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Characterization of tidal land for suitability of *Arenga pinnata* Merr. plant development

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ABSTRACT

Sugar palm has an economic and ecological functions. Sugar palm is also able to adapt to marginal land including tidal. This study aims to identify land characteristics for their suitability for tidal. This land survey research was carried out in the Tenayan Raya, Pekanbaru. Sampling points are based on the overlay of land system maps, soil type maps and peat depth maps. Assessment of land suitability for palm trees is carried out using the limiting factor method in actual and potential conditions. The assessment results show that the actual land suitability of all SLH is not current suitable (N1) with the limiting factor for toxicity (xc), with very high Fe levels. Limiting factors of Fe can be overcome by water management, amelioration (supplement of organic material), liming and fertilization. Potential land suitability of all SLH is marginally suitable (S3).
Keywords: sugar palm, land suitability, limiting factors, tidal land

ABSTRAK

Tanaman Aren memiliki fungsi ekonomi dan ekologis. Aren juga mampu beradaptasi pada berbagai kondisi lahan marginal termasuk lahan pasang surut. Penelitian ini bertujuan untuk mengidentifikasi karakteristik lahan untuk kesesuaiannya pada lahan rawa pasang surut. Penelitian survei tanah ini dilaksanakan di daerah Tenayan Raya, Kota Pekanbaru. Titik pengambilan sampel berdasarkan hasil overlay peta sistem lahan, peta jenis tanah dan peta kedalaman gambut. Penilaian kesesuaian lahan untuk tanaman aren dilakukan dengan metode faktor pembatas dalam keadaan aktual dan potensial. Hasil penilaian menunjukkan kesesuaian lahan aktual pada semua SLH tidak sesuai (N1) saat ini dengan faktor pembatas toksisitas (xc) yaitu kadar Fe yang sangat tinggi. Faktor pembatas Fe dapat diatasi dengan pengelolaan air, ameliorasi (pemberian bahan organik), pengapuran dan pemupukan. Kesesuaian lahan potensial pada semua SLH adalah sesuai marginal (S3).
Kata kunci: aren, kesesuaian lahan, faktor pembatas, rawa pasang surut

1. Introduction

Aren is a multipurpose plant that serves both conservation and production purposes (Alam and Baco, 2004). Its spreading roots prevent soil erosion. Aren is also highly adaptable to a variety of soil and agroclimatic conditions, from lowlands to highlands. In Indonesia, aren grows in almost all regions, especially in hilly areas and areas with high humidity (Sunanto, 1993). Its ability to adapt well to various land conditions makes aren a very promising crop for development in swampy areas (Effendi, 2009).

Aren cultivation is still mostly carried out by farmers but has not yet been developed on a large scale. Conventional and suboptimal management practices have resulted in low areca palm productivity. Areca palms grown in several areas in Riau cover a total area of 87 ha with an average yield of 1,333 kg/ha (in the form of brown sugar) (Riau Provincial Plantation Service, 2021).

Tidal swamp land has the potential to be developed as agricultural land for aren, but this land has several problems in terms of soil fertility, including low soil pH and nutrient content, high Fe and aluminum content, and frequent waterlogging that cannot be controlled (Purnomo et al., 2005). The soils that develop on tidal swamp land consist of alluvial and peat soils. Alluvial soils are fertile and suitable for use as agricultural land. Alluvial soils are formed as a result of mud deposits carried by river currents and other sedimentation. Alluvial soil has an unclear profile, is gray to brown in color with a clay or sandy clay texture, and has varying levels of fertility from moderate to high (Haryanta et al., 2017). Peat soil is formed from the weathering of plant residues with varying degrees of decomposition. Peat soil is generally acidic, poor in available nutrients, and has limitations in terms of physical and chemical properties (Noor, 2004). This study aims to identify the characteristics and suitability of tidal swamp land based on factors that inhibit the growth of aren plants.

