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DEVELOPMENT OF SUSTAINABLE PALM OIL FARMING IN THE KRUENG KEREUTO WATERSHED

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ABSTRACT

This research was conducted in the Krueng Kereuto watershedfrom October - November 2022. The objectives of this study were: to assess the suitability of land for oil palm plantations, to examine the effect of oil palm-based farming types on erosion and to analyze agrotechnology. The observation locations are on land map units 1, 3, 4, 5, 20, 21, 24, 25, 26, 27 and 28. The research method used in this research is a survey method which consists of four stages, namely: 1) the preparation stage 2) preliminary survey stage, 3) main survey stage and 4) data analysis and results presentation stage.The results showed that the assessment of land suitability for oil palm plantations in the Krueng Keureto watershed consisted of a moderately suitable class (S2) and a marginal suitable class (S3), with the limiting factor for oxygen availability (oa), namely obstructed drainage, nutrient retention limiting factor (nr) namely base saturation, pH and C-organic and the limiting factor for erosion hazard (eh) is the slope.The results of the erosion calculation show that the highest erosion prediction value occurs in the use of mixed gardens and shrubs.The predictive value of erosion on scrub land use (SST 3, 4, 5) ranged from 11.82 - 192.04 tonnes ha-1yr-1. This value is still far above the tolerable erosion value (ETol), which is 21.50 - 24.96 tons ha-1 year-1. Erosion prediction on mixed garden land use (SST 1, 20 and 21) ranges from 27.50 - 365.38 ton ha-1 year-1, this prediction value is still above the ETol value, namely 15.50 – 20.40 tons ha-1 year-1.

Keywords***: Krueng Kereuto Watershed, Erosion, Agrotechnology.***

1. INTRODUCTION

The floods that hit North Aceh district in recent years have had implications for a decline in economic growth in various sectors, especially in the agricultural sector. The floods that occurred in early 2022 inundated 18 of the 27 sub-districts in North Aceh district and it is estimated that the losses incurred due to these floods reached hundreds of billions. Forests have an important role in conserving watersheds, where there is less and less forest, various problems arise in watershed management, this is because forests have the following properties: to dampen high river discharges during the rainy season, forests have thick litter so that it makes it easier for water to seep into the ground and drain it freely slowly down the river. Forests also have many macro pores in the soil that allow rapid movement of water into the soil. Because of the beneficial role of forests, forests need to be maintained. If the forest has already been cleared (especially in parts of the watershed that are sensitive to erosion), it is necessary to try to use the land so that it is close to the shape of the forest (Agus, 2004). The intensity of land use change in the Krueng Kereuto watershed is currently increasing, this is due to development activities and the rate of population growth which continues to increase every year. Increasing changes in land use will have a negative effect on the hydrological conditions of a watershed(Grand *et al., 2015).*

According to Kartodihardjo et al. (2004) land use in a watershed generally pays little attention to the interrelationships of the constituent elements of the watershed system, even though

the environmental carrying capacity of a watershed is determined by many factors which have complex relationships and interrelationships and this is one of the causes of watershed damage in Indonesia. The Krueng Kereuto River Basin with an area of 103,199 ha, consists of the Krueng Kereuto Sub-watershed, the Krueng Pirak Sub-watershed, the Krueng Peuto Sub-watershed and the Alue Geudebang Sub-watershed(BPDAS Krueng Aceh, 2020). The Krueng Kereuto watershed is one of the watersheds in North Aceh with high cases of forest conversion, one of which is agricultural land, one of which is done by the community for cultivating oil palm plants. North Aceh District, especially in the Krueng Kereuto Watershed, has great potential in the plantation sector, this is because oil palm is a superior commodity with an area of 15,789 hectares of palm oil with a production of 166,752 tonnes and this can be seenwith the existence of one of PTPN-I's oil palm plantations covering an area of 7506 hectares and a people's plantation managed by one of the Mandiri Prosperous Plantation Cooperatives covering an area of 1987.6 hectares. This smallholder plantation is one of the smallholder plantations in Aceh province whose land clearing fund is funded by the Oil Palm Plantation Fund Management Agency (BPDPKS). For this reason, research is needed on the development of sustainable oil palm farming in the Krueng Kereuto watershed. The sustainable indicators used in this study refer to the indicators put forward by Sinukaban (2007), namely a decent income for each farmer, the applied agrotechnology does not cause damage to land resources (erosion), and is acceptable and developed (replicable) by farmers with local knowledge and resources owned by farmers.

