Land suitability evaluation for *Arenga pinnata* cultivation as a source of traditional cuisine, Horog-Horog, in 3 districts of Jepara Regency, Central Java

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Abstract. *Arenga pinnata* (sugar palm) is an economically and ecologically important palm in Jepara Regency. People of Jepara have been extracting the starch from its stem as the main raw material for traditional cuisine, horog-horog. Sugar palm stands can conserve soil and water. Their large stems store relatively much carbon rather than other agricultural monocot plants. Thus, sugar palm cultivation plays an important role in climate change mitigation. However, the areal of sugar palm cultivation was limited. Thus, land evaluation was needed to predict land performance over time to support sugar palm cultivation. The purposes of the present study were to identify land characteristics and their suitability for sugar palm cultivation. This research was conducted in Bangsri, Kembang, and Pakis Aji Districts. The purposive sampling method was used for the field survey. In total, there were 20 land units (9,232.17 ha) across those three districts. Furthermore, to determine land suitability for sugar palm cultivation, the matching method was applied. Thus, the data from field surveys and laboratory tests were used. The obtained results in the present study indicated that 13 land units were classified as S3 (marginal) and 7 land units were classified as N (not suitable). However, there were some limiting factors in the field that must be addressed to support sugar palm cultivation in S3, such as water availability (wa), rooting condition (rc), and nutrient retention (nr). Furthermore, in the land unit that was classified as N the main limiting factor was slope (>30%).

1. Introduction

*Arenca pinnata* Merr. (sugar palm) is economically and ecologically important palm in Jepara. Traditional Jepara food, namely horog-horog made from flour, the flour itself comes from the stem of the plant. In addition, almost all of sugar palm parts have economic values, such as: sugar palm fruits for beverage component; leaves bones for broom; fiber for rope, brushes, or others; sap for beverage, alcohol, vinegar, bio-ethanol, and palm sugar [1]. To maintain the fertility of land productivity [2] sugar palm can be used to conserve soil and water [3]. In addition, sugar palm also supports certain fauna habitats [4]. Sugar palm produces a very large amount of biomass so it has an important role in the cycle of CO₂ [5]. Other monocot plants only store a very small amount of carbon compared to sugar palm which can store a very large amount of carbon. Sugar palm can grow with maximum stem diameter up to 65 cm and a height of 15-20 m [6]. Thus, sugar palm cultivation plays an important role in climate change mitigation.
However, the area for palm cultivation is limited. Therefore, land evaluation is needed to predict land performance overtime to support sugar palm cultivation. Some of the data seen from the sub-districts in Jepara Regency that cultivate sugar palm plants are in 3 sub-districts, namely Bangsri, Kembang, and Pakis Aji Districts. No one has done any research on this before. Therefore, it is necessary to assess the land suitability class based on the criteria of physical characteristics so that the land can support sugar palm production and its sustainability. The development of sugar palm on suitable land requires data and information regarding the potential and suitability of land use. Careful and precise planning is needed in making land development decisions that follow the sugar palm criteria to get optimal results. Appropriate planning and decision-making must be based on accurate data and information on land conditions. Therefore, the purpose of this study was to identify the characteristics of the land and its suitability for sugar palm cultivation.

2. Materials and methods

2.1. Study site
Jepara Regency located at 110°9’48,02” to 110°58’37,40” E and 5°43’20,67” to 6°47’25, 83” S. This research was conducted in three districts of Jepara Regency, namely Pakis Aji, Bangsri, and Kembang Districts from August 2020 to January 2021. The average altitude of those three districts is 315 above sea level and temperature 28 °C. Furthermore, soil analysis was conducted at the Faculty of Agriculture, Universitas Sebelas Maret, Surakarta.

2.2. Materials
Computer with ArcGIS 10.4 software, printer, GPS, altimeter, compass, ground drill, hoe and shovel, plastic bags, camera, stationery and other supporting equipment, Jepara Regency RBI Map, soil type map, land use map, slope map, administrative map, and climatological data were used in the present study. In addition, the chemicals such as NaF; H2O; H2O2 10%; HCl 1,2 N; KCNS 10%; K3Fe(CN)6 0.5%; and HCl 10% were used for soil analysis in the field. Furthermore, H2O; ammonium acetate; alcohol; NaCl; concentrated NaOH; Zn; H3BO3 storage solution; HCl 0.1 N; K2Cr2O7; Concentrated H2SO4; CuSO4.K2SO4; Olsen's solution; ammonium molybdate; SnCl2 and standard solution were used for soil analysis in the laboratory.

2.3. Research steps

2.3.1. Land Map Unit (LMU) determination and soil sampling location. The land map unit was determined by overlapping administrative map (scale 1: 40,000 from Indonesia Geospatial Portal 2020), soil type map (Regional Development Planning, Research, and Development Agency of Jepara Regency 2013), slope map (Jepara Regency Map 2020), and land use map by using ArcGIS 10.4 software. The result of overlapping maps in (Figure 1) showed that there was 20 land map unit (LMU).