2. Methods

This study was conducted in the tidal swamp area of Tenayan Raya District, Pekanbaru City, Riau Province. Soil sample analysis was carried out at the Soil Science Laboratory, Faculty of Agriculture, University of Riau. The study lasted for three months, from August to October 2023. The research method was a soil survey. The homogeneous land unit (SLH) map for determining the field observation location was obtained from the overlay of the land system map (LREPP, 1995), the land and soil unit map (Puslittanak, 1992), and the peat depth map (BBSDL, 2010).

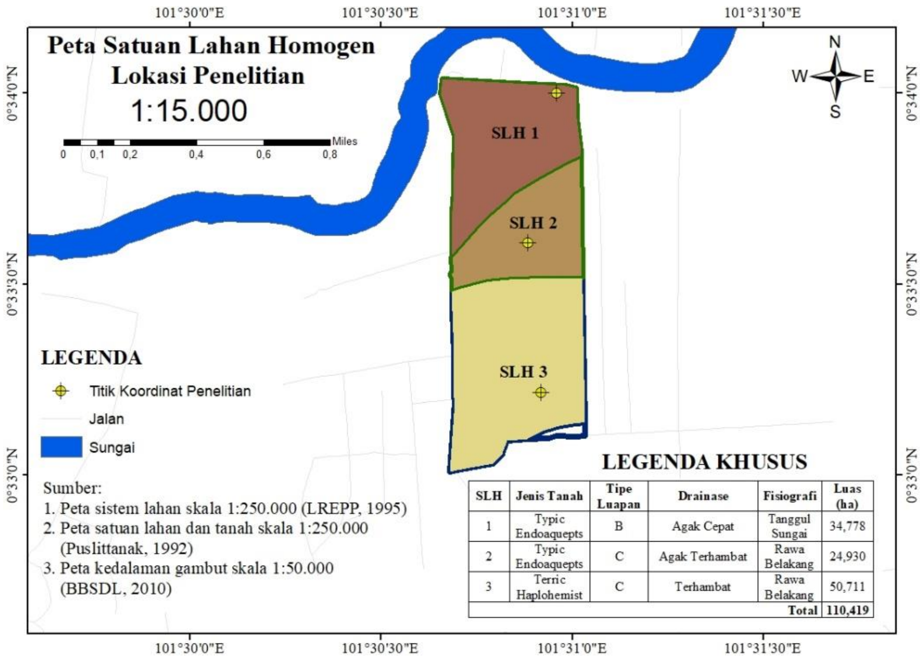

Figure 1. Land Unit Map of the Research Location

The observation points and soil sampling points were determined at 3 SLH. Soil sampling for chemical analysis was carried out to the depth of plant roots (0-20 cm and 20-40 cm), while soil samples for physical analysis were taken to a depth of 100 cm.

The suitability of land for palm cultivation in tidal swamp areas was determined based on the FAO framework (1976) with several modifications from the Soil Research Institute (2003) and the West Java Provincial Plantation Service (2018). The assessment of tidal swamp land suitability for palm cultivation uses a matching method, which compares the quality and characteristics of tidal swamp land as observation parameters with the criteria for palm cultivation requirements. Land suitability assessment is carried out in actual and potential conditions. The framework of this system is divided into 4 classes, namely S1 (very suitable), S2 (sufficiently suitable), S3 (marginally suitable) and N (unsuitable).

3. Result and Discussion

3.1. Climate Characteristics

Climate data for the research location was obtained from the Pekanbaru BMKG station. The highest average monthly rainfall at the research location from 2013 to 2022 occurred in April at 477.15 mm and November at 453.73 mm, while the lowest average rainfall occurred in August with an average rainfall of 213.09 mm. According to Djaenuddin et al. (2000), the rainfall required for optimal growth of aren plants is >1200 mm.year-1, while for the formation of crowns on aren plants, rainfall between 1200-3500 mm.year-1 is required (Effendi, 2009). Based on the results of climate classification according to Schmidt-Ferguson, the research location is included in climate type A (very wet), where the average monthly rainfall is >100 mm.

