

Spatial Distribution Analysis of Soil Fertility Levels in Lembo Sub-District, North Konawe District

Fitria Asgianti Lasahari¹, Ahmad Hidayat¹, La Ode Hadini¹

¹Department of Geography, Faculty of Mathematics and Natural Sciences, Universitas Halu Oleo, Indonesia

ARTICLE INFO

Keywords: Soil fertility; C-organic; KB; P^2O_5 ; K^2O_5 ; KTK

Received: April 30, 2024

Accepted: Mei 30, 2024

Published: June 1, 2024

ABSTRACT

Lembo Sub-district possesses extensive agricultural land with the potential to achieve sustainable food self-sufficiency through appropriate land use. This research aims to analyze soil fertility levels and determine the spatial distribution of soil fertility in Lembo Sub-district, North Konawe Regency. The parameters of this study include: C-organic, base saturation (KB), phosphorus pentoxide (P^2O_5), potassium oxide (K^2O_5), and cation exchange capacity (CEC). Materials used in this study include: SHP of Lembo Sub-district, soil type maps, and DEMNAS data. Data were obtained from observations at seven locations and laboratory analysis. The analysis methods used are spatial analysis and quantitative descriptive analysis. The results indicate that: the highest CEC value is 24.60 me/100g and the lowest is 19.80 me/100g; the highest base saturation is 48.70% and the lowest is 29.80%; the highest P^2O_5 value is 16.90 ppm and the lowest is 12.70 ppm. The highest K^2O_5 value is 25.10 me/100g and the lowest is 17.90 me/100g. The highest C-organic value is 1.90% and the lowest is 0.70%. Spatially, soil fertility across Lembo Sub-district is categorized as low (R).

*Corresponding author: flasahari@gmail.com

Introduction

Indonesia consistently develops its economy through the agricultural sector. This focus is driven by Indonesia's abundant natural resources. However, despite government efforts, current measures have not yet met domestic needs. Regional development involves economic growth that considers spatial and temporal variables. The diverse physical and social characteristics of Indonesia's regions present various potentials. These differences in regional potential lead to disparities, such as inter-regional, rural-urban, and income group inequalities.

Fertile soil is crucial for optimal plant growth due to the availability of essential nutrients. Consequently, maximum growth of cultivated plants can be achieved. However, soil fertility alone does not indicate the sufficiency of all growth factors. It must be related to the physical and chemical properties of the soil, encompassing the nutrient needs required by plants. Each

Spatial Distribution Analysis of Soil Fertility Levels in Lembo Sub-District, North Konawe District

soil used for cultivation varies in fertility levels, determined by the management practices applied. These practices are key determinants in the growth outcomes of cultivated plants.

Soil fertility does not merely reflect the types of nutrients present but also their availability (Baja et al., 2007). One factor that can reduce crop yields is nutrient deficiency in the soil. To address this, fertilization can be used to supplement nutrient levels (Puja et al., 2015). The value of soil fertility for agricultural sectors varies significantly. Proper soil management is a critical factor influencing plant growth and yield (Sartohadi et al., 2014). Studying soil fertility involves analyzing soil nutrients and providing fertilization recommendations (Pinatih et al., 2016, in Ahmad et al., 2022).

Lembo Sub-district cultivates various crops, including lowland rice, upland rice, and secondary crops such as maize, soybeans, peanuts, mung beans, cassava, and sweet potatoes. A significant portion of the Lembo Sub-district community in North Konawe Regency relies on agriculture for their economic income. The local community utilizes the available natural resources for their livelihoods. Given this background, the research titled "Analysis of Spatial Distribution of Soil Fertility Levels in Lembo Sub-district" is necessary to determine the soil fertility levels in Lembo Sub-district, North Konawe Regency, and to map the spatial distribution of soil fertility in the region.

