Utilization of spatial technology in making land suitability class map for mango (*Mangivera indica L.*) plants in south langowan district, Minahasa East Coast

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Abstract. Land suitability evaluation is very important in the process of matching land types to specific uses. This study aims to make a map of the distribution of land suitability classes for mango plants in South Langowan District by utilizing Spatial Technology. This research was conducted using field survey and geoprocessing methods. Data collection techniques are documentation, observation, and laboratory analysis. Determination of land suitability classes using the method from FAO, namely matching the observation variables there the conditions for growing mango (Mangivera indica L.) plants and land quality/characteristics. In this study, 30 land map units covering an area of 4910.82 Ha were obtained which were spread over several villages in South Langowan District. The resulting land suitability class map is S1 land suitability class (Highly suitable) for nutrient retention criteria and available nutrients. While the criteria for temperature and rooting media are included in the land suitability class S2 (Moderately suitable) and for the criteria for water availability and the level of erosion hazard are generally included in class S3 (Marginally suitable). While the level of erosion hazard is a criterion that gives class N (Not suitable) for mango plants in 12 (twelve) land mapping units with an area of 258.16 Ha or around 5.26%. Meanwhile, 18 (eighteen) land mapping units covering an area of 4652.66 Ha, or around 94.74% are suitable for the development of mango plants.

1 Introduction

1.1 Background

Mango (Mangifera indica L.) is a fruit plant that has a high selling value in the local market. In the world, mango plants are included in a group of five main fruit crops besides bananas, oranges, grapes, and apples [1]. In general, the world market requires mangoes for industrial raw materials (processed fruit) and to meet consumption needs as a table fruit. Mango plants are also widely developed in Indonesia, including the Minahasa Regency. However, mango

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production in Minahasa Regency continues to decline every year. Based on data from the Central Bureau of Statistics [2], mango production in Minahasa Regency decreased from 4243 quintals in 2020 to 1964 quintals in 2022. Meanwhile, mango production in Langowan Selatan District was recorded at only 98 quintals in 2020. This shows that mango production in Langowan Selatan District is still very minimal. In addition, mango farmers in this area generally use mangoes for their own consumption and have not thought about marketing them on a large scale.

In line with the plan to develop mango horticulture, in South Langowan District, one of the main performance targets set is the establishment of fruit crop production center areas through cultivation facilities and infrastructure that can be utilized for land expansion and land optimization through improved business management and plant maintenance. However, the horticultural development plan for mango plants in the South Langowan District will face many challenges. The biggest challenge that must be faced is that the increasing population growth causes an increase in the need for agricultural land, this is what drives the reduction of fertile agricultural land and has the potential to meet the needs of life.

In an effort to obtain suitable land for the development of horticultural commodities, especially mango plants, an instrument that can be scientifically justified is needed. One of the instruments used is the land evaluation approach, which is an assessment that provides information on potential and or land use as well as production expectations that may be obtained as well as environmentally friendly land use [3]. The results of the land evaluation will provide information and/or directions for land use as needed [4]. So that by evaluating the land, it can know the locations that are suitable for a plant, the land suitability class, and the characteristics of the land for a plant.

South Langowan Sub-District is a sub-district located in the Minahasa East Coast tourism area, where this area is experiencing quite rapid development as the infrastructure for the Trans Sulawesi road network is being built. The beauty of the beach is a natural attraction that has been hidden all this time and is now being visited by local and foreign tourists. By looking at the potential of this tourism area, also to add economic value to the surrounding community, it is important to pay attention to South Langowan District so that it can be transformed into a mango production center area. This research study on the Utilization of Spatial Technology in the Making of Land Suitability Class Maps for Mango (Mangivera indica L.) Plants in South Langowan District, Minahasa East Coast was carried out to answer the community's needs in managing mango plants according to the characteristics of the land so that it influences the development of sustainable mango production in the area.

1.2 Formulation of the Problem

How to make a map of the distribution of land suitability classes for mango plants in South Langowan District by using spatial technology?

1.3 Research Purposes

Make a map of the distribution of land suitability classes for mango plants in South Langowan District by utilizing spatial technology.

1.4 Benefits of Research

This research is expected to provide benefits in the form of land suitability information to land users, namely farmers, the government, and the private sector in the development of sustainable mango crop production.

2 Methodology

2.1 Research Sites

This research was conducted in the South Langowan District, Minahasa Regency, North Sulawesi Province. South Langowan District has an area of ± 7009.06 Ha or around 70.09 Km2 which consists of 10 Villages. Temboan Village is the village with the largest area, namely 2363.53 Ha or around 33.72% of the area of South Langowan District. Meanwhile, the village with the smallest area is the capital of South Langowan District, namely Winebetan Village, which has an area of 74.95 hectares or around 1.07% of the area of South Langowan District. A map of research locations can be seen in Figure 1.

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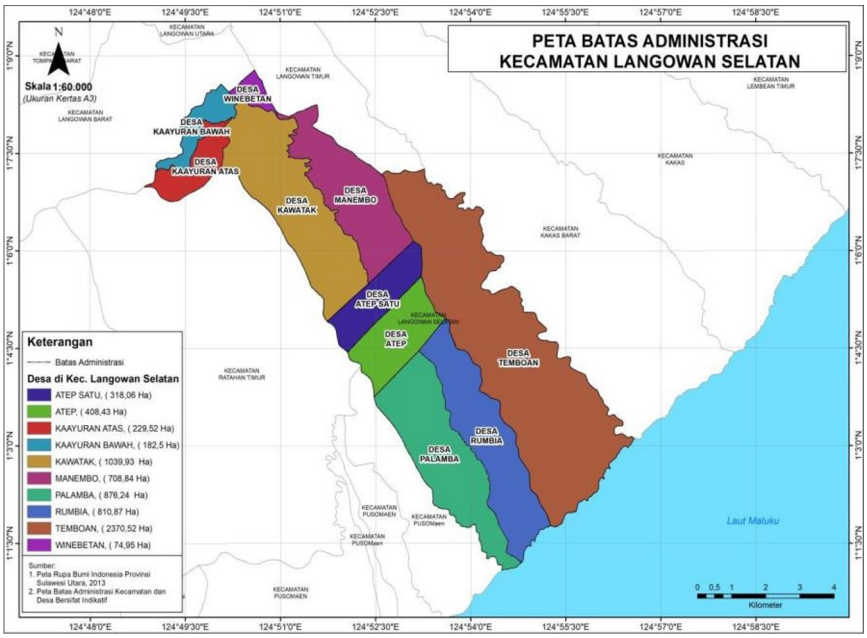

Fig. 1 Administrative Boundary Map of South Langowan District.