1.1. Research Objectives

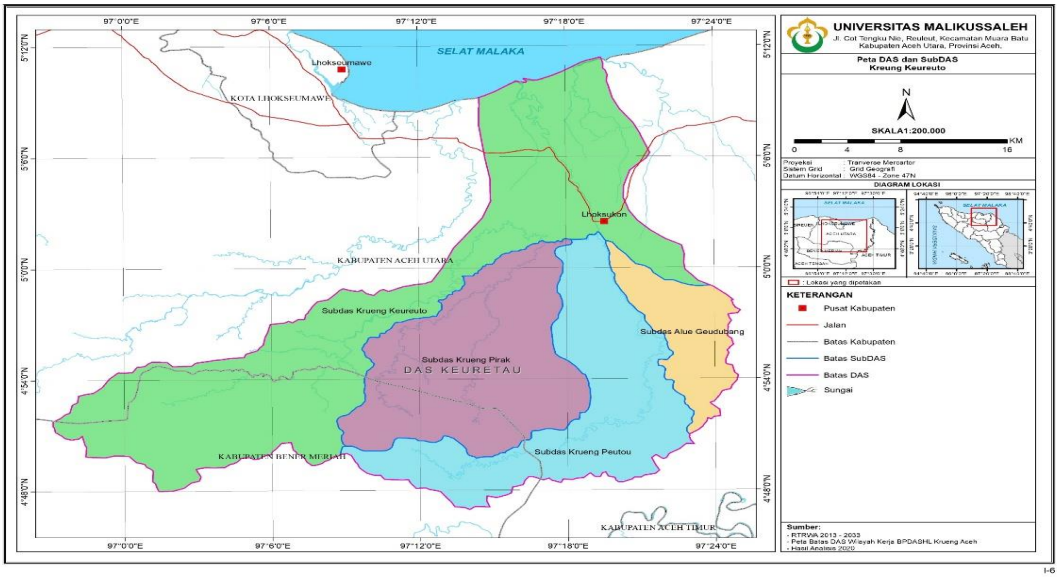
The aim of this studyassess the level of land suitability for oil palm plantations,examines the effect of oil palm-based farming types on erosion and agrotechnology analysis.

2. RESEARCH METHODS

2.1.Tempchat and Time

This research was carried out in the Krueng Kereuto watershed which crosses two districts, namely Bener Meriah district and North Aceh district. The research location is 40 km from the city of Lhokseumae while the outlet of the three Krueng Keureto sub-watersheds is directly to the district capital of North Aceh. (Figure 1). Field research lasted for 2 months, from October - November 2022.

Figure 1. 2.2. Research Location (Krueng Kereuto Watershed)



Tools and materials

The tools used in this study consisted of sample rings, abney levels, GPS (Global Positioning System), soil drills, hoes, scopes, water passes, stationery, computer sets and Arc GIS 9.3 software. The materials needed in this study are chemicals used for soil analysis in the laboratory.

Research methods

The research method used in this study is a survey method which consists of: 1) preparation stage, 2) preliminary survey stage, 3) main survey stage and 4) data analysis stage and results presentation.

2.3.Data Collection Techniques

Land Soil data used in this study were obtained from field observations and soil analysis results in the laboratory that represent each land map unit. The soil samples taken consisted of intact soil samples for analysis of soil physical properties (permeability, bulk density) and non-intact soil samples for analysis of chemical properties (C-organic, pH, CEC, KB, N, P and K) and texture. land.

Data analysis

Data analysis included analysis of biophysical data (physical and chemical properties of soil, land characteristics and climate) for analysis of evaluation of oil palm land and assessment of erosion prediction.

