* 365: 314-325. Springer, Berlin, Heidelberg.

Patompo, P. D., Mawara, J. M., & Joseph, B. R. V. 2018. Potensi Lahan Tanaman Pisang Abaka (Musa textilis NEE) di PT. Viola Fiber International Desa Silian Kabupaten Minahasa Tenggara. *E-Journal Unsrat*, *1*(1).

Pham, T. G., Degener, J., & Kappas, M. 2018. Integrated universal soil loss equation (USLE) and Geographical Information System (GIS) for soil erosion estimation in A Sap basin: Central Vietnam. *International Soil and Water Conservation Research*, *6* (2), 99-110.

Prayoga, M. K., and Ismail, A., 2020. Keragaman Hayati Agroekosistem Pisang (Musa sp.) di Jawa Barat. *Composite: Jurnal Ilmu Pertanian*, 2(02): 42–55.

Prihati, R. N., 2013. Analisis Potensi Wilayah Kecamatan Berbasis Komoditas Pertanian Dalam Pembangunan Daerah Di Kabupaten Karanganyar (Pendekatan Location Quotient dan Shift Share Analysis). Program Studi Agribisnis, Fakultas Pertanian, Universitas Sebelas Maret, Surakarta (Skripsi).

Pusdatin (Pusat Data dan Pertanian), 2016. *Outlook Komoditas Pisang*. Pusat Data dan Sistem Informasi Pertanian Kementerian Pertanian, Jakarta.

Pusponegoro, I. H., Mujiyo, Suntoro, Herawati, A., & Widijanto, H. 2018. Planning of banana plant development based on the land conservation aspect in Jenawi District. *Journal of Degraded and Mining Lands Management*, Vol *5*(4).

Rahmawaty, R., Siregar, N. C., and Rauf, A., 2016. Kesesuaian Lahan Tanaman Jati; ”Studi Kasus Di Arboretum Kwala Bekala, Universitas Sumatera Utara”. *Jurnal Penelitian Ekosistem Dipterokarpa*, 2(2): 73–82.

Ravi, I., and Vaganan M. M., 2016. Abiotic Stress Tolerance In Banana. In Abiotic Stress Physiology of Horticultural Crops. *Springer, New Delhi*.

Rizal, M., and Sasmita, S., 2014. *Assessment of Fertilization Technology toward Vegetative Growth of Banana Plant in East Kalimantan*. Prosiding Seminar Nasional Hari Pangan Nasional ke-34: Pertanian-Bioindustri Berbasis Pangan Lokal Potensial, 119–128.

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. In *Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian, Badan Penelitian dan Pengembangan Pertanian*.

Rodinah, Razie, F., Nisa, C., and Hardarani, N., 2017. The Growth Performance of Micropropagated Talas Banana (Musa paradisiaca Var. Sapientum L) Seedlings Cultivated On Peatlands. *Journal of Wetlands Environmental Management*, 5(1): 1-9.

Robinson, J. C., & Galán Saúco, V. (2010). *Bananas and Plantains: Second Edition*. CAB International, Wallingford, UK.

Sasmita, M. R. S. (n.d.). *TANAMAN PISANG DI KALIMANTAN TIMUR Assessment of Fertilization Technology toward Vegetative Growth of Banana Plant in East Kalimantan*. 119–128.

Schiemenz, K., & Eichler-Löbermann, B. 2010. Biomass ashes and their phosphorus fertilizing effect on different crops. *Nutrient Cycling in Agroecosystems*, *87*(3), 471–482.

Sutapa, I. W., 2010. Analisis Potensi Erosi pada Daerah Aliran Sungai (DAS) di Sulawesi Tengah. *SMARTek*, 8(3): 169-181.

Syaputra, D., Alibasyah, M. R., and Arabia, T., 2015. Pengaruh Kompos dan Dolomit Terhadap Beberapa Sifat Kimia Ultisol dan Hasil Kedelai (Glycine max l. Merril) pada Lahan Berteras. *Jurnal Manajemen Sumberdaya Lahan*, 4(1): 535–542.

Tufaila, M., Laksana, D. D., and Alam, S. 2014. Aplikasi kompos kotoran ayam untuk meningkatkan hasil tanaman mentimun (Cucumis sativus L.) di tanah masam. *Agroteknos*, 4(2): 120–127.

Ulfa, H., Ningsih M. S., and Mustika, M. 2014. Memanfaatkan data fisika dan kimia tanah untuk menilai kesesuaian lahan tanaman pepaya dipolitani. *Jurnal Nasional Ecopedon*, *2*(2), 41–44.

Yao, Y., Dai, Q., Gao, R., Gan, Y., & Yi, X. 2021. Effects of rainfall intensity on runoff and nutrient loss of gently sloping farmland in a karst area of SW China. *Plos one*, *16*(3), e0246505.