2.2 Tools and Materials

The tools used are a set of personal computers (PC) with software, Arc GIS 10.4 Software, Ms. Excel 2010, Avenza Map, and fieldwork equipment consisting of: an earth drill, compass, plastic, meter, camera, and stationery. The materials used in the study were soil samples, slope maps, soil type maps, land use maps, administrative maps of South Langowan District, SAS Planet Software, and chemicals for laboratory tests.

2.3 Research Methods

The method used in this study is the matching method which aims to analyze the condition of the land in the field with the criteria or conditions for growing mango plants [5]. This study used land units as populations and each land unit was sampled by purposive sampling according to the purpose of the land map unit. Land units in the South Langowan District are obtained from the results of map overlays in the ArcGIS application using a geographic information system. The maps that are overlaid are slope maps, soil type maps and land use

maps, each with a scale of 1:50,000 obtained from the Topographic Map of Indonesia (RBI map) and the Spatial Plans and Regional Plans (RTRW) of Minahasa Regency. The research data were taken through field observations, laboratory tests and collection of primary and secondary data, then processed in ArcGIS and analyzed spatially to determine the land suitability classification of mango plants and their distribution map in South Langowan District. The results of the assessment are in the form of land suitability classes and subclasses. Land suitability classes and subclasses are determined from the heaviest limiting factors. Land boundaries can consist of one or more land characteristics. Criteria for land suitability for mango (Mangivera indica L.) plantations can be seen in Table 2.

The research variables are as follows: (1) C-Organic (Walkey Kjedahl Method); (2) Total Nitrogen (Kjedahl Method); (3) P available (Bray I method); (4) K available (Bray I method); (5) pH (pH meter); (6) Climate data (rainfall and average temperature); (7) Soil texture (Kang Biaw Tjwan and Putu Djapa Winaya pipette method); (8) Slope; (9) Soil depth; (10) Soil Structure.

2.4 Research Flow Chart

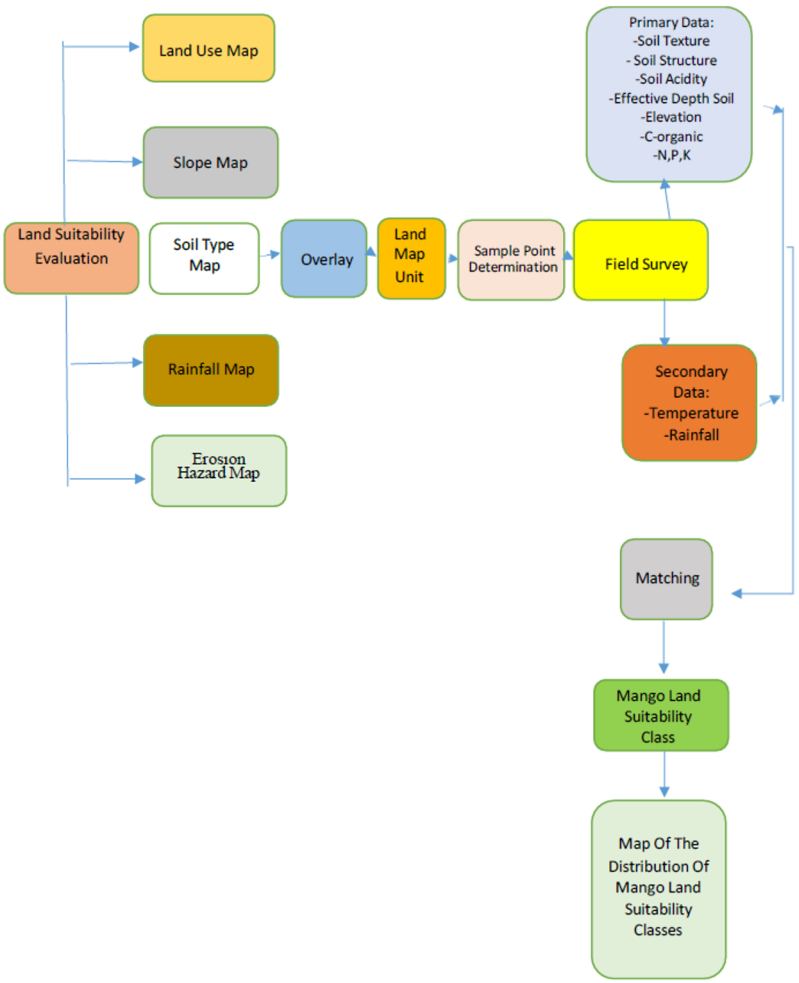

Fig. 2 Research Flow Chart.

Table 1 Criteria for Land Suitability for Mango Plants (Mangifera indica L.) [6].

