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Research Article

Planning of banana plant development based on the land conservation aspect in Jenawi District

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Abstract : Banana is one type of fruits that is very potential to grow to support food security because it contains source of vitamins, minerals, and carbohydrates. Jenawi District has a dry land area that is potential for the development of banana plants. The purpose of this research was to plan the development of banana plants in accordance with the land conservation aspect against the threat of the erosion. The research was conducted by making land unit map, field survey, analysis of soil sample in the laboratory, and data analysis of erosion hazard level. Land unit mapping was made by overlay method so there were 12 units of land with the same land conditions. Field survey and sample analysis at the observation point was conducted to obtain the parameters: slope gradient, depth of solum, surface unity, slope length, bulk density, soil texture, soil C-organic, and soil permeability. The analysis of land conservation aspects for banana plants was determined from the level of erosion hazard with the USLE (Universal Soil Loss Equation) method. The results showed that the threat of moderate to severe erosion hazard for banana crops was overcome by the efforts of land conservation techniques using a good construction bench terrace. The threat of erosion hazard after land conservation directives is very low to low. The amount of the erosion prediction for banana plant planning in garden is 35.80 t/ha/yr (unit B unit), land use of dry fields is 29.82 t/ha/yr (land unit I), 31.54 t/ha/yr (land unit K), and 13.72 t/ha/yr (unit land L).

Keywords: *banana, method of USLE soil erosion, soil conservation*

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Introduction

Agricultural commodities in Jenawi have a fast growing with 47 commodities (Priharti et al., 2013), one of which is banana plant. The area of Jenawi is about 5,608.28 ha with the use of paddy field 524.14 ha and dry land 5,084.14 ha. The use of dry land is for yard and building 765.00 ha, dry field/garden 1,991.00 ha, state forest 1,600.67 ha, grassland 11.00 ha and plantation 611.00 ha. Jenawi has the dominant dry land area so it is potential for the development of banana plants.

Planning for the development of banana plants aims to meet the needs of fruit consumption in line with the increasing number of residents and public awareness of the importance of banana nutrients containing sources of vitamins, minerals, and carbohydrates (Ambarita et al., 2015). Banana plants are quite tolerant to altitude and drought. In conditions of water shortage, banana plants are still growing because the water is still being supplied from aqueous stems though it has very little production. Land use for the growth of banana plants should see to some various aspects, one of which is the land conservation aspect to the threat of soil erosion hazard (Ritung et al., 2011). Land degradation due to soil erosion can lead to decrease soil fertility, top soil removal, reduce soil thickness resulting in reducing land productivity, and land use ability (Saragih et al., 2014). Factors affecting erosion include: rainfall intensity, slope inclination, and vegetation of land cover (Rahim,

2003). Improper land management will accelerate the land degradation due to the erosion and high intensity surface flow (Sutrisno and Heryani, 2013). Proper land use is a major step in good cultivation of plants and soil conservation programs (Sulastri et al., 2015). Land conservation is an effort to manage the land by improving, maintaining and increasing land use in accordance to its function. Soil conservation methods can be done either mechanically or vegetatively. Mechanical conservation techniques are physically treatments to the soil such as manufacture of terraces to reduce the surface flow and erosion and to increase the ability of the soil to absorb the water. Vegetative conservation techniques are the use of plants or plant remnants as soil protector media from erosion, inhibiting water runoff, and improving soil properties (Subagyono et al., 2003).

Some of the reasons above become the basis for consideration for research to plan the development of banana plants based on aspects of land conservation in Jenawi District.

Materials and Methods

Study area

The research was conducted at Jenawi, Karanganyar which is geographically located at coordinates 111°4'54,063–111°11'40,01 BT and 7°37'14,103–7°31'39,311 LS. Jenawi is located on the western slopes of Mount Lawu with the topography of hilly to mountainous areas and is formed predominantly from 3 volcanic geological formations namely Qvl, Qlla, and Qvjb.

Methodology

This research was an explorative research with a survey approach supported by the analysis of soil samples by doing direct observation in the field and analysis in the laboratory. The instruments used in this research were ground drill, GPS, compass, clinometer, roller meter, meter, hoe, dagger, plastic, sample ring, marker, and laboratory analysis equipment. Geographical information processing equipment (GIS) used were ArcView 3.3 software (ESRI, 2000; Prahasta, 2004). The materials used soil samples, RBI map scale 1: 25.000 (Bakosurtanal, 2010), thematic maps (soil type, slope, rainfall, and land use) Jenawi Sub district (Puslittanak, 1994).