Methodology

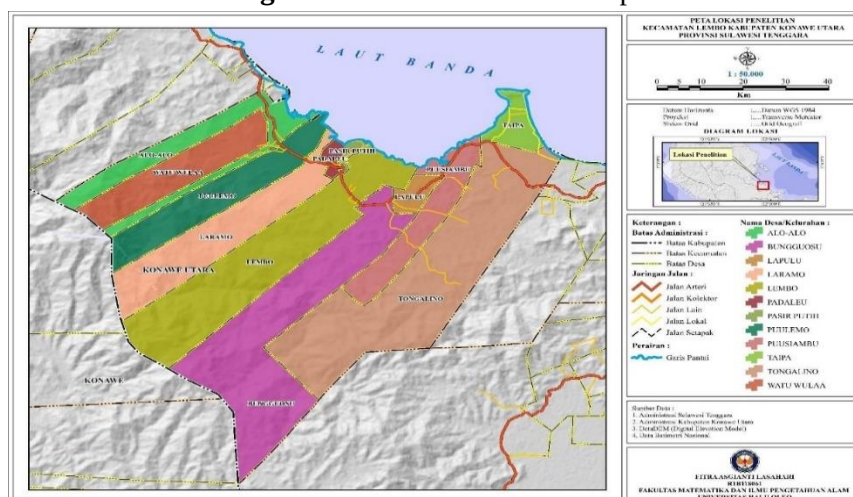
Research Location

Geographically, Lembo Sub-district is located in the northern part of North Konawe Regency, extending from north to south between 02°97' to 03°86' south latitude, and from west to east between 121°49' to 122°49' east longitude. Lembo Sub-district is bordered to the north by Lasolo Sub-district, to the east by the Banda Sea, to the south by Konawe Regency, and to the west by Konawe Regency.

Lembo Sub-district is divided into 12 areas: Tongalino Village, Taipa Urban Village, Puusiambu Village, Bungguosu Village, Lembo Urban Village, Pasir Putih Village, Padaleu Urban Village, Puulemo Village, Alo-Alo Village, Lapulu Village, Laramo Village, and Watu Wula Village.

Lembo Sub-district experiences two seasons: the dry season and the rainy season. The seasonal conditions are heavily influenced by wind currents blowing over the area. From December to May, winds carry moisture from Asia and the Pacific Ocean, resulting in the rainy season. Around September, wind currents become unpredictable, leading to variable rainfall. This transitional season is locally known as "pancaroba."

Figure 1. Research Location Map



Population and Sample

1. Population

The population refers to the general area comprising objects (subjects) with specific qualities and characteristics set by the researcher for study and analysis. In this study, the population is the land use in Lembo Sub-district.

2. Sample

The sample represents a portion of the population with similar characteristics. In this study, the sample includes soil samples collected from field observations, which will be tested in the laboratory. Sampling was done using purposive sampling based on the land unit map of Lembo Sub-district, North Konawe Regency.

Research Data

1. Primary Data

Primary data is collected directly from field surveys. This includes soil samples and the coordinates of sampling points collected during field surveys.

2. Secondary Data

Secondary data is previously collected and reported by others. In this study, secondary data includes references from previous research and data from the Statistics Indonesia (BPS) of North Konawe Regency.

Research Stages

The preparation stage involves initial steps such as data collection, theoretical foundation gathering, understanding the research concept, and processing data. Theoretical foundations are obtained from the internet, books, journals, and other sources to understand the research objectives and issues in the study area. The preparation stage consists of six steps: creating the location map, collecting literature, conducting field observations, laboratory testing, research methods, and data analysis.

1. Creating the Location Map

The location map is created using ArcGIS 10.8 software with data from the administrative SHP of North Konawe Regency, supplemented with SHP of road networks, river networks, coastline, and topographic data from the national digital elevation model (DEMNAS). This map is used to define the study area and administrative boundaries.

2. Collecting Literature

Literature collection involves gathering information and references to support the research. Sources include research journals similar to this study, books, and online media.

3. Field Observation

During field observations, researchers collect soil samples using GPS to locate sampling points based on the land unit map of Lembo Sub-district, North Konawe Regency. Tools used for soil sampling include GPS, hoes, shovels, sample rings, cutters, and stationery.

4. Laboratory Testing

Soil samples collected from the field are tested in the laboratory for chemical properties, including Cation Exchange Capacity (CEC), Potassium (K_2O), Base

Spatial Distribution Analysis of Soil Fertility Levels in Lembo Sub-District, North Konawe District

Saturation, Phosphorus Pentoxide (P_2O_5), and Organic Carbon (C-Organic). These tests determine the soil fertility levels in Lembo Sub-district, North Konawe Regency.

5. Research Methods

This study uses a survey method, combining laboratory analysis and descriptive analysis. Laboratory results are analyzed to determine soil fertility levels in Lembo Sub-district, North Konawe Regency, based on specific criteria.