Land Quality/ Characteristics	**Symbol**	**Land Suitability Class**			
		S1	**S2**	**S3**	**N**
Temperature	(t)				
Annual Average (^{0}C)		28-30	>30-31	>32	Td
			24<28	<24	
Water availability	(w)	()			
Dry Month (<75 mm)		>5-7	NA	NA	>7
		3<4			<3
Rainfall/Year (mm)		1000-1500	>1500-2000	<750-1000	<750
				>2000-2500	>2500
Humidity (%) at Harvest		>42	>36-42	30-36	<30
Rooting Media Soil Drainage	(r)				
		Excessively Drained	Moderately Well Drained	Imperfectly Drained	NA
Texture		L, Sil, SC L, SC	C, SL, SC	hC, Str C	
Effective Depth (cm)		>150	100-150	75-100	<75
Nutrient Retention	(f)				
CEC Soil		>Moderate	Poor	Very Low	-
Moisture Availability (%)		>35	20-35	<20	-
Soil pH		6.0-7.0	5.5<6.0	4.5<5.5	NA
			>7.0-7.5	7.5-8.0	
C-Organic (%)		>0.8	<0.8	>7.5-8.0	NA
Toxicity	(x)				
Salinity (mmhos/cm)		<2	2-6	>6-10	NA
		>15	15-20	20-25	>25
Sodisity (Alkalinitas/ESP) (%)		-	-	-	-
		>125	100-125	60-100	<60
Nutrients Available	(n)				
Total N		>Moderate	Poor	Very Low	NA
P_2O_5		>Moderate	Poor	Very Low	NA
K2O		High	Moderate	Poor	NA
Erosion Hazard	(e)				
Erosion Hazard		SR	R	S	B
Slope (%)		<3	3-8	>8-15	>15-25
Flood Hazard	(b)	F0	F0	F1	F2

Caption:
NA : Not Applicable S : Sand
Str C : Clay particle Si : Sand Particle
L : Loam

3 Results and Discussion

3.1 Land Unit

Land units are location groups related to land forms that have certain characteristics of one region to another. In this study, land units were obtained from land use maps, slope maps and soil type maps, rainfall maps and erosion hazard maps.

3.1.1 Land Use in South Langowan District

Based on data from the 2013 Indonesian Topographical Map of North Sulawesi Province, there are 11 (eleven) types of land use in South Langowan District. This land use is dominated by plantations/gardens covering an area of 5448.90 Ha or around 77.74% of the area of South Langowan District. Land use in South Langowan District can be seen in Table 2. and a map of the distribution of land use in Figure 3.

Table 2 Land Use in South Langowan District.

Land Use	Areas (Ha)	Percentage (%)
Pond Water	0.21	0.003
Swamp Water	2.36	0.03
Beach Tourism / Recreation	0.23	0.003
Sand / Sand Dunes Land	0.14	0.002
Sand / Sea Sand Dunes	0.01	0.000
Plantation / Garden	5448.90	77.74
Settlements and Places of Activity	73.94	1.05
Ricefield	173.67	2.48
Shrubs / Reeds	1049.77	14.98
Vacant / Bare Land	4.44	0.06
Moor / Field	255.38	3.64
Total	**7,009.06**	**100**

Source: Topographic Map of Indonesia (RBI map) of North Sulawesi Province (2013)

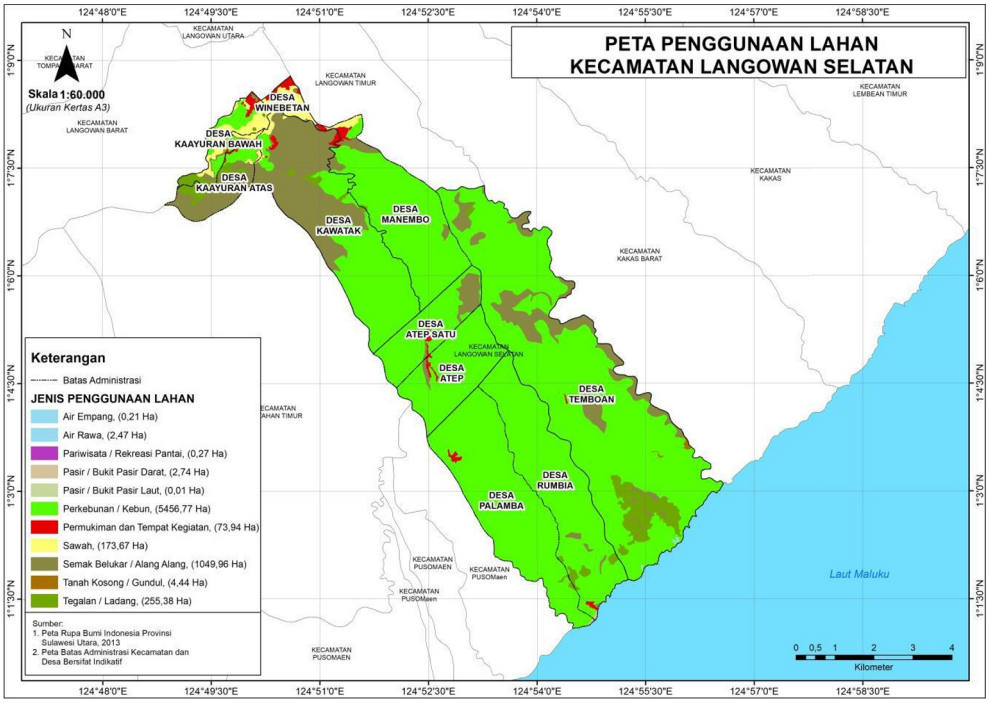

Fig. 3 Land Use Map of South Langowan District.

3.1.2 Slope in South Langowan District

Based on the results of the analysis of land potential in South Langowan District, 3 (three) slope classes were obtained. Most of the area of South Langowan District belongs to the high slope category (15-40%) with an area of 5694.21 Ha or around 81.24% of the area of South Langowan District. And there are no flat areas in South Langowan District. Slope classes in South Langowan District can be seen in Table 3 and the distribution map of slope classes in Figure 4..

Table 3 Slope in South Langowan District.