Map of land units in Jenawi were grouped into 12 units of lands having similar land conditions based on overlay results. The number of samples per unit of land was repeated four times. Data collections observed directly from the survey activity conditions in the field included: slope gradient, depth of solum, surface unity, and slope length. Analysis of soil samples in the laboratory was done to obtain the parameters: of bulk density, soil texture, soil C-organic, and soil permeability.

Data analysis in the determination of land conservation efforts was done by knowing of the level of erosion hazard. The first step was to determine the class of erosion hazard level to calculate the prediction of soil erosion using USLE (Universal Soil Loss Equation) method (Asdak, 1985). The USLE method is a method of erosion estimation developed by Wischmeier and Smith (1978), it is used to predict erosion in a place or land. The approach with USLE helps land management, identifies problems, and implements best management practices (Lufafa et al, 2003). The prediction of erosion obtained from the USLE equation is A = R. K. LS. C. P.

The second step was class determination of soil erosion hazard level that is related to the depth of soil solum. At the same soil erosion value, the deeper the soil solum the lower the erosion hazard, and the shallower soil solum the higher the erosion hazard.

Table 1. Level of erosion hazards

Level	Erosion Hazard (t/ha/year)
I	< 15
II	15-60
III	60-180
IV	180-480
V	> 480

Source: Regulation of Forestry Minister No 32, 2009

Table 2. Class of erosion hazard level

Soil depth (cm)	Erosion hazardous levels				
	I	II	III	IV	V
> 90	SR	R	S	B	SB
60-90	R	S	B	SB	SB
30-60	S	B	SB	SB	SB
< 30	B	SB	SB	SB	SB

Note : SR (very low), R (low), S (medium), B (high), SB (very high).
Source: Regulation of Forestry Minister No 32, 2009

Field verification results and observations in the laboratory were processed and analyzed to determine the level of soil erosion hazard. The method used was the matching method of erosion hazard class and the level of erosion hazard. Method of matching is by comparing actual verified soil erosion data with grade value of erosion hazard, then comparing the grade value of

erosion hazard to solum depth. So, with this way, the class of erosion hazard level will be obtained. Map arrangement was made from the data of hazard level of soil erosion used ArcView 3.3 software. This is the way of the map of location information and the extent of erosion hazard in Jenawi is obtained.

Results and Discussion

The units of land in Jenawi

Soil sampling refers to map of land units is obtained by overlaying thematic maps (soil types, slope, rainfall, and land use). Land unit map making is a description and grouping of land based on soil type uniformity, slope, rainfall and land use. The land unit is designed to describe the properties of the soil according to the planned activities in the area under observation. The numbers of land units are 12 by adjusting to the purpose and scale of activities. This unit of land is the unit of analysis as the basis for the determination of site sampling which then conducted field observation, soil sampling and analysis in the laboratory.

The level of hazard erosion

Banana plants can grow optimally in areas an average air temperature of 25 – 27 ^{0}C, humidity > 60%, altitude < 1.200 m above sea level (asl), rainfall 1,500 – 2,500 mm/year and long dry months (rainfall < 60 mm/month) 0 - 3 months (Ritung et al., 2013).