The average temperature at the research location over the last 10 years was 27.25 °C. The average duration of sunshine over the last 10 years at the research location was 4.34 hours. The lowest sunshine duration occurred in September at 3.56 hours, while the highest occurred in July at 5.51 hours. The average humidity at the research site is 80.74%. According to Puturuhu et al. (2011), the average air humidity that is very conducive to the growth and development of aren is 81-96.4%.

3.2. Land Characteristics

SLH 1 is located at coordinates 101°30' 57.7“E 00°34'00.1”N. The physiography of this SLH is a river embankment, with a type B floodplain, fairly rapid drainage, and a slope gradient of <3%. The vegetation found in the field consists of reeds, teki grass, and cassava trees. The soil classification at SLH 1 is included in the Endoaquepts soil group.

SLH 2 is located at coordinates 101°30' 54“E 00°33'36”N, with a physiography of back swamp, a type C floodplain, moderately obstructed drainage, and a slope gradient of <3%. The vegetation found includes: pakis kelabang, merkubung, putri malu, and mahang. The soil classification at SLH 2 belongs to the Endoaquepts group.

SLH 3 is located at coordinates 101°30'55.2“E 00°33'13.0”N, with a physiography of back swamp, a type C floodplain with obstructed drainage, and a slope gradient of <3%. The vegetation found includes: teki grass, belulang grass, acacia trees, and oil palms. The soil classification at SLH 3 belongs to the Haplohemist soil group.

3.3. Soil Physical Characteristics

The texture class of the top layer of SLH 1 is sandy loam and loamy sand with the following percentages for each fraction: sand fraction 65.78−81.18%, silt fraction 7.59−20.03%, and clay fraction 11.23−14.19%. The soil texture in the bottom layer is dusty clay loam with percentages of each fraction as follows: sand fraction 27.13-26.47%, dust fraction 72.20-73.11%, and clay fraction 0.43-0.67%. The texture class in the upper and lower layers of SLH 2 is sandy loam and clay with percentages of each fraction, namely, sand fraction 15.63-73.50%, silt fraction 13.22-26.04%, and clay fraction 8.19-58.32%.

Rukmi et al. (2017) stated that sandy loam soil has larger macro pores than micro pores, so its water and nutrient retention capacity is small but very efficient in terms of water and air circulation. Thus, sugar palms can grow and develop well. Effendi (2009) states that sugar palm plants are very suitable for clayey and sandy soil conditions, as well as sloping land.

The fiber content test at a depth of 0-20 cm showed the lowest fiber content of 18%. The highest fiber content was found at a depth of 60-80 cm with a fiber content of 41%. Based on the results of the fiber content analysis, it was found that the level of peat maturity at the research site (SLH 3) was hemic. Hemic peat is peat that has a moderate level of decomposition (half-mature), with some of the organic material having undergone decomposition and some remaining in the form of fibers. The varying levels of peat maturity are formed from different material content, environmental conditions, and time (Najiyati et al., 2005).

3.4. Soil Chemical Characteristics

The pH value of the soil in SLH 1 (0-20 cm) is 5.31, and SLH 1 (20-40 cm) is 5.15. The pH value of the soil in SLH 2 (0-20 cm) is 5.13, and SLH 2 (20-40 cm) is 5.07. The soil pH value at SLH 3 (0-20 cm) is 3.85, while SLH 3 (20-40 cm) has a value of 3.87. The acidic to very acidic soil reaction at the research site is caused by the parent material, vegetation, organic matter content in the soil, and climatic factors. According to Utomo et al. (2016), soil acidity is influenced by the decomposition of organic matter added to the soil, a process that is initially controlled by the initial composition of the parent material. H-dd content is the main source of H+. High H-dd values in the soil cause the soil pH to decrease. Hossain and Uddin (2011) stated that soils with acidic pH conditions contain many exchangeable H+ ions (H-dd). Exchangeable hydrogen (H-dd) will decrease as the soil pH increases. At the research site, the exchangeable hydrogen content in the upper layer (0-20 cm) of SLH was 4.0 me.100g-1, while in the lower layer (20-40 cm) of SLH it was 4.4 me.100g-1. H-dd in SLH 2 upper layer (0-20 cm) was 6.4 me.100g-1, while in SLH 2 lower layer (20-40 cm) it was 6.8 me.100g-1. H-dd in SLH 3 upper layer (0-20 cm) is 3.2 me.100g-1, SLH 3 lower layer (20-40 cm) is 5.6 me.100g-1.