Slope Classes	Areas (Ha)	Percentage (%)
Moderat Slope (5-15%)	112.80	1.61
High Slope (15-40%)	5694.21	81.24
Very Steep (>40%)	1202.05	17.15
Total	**7,009.06**	**100**

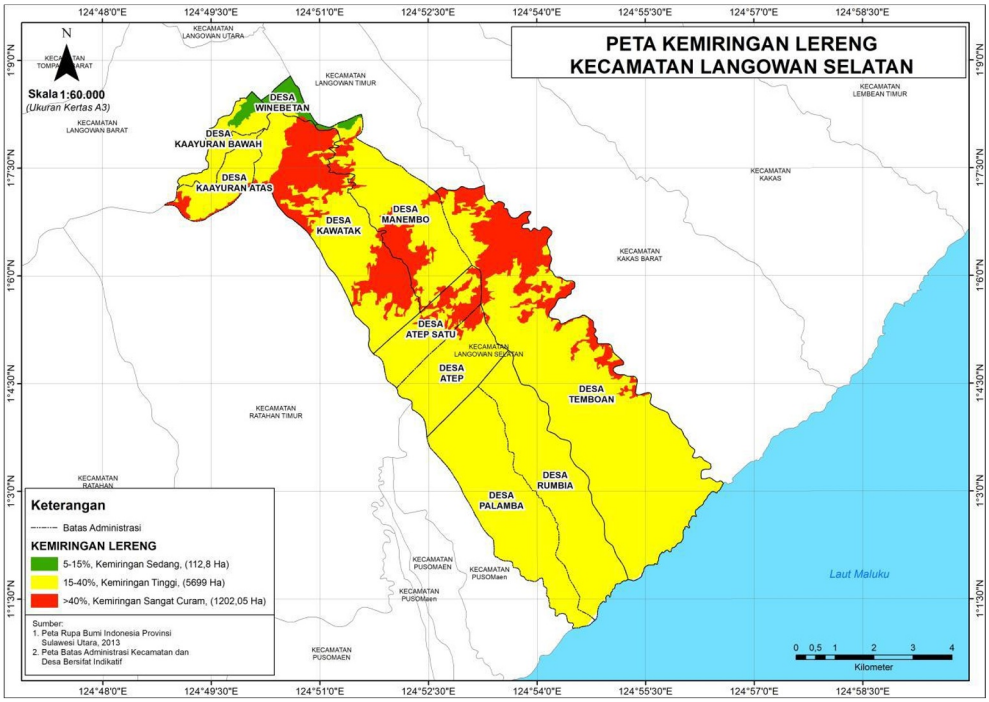

Fig. 4 Slope Map of South Langowan District.

3.1.3 Soil Types in South Langowan District

Classification of different types of soil is based on the nature of the soil which requires different processing treatments. Most of the area of South Langowan District has Eutropepts and Dystropepts soil types with an area of 5093.73 Ha or around 72.67% and 1774.11 Ha or 25.31% of the area of South Langowan District respectively. Eutropepts is a soil type that has an argillic horizon with low base saturation (<35%) which decreases with soil depth. These soil types are reddish-brown lateric soils and red-yellow podzolic soils. Dystropepts is a type of soil in the humid region that has a laterated horizon but does not show extreme illuviation and weathering. These soil types are brown forest, humic hill, and low humic hill

[7]. Soil types in South Langowan District can be seen in Table 4 and a map of the distribution of soil types in Figure 5.

Table 4 Soil Types in South Langowan District.

Soil Types	Areas (Ha)	Percentage (%)
Dystropepts	1774.11	25.31
Eutropepts	5093.73	72.67
Tropaquepts	141.22	2.01
Total	**7,009.06**	**100**

Source: North Sulawesi Province of Spatial Plans and Regional Plans (RTRW) Map (2014-2024).

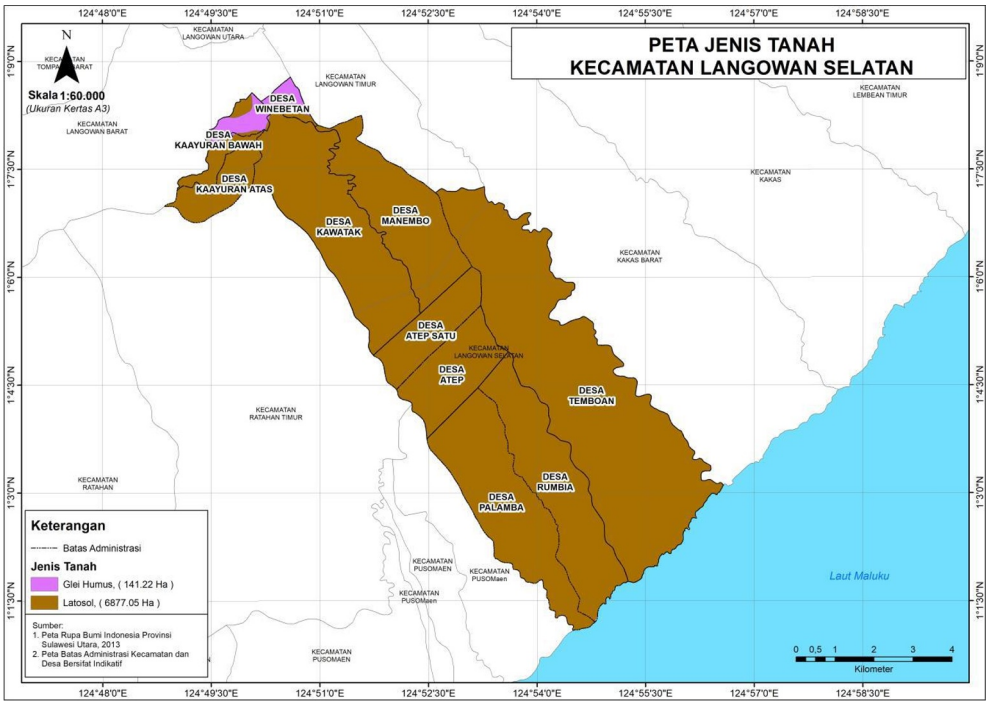

Fig. 5 Map of Soil Types of South Langowan District.

3.1.4 Erosion Hazard Level in South Langowan District

The potential for soil erosion that occurs in South Langowan District, Minahasa Regency tends to have a moderate erosion potential level (S) with an erosion rate of 60-180 tonnes/ha/year. This level of erosion hazard has the largest area, namely 5162.51 Ha or around 73.65% of the area of South Langowan District. The level of erosion hazard in South Langowan District can be seen in Table 5 the distribution map is shown in Figure 6.