2.3.2. Field survey and sample/data collection. The purposive sampling method was used for the field survey. There were 3 soil types found in the field: entisols, andisols, and inceptisols. In total, there were 20 land units (9,232.17 ha) across those three districts. At each land unit, there were 20 points were drilled up to 100 cm or until reach bedrock. Furthermore, the soil samples obtained from drilling were directly analyzed in the field by soil rapid analysis for their physical properties, such as texture, consistency, pH, salinity, color, organic matter content, lime content, aeration and drainage. In addition, soil chemical properties analysis was analyzed in the laboratory by collecting soil samples from each LMU. The soil was taken from 30 cm of depth by drilling and repeated 3 times for each location and then stored in plastic bags. Figure 2 shows the average values on precipitation and temperature during the last 10 years (2011-2020) obtained from BPS-Statistics of Jepara Regency. From that data, it can be seen that the highest rainfall or value precipitation was in January at 3,130.57
mm/year and the lowest was in August at 43 mm/year. Meanwhile, the highest temperature was in April of 28.67°C and the lowest was in February of 27.10°C.

Figure 1. Land map unit for sugar palm in Bangsri, Kembang and Pakis Aji Districts, Jepara Regency, Central Java.

Figure 2. The average precipitation and temperature at Jepara Regency during the last 10 years (2011-2020).
2.3.3. Soil analysis in the laboratory. In the laboratory, the soil was air-dried for several days and sifted. Table 1 shows methods used in the laboratory.

| No | Parameter       | Unit | Method                                      | References |
|----|-----------------|------|---------------------------------------------|------------|
| 1. | pH              |      | Elektrometri                                | [7]        |
| 2. | C-organic       | %    | Walkey and Black                            | [8]        |
| 3. | N total         | %    | Kjeldahl                                    | [9]        |
| 4. | P available     | ppm  | Bray I/Olsen                                 | [9]        |
| 5. | K available     | me/100g | Ekstraksi NH_{4}OAc 1 N pH 7 | [9]        |
| 6. | Cation exchange | me/100g | Ekstraksi NH_{4}OAc 1 N pH 7 | [9]        |
| 7. | Base saturation | %    | Ekstraksi NH_{4}OAc 1 N pH 7 | [9]        |
| 8. | Texture         | %    | Pipet                                       | [9]        |
| 9. | Salinity        | dS/m |                                             | [9]        |

2.3.4. Data analysis. In the present study the land suitability class analysis, prediction of the erosion is also needed. The prediction of erosion was determined based on USLE (Universal Soil Loss Equation) method by the equation (1):

\[
A = f \left( R \times K \times L \times S \times C \times P \right)
\]

The prediction of erosion was analyzed for each land unit by overlapping rain intensity, soil type, slope, soil depth, and land use maps to obtain an erosion hazard map. Moreover, after obtaining the final overlay map and results on the erosion calculations, the land suitability class was determined. The determination of the actual land suitability (current suitability) of each land unit in the present study was conducted by using the matching method between land quality and plant growth requirements without any improvement in limiting factors. Furthermore, potential land suitability was determined by considering the input and management actions given to each land unit. After conducting corrective efforts to the limiting factors, the comparison was done one more time between land quality and growth requirements of sugar palm.

3. Results and discussion

To determine the suitability of a particular land, it is necessary to conduct a land suitability analysis, so that the use of the land can be considered [11]. Land suitability is divided into actual land suitability and potential land suitability. Actual land suitability resulted in an assessment based on the current land conditions, without significant improvement and management levels to overcome these limitations [12]. Actual land conditions are in Figure 1, according to [14] after land management is carried out, the land suitability class changes to a level or what is called potential land suitability with each limiting factor. Meanwhile, potential land suitability results in improved land conditions [13]. Land suitability classification (actual and potential land suitability class of sugar palm) was listed in Table 2 and delineated in Figure 3 and Figure 4.

Based on matching results between land characteristics with land suitability for sugar palm in Pakis Aji District, Bangsri District, and Kembang District, land suitability for sugar palm is marginally suitable (S3) and not suitable (N) (Figure 3). Shows the actual land suitability class pada LMU 1, 7, 9, 15, and 16 was marginally suitable (S3) with limiting factors of water availability (wa), rooting condition (rc), nutrient retention (nr) found in with a land area of 1,202.63 ha. Problems with these limiting factors can be fixed in potential land suitability classes with irrigation and liming or by adding organic matter. However, for the limiting factor of the rooting condition (rc) texture, no improvement efforts can be made. So that at LMU 1, 7, 9, 15, and 16 after repairs can be made, the land suitability class becomes S3 (rc).
Table 2. The area of actual and potential land suitability classes for sugar palm.