2.4.Analysis of Land Characteristics

Analysis of land characteristics was analyzed descriptively including biophysical data and continued with an assessment of land suitability classes. Class assessmentLand suitability for oil palm plantations is based on a classification frameworkissued by FAO (1976), namely by assessing or comparing the quality of the land in each unit of land map with the land suitability criteria for oil palm plantations compiled by Djaenudin et al., (2003)

Erosion

Erosion measurements were carried out for each land map unit and type of farming using the Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1978 in Arsyad, 2012). This data is used to plan the appropriate type of oil palm-based farming and agrotechnology for each land map unit in the Krueng Kereuto Watershed.

The USLE equation used to calculate erosion predictions is as follows:

$$\mathbf{A = RKLSCP}$$

where: A = amount of eroded soil (ton ha^{-1}year-1); R = index factor (erosivity) of rain; K = soil erodibility factor; L = slope length factor; S = slope steepness factor; C = soil cover vegetation factor and plant management; P = soil conservation factor

Tolerable erosion (ETol)

Tolerable erosion (ETol) is the value of the tolerance limit of erosion that occurs and is calculated by the Wood and Dent equation (1983).

$$\text{ETol} = \frac{DE - D_{\min}}{UGT} + LPT$$

where : ETol = tolerable erosion (mm yr-1) ; DE (equivalent depth) = (effective soil depth (mm) x soil depth factor according to soil suborder; Dmin= minimum soil depth (mm) and UGT= land use age; LPT = soil formation rate

2.5.Agrotechnology analysis (soil conservation measures)

The selection of agrotechnology is preceded by an inventory of existing agrotechnology in the Krueng Kereuto watershed, then an agrotechnology analysis is carried out for each type of oil palm-based farming based on erosion prediction values. Selected agrotechnology is evaluated based on a comparison of erosion resulting from the application of several types of oil palm-based farming with ETol values. Selection of agrotechnologycarried out based on a simulation using the USLE model (Weischmeier and Smith 1978). The criteria used to determine the maximum CP value used as an alternative to agrotechnology are the CP values that result in erosion that is less than or equal to the erosion that can be tolerated (ETol), namely:

$$A \leq Ethol \text{ or } RKLSCP \leq Ethol$$

$$CP \leq \frac{Etol}{RKLS} \text{ or } CPrek \leq CPmax$$

3. RESULTS AND DISCUSSION

3.1., Land Map Unit in the Krueng Keureuto Watershed

The land map unit map is obtained from the results of overlaying soil type maps, slope maps and land use maps, the Krueng Keureuto watershed with an area of103,665.95 hectares consisting of 40 land map units (SPL). Furthermore, the intensive observations in this study were land map units 1, 3, 4, 5, 20, 21, 24, 25, 26, 27 and 28 (Table 1 and Figure 2).

Table 1. Land Map Units in the Krueng Keureuto Watershed

SPL	Land Use	Type of soil	Slope (%)
1	Mixed Garden	Inceptisols	0 - 8
2	pond	Inceptisols	0 - 8
3	Shrubs	Inceptisols	0 - 8
4	Shrubs	Ultisol	0 - 8
5	Shrubs	Ultisol	15 - 25
6	Exxonmobil	Inceptisols	0 - 8
7	Forest	Inceptisols	8 - 15
8	Forest	Ultisol	25 - 40
9	Forest	Ultisol	8 - 15
10	Forest	Inceptisols	25 - 40
11	Forest	Ultisol	> 40
12	Forest	Inceptisols	> 40
13	Production forest	Inceptisols	> 40
14	Production forest	Inceptisols	25 - 40
15	Production forest	Inceptisols	8 - 15
16	Production forest	Ultisol	15 - 25
17	Production forest	Ultisol	25 - 40
18	Production forest	Ultisol	> 40
19	Production forest	Ultisol	8 - 15
20	Mixed Garden	Ultisol	15 - 25
21	Mixed Garden	Ultisol	0 - 8
22	Water Body	Inceptisols	0 - 8
23	Water Body	Ultisol	0 - 8
24	Open field	Inceptisols	0 - 8
25	Open field	Ultisol	0 - 8
26	Plantation	Ultisol	0 - 8