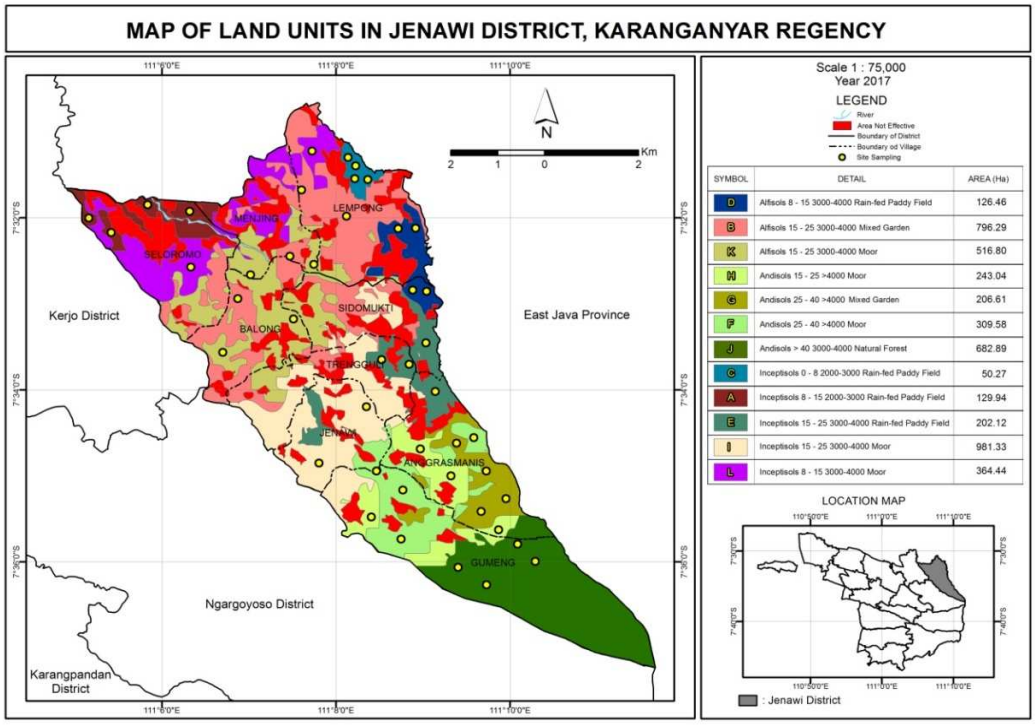

Figure 1. Map of land units in Jenawi District

According to Mujiyo et al (2017), land in the central-upper (eastern) Jenawi is unsuitable for banana crops because it is an area with an average height of 2.056 m asl, low temperatures averaging 13.8 °C and high rainfall average 4,000 mm/year. Temperatures that are too cold and not good for the growth of bananas, whereas if too hot, it will have an impact on the dryness of the leaves and fruits. The success of banana cultivation is not only determined by soil fertility and banana cultivation techniques, but also the climate which greatly affects the growth of banana plants (Salau et al., 2016). Banana plants can still survive at a daily temperature of 20-30^{o}C and weekly rainfall of 50 - 70 mm (Israeli and Lahav, 2017). Determining aspect of land conservation directives is seen from the results of erosion hazard rates calculated using the USLE (Universal Soil Loss Equation) method. It is used to estimate the magnitude of erosion for different land use conditions and different climatic conditions. The value of erosion prediction (A) is presented in Table 3.

Table 3. Large erosion of USLE prediction in Jenawi

Land Unit	Land Use	R	K	LS	C	P	Erosion Prediction (A) (t/ha/year)	Depth of Solum (m)	Class of Erosion Hazards
A	Rice fields	2,800.20	0.27	1.28	0.01	0.15	1.45	73.75	Low
B	Garden	2,800.20	0.25	3.23	0.31	0.15	104.04	92.00	Medium
C	Rice fields	2,800.20	0.26	0.37	0.01	0.04	0.11	80.75	Low
D	Rice fields	2,800.20	0.41	2.21	0.01	0.15	3.80	84.25	Low
E	Rice fields	2,800.20	0.36	4.52	0.01	0.40	18.26	85.25	Medium
F	Dry fields	2,800.20	0.28	10.73	0.35	0.40	1,185.08	102.75	Very High
G	Garden	2,800.20	0.20	15.01	0.46	0.40	1,512.02	111.75	Very High
H	Dry fields	2,800.20	0.18	4.71	0.20	1.00	467.23	133.25	High
I	Dry fields	2,800.20	0.30	4.43	0.20	0.60	447.25	91.50	High
J	Forest	2,800.20	0.40	35.90	0.005	1.00	201.47	115.75	High
K	Dry fields	2,800.20	0.34	2.05	0.50	0.15	147.82	91.25	Medium
L	Dry fields	2,800.20	0.20	1.54	0.20	1.00	171.50	92.50	Medium