Table 1. The results of soil chemical analysis at each SLH

			SLH		
No.	Parameters	Depth (cm)	SLH 1	SLH 2	SLH 3
1.	pH H_2O	0-20	5.31	5.13	3.85
		20-40	5.15	5.07	3.87
2.	Cation exchange capacity (me/100g)	0-20	15.69	21.26	57.96
		20-40	12.65	26.57	58.91
3.	Base saturation (%)	0-20	36.72	11.96	3.20
		20-40	21.27	6.79	8.54
4.	C-organic (%)	0-20	0.61	1.24	28.79
		20-40	14.88	0.94	47.00
5.	Fe content (ppm)	0-20	2753	4308	2340
		20-40	2575	3445	2160

The Cation Exchange Capacity (CEC) value of the soil at the research site is classified as low to very high. The CEC at the study site falls within the low to very high criteria. The CEC value in SLH 1 (0-20 cm) is 15.69 me.100g-1, while SLH 1 (20-40 cm) is 12.65 me.100g-1. The CEC value in SLH 2 (0-20 cm) was 21.26 me.100g-1, and in SLH 2 (20-40 cm) it was 26.57 me.100g-1. The CEC value in SLH 3 (0-20 cm) was 57.96 me.100g-1, and SLH 2 (20-40 cm) was 58.91 me.100g-1. The variation in soil CEC values is thought to be caused by differences in parent material and organic matter content in each SLH. Soil with high CEC can absorb and provide good nutrients for plants (Rofik et al., 2019).

The Base Saturation Value (BSV) at the research site was classified as very low to low. The base saturation level (BSV) at the research site in SLH 1 (0-20 cm) was 36.72%, and in SLH 1 (20-40 cm) it was 21.27%. The levels in SLH 2 (0-20 cm) were 11.96%, and in SLH 2 (20-40 cm) were 6.79%. The levels in SLH 3 (0-20 cm) were 3.20%, and in SLH 3 (20-40 cm) were 8.54%. The low KB value at the study site was caused by low soil pH. Soils with low pH generally have low base saturation as well; soil pH and base saturation have a positive correlation (Hardjowigeno, 2010).

The Ca-dd content at the study site was very low to low. The Ca-dd content in SLH 1 (0-20 cm) was 2.47 me.100g-1, while in SLH 1 (20-40 cm) it was 1.05 me.100g-1. The Ca-dd content in SLH 2 (0-20 cm) was 1.54 me.100g-1, while in SLH 2 (20-40 cm) it was 0.88 me.100g-1. The Ca-dd content in SLH 3 (0-20 cm) was 1.15 me.100g-1, while SLH 2 (20-40 cm) was 3.32 me.100g-1.

The Mg-dd content at the research site ranged from low to high. The Mg-dd content in SLH 1 (0-20 cm) was 2.45 me.100g-1, while in SLH 1 (20-40 cm) it was 1.27 me.100g-1. The Mg-dd content in SLH 2 (0-20 cm) was 0.62 me.100g-1, while in SLH 2 (20-40 cm) it was 0.58 me.100g-1. The Mg-dd content in SLH 3 (0-20 cm) was 0.28 me.100g-1, while SLH 2 (20-40 cm) was 0.69 me.100g-1.

The Na-dd content at the research site was low to moderate. The Na-dd content in SLH 1 (0-20 cm) was 0.16 me.100g-1, while in SLH 1 (20-40 cm) it was 0.11 me.100g-1. The Na-dd content in SLH 2 (0-20 cm) was 0.12 me.100g-1, while in SLH 2 (20-40 cm) it was 0.12 me.100g-1. The Na-dd content in SLH 3 (0-20 cm) was 0.14 me.100g-1, while SLH 2 (20-40 cm) was 0.48 me.100g-1.