27	Plantation	Ultisol	25 - 40
28	Plantation	Inceptisols	0 - 8
29	Settlement	Ultisol	0 - 8
30	Settlement	Inceptisols	0 - 8
31	Settlement	Inceptisols	8 - 15
32	Settlement	Ultisol	8 - 15
33	Swamp	Inceptisols	0 - 8
34	Swamp	Ultisol	0 - 8
35	Swamp	Ultisol	8 - 15
36	North Aceh Office	Inceptisols	0 - 8
37	North Aceh Office	Ultisol	0 - 8
38	Ricefield	Inceptisols	0 - 8
39	Ricefield	Ultisol	0 - 8
40	Ricefield	Inceptisols	8 - 15

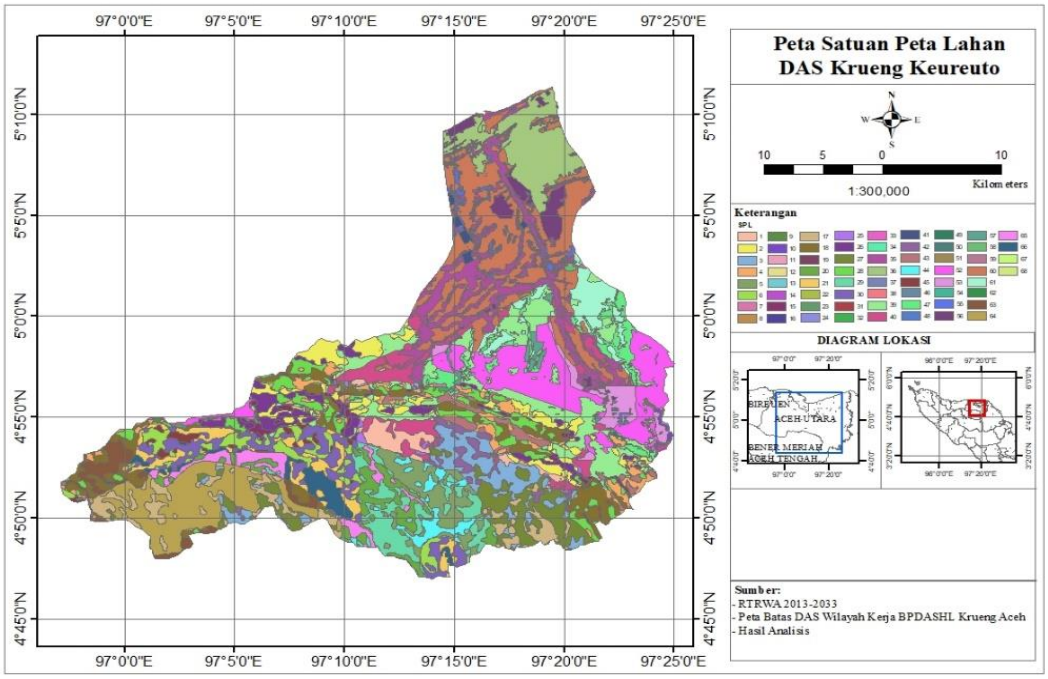


Figure 2. Map of Land Map Units in the Krueng Kereuto Watershed

Judging from the characteristics of each land map unit, generally the soil in the Krueng Keureto watershed has a very low to low soil fertility rate which affects the availability of nutrients for plants. For this reason, in the development of sustainable agriculture in the Krueng Keureto watershed, agrotechnology measures need to be designed in such a way. For this reason, the first step that must be taken in this study is to evaluate the land (land suitability). The results of the land evaluation will provide alternative land uses and management actions needed so that the land can be used sustainably (Arsyad 2012).

3.2.Evaluation of Land Suitability for Oil Palm Plantations

Evaluation of land suitability is the level of suitability of a plot of land for a particular use by matching land characteristics (land and environmental characteristics) with the criteria of each plant. Land characteristics used in determining land suitability classes include topography, soil

drainage, soil depth, soil texture, soil pH, CEC, salinity, pyrite content, flooding/inundation and rock outcrops on the soil surface. Climate data consists of annual average rainfall and number of dry months, as well as air temperature obtained from climate observation stations. The results will then be described on a land unit map that is being intensively observed.