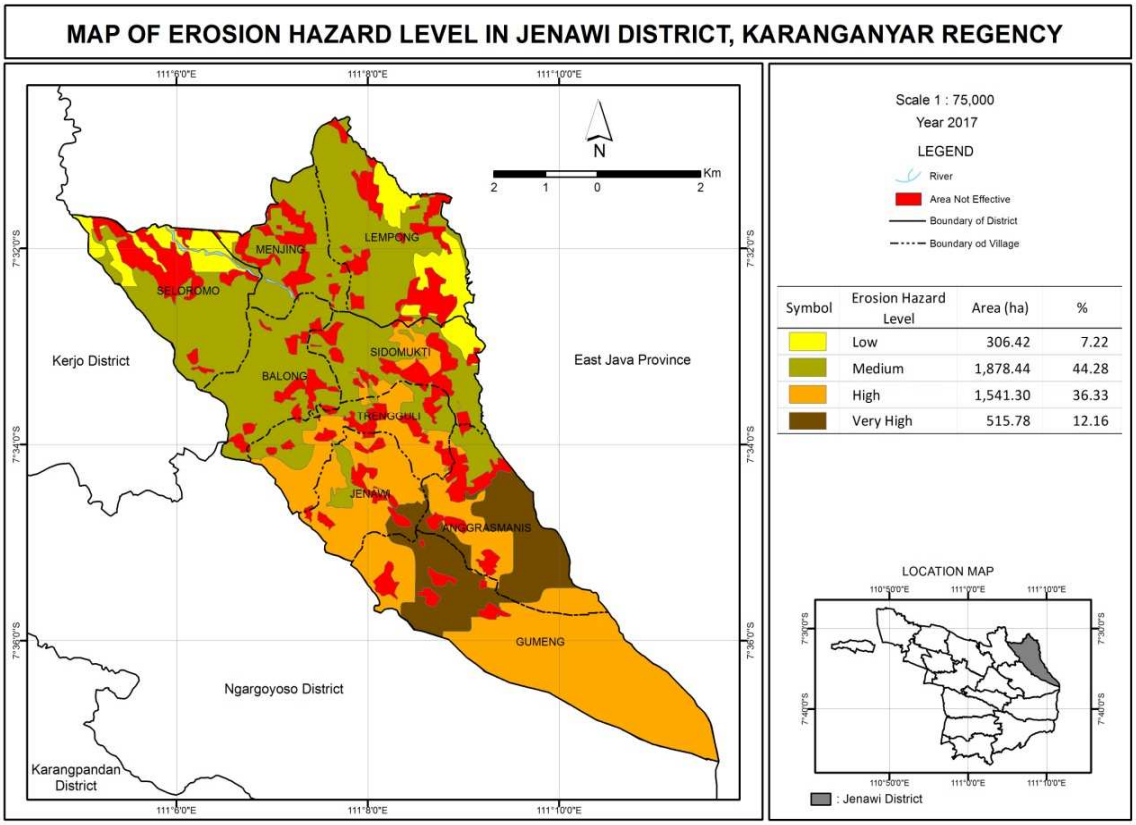

Figure 2. Map of erosion hazard level in Jenawi District

High to very high level of erosion hazards are associated with factors of slope or deforested land, grassland or bush land cover (Ali and Hagos, 2016). Soil erosion and loss of soil organic is affected by climate (rainfall), topography (slope inclination), soil characteristics (soil test and organic matter), and human activity in cultivating agricultural land (Mey et al., 2015). Prediction of erosion hazard in Jenawi is very high in F and G land units caused by dominant factors such as steep slope magnitude and land conservation techniques such as poor construction bench terraces. The severity of soil erosion depends on the terraces of the bench structures and soil cover conditions (Sang-Arun et al., 2006). Degraded land cover should receive effective conservation attention and priority by planting trees to keep the soil covered by roots.

Table 4. Planning of management crop and land conservation directives

Land Unit	Land Use	Existing Conditions		Land Conservation Directives		Prediction of Erosion before Planning (t/ha/yr)	Prediction of Erosion after Planning (t/ha/yr)
		C	P	C	P		
A	Rice fields	Irrigated rice	Ridge terrace	Irrigated rice	Ridge terrace	1.45 (low)	1.45 (low)
B	Garden	Grass, banana, sengon	Bench terrace, average	Banana	Bench terrace, good	104.04 (medium)	35.80 (low)
C	Rice fields	Irrigated rice	Bench terrace, good	Irrigated rice	Bench terrace, good	0.11 (low)	0.11 (low)
D	Rice fields	Irrigated rice	Bench terrace, average	Irrigated rice	Bench terrace, good	3.80 (low)	1.01 (low)
E	Rice fields	Irrigated rice	Bench terrace, poor	Irrigated rice	Bench terrace, average	18.26 (medium)	6.85 (low)
F	Dry fields	Tea, guava, grass	Bench terrace, poor	Tea, guava, grass	Bench terrace, average	1185.08 (very high)	444.40 (high)
G	Garden	Teak, coconut, grass	Bench terrace, poor	Teak, coconut, grass	Bench terrace, average	1512.02 (very high)	567.01 (very high)
H	Dry fields	Cassava, sengon, cocoa, coconut	Without soil conservation	Cassava, sengon, cocoa, coconut	Traditional terrace	467.23 (high)	163.53 (medium)
I	Dry fields	Coconut, sengon, grass	Contour cropping	Mix garden + Banana	Bench terrace, good	447.25 (high)	29.82 (low)
J	Forest	Undisturbed forest, sparse litter	Without soil conservation	Undisturbed forest, sparse litter	Traditional terrace	201.47 (high)	70.51 (medium)
K	Dry fields	Teak, rubber, coconut, cassava	Bench terrace, average	Banana	Bench terrace, good	147.82(medium)	31.54 (low)
L	Dry fields	Cassava, teak, grass	Without soil conservation	Banana	Bench terrace, good	171.50 (medium)	13.72 (very low)