6. Data Analysis Stages

Data analysis involves using various maps, such as administrative maps, soil type maps, land unit maps, elevation maps, and rainfall maps. These thematic maps support the determination of soil fertility in Lembo Sub-district, North Konawe Regency. The sample results are analyzed using established methods and criteria to determine soil fertility levels. Geographic Information Systems (GIS) are essential in this research to analyze and visualize the spatial distribution of soil fertility in Lembo Sub-district, North Konawe Regency.

Result

Soil Fertility

Based on laboratory analysis of seven soil samples, the following results were obtained for soil fertility parameters:

1. Cation Exchange Capacity (CEC): CEC was predominantly moderate in samples 2, 3, 5, 6, and 7, while samples 1 and 4 exhibited low fertility.
2. Base Saturation: Base saturation was mostly moderate in samples 2, 3, 5, and 7, whereas samples 1, 4, and 6 showed low fertility levels.
3. Phosphorus Pentoxide (P_2O_5): P_2O_5 levels were uniformly low across all seven samples, indicating a general phosphorus deficiency.
4. Potassium Oxide (K_2O_5): K_2O_5 levels were mostly low in samples 1, 2, 3, 6, and 7, with samples 4 and 5 showing very low levels, indicating a critical potassium deficiency.
5. Organic Carbon (C-Organic): Organic carbon levels were predominantly low in samples 1, 2, 3, 4, and 7, with samples 5 and 6 showing very low levels, which can affect soil structure and fertility.

Overall, the soil fertility status for CEC, base saturation, P_2O_5 , K_2O_5 , and C-Organic in samples 1 through 7 was determined to be low.

The analysis of land units in Lembo Sub-district revealed 19 distinct land units, as presented in Table 1 and spatially in Figure 2. Table 2 shows that the largest land unit, H,Hpld, covers 5,956.19 hectares (50.81%), while the smallest unit, T,Edq, covers 9.22 hectares (0.08%).

Table 1. Land Unit Areas in Lembo Sub-district

No	Land Unit	Area (Ha)	Percentage (%)
1	H,Dys	41.56	0.35
2	H,Hpld	5,956.19	50.81
3	Sm,Dys	260.36	2.22
4	Sm,Edq	29.30	0.25
5	Sm,Hpld	492.74	4.20
6	P,Dys	5.93	0.05
7	P,Edq	79.32	0.68
8	P,Hpld	9.24	0.08

9	<i>P,Uds</i>	11.56	0.10
10	<i>M,Dys</i>	20.42	0.17
11	<i>M,Edq</i>	164.66	1.40
12	<i>M,Hpld</i>	348.70	2.97
13	<i>M,Uds</i>	53.43	0.46
14	<i>PLKC,Dys</i>	1,757.64	14.99
15	<i>PLKC,Edq</i>	657.51	5.61
16	<i>PLKC,Hpld</i>	1,656.26	14.13
17	<i>PLKC,Uds</i>	127.76	1.09
18	<i>T,Edq</i>	9.22	0.08
19	<i>T,Hpld</i>	41.74	0.36
<i>Total</i>		11,723.55	100

