SEAS (Sustainable Environment Agricultural Science) E-ISSN 2614-0934
http://ejournal.warmadewa.ac.id/index.php/seas
Volume 08, Number 02, October 2024, Pages:89~95 http://dx.doi.org/10.22225/seas.8.2.10595.89-95

Evaluation of Land Suitability for Coconut Plants in Airmadidi District, North Minahasa Regency, North Sulawesi

Rahadian Adi P[1*], Aditya Dyah Utami[2], Panji Romadhon[3], Heri Setyawan[4]

[1]Argoecotechnology, Mulawarman University, Indonesia
[2,3]Soil Science, Lambung Mangkurat University, Indonesia
[4]Pantation Community Academy Yogyakarta, Indonesia

*Corresponding author. Email: (rahadian_ap@unmul.ac.id)

Abstract

Coconut plants are important for the community because each part has economic value. The community plants coconuts without knowing the suitability class of the land, so there are lands that have less than optimal production levels. The purpose of the study was to identify the actual and potential land suitability classes for coconut plants in Airmadidi District. The research method used was the survey method. Determination of land suitability classes used a matching method between land characteristics and land suitability criteria. The results showed that the actual land suitability class in the Airmadidi District land unit was quite suitable (S2) and marginally suitable (S3) with limiting factors of water availability (wa) in the form of rainfall, nutrient retention (nr) in the form of Soil CEC and nutrient availability (na) in the form of N-Total, P_2O_5 and K_2O. The potential land suitability class in the Airmadidi District land unit was very suitable (S1) and quite suitable (2) with limiting factors of available nutrients (na) in the form of N-Total, P_2O_5 and K_2O.

Keywords: Evaluation, Land Suitability, Coconut, Airmadidi

1. Introduction

North Minahasa Regency is the area with the second largest coconut production in North Sulawesi after South Minahasa Regency, which is 40,090 tons with a planting area of 36,745 ha in 2022 [1]. Coconut is one of the leading commodities in the North Minahasa region [2]. Airmadidi District is one of the districts in North Minahasa Regency with a coconut planting area of 3,609.84 ha and coconut production of 3,859.78 tons [3]. Coconut plants are important for the community, because every part of the plant has economic value. The community processes coconuts into copra and coconut oil. Coconut oil has become a leading export commodity from year to year [4].

The development of high-value commodities in a region requires regional planning related to areas that have the potential for commodity development. Utilization of resource potential is a regional development planning business technique based on regional potential. A region will develop if it has a leading sector that can drive regional economic development [5]. FAO states that for plants to produce optimally, certain requirements are needed [6]. Plants can grow and produce high quality, if cultivated in a suitable environment [7]. Increasing coconut production can be done through land intensification and extensification. Both methods can be done simultaneously if supported by land suitability evaluation assessment. Land evaluation is the process of estimating the potential of land resources for various specific uses (agriculture and non-agriculture) [8]. Land that has agricultural potential is expected to produce high productivity, so land use must be in accordance with its potential [9]. Land suitability evaluation is an assessment of the level of land suitability for a particular land use or commodity. The goal of land suitability evaluation is to determine the limiting factors that inhibit productivity and the effectiveness of plant cultivation.

Based on the description above, it is necessary to conduct an evaluation of land suitability for coconut plants in Airmadidi District, so that the characteristics of the land that are limiting factors in coconut growth and production can be identified. The purpose of this study was to determine the actual and potential land suitability class for coconut plants in Airmadidi District.

2. Material and Methods

Airmadidi District is administratively part of North Minahasa Regency. Airmadidi District borders Dimembe District to the north; to the east: Kauditan District; to the south Minahasa Regency; to the west Kelawat District and Minahasa Regency. The area of Airmadidi District has an area of 3,900.75 Ha, there is a dry land farming area of 465.53 Ha, and mixed farming of 675.21 Ha [10]. Airmadidi District has a plain topography, at an altitude of 0 - 250 meters above sea level. Airmadidi District has an average rainfall of 289 mm, an average temperature of 21-22 ^{o}C.

The study was conducted using a survey method consisting of 4 stages, namely pre-survey, main survey, soil analysis, and data processing. Soil sampling using a soil drill on the land unit. Soil samples were taken in 6 land units. Soil samples came from composite results at a depth of 0-40 cm. Analysis of chemical and physical properties of soil was conducted in the Soil Chemistry and Physics Laboratory of the Center for Standard Testing of Agricultural Land Resources Instruments (BBSIP SDLP). The methods used in soil analysis include: soil pH (pH meter), soil texture (pipette), N-Total (Kjeldahl), P_2O_5 and K_2O (HCl 25%), Soil CEC (leaching with 1 N Ammonium Acetate pH 7), C-Organic (Walkey and Black). Soil analysis data were then interpreted into soil fertility class criteria according [11]. Calculation of wet and dry months using the Oldeman system [12], wet months have an average rainfall of > 200 mm, humid months have an average rainfall of 100-200 mm, and dry months have rainfall <100 mm. Air temperature was obtained using the elevation value or height of the place and calculated using the Braak equation [13], which is 26.3 ^{o}C - (0.01 x elevation in meters x 0.6 ^{o}C). The process of determining land suitability class is determined by matching land characteristics with the criteria for coconut plant land suitability that have been formulated in the technical instructions for land evaluation for agricultural commodities [14,15]. The process of determining land suitability class using the matching method is determined by the heaviest limiting factor in the land unit. The results of the land suitability evaluation are displayed in the form of a table of actual and potential land suitability.