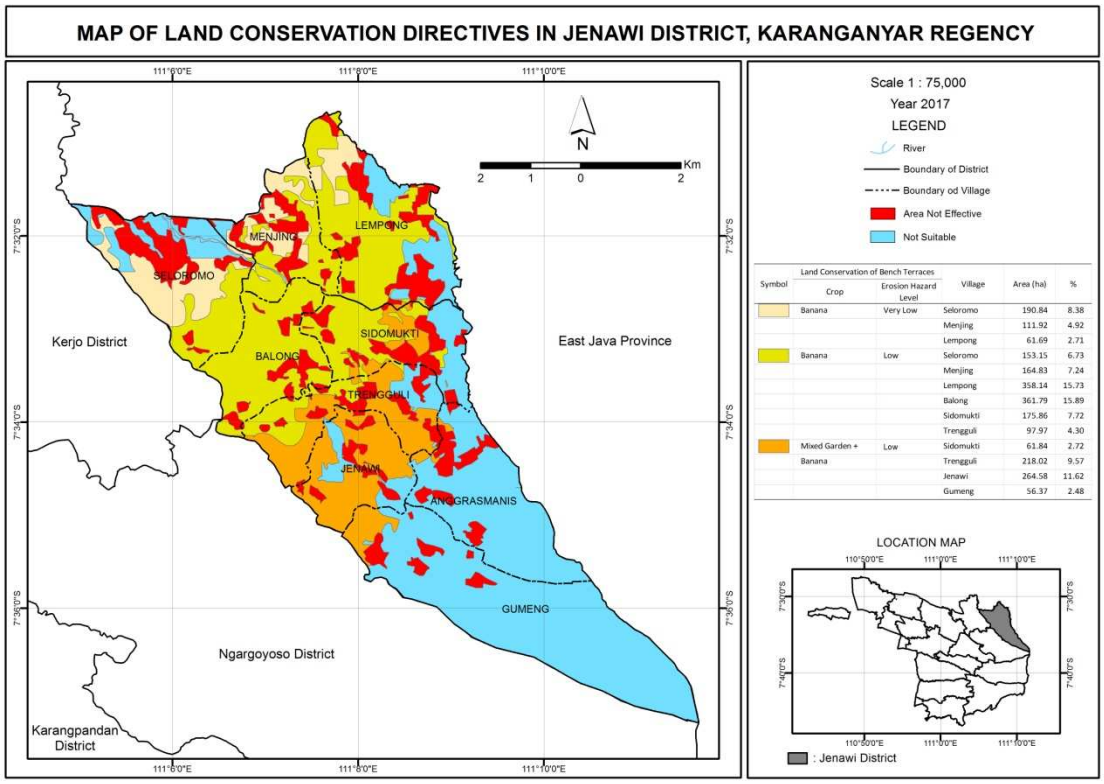

Figure 3. Map of land conservation directives in Jenawi District

The land conservation directives

Land conservation is done with the aim of minimizing erosion so the land productivity will increase (Meylina et al., 2015). The land conservation directives in the various categories of erosion hazard in Jenawi covers the level of erosion hazard is low to very high. Soil conservation can mechanically help to minimize erosion by overcoming the adverse impact of slope and large slope length (Sutrisno et al., 2013). In erosion management, to reduce the C factor, the land use should use with plants that have wide leaves (Pham et al., 2018). Direction of land conservation in Jenawi presented in table as follows: The use of wetland on units A, C, D, and E is not used in planning the development of banana crops. In units F and G are not suitable for banana plants because they have very high erosion hazards. The most powerful factors affects very high erosion threats are rainfall, slope, and land conservation measures. Climate change is shown to affect soil erosion that is able to change the amount of energy available in rainfall to be released and then bring sedimentation (Maeda et al., 2010).