3.3.Land Suitability For Oil Palm Plantations

The results of the evaluation of land suitability for oil palm plantations in the Krueng Keureto watershed show that the land in the Krueng Keureto watershed is very suitable for the development of oil palm plantations, where the suitability classes for oil palm plantations consist of moderately suitable classes (S2) and marginal suitable classes (S3). with the limiting factor of oxygen availability (oa), namely obstructed drainage, the limiting factor of nutrient retention (nr), namely base saturation, pH and C-organic and the limiting factor of erosion hazard (eh), namely slope. A clearer description, land suitability class for oil palm plantations can be seen in Table 2.

Table 2. Land suitability classes in the Krueng Keureto watershed

Compatibility Class	Land Map Unit	WIDE	
		Ha	(%)
S2oa-1	26	6952.38	19,48
S2nr-2, 3	3, 4	14584.27	40.88
S2nr-2, 4	24, 25, 28	1657.51	4.64
S3oa-1	1, 21	9316,16	26,11
S3eh-1	5, 20, 27	3165.89	8.87

Information : S2=moderately suitable, S3 = marginally suitable, oa = oxygen availability ; nr = nutrient retention; eh = erosion hazard.

Source: Analysis of primary data (2022)

Based on Table 2 above, it can be seen that the limiting factor for nutrient retention (nr) is the most dominant limiting factor, for this reason efforts are needed to improve it so that the quality of the land in the research location can provide high production and income in a sustainable manner. The improvement efforts that need to be carried out are by providing organic matter, liming, fertilizing, and applying vegetative soil and water conservation techniques (Murtilaksono, 2019). This is also in line with the opinion of Alvi, et al, (2018) where the use of organic fertilizers can increase soil fertility and quality in plants. FurthermoreNisa (2020)added that the application of mucuna bracteata organic mulch can improve the chemical properties of the soil and the growth of oil palm plant roots. So that the organic matter content in the soil does not decrease due to the decomposition process of mineralization, it is recommended that during soil tillage the addition of organic matter absolutely must be given every year, because without the addition of organic matter it can cause chemical, physical and biological degradation of the soil which can damage soil aggregates and cause compaction. land. The limiting factor for base saturation is always associated as an indication of the fertility of a soil. The ease of releasing trapped ions for plants depends on the degree of base saturation. The soil is very fertile if the base saturation is > 80%, the fertility level is moderate if the base saturation is between 50-80% and infertile if the base saturation is < 50%. This is based on the nature of soils with a base saturation of 80% will liberate basic cations that can be exchanged more easily than soils with a base saturation of 50%. Overall, oil palm plants are suitable for development in research locations. For the limiting factor of slopes (15-25%), especially in the area of oil palm plantations, it is necessary to make frequent terraces which are included with the planting of terrace reinforcement, namely planting grass on the lip of the terrace.

3.4.Erosion and Erosion Tolerance

The results of the analysis of erosion calculations show that almost all of the SSTs under intensive observation have erosion prediction values above the erosion tolerance limit (ETol), only SST 3 (use of shrubs), SST 7 (use of forest land) whose erosion prediction values are below tolerance limit erosion value. More details on the calculation of erosion prediction values can be seen in Table 9 and the erosion tolerance limit values can be seenin Table 3. Erosion prediction in the Krueng Keureto watershed was carried out on land map units (SST) which were intensively observed (SST 1, 3, 4, 5, 7, 13, 20, 21, 24, 25, 26, 27 and 28) using the USLE equation (Universal of Soil Loss Equation).The calculation results show that the highest erosion prediction value occurs in the land use of mixed gardens and shrubs.The predictive value of erosion on scrub land use (SST 3, 4, 5) ranged from 11.82 - 192.04 tonnes ha-1yr-1. This value is still far above the tolerable erosion value (ETol), which is 21.50 - 24.96 tons ha-1 year-1. Erosion prediction on mixed garden land use (SST 1, 20 and 21) ranges from 27.50 - 365.38 ton ha-1 year-1, this prediction value is still above the ETol value, namely 15.50 – 20.40 tons ha-1 year-1.