Figure 2. Land unit map of lembo sub-district

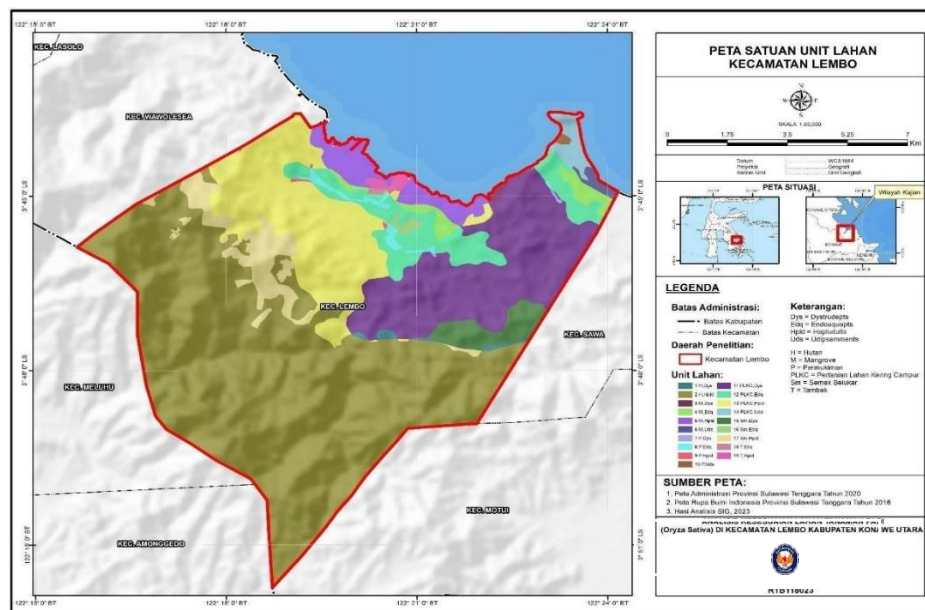
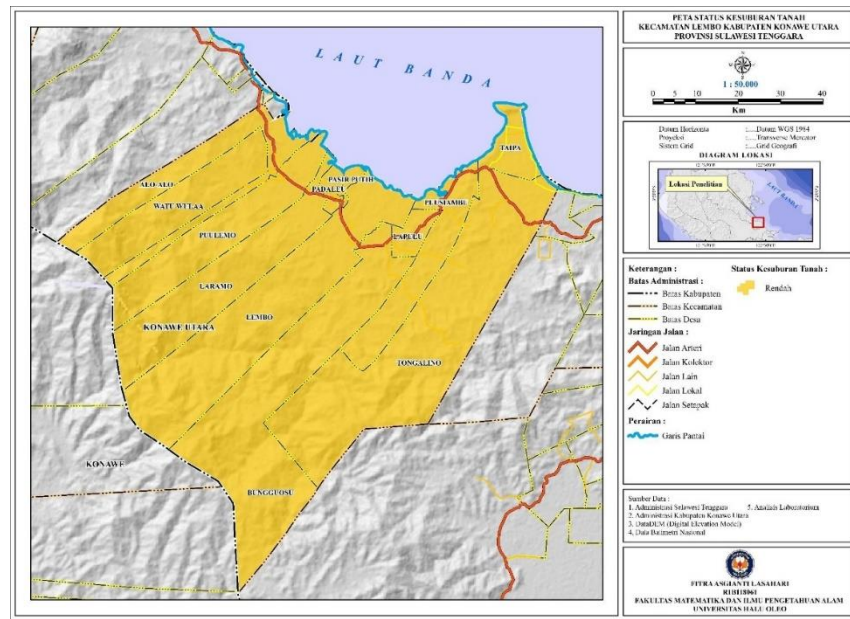


Table 2. Soil Fertility Analysis Results

No	Sample Code	CEC	BS	P2O5	K2O5	C-Organic	Soil Fertility Status
1	Soil 1	R	R	R	R	R	R
2	Soi 2l	S	S	R	R	R	R
3	Soi 3l	S	S	R	R	R	R
4	Soi 4l	R	R	R	SR	R	R
5	Soi 5l	S	S	R	SR	SR	R
6	Soi 6l	S	R	R	R	SR	R
7	Soil 7	S	S	R	R	R	R

For a clearer understanding of the final soil fertility status in Lembo Sub-district, refer to Figure 3.

Figure 3. Soil Fertility Status Map of Lembo Sub-district



Soil Fertility Parameters

1. Cation Exchange Capacity (CEC)

Laboratory analysis of seven soil samples from Lembo Sub-district showed that the highest CEC was 24.60 me/100g in sample 3, which falls into the high category (21-40 me/100g). The lowest CEC was 19.80 me/100g in sample 4, falling into the moderate category (10-20 me/100g). Overall CEC values are presented in Table 4.7.

Tabel 3. Cation Exchange Capacity (CEC) Analysis Results

No	Parameter	Unit	Sample						
			1	2	3	4	5	6	7
1	CEC	Me/100g	20.20	21.70	24.60	19.80	22.30	21.40	23.50
Criteria			R	S	S	R	S	S	S

Key: S (Moderate), R (Low). Source: Laboratory Analysis Results, 2023

2. Base Saturation (KB)

The highest base saturation was 48.70% in sample 7, which falls into the high category (50-70%). The lowest base saturation was 29.80% in sample 1, falling into the low category (20-35%). Overall base saturation values are presented in Table 4.8.