The low levels of base cations at the study site were due to high rainfall, which caused the bases to be easily washed away. Soekamto (2015) stated that low base cation content can be caused by high rainfall in the area, which causes these bases to be easily washed away.

Organic C at the study site ranged from very low to very high. Organic C content in SLH 1 (0-20 cm) was 0.61%, while SLH 1 (20-40 cm) was 14.88%. The organic C content in SLH 2 (0-20 cm) was 1.24%, while in SLH 2 (20-40 cm) it was 0.94%. The organic C content in SLH 3 (0-20 cm) was 28.79%, while in SLH 3 (20-40 cm) it was 47.00%. The difference in organic C content at the study sites was due to differences in parent material and the diversity and density of vegetation on the surface of each SLH. High plant diversity can increase soil organic C through carbon input and increase soil microbial diversity and activity (Lange et al., 2015).

Total Fe at the study site was classified as very high. The Fe content in the upper layer (0-20 cm) of SLH 1 was 2753 ppm, while that in the lower layer (20-40 cm) of SLH 1 was 2575 ppm. The Fe content in SLH 2 upper layer (0-20 cm) was 4308 ppm, while in SLH 2 lower layer (20-40 cm) it was 3445 ppm. The Fe content in the upper layer (0-20 cm) of SLH 3 was 2340 ppm, while that in the lower layer (20-40 cm) was 2160 ppm. Tidal swamps often contain sediment deposits rich in minerals, including Fe. High concentrations of microelements or metals such as Fe can occur due to mixing with mineral materials beneath the peat layer (Fahmi et al., 2010). In addition to being an essential microelement for plants, iron has the potential to be toxic to plants at high concentrations.

3.5. Evaluation of Land Suitability for Aren Plantation

The actual land suitability class for sugar palm cultivation in tidal swamp land at SLH 1, SLH 2, and SLH 3 in the upper layer (0-20 cm) and lower layer (20-40 cm) is marginally unsuitable (N1) with a very high Fe content limiting factor (Table 2, Table 3, and Table 4).

Table 2. Classification of land suitability for palm cultivation in SLH 1 tidal swamps

Land Characteristics (Land Quality)	SLH 1 (0-20 cm)				SLH 1 (20-40 cm)			
	Value	ALS	Input	PLS	Value	ALS	Input	PLS
Drainage (oa)	fairly fast	S3	+++	S2	fairly fast	S3	+++	S2
Texture (rc)	fairly coarse	S3	+	S3	fairly coarse	S3	+	S3
Soil Depth (rc)	80 cm	S2	-	S2	80 cm	S2	-	S2
Peat thickness (rc) cm	-	-	-	-	-	-	-	-
Peat maturity (rc)	-	-	-	-	-	-	-	-
Peat CEC (nr)	15,69 cmol	S2	+	S1	12,65 cmol	S2	+	S1
Base saturation (%) (nr)	36,72%	S1	-	S1	21,27%	S2	+	S1
pH H_2O (nr)	5,31	S2	+	S1	5,15	S2	+	S1
C-organic (nr)	0,61%	S3	+	S2	14,88%	S1	-	S1
Fe (xc)	2753 ppm	N1	+++	S3	2575 ppm	N1	+++	S3
Land suitability		N1 xc		S3 xc,rc		N1 xc		S3 xc, rc

Note: ALS = Actual Land Suitability; PLS = Potential Land Suitability; S1 = highly suitable; S2 = moderately suitable; S3 = marginally suitable; N1 = marginally unsuitable; N2 = permanently unsuitable; - = no input; + = low input; ++ = moderate input; +++ = high input. * oa = Oxygen availability; rc = Root medium; nr = Nutrient retention; xc = Toxicity.