3.5.Agrotechnology Analysis (Soil Conservation Measures*)*

Based on erosion prediction calculations which are then compared with the erosion tolerance limit (ETol) value, it is necessary to carry out soil conservation measures (agrotechnology) in almost all SSTs which are intensive observations, only for forest land use (SPL 7) and plantation land use (SPL 28). the erosion prediction value is below the erosion tolerance limit The soil conservation efforts that must be carried out at SST 1.20 with the use of mixed garden land, namely by implementing a cacao + cassava planting pattern coupled with soil conservation techniques in the form of mulching. Furthermore, for the use of shrub land (SPL 3, 4 and 5) and land use on open land (SPL 24 and 25) the effort to manage plants and soil conservation measures that must be carried out is by planting woody plants intercropped with food crops (agroforestry) where litter from food crops can be used as mulch. This effort can reduce the rate of erosion below the tolerance limit, and this is in line with the resultsstudyNaharudin (2018). In the use of plantation land (SPL 26, 27 and 28) soil conservation efforts that must be carried out are by making terraces and adding mulch in order to reduce the rate of erosion that occurs. This is in line with the results of a study by Ariyanti et al (2018) where the creation of mound terraces on sloping areas included with the provision of ground cover plants can reduce the runoff rate. In more detail, the recommended soil conservation techniques to be carried out at the research location, especially on the land map units which are the subject of intensive observation, can be seen in Table 4

Table 4. Soil Conservation Measures (Agrotechnology) in the Krueng Keureto Watershed

PL	A (tonnes/ha/yr)	ETol (tonnes/ha/yr)	Use Land	Repair Business	
				Planting pattern (C)	Soil Conservation (P)
	8.36	20.40	Mixed Garden	cocoa + cassava + nuts	remaining tan legumes -mulch
	10.92	21.50	Shrubs	Agroforestry	plant residues - mulch
	9.69	24.96	Shrubs	bean strips	plant residues - mulch
	1.12	21.80	Shrubs	Agroforestry	plant residues - mulch
	22.84	27.78	Forest	forest is maintained	-
	17.6	18	Production	existing cropping patterns	terrace construction

3	3	.50	forest		
0	2.57	19.10	Mixed Garden	cropping pattern of corn among other tans	plant residues - mulch
1	0.72	15.50	Mixed Garden	Agroforestry	plant residues - mulch
4	17.76	27.50	Open field	Agroforestry	-
5	7.98	27.31	Open field	Agroforestry	-
6	17.24	27.78	Plantation	Intercropping pattern	Making terraces
7	5.44	15.40	Plantation	Existing plants + nuts	Giving mulch
8	4.32	20.02	Plantation	The cropping pattern is maintained	Giving mulch

4. CONCLUSION

1. The results of the evaluation of land suitability for oil palm plantations in the Krueng Keureto watershed show that the land in the Krueng Keureto watershed is very suitable for the development of oil palm plantations, where the suitability classes for oil palm plantations consist of moderately suitable classes (S2) and marginal suitable classes (S3). with the limiting factor of oxygen availability (oa), namely obstructed drainage, the limiting factor of nutrient retention (nr), namely base saturation, pH and C-organic and the limiting factor of erosion hazard (eh), namely slope.
2. The results of the erosion calculation show that the highest erosion prediction value occurs in the use of mixed gardens and shrubs.The predictive value of erosion on scrub land use (SST 3, 4, 5) ranged from 11.82 - 192.04 tonnes ha-1yr-1. This value is still far above the tolerable erosion value (ETol), which is 21.50 - 24.96 tons ha-1 year-1. Erosion prediction on mixed garden land use (SST 1, 20 and 21) ranges from 27.50 - 365.38 ton ha-1 year-1, this prediction value is still above the ETol value, namely 15.50 – 20.40 tons ha-1 year-1.

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