Tabel 4. Base Saturation Analysis Results

No	Parameter	Unit	Sample						
			1	2	3	4	5	6	7
1	Base Saturation	%	29.80	36.70	42.10	34.50	40.60	33.90	48.70
Criteria			R	S	S	R	S	R	S

Key: S (Moderate), R (Low). Source: Laboratory Analysis Results, 2023

3. Phosphorus Pentoxide (P₂O₅)

The highest phosphorus pentoxide (P₂O₅) value was 16.90 ppm in sample 6, which falls into the moderate category (20-40 ppm). The lowest P₂O₅ value was 12.70 ppm in sample 3, falling into the low category (10-20 ppm). Overall P₂O₅ values are presented in Table 5

Spatial Distribution Analysis of Soil Fertility Levels in Lembo Sub-District, North Konawe District

Table 5. Phosphorus Pentoxide (P₂O₅) Analysis Results

No	Parameter	Unit	Sample						
			1	2	3	4	5	6	7
1	P ₂ O ₅	ppm	12.80	13.70	12.70	14.60	13.70	16.90	14.40
Criteria			R	R	R	R	R	R	R

Key: R (Low). Source: Laboratory Analysis Results, 2023

4. Potassium Oxide (K₂O₅)

The highest potassium oxide (K₂O₅) value was 25.10 me/100g in sample 7, which falls into the moderate category (20-40 me/100g). The lowest K₂O₅ value was 17.90 me/100g in sample 5, falling into the low category (10-20 me/100g). Overall K₂O₅ values are presented in Table 4.10.

Table 6. Potassium Oxide (K₂O₅) Analysis Results

No	Parameter	Unit	Sample						
			1	2	3	4	5	6	7
1	K ₂ O ₅	me/100g	21.17	20.64	22.60	18.60	17.90	22.40	25.10
Criteria			R	R	R	SR	SR	R	R

Key: R (Low), SR (Very Low). Source: Laboratory Analysis Results, 2023

5. Organic Carbon (C-Organic)

Organic carbon (C-Organic) analysis of soil samples taken from a depth of 20-70 cm in Lembo Sub-district showed the highest value of 1.90% and the lowest value of 0.70%. Detailed results are presented in Table 7

Table 7. Organic Carbon (C-Organic) Analysis Results

No	Parameter	Unit	Sample						
			1	2	3	4	5	6	7
1	C-Organic	%	1.80	1.60	1.10	1.90	0.70	0.84	1.10
Criteria			R	R	R	R	SR	SR	R

Key: R (Low), SR (Very Low). Source: Laboratory Analysis Results, 2023

Discussion

Soil Fertility Levels

Soil fertility status assessment was conducted according to the technical guidelines for soil fertility evaluation, using specific criteria for soil fertility status. The criteria for soil fertility levels are as follows:

Table 8. Criteria for Evaluating Soil Chemical Properties

No	Parameter	Very low	low	miderate	high	Very high
1	CEC (me/100g)	<5	5-15	16-24	25-40	>40
2	Base Saturation (%)	<20	20-35	36-50	50-70	>70
3	P ₂ O ₅ (ppm)	<10	10-20	21-40	41-60	>60
4	K ₂ O (me/100g)	<10	10-20	21-40	41-60	>60
5	Organic Carbon (%)	<1	1-2	2,01-3	3-5	>5

Source: Technical Guidelines for Soil Fertility Evaluation, PPT (1995 in Ahmad Hidayat, 2022)

Soil Fertility Status

Based on the laboratory analysis, the soil fertility status of the samples from Lembo Sub-district is summarized in Table 9.

Table 9. Soil Fertility Status

No	CEC	Base Saturation	P2O5 K2O5 C-Organik	Soil Fertility Status
1	High	High	2 High Without Low	High
2	High	High	2 High With Low	Moderate
3	High	High	2 Moderate Without Low	High
4	High	High	2 Moderate With Low	Moderate
5	High	High	TSR	Moderate
6	High	High	2 Low With High	Moderate
7	High	Moderate	2 Low With Moderate	Low
8	High	Moderate	2 High Without Low	High
9	High	Moderate	2 High With Low	Moderate
10	High	Moderate	2 Moderate Without Low	Moderate
11	High	Moderate	Other Combinations	Low
12	High	Low	2 High Without Low	Moderate
13	High	Low	2 High With Low	Low
14	High	Low	Other Combinations	Low
15	Moderate	High	2 High Without Low	Moderate
16	Moderate	High	2 High With Low	Moderate
17	Moderate	High	Other Combinations	Low
18	Moderate	Moderate	2 High Without Low	Moderate
19	Moderate	Moderate	2 High With Low	Moderate
20	Moderate	Moderate	Other Combinations	Low
21	Moderate	Low	3 High	Moderate
22	Moderate	Low	Other Combinations	Low
23	Low	High	2 High Without Low	Moderate
24	Low	High	2 High With Low	Low
25	Low	High	2 Moderate Without Low	Sedang
26	Low	High	Other Combinations	Low
27	Low	Moderate	2 High Without Low	Moderate
28	Low	Moderate	Other Combinations	Low
29	Low	Low	All Combinations	Low
30	Very Low	TSR	All Combinations	Very Low