Table 5. Erosion Hazard Level in South Langowan District.

Erosion Hazard Level (TBE)	Erosion Rate (ton/ha/year)	Areas (Ha)	Percentage (%)
Very Light (SR)	< 15	7.65	0.11
Slight (R)	15 – 60	712.66	10.17
Medium (S)	60 – 180	5162.51	73.65
Severe (B)	180 – 480	1078.84	15.39
Very Heavy (SB)	> 480	47.40	0.68
Total		**7,009.06**	**100**

Source: USLE Erosion Analysis Results (2023).

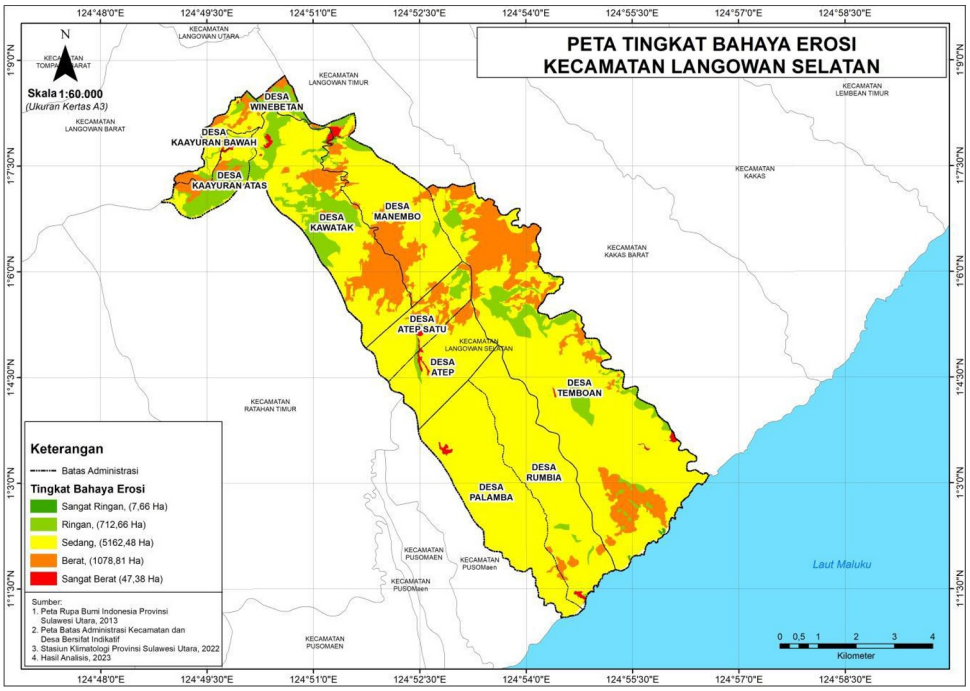

Fig. 6 Erosion Hazard Level Map of South Langowan District.

3.1.5 Rainfall in South Langowan District

Based on data obtained from the Meteorology Climatology and Geophysics Council (BMKG) North Minahasa Climatology Station, North Sulawesi Province, the average rainfall throughout 10 (ten) years, namely 2011 – 2021 in South Langowan District, is around 2000 – 2500 mm. It is known that the height of the South Langowan sub-district is 801 meters above sea level (Minahasa Regency in Figures, 2022). Rainfall in South Langowan District can be seen in Table 6 and a map of rainfall in South Langowan District is shown in Figure 7.

Table 6. Rainfall in South Langowan District.

Rainfall (mm)	Areas (Ha)	Percentage (%)
2000 - 2500 (Moderate)	7,009.06	100.00
Total	**7,009.09**	**100**

Source: The Meteorology Climatology and Geophysics Council (BMKG) Station on North Minahasa (2011-2021)

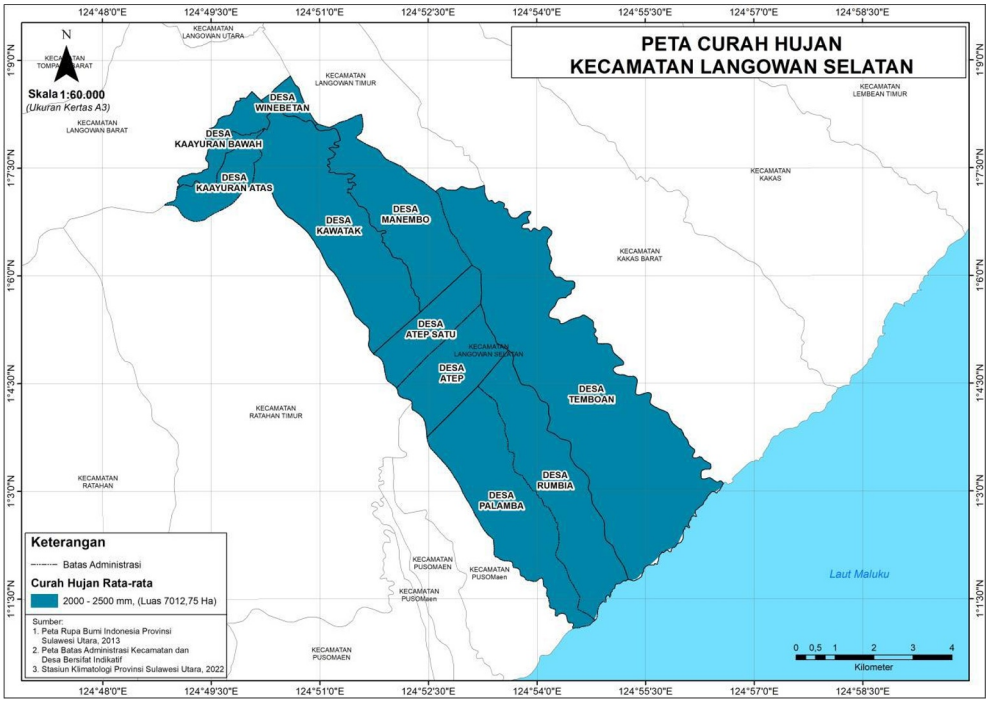

Fig. 7. Rainfall Map of South Langowan District.