| Land Map Unit (LMU) | Actual   | Potential | Area | %  |
|---------------------|----------|-----------|------|----|
|                     |          |           |      |    |
| 1                   | S3-wa, rc, nr | S3-rc     | 61.62 | 0.67 |
| 2                   | S3-wa, rc, nr, eh | S3-rc | 225.76 | 2.44 |
| 3                   | S3-wa, rc, nr, eh | S3-rc | 2,660.94 | 28.82 |
| 4                   | S3-wa, rc, nr, eh | S3-rc | 77.77 | 0.84 |
| 5                   | S3-wa, rc, nr, eh | S3-rc | 269.95 | 2.92 |
| 6                   | N-eh     | S3-rc     | 745.71 | 8.08 |
| 7                   | S3-wa, rc, nr | S3-rc     | 48.80 | 0.53 |
| 8                   | S3-wa, rc, nr, eh | S3-rc | 380.94 | 4.13 |
| 9                   | S3-wa, rc, nr | S3-rc     | 14.37 | 0.15 |
| 10                  | S3-wa, rc, nr, eh | S3-rc | 64.84 | 0.70 |
| 11                  | N-eh     | S3-rc     | 1,624.19 | 17.6 |
| 12                  | N-eh     | S3-rc     | 99.58  | 1.08 |
| 13                  | N-eh     | S3-rc     | 167.22 | 1.81 |
| 14                  | S3-wa, rc, nr, eh | S3-rc | 106.53 | 1.15 |
| 15                  | S3-wa, rc, nr | S3-rc     | 710.27 | 7.70 |
| 16                  | S3-wa, rc, nr | S3-rc     | 367.57 | 3.98 |
| 17                  | S3-wa, rc, nr, eh | S3-rc | 527.77 | 5.72 |
| 18                  | N-eh     | S3-rc     | 154.39 | 1.67 |
| 19                  | N-eh     | S3-rc     | 521.83 | 5.65 |
| 20                  | S3-wa, rc, nr, eh | S3-rc | 402.12 | 4.35 |
|                     |           |           | 9,232.17 | 100.00 |

Information: S3= marginally suitable; N= not suitable; wa= water availability; rc= rooting condition; nr= nutrient retention; eh= erosion hazard.

Based on the results of matching soil characteristics data with the growing requirements for palm plants, the actual land suitability class is marginally suitable (S3) with limiting factors such as water availability (wa), rooting condition (rc), nutrient retention (nr), and erosion hazard (eh) at LMU 2, 3, 4, 5, 8, 10, 14, 17, and 20 with an area of 4,716.62 ha. Problems with these limiting factors can be fixed in potential land suitability classes with irrigation efforts; doing liming business or it can be with the addition of organic material; and efforts to reduce the rate of erosion, terracing, contour parallel planting, planting cover crops. However, for the limiting factor of the rooting condition (rc) texture, no improvement efforts can be made. So that at LMU 2, 3, 4, 5, 8, 10, 14, 17, and 20 after repairs can be made, the land suitability class becomes S3 (rc). As well as for the not suitable class (N) with the limiting factor erosion hazard (eh), each of which is found at LMU 6, 11, 12, 13, 18, and 19 with a land area of 3,312.92 ha. Problems on the limiting factors can be corrected at the potential land suitability classes with efforts to reduce the rate of erosion, terracing, contour parallel planting, planting cover crops.

Meanwhile, potential land suitability of the 20 LMU, which consist of various land suitability classes, but for improvements that can be made, they change to class S3, all of them with limiting factors rooting condition (rc), where only these factors cannot be repaired (Figure 4).
Figure 3. Map of actual land suitability for sugar palm.

Figure 4. Map of potential land suitability for sugar palm.

Land improvement efforts in these 3 sub-districts require high management of land characteristics. Because it is classified in the S3 class, this limiting factor requires high costs. If no improvement efforts are made in this class, it will affect the productivity of the land. The limiting factor for water
availability (wa) in the 3 districts in the high rainfall. This can be overcome through weather modification techniques that function to reduce rainfall. However, this technique requires a large cost on each handling. Another way that can be done is to use plant planting methods that can absorb a lot of water and also by managing proper irrigation techniques. Limiting factor erosion hazard (eh) and the slope is very important to be an improvement because it classified as N class. The topographic wetness index is a proxy for soil water content; it is a function of slope and the area of the catchment that drains into a focal pixel [15]. Slope problems can be overcome by terracing techniques. Limiting factors of pH and C-organic can bring on the plant to the minimum productivities of *niira* and sugar palm. Lower base saturation indicates that the base cation content of a field is also lower. Giving lime and fertilizing the soil can overcome lower base saturation [16]. The effort of these limiting factors is the addition of natural fertilizers to the land unit.

4. Conclusion
Based on the research results, the conclusion can be drawn that the actual land suitability class is classified as marginal suitable (S3) with limiting factors such as water availability (wa), rooting condition (rc), nutrient retention (nr), and erosion hazard (eh) as limiting factors and not suitable (N) with erosion hazard limiting factor (eh). Climate change has an impact on weather patterns, one of which is rainfall. Rainfall in 3 sub-districts is high, but improvements can be made which can be done above with appropriate weather modification techniques or irrigation (irrigation) techniques. Improvements to the limiting factor of nutrient retention by adding organic matter, erosion hazard can be improved with terracing techniques, but rooting conditions, especially texture, cannot be improved. Based on the improvement efforts made, the potential land suitability class is classified as Marginal Suitable (S3) with a texture limiting factor.

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