Key: SR (Very Low), R (Low), S (Moderate), T (High), TSR (High, Moderate, Low).

Source: Technical Guidelines for Soil Fertility Evaluation, PPT Bogor, 1995

The assessment of soil fertility status was based on the following criteria: Cation Exchange Capacity (CEC), Base Saturation (KB), Phosphorus Pentoxide (P2O5), Potassium Oxide (K2O), and Organic Carbon (C-Organic). These parameters were measured and categorized according to their respective scales as defined in the technical guidelines.

1. CEC (Cation Exchange Capacity): The highest CEC value was 24.60 me/100g found in sample 3, categorized as high. The lowest CEC value was 19.80 me/100g in sample 4, falling into the moderate category.
2. Base Saturation (KB): The highest base saturation was 48.70% in sample 7, categorized as high, while the lowest was 29.80% in sample 1, falling into the low category.
3. Phosphorus Pentoxide (P2O5): The highest P2O5 value was 16.90 ppm in sample 6, categorized as moderate. The lowest was 12.70 ppm in sample 3, categorized as low. All samples fell into the low category for P2O5.
4. Potassium Oxide (K2O5): The highest K2O5 value was 25.10 me/100g in sample 7, categorized as moderate, while the lowest was 17.90 me/100g in sample 5, categorized as low.

Spatial Distribution Analysis of Soil Fertility Levels in Lembo Sub-District, North Konawe District

5. Organic Carbon (C-Organic): The highest organic carbon content was 1.90% in sample 4, categorized as low. The lowest was 0.70% in sample 5, categorized as very low.

Overall, the soil fertility status across Lembo Sub-district was predominantly low, with variations in specific parameters. The detailed analysis and categorization of each parameter provide a comprehensive understanding of the soil's fertility levels, which is crucial for effective land management and agricultural planning.

Conclusion

Based on the results and discussion, and to address the research objectives, the following conclusions are made:

1. The highest organic carbon (C-Organic) value was found in soil sample 4 (1.90%), while the lowest value was in soil sample 5 (0.70%).
2. The highest potassium oxide (K₂O₅) level was found in soil sample 7 (25.10 me/100g), while the lowest level was in soil sample 5 (17.90 me/100g).
3. The highest phosphorus pentoxide (P₂O₅) level was found in soil sample 6 (16.90 ppm), while the lowest level was in soil sample 3 (12.70 ppm).
4. The highest Cation Exchange Capacity (CEC) value was found in soil sample 3 (24.60 me/100g), while the lowest value was in soil sample 4 (19.80 me/100g).
5. The highest base saturation level was found in soil sample 7 (48.70%), while the lowest level was in soil sample 1 (29.80%).

The spatial distribution of soil fertility in Lembo Sub-district is divided into several soil fertility criteria:

1. Base saturation is predominantly in the moderate fertility category (S).
2. Cation Exchange Capacity (CEC) is also predominantly in the moderate fertility category (S).
3. Phosphorus pentoxide (P₂O₅) is predominantly in the low fertility category (R).
4. Potassium oxide (K₂O₅) is predominantly in the low fertility category (R).
5. Organic carbon (C-Organic) is predominantly in the low fertility category (R).

Overall, the five soil fertility parameters indicate that the soil fertility in Lembo Sub-district is predominantly low (R).