Table 3. Classification of land suitability for palm cultivation in SLH 2 tidal swamps

Land Characteristics (Land Quality)	SLH 2 (0-20 cm)				SLH 2 (20-40 cm)			
	Value	ALS	Input	PLS	Value	ALS	Input	PLS
Drainage (oa)	Somewhat restricted	S3	+++	S2	Somewhat restricted	S3	+++	S2
Texture (rc)	Fine	S1	-	S1	Fine	S1	-	S1
Soil Depth (rc)	100 cm	S2	-	S2	100 cm	S2	-	S2
Peat thickness (rc) cm	-	-	-	-	-	-	-	-
Peat maturity (rc)	-	-	-	-	-	-	-	-
Peat CEC (nr)	21,26 cmol	S1	-	S1	26,57 cmol	S1	-	S1
Base saturation (%) (nr)	11,96 %	S3	+	S2	6,79%	S3	+	S2
pH H_2O (nr)	5,13	S2	+	S1	5,07	S2	+	S1
C-organic (nr)	1,24%	S2	+	S1	0,94%	S2	+	S1
Fe (xc)	4308 ppm	N1	+++	S3	3445 ppm	N1	+++	S3
Land suitability		N1 xc		S3 xc		N1 xc		S3 xc

Note: ALS = Actual Land Suitability; PLS = Potential Land Suitability; S1 = highly suitable; S2 = moderately suitable; S3 = marginally suitable; N1 = marginally unsuitable; N2 = permanently unsuitable; - = no input; + = low input; ++ = moderate input; +++ = high input. * oa = Oxygen availability; rc = Root medium; nr = Nutrient retention; xc = Toxicity.

Table 4. Classification of land suitability for palm cultivation in SLH 3 tidal swamps

Land Characteristics (Land Quality)	SLH 3 (0-20 cm)				SLH 3 (20-40 cm)			
	Value	ALS	Input	PLS	Value	ALS	Input	PLS
Drainage (oa)	Restricted	S3	+++	S2	Restricted	S3	+++	S2
Texture (rc)	Organic matter	-	-	-	Organic matter	-	-	-
Soil Depth (rc)	>100 cm	S1			>100 cm	S1	-	S1
Peat thickness (rc) cm	80 cm	S2	-	S2	80 cm	S2	-	S2
Peat maturity (rc)	Hemik	S1	-	S1	Hemik	S1	-	S1
Peat CEC (nr)	57,96 cmol	S1	-	S1	58,91 cmol	S1	-	S1
Base saturation (%) (nr)	3,20%	S3	+	S2	8,54%	S3	+	S2
pH H_2O (nr)	3,85	S3	+	S2	3,87	S3	+	S2
C-organic (nr)	28,79%	S1	-	S1	47,00%	S1	-	S1
Fe (xc)	2340 ppm	N1	+++	S3	2160 ppm	N1	+++	S3
Land suitability		N1 xc		S3 xc		N1 xc		S3 xc

Note: ALS = Actual Land Suitability; PLS = Potential Land Suitability; S1 = highly suitable; S2 = moderately suitable; S3 = marginally suitable; N1 = marginally unsuitable; N2 = permanently unsuitable; - = no input; + = low input; ++ = moderate input; +++ = high input. * oa = Oxygen availability; rc = Root medium; nr = Nutrient retention; xc = Toxicity.

Iron (Fe) is a micronutrient that plays an important role in plant growth. Fe can undergo changes in flooded conditions, namely reduction from Fe3+ to Fe2+. This change is very beneficial for plants because iron is widely available and absorbed by plants in the form of ferrous iron (Fe2+). However, if Fe reduction exceeds the amount needed by plants, it will cause toxicity in plants. Effendi et al. (2015) stated that iron plays an important role in plant metabolism. However, iron becomes toxic when it accumulates in large amounts in plant tissues. The amount of Fe in the soil affects the availability of phosphate nutrients for plant growth. When Fe levels are high, phosphate binds with Fe and forms bonds that are insoluble in water, resulting in phosphate being unavailable for plant growth. The concentration of Fe in the soil that causes Fe toxicity varies with the pH of the soil solution. The critical limit of Fe concentration in soil solution that causes Fe toxicity is around 100 ppm at pH 3.7 and 300 ppm or higher at pH 5.0 (Sahrawat, 2010). According to Sudaryono (2009), the iron or Fe content in soil for plantation crops ranges from 40-58 ppm, which is classified as high to very high.