3.1.6 Land Unit of South Langowan District

Based on the overlay results of land use maps, soil types, rainfall and erosion hazard levels, 432 land units were obtained with each land characteristic. After that, sorting the classification of land suitability for mango plants was carried out with limitations on land that was used only for plantations/gardens and fields/fields so that 30 land units were obtained. The land units in South Langowan District obtained from the dissolved results can be seen in Table 7 and the map of land units in South Langowan District in Figure 8.

Table 7 Land Unit of South Langowan District.

Land Unit	Land Use	Soil	Rainfall (mm)	Erosion Hazard Level
1	Plantations / Gardens	Eutropepts	2000 - 2500	Moderate
2	Plantations / Gardens	Eutropepts	2000 - 2500	Moderate
3	Plantations / Gardens	Eutropepts	2000 - 2500	Moderate
4	Moor / Field	Dystropepts	2000 - 2500	Strong
5	Moor / Field	Eutropepts	2000 - 2500	Strong
6	Plantations / Gardens	Dystropepts	2000 - 2500	Moderate
7	Plantations / Gardens	Tropaquepts	2000 - 2500	Strong
8	Plantations / Gardens	Eutropepts	2000 - 2500	Moderate
9	Plantations / Gardens	Tropaquepts	2000 - 2500	Moderate
10	Plantations / Gardens	Eutropepts	2000 - 2500	Slight
11	Moor / Field	Dystropepts	2000 - 2500	Strong

12	Moor / Field	Tropaquepts	2000 - 2500	Strong
13	Moor / Field	Eutropepts	2000 - 2500	Strong
14	Plantations / Gardens	Dystropepts	2000 - 2500	Moderate
15	Plantations / Gardens	Eutropepts	2000 - 2500	Moderate
16	Plantations / Gardens	Eutropepts	2000 - 2500	Moderate
17	Moor / Field	Dystropepts	2000 - 2500	Strong
18	Plantations / Gardens	Dystropepts	2000 - 2500	Moderate
19	Plantations / Gardens	Eutropepts	2000 - 2500	Moderate
20	Plantations / Gardens	Dystropepts	2000 - 2500	Slight
21	Moor / Field	Dystropepts	2000 - 2500	Strong
22	Plantations / Gardens	Eutropepts	2000 - 2500	Moderate
23	Moor / Field	Eutropepts	2000 - 2500	Strong
24	Plantations / Gardens	Eutropepts	2000 - 2500	Moderate
25	Moor / Field	Eutropepts	2000 - 2500	Strong
26	Plantations / Gardens	Dystropepts	2000 - 2500	Moderate
27	Plantations / Gardens	Eutropepts	2000 - 2500	Moderate
28	Moor / Field	Dystropepts	2000 - 2500	Strong
29	Moor / Field	Eutropepts	2000 - 2500	Strong
30	Moor / Field	Tropaquepts	2000 - 2500	Moderate

Source: Analysis Results (2023)

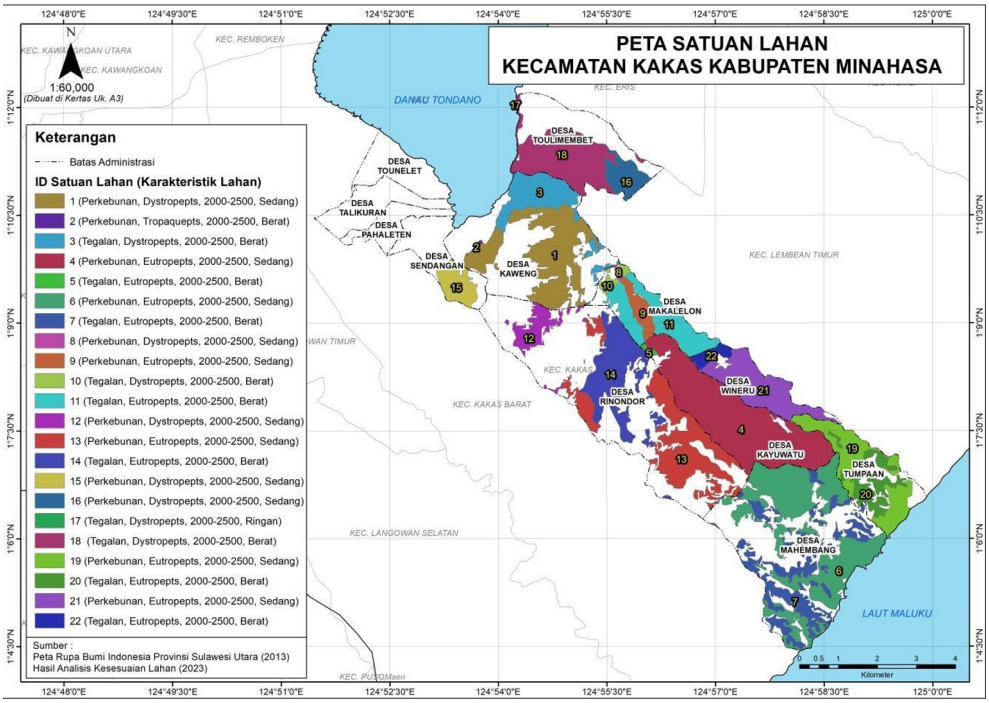

Fig. 8. Land Unit Map of South Langowan District.

3.2 Analysis of Soil Chemical Properties

Based on the results of the analysis, the average C-Organic criterion is in very low condition. The C-organic content reflects the organic matter content in the soil which is used as a reference in conducting management. In addition, organic matter is one of the ingredients for forming soil aggregates which functions as an adhesive between soil particles in the formation of soil structure [8]. This situation is sufficient to determine the success of plant cultivation because organic matter can increase soil fertility both chemically, physically, and biologically. According to research conducted by [9], states that the organic matter content must be maintained at not less than 2%, while based on the results of the analysis the average organic matter content is less than 1%.