Units of H and J are unsuitable for banana crops because they are at an average altitude > 2,000 m asl, air temperature 14^{o}C, and rainfall > 4,000 mm/year. The most dominant factor in the threat of severe erosion is high rainfall and no land conservation measures. If there is no erosion control solution such as without any conservation action, the P value must be 1.0 as it is considered an uncertain value (Morgan and Nearing, 2011). Management of land conservation techniques can be implemented to minimize the potential for land damage, especially those caused by rainfall (Herawati et al., 2017).

Units of B, I, K, and L are suitable for banana crops because they are located in lower areas with an average elevation of 610 m asl, air temperature 22.6^{o}C, and rainfall 3,000-4,000 mm/year, and are subject to erosion hazard, medium to high. Plant management at Jenawi with single banana cultivation can be developed in Seloromo (343.99 ha), Menjing (276.75 ha), Lempong (419.83 ha), Balong (361.79 ha), Sidomukti (175.86 ha), and Trengguli (97.97 ha). In mixed plantation with intercropping crop, the banana plant can be developed in Sidomukti (61.84 ha), Trengguli (218.02 ha), Jenawi (264.58 ha), and Gumeng (56.37 ha). According to Forestry Minister No.32 Year 2009, the crop management index for single crop of banana with value of C is 0.4 and intercropping crop of banana plant with value of C is 0.2. The conservation directives on the B, I, K and L units are

recommended with conservation techniques of good construction bench terrace, so the amount of erosion prediction is reduced. The magnitude of the prediction of erosion after the land conservation directive for banana plant planning in garden is 35.80 t/ha/yr (B), the land use of dry fields is 29.82 t/ha/yr (I), 31.54 t/ha/yr (K), and 13.72 t/ha/yr (L). The establishment of bench terraces and afforestation systems is used as a technique to restore degraded dry land through runoff and tree planting (Stavi et al., 2015). On the edge of the terrace needs to be reinforced with rocks which can be planted with core reinforcement plants such as grass or lamtoro plants, and can be planted also with horticultural crops such as srikaya, pineapple and banana (Atmojo, 2008).

The precision of the terracing model toward the effects of terrestrial degradation can still be enlarged or influenced by factors such as land and crop ownership (Schönbrodt-Stitt et al., 2013), so the land conservation management practices should consider biophysical, social-economic and institutional aspects (Basuki et al., 2016). Land conservation techniques have shown to reduce topographic differences and sedimentary connectivity so shortly it will also reduce soil erosion and sediment delivery (Haiyan and Liying, 2017). In addition to the efforts of land conservation techniques, it can also be done through reforestation with cropping patterns, grass planting on the soil surface, and drainage improvements so that the stability of the slope is maintained. Methods for reducing soil erosion include protecting top soil, reducing soil treatment, especially using machinery, adding organic or mulch ingredients, crop rotation, and making terracing (Porazinska and Wall, 2013).

Conclusion

Development planning for banana crops can be done on the use of garden land (unit B) and dry fields area (units I, K, and L). The land has a threat of medium to high erosion hazard so it needs to be overcome with the efforts of land conservation techniques. Plant management in Jenawi with single banana cultivation can be developed in Seloromo (343.99 ha), Menjing (276.75 ha), Lempong (419.83 ha), Balong (361.79 ha), Sidomukti (175.86 ha), and Trengguli (97.97 ha). In mixed garden with intercropping banana plants, it can be developed in Sidomukti (61.84 ha), Trengguli (218.02 ha), Jenawi (264.58 ha), and Gumeng (56.37 ha). The suggested land conservation directives are land conservation techniques using good construction bench terraces. The threat of erosion hazard after the direction of land conservation is very low to low. The amount of erosion prediction using good construction bench terrace for banana plant planning is 35.80 t/ha/yr (B), land use is 29.82 t/ha/yr (land unit I), 31.54 t/ha/yr (unit of K land), and 13.72 t/ha/yr (L). On the edge of the terrace, it can be reinforced with rocks and planted with core reinforcement plants such as grass or lamtoro.

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