References

- Agustian, I., & Simanjuntak, B. H. (2018). Penilaian Status Kesuburan Tanah Dan Pengelolaannya, Di Kecamatan Karanggede, Kabupaten Boyolali, Jawa Tengah.
- Agustina, C., Kusumarini, N., & Rayes, M. L. (2022). Pemetaan Kelas Kapabilitas Kesuburan Tanah Sebagai Dasar Identifikasi Permasalahan dan Strategi Pengelolaan Lahan Sawah. *Jurnal Tanah dan Sumberdaya Lahan*, 9(2), 421- 429.
- Batu, H. M. R. P., Talakua, S. M., Siregar, A., & Osok, R. M. (2019). Status kesuburan tanah berdasarkan aspek kimia dan fisik tanah di DAS Wai Ela, Negeri Lima, Kabupaten Maluku Tengah, Provinsi Maluku. *Jurnal Budidaya Pertanian*, 15(1), 1-12.
- Bolly, Y. Y., & Apelabi, G. O. (2022). Analisis Kandungan Bahan Organik Tanah Sawah sebagai Upaya Penilaian Kesuburan Tanah di Desa Magepanda Kecamatan Magepanda Kabupaten Sikka. *Agrica: Journal of Sustainable Dryland Agriculture*, 15(1), 26-32.
- Dala, Y., & Mutiara, C. (2019). Evaluasi Kesuburan Tanah Sawah Di Desa Ranokolo Kecamatan Maurole Kabupaten Ende. *AGRICA: Journal of Sustainable Dryland Agriculture*, 12(2), 102-110.

Spatial Distribution Analysis of Soil Fertility Levels in Lembo Sub-District, North Konawe District

- Hidayat, A., Adzima, A. F., & Khairisa, N. H. (2022). Analysis of Soil Fertility Status on Agricultural Land in West Sinjai District. *Tunas Geografi*, 11(1), 65-72.
- Lubis, R. M., & Siregar, D. (2019). Evaluasi status kesuburan tanah kebun kelapa sawit FP-UISU di desa Mancang kecamatan Selesai kabupaten Langkat. *Agriland: Jurnal Ilmu Pertanian*, 7(1), 22-26.
- Megawaty, D. A., & Simanjuntak, R. Y. (2017). Pemetaan Penyebaran Penyakit Demam Berdarah Dengue Menggunakan Sistem Informasi Geografis Pada Dinas Kesehatan Kota Metro. *Explore: Jurnal Sistem Informasi Dan Telematika (Telekomunikasi, Multimedia Dan Informatika)*, 8(2).
- Nganji, M. U., & Sudarma, I. M. A. (2023). Analisis Status Kesuburan Tanah pada Lahan Budidaya Rumput Odot (*Pennisetum purpureum* CV. MOOT) Dengan Perlakuan Pupuk Bokashi Sludge Biogas Berbeda. *Jurnal Tanah dan Sumberdaya Lahan*, 10(2), 223-229.
- Perrina, M. G. (2021). Literature Review Sistem Informasi Geografis (SIG). *Journal of Information Technology and Computer Science (JOINTECOMS)*.
- Prabowo, R., Bambang, A. N., & Sudarno, S. (2019). Analisa Sebaran Kesuburan Tanah Lahan Sawah (Studi Kasus Daerah Pertanian Kota Semarang). *Cendekia Eksakta*, 4(2).
- Rachmadiyanto, A. N., Wanda, I. F., Rinandio, D. S., & Magandhi, M. (2020). Evaluasi kesuburan tanah pada berbagai tutupan lahan di Kebun Raya Bogor. *Buletin Kebun Raya*, 23(2), 114-125.
- Sari, A. N., Muliana, M., Yusra, Y., Khusrizal, K., & Akbar, H. (2022). Evaluasi Status Kesuburan Tanah Sawah Tadah Hujan dan Irigasi di Kecamatan Nisam Kabupaten Aceh Utara. *Jurnal Ilmiah Mahasiswa Agroekoteknologi*, 1(2), 49- 57.
- Siregar, E. G., Adi, I. G. P. R., & Supadma, A. N. (2021). Pemetaan status kesuburan tanah sawah berbasis sistem informasi geografis di Subak Buaji dan Subak Padanggalak Kecamatan Denpasar Timur. *Jurnal Agroekoteknologi Tropika* ISSN, 2301, 6515.
- Subhan, E., Salampak, S., Embang, A. E., & Masliani, M. (2019). Analisis Tingkat Kesuburan Tanah Lahan Bekas Penambangan Batubara PT. Senamas Energindo Mineral Kabupaten Barito Timur Provinsi Kalimantan Tengah. *Media Ilmiah Teknik Lingkungan (MITL)*, 4(2), 34- 40.