Efforts that can be made to overcome high Fe levels in the soil include water management (Indriyati et al., 2011), amelioration (Fairhurst et al., 2002), liming, and fertilization (Rosmaiti et al., 2017). The problem with tidal land in plantation crop cultivation is excess water during the generative phase of the plant, while delaying planting will result in water shortage during that phase. This water status problem can be overcome by building an appropriate drainage system (Imanudin and Susanto, 2008). Water management is not only to reduce or increase surface water availability, but also to reduce soil acidity, prevent soil acidification due to the oxidation of the pyrite layer, prevent the dangers of salinity and flooding, and wash away toxic substances such as Fe that accumulate in the plant root zone.

Amelioration or the addition of organic soil conditioners is an effort that can be made to accelerate soil quality improvement. Organic matter allows chelation to occur, which is an organic compound that binds with metal cations such as Fe. Research by Situmorang (1999) states that the incorporation of organic matter from Mucuna sp, which contains humic acid, can reduce the concentration of Fe in the soil. The addition of organic matter to the soil can reduce Fe levels. This is because during the decomposition process, organic matter produces organic acids that can form chelate bonds with Al and Fe ions, thereby reducing the solubility of Al and Fe ions, thus increasing P availability.

Liming and fertilization can also be done to overcome high Fe levels. Soil with an acidic reaction results in macro nutrients not being available in sufficient quantities for plants, but micro nutrients that are needed in small amounts increase, making them toxic to plants, such as Al, Mn, and Fe. Applying lime can increase the concentration of low soil pH to near neutral. Lime contains Ca compounds that can neutralize the adverse effects of Fe and the unfavorable effects of soil acidity (Nurmansyah, 2010).

The limiting factors found in the field need to be addressed so that all SLH can be optimally used as palm cultivation land. To overcome limiting factors in N1 and improve land suitability classes requires high capital, so assistance or intervention from the government or private sector is needed. Based on the limiting factors found at the research site, management recommendations can be designed for the research site.

The land suitability evaluation map for palm cultivation at the research site is presented in Figure 2.