Table 8. Results of Analysis of Soil Chemical Properties [12].

Land Unit	Land Use	C-Organik	N	P	K	pH
1	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
2	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
3	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
4	Moor / Field	0.92	20.77	27.22	27.22	5.80
5	Moor / Field	0.08	20.77	27.22	27.22	5.80
6	Plantations / Gardens	0.92	22.11	27.23	27.23	6.40
7	Plantations / Gardens	0.92	22.11	27.23	27.23	6.40
8	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
9	Plantations / Gardens	0.92	22.11	27.23	27.23	6.40
10	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
11	Moor / Field	0.92	20.77	27.22	27.22	5.80
12	Moor / Field	0.92	20.77	27.22	27.22	5.80
13	Moor / Field	0.08	20.77	27.22	27.22	5.80
14	Plantations / Gardens	0.92	22.11	27.23	27.23	6.40
15	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
16	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
17	Moor / Field	0.92	20.77	27.22	27.22	5.80
18	Plantations / Gardens	0.92	22.11	27.23	27.23	6.40
19	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
20	Plantations / Gardens	0.92	22.11	27.23	27.23	6.40
21	Moor / Field	0.92	20.77	27.22	27.22	5.80
22	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
23	Moor / Field	0.08	20.77	27.22	27.22	5.80
24	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
25	Moor / Field	0.08	20.77	27.22	27.22	5.80
26	Plantations / Gardens	0.92	22.11	27.23	27.23	6.40
27	Plantations / Gardens	0.08	22.11	27.23	27.23	6.40
28	Moor / Field	0.92	20.77	27.22	27.22	5.80
29	Moor / Field	0.08	20.77	27.22	27.22	5.80
30	Moor / Field	0.92	20.77	27.22	27.22	5.80

Meanwhile, the content of soil conditions at the study site still needed an N element for soil fertility to improve soil quality, especially to support the vegetative period of plants according to the function of the N element. will be green) and helps the process of protein formation. Lack of protein will cause plant growth to be depressed, leaves become dry, root growth is limited and leaves tend to fall off easily [10]. The land unit with the smallest erosion hazard index value (low) of 0.04 has an erosion rate of 1.27 tons/ha/year ID 323 with an area of 111.09 ha. This land unit is scattered in the upstream of Kamenti Tulap watershed in

KapataranVillage and Kayubesi Village with moderately sloping conditions and it's utilized as a mixed garden.

The available P content in South Langowan District was 27.23 ppm and was classified as being in the moderate criteria. According to [10], phosphorus plays a role in cell division, the formation of flowers, fruits, and seeds, accelerating maturation, stems not easily collapsing, and root development. Meanwhile, the K-available content is moderate. The role of potassium nutrient in plant metabolism is very large, potassium nutrient also serves to strengthen the stem. If the quality of the stems of the plants is not good because of low potassium in the soil and in the plants, the plants will be easily attacked by pests and diseases through the plants. In addition, potassium functions to activate enzymes, and regulate the absorption of other elements and root growth [6].

The soil pH in South Langowan District is in the range of 5.8-6.4 (classified as slightly acidic). In this pH range, most of the nutrients are easily available, both macro and micronutrients. Soil pH is very influential for plant growth both directly and indirectly [11]. If the pH is below 5.5, it should be limed with dolomite. Soil pH is important because soil organisms and plants are very responsive to chemical properties and their environment. The results of the analysis of organic-C, total- N, available-P, available-K, and soil pH in the South Langowan District are presented in Table 3.7.

3.3 Analysis of Soil Physical Properties

The results of the analysis of the physical properties of the soil used in South Langowan District are temperature, rainfall, soil depth, and the level of erosion hazard. The results of the analysis of the physical properties of the soil are presented in Table 9..

Table 9. Results of Analysis of Soil Physical Properties [12].

Land Unit	Land Use	Temperature (^{0}C)	Rainfall (mm/tahun)	Soil Depth (cm)	Erosion Hazard Level
1	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
2	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
3	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
4	Moor / Field	26.60	2000 - 2500	100-150	Strong
5	Moor / Field	26.60	2000 - 2500	100-150	Strong
6	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
7	Plantations / Gardens	26.60	2000 - 2500	100-150	Strong
8	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
9	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
10	Plantations / Gardens	26.60	2000 - 2500	100-150	Slight
11	Moor / Field	26.60	2000 - 2500	100-150	Strong
12	Moor / Field	26.60	2000 - 2500	100-150	Strong
13	Moor / Field	26.60	2000 - 2500	100-150	Strong
14	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate

15	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
16	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
17	Moor / Field	26.60	2000 - 2500	100-150	Strong
18	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
19	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
20	Plantations / Gardens	26.60	2000 - 2500	100-150	Slight
21	Moor / Field	26.60	2000 - 2500	100-150	Strong
22	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
23	Moor / Field	26.60	2000 - 2500	100-150	Strong
24	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
25	Moor / Field	26.60	2000 - 2500	100-150	Strong
26	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
27	Plantations / Gardens	26.60	2000 - 2500	100-150	Moderate
28	Moor / Field	26.60	2000 - 2500	100-150	Strong
29	Moor / Field	26.60	2000 - 2500	100-150	Strong
30	Moor / Field	26.60	2000 - 2500	100-150	Moderate

3.4 Evaluation of Land Suitability for Mango Plants

From the results of the land suitability class study, an overview of the conditions of each land mapping unit (SPL) was obtained. Land suitability classes for Mango (Mangifera indica L.) in South Langowan District can be seen in Table 10 below and a map of the distribution of land suitability classes can be seen in Figure 9.

Table 10 Land Suitability Class for Mango Plants in South Langowan.

Land Unit	Land Use	Villages	Land Suitability Classes	Information	Areas (Ha)
1	Plantations / Gardens	Atep	S3	Marginally suitable	373.18
2	Plantations / Gardens	Atep Satu	S3	Marginally suitable	201.99
3	Plantations / Gardens	Kaayuran Atas	S3	Marginally suitable	32.53
4	Moor / Field	Kaayuran Atas	N	Not Suitable	25.94
5	Moor / Field	Kaayuran Atas	N	Not Suitable	15.25
6	Plantations / Gardens	Kaayuran Bawah	S3	Marginally suitable	0.10
7	Plantations / Gardens	Kaayuran Bawah	N	Not Suitable	17.04
8	Plantations / Gardens	Kaayuran Bawah	S3	Marginally suitable	25.72

9	Plantations / Gardens	Kaayuran Bawah	S3	Marginally suitable	11.26
10	Plantations / Gardens	Kaayuran Bawah	S2	Moderately Suitable	4.40
11	Moor / Field	Kaayuran Bawah	N	Not Suitable	1.54
12	Moor / Field	Kaayuran Bawah	N	Not Suitable	1.78
13	Moor / Field	Kaayuran Bawah	N	Not Suitable	18.43
14	Plantations / Gardens	Kawatak	S3	Marginally suitable	200.22
15	Plantations / Gardens	Kawatak	S3	Marginally suitable	9.71
16	Plantations / Gardens	Kawatak	S3	Marginally suitable	109.56
17	Moor / Field	Kawatak	N	Not Suitable	10.01
18	Plantations / Gardens	Manembo	S3	Marginally suitable	420.57
19	Plantations / Gardens	Manembo	S3	Marginally suitable	80.71
20	Plantations / Gardens	Manembo	S2	Moderately Suitable	0.02
21	Moor / Field	Manembo	N	Not Suitable	1.23
22	Plantations / Gardens	Palamba	S3	Marginally suitable	865.29
23	Moor / Field	Palamba	N	Not Suitable	4.03
24	Plantations / Gardens	Rumbia	S3	Marginally suitable	772.58
25	Moor / Field	Rumbia	N	Not Suitable	21.55
26	Plantations / Gardens	Temboan	S3	Marginally suitable	35.36
27	Plantations / Gardens	Temboan	S3	Marginally suitable	1508.03
28	Moor / Field	Temboan	N	Not Suitable	2.44
29	Moor / Field	Temboan	N	Not Suitable	138.92
30	Moor / Field	Winebetan	S3	Marginally suitable	1.43
Total Areas				**4910.82**	

Source: Analysis Results (2023).

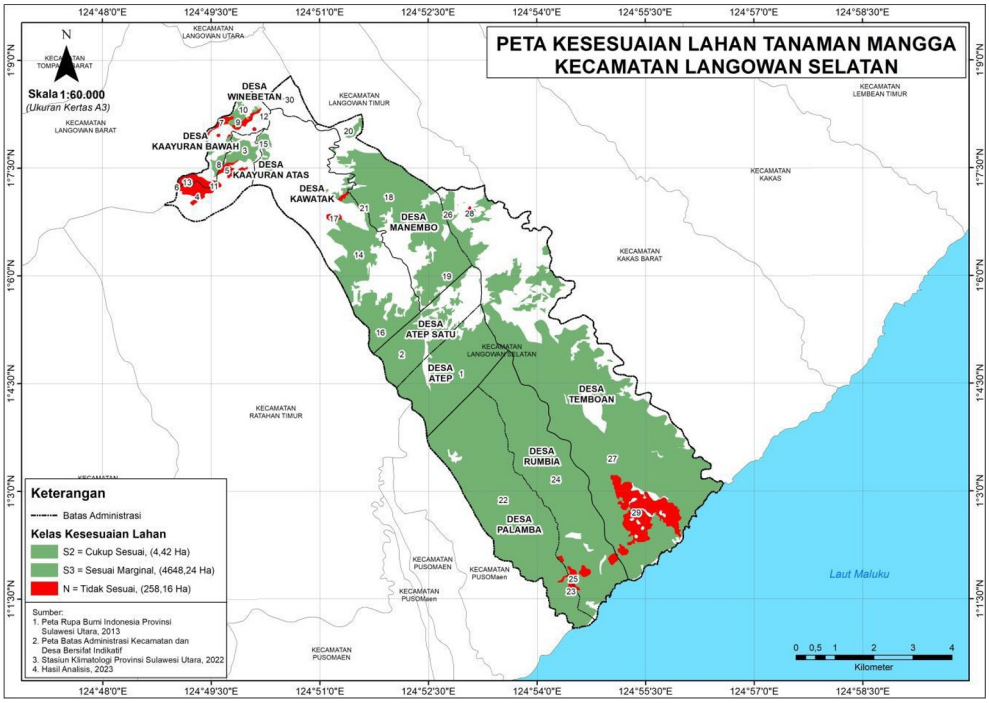

Fig. 9. Land Suitability Map for Mango (Mangivera indica L.) Plants in South Langowan District.

4 Conclusion and Recommendation

4.1 Conclusion

In this study, 30 land mapping units covering an area of 4910.82 Ha were obtained which were spread over several villages in Kakas District, namely Atep, Atep Satu, Kaayuran Atas, Kaayuran Bawah, Kawatak, Manembo, Palamba, Rumbia, Temboan, and Winebetan Villages. Land suitability for the development of mango (Mangivera indica L.) plants in Kakas District is in the S1 land suitability class (Highly suitable) for the criteria for nutrient retention and available nutrients, while the temperature and rooting media criteria are included in the S2 land suitability class (Moderately suitable) and for the criteria for water availability and hazard level. Erosion is generally included in class S3 (Marginally suitable). The level of erosion hazard is a criterion that gives class N (Not suitable) for mango plants in 12 (twelve) with an area of 258.16 Ha or around 5.26%. Meanwhile, 18 (eighteen) land units covering an area of 4652.66 Ha or around 94.74% are suitable for the development of mango plants.

4.2 Recommendation

For the development of mango plants in Kakas District, it is necessary to improve or mitigate the limiting factors for the land suitability class of mango (*Mangivera indica L.*) plants.

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