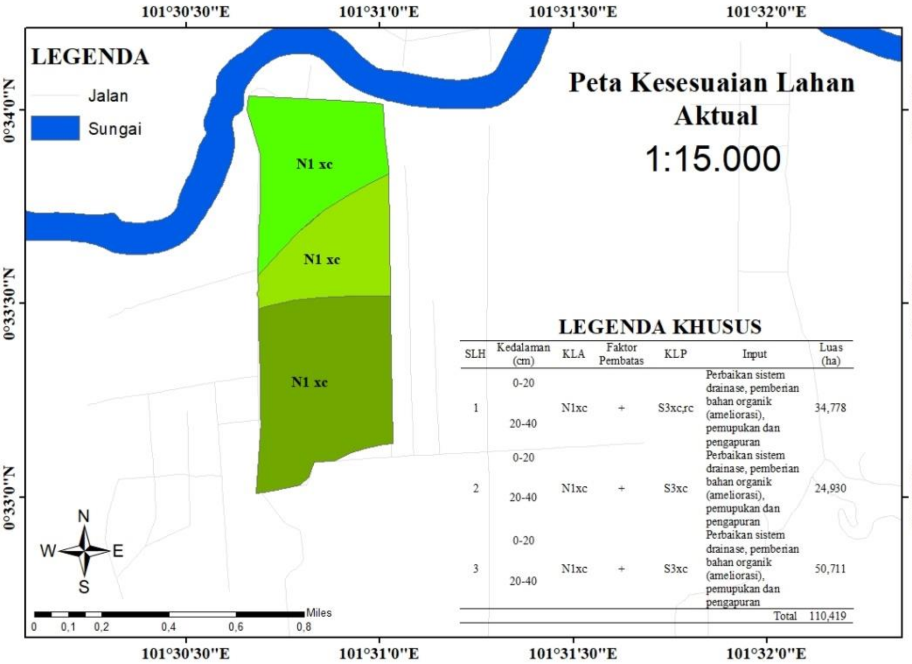

Figure 2. Map of Land Suitability for Aren Plants

After improvements were made to limiting factors by applying low to high inputs to each homogeneous land unit (SLH), the suitability of potential land for sugar palm cultivation in tidal swamp SLH 1 in the upper layer (0-20 cm) and lower layer (20-40 cm) became marginally suitable (S3xc, rc), SLH 2 and SLH 3 in the upper layer (0-20 cm) and lower layer (20-40 cm) became marginally suitable (S3xc).

Regarding the problem of oxygen availability (oa) at the research site, efforts can be made to improve the drainage system. The creation of a drainage system is absolutely necessary to remove excess water. Good drainage allows for the diffusion of oxygen and carbon dioxide from plant roots (Hakim et al., 1986). The level of drainage management efforts is high because the creation of drainage requires large costs, therefore government intervention or private projects are needed.

Regarding the limiting factor of rooting media (rc), namely texture, improvement efforts cannot be made because it is permanent. Yanis et al. (2014) stated that rooting media, namely soil texture, cannot be easily improved or is permanent because soil texture is natural and permanent from the weathering process of parent rock. Meanwhile, Sutanto (2005) states that soil texture is permanent/not easily changed and has a major influence on other soil properties such as structure, consistency, soil looseness, runoff, infiltration capacity, and others.

Problems with limiting factors for nutrient retention (nr), namely organic carbon, base saturation, and pH, can be improved by applying organic matter, fertilizing, and liming. The limiting factor of organic carbon can be improved by adding organic matter. Affandi et al. (2012) stated that the application of organic materials can increase the organic carbon content in the soil, and an increase in organic carbon in the soil can also have a positive effect on the physical, chemical, and biological properties of the soil. The addition of organic matter to increase the organic carbon value in soil can be done by applying organic fertilizers and compost. Compost application can increase soil organic carbon content, improve water retention and soil aggregates, and increase microorganism activity in the soil (Sukartono et al., 2011).

Limiting factors such as base saturation and soil reaction (pH) can be improved by applying lime and fertilizer. Low base saturation indicates a low content of base cations in the soil and a higher content of acid cations such as H+ and Al3+, which generally makes the soil acidic. Base cations are generally nutrients required by plants. In addition, bases are generally easily leached, so that the soil has not undergone much leaching and is fertile. Base saturation is closely related to soil pH, where soils with low pH have low base saturation, while soils with high pH have high base saturation. Liming can increase soil pH and suppress the solubility of elements that are toxic to plants.

Liming can increase soil pH and suppress the solubility of elements that are toxic to plants. Liming aims to add elements containing Ca and Mg to the soil so that their availability can be increased. Lime is an easily obtainable soil conditioner. Lime can be administered in the form of calcite (CaCO3) and dolomite (Ca.Mg(CO_3)2). According to Lestari et al. (2018), liming will increase soil pH and the content of base cations such as Ca and Mg, for example dolomite lime.

Efforts to improve limiting factors aim to increase the suitability class of potential land so that plants can grow optimally. This is the goal of land suitability evaluation, which is to ensure continuity between the climate of the study area, land quality and characteristics, so that the potential of the study area can be identified and facilitate the development of palm cultivation areas.

4. Conclusion

All Homogeneous Land Units (SLH) at the research site currently have actual land suitability that is not suitable (N1). The tidal swamp land characteristics in each HLU have a toxicity limiting factor (xc), namely very high Fe levels. The Fe limiting factor can be overcome with proper water management, amelioration, liming, and fertilization. The potential land suitability in all HLUs is marginally suitable (S3).

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