3. Results and Discussion

3.1 Land characteristics of Airmadidi District

Land characteristics in the coconut development area in Airmadidi District are in the use of dry land and mixed plantations. The results of the survey and analysis of soil samples in the laboratory are presented in Table 1. Based on Table 1, the soil sample collection location includes 6 (six) land units with land characteristics at a depth of 0-40 cm. The soil type in the land units consists of Vitrandic Eutrudepts and Typic Eutrudepts. The parent material of both types of soil comes from andesite tuff. Based on the climate classification, Airmadidi District is included in the Type B Climate Zone with characteristics of 8 wet months and 5 humid months. The landform at the research location is dominated by volcanic slopes originating from Mount Klabat. The height of the land units ranges from 154-403 m above sea level. The average air temperature in the research area is 26 ^{o}C. Permeability in the land units is included in the moderate category.

Soil characteristics such as texture, depth, and drainage that affect plant roots vary greatly. Soil texture based on the ratio of sand, dust, and clay fractions [16] is categorized as Sandy Clay Loam. The effective depth of each land unit is >100 cm and good drainage. Soil pH ranges from 6 to 6.6 (slightly acidic). Soil pH plays an important role in determining how easily plants absorb nutrients [17]. If the soil pH is neutral, then nutrients are easily absorbed by plants

Table 1
Characteristics of land units at a depth of 0-40 cm in Airmadidi District for Evaluation of Land Suitability for Coconut Plantations

Land characteristics	Land Unit					
	1	2	3	4	5	6
Temperature (tc)						
Average temperature (mm)	26,06	26,12	26,21	26,21	26,16	26,14
Water aviability (wa)						
Rainfall (mm)	3.475	3.475	3.475	3.475	3.475	3.475
Length of dry months (month)	0	0	0	0	0	0
Humidity (%)	86,5	86,5	86,5	86,5	86,5	86,5
Oxygen aviability (oa)						
Drainage	Good	Good	Good	Good	Good	Good
Rooting content (rc)						
Texture	SL	SCL	SCL	SCL	SCL	SCL
Coarse material	2	2	1	1	1	2
Soil depth (cm)	120	130	110	130	150	130
Peat						
Thickness (cm)						
Maturity						
Nutrient retention (nr)						
Soil CEC (cmol)	10,07	9,6	12,96	8,55	9,87	8,26
Base saturation (%)	90	67	92	86	83	81
pH H_2O	6,6	5,6	6,6	6,3	6,2	6
C-Organic (%)	3,28	1,63	2,12	1,58	1,87	2,36
Nutrient aviability (na)						
N-Total (%)	0,25	0,15	0,18	0,15	0,16	0,25
P_2O_5 (mg/100 g)	50	59	26	20	96	76
K_2O (mg/100 g)	4	16	36	13	61	21
Toxicity (xc)						
Salinitty						
Sodiscity (xn)						
Alkalinity / ESP (%)	1,59	2,19	2,16	1,75	2,53	2,78
Sulfidic Danger (xs)						
Sulfidic depth (cm)	0	0	0	0	0	0
Erosion Hazard (eh)						
Slope (%)	10	3	7	6	4	4
Erosion hazard	SR	SR	SR	SR	SR	SR
Flood hazard (fh)						
Height (cm)	0	0	0	0	0	0
Duration (day)	0	0	0	0	0	0
Land preparation (lp)						
Rocks on surface (%)	1	1	2	2	1	2
Rocks outcrop (%)	1	2	1	1	0	1

Source: Laboratory Analysis Results BBSIP SDLP
Information:
SL: Sandy Loam; SCL: Sandy Clay Loam; SR: Sangat Ringan

The N-Total value ranges from 0.15% to 0.25% (low-moderate). Nitrogen is one of the macronutrients needed by most plants. Nitrogen is absorbed in the form of negatively charged nitrate ions and remains in the soil solution. Nitrate ions cannot be utilized by plants because they are easily washed away by water flow [18]. Rainfall in the Airmadidi District of 3,475 mm/year plays a role in accelerating the rate of Nitrogen nutrient leaching. Although the presence of Nitrogen in the soil is very important, nitrogen can become unavailable to plants or easily lost [19]. It is important to provide nitrogen regularly to replace nutrients lost or absorbed by plants. Soil nitrogen levels are closely related to differences in soil parent material, climate, and management methods. Organic matter acts as a buffer for nutrients because it has the function of adding nutrients [20]. Organic matter in the soil is seen from the content of C-Organic and N-Total [20]. The C-Organic value ranges from 1.58% to 3.28%. The role of soil organic matter (humus) is needed by plants [21]. Topographic differences will affect the intensity of organic matter decomposition on the soil surface, and ultimately can affect plant growth [20]. Phosphorus is one of the essential macronutrients for plants that is needed in large quantities, but not higher than N and K [21]. The available P content ranges from 20 to 96 mg/100 g, included in the low to high category. Phosphorus content in soil is influenced by many factors, including soil pH. At pH 6.0 - 7.0 P will be well available in the soil [22].

Cation exchange capacity (CEC) is the ability of soil to exchange cations [23]. The CEC content of soil ranges from 8.26 to 10.07 cmol, which is included in the low to medium category. The CEC value of soil reflects the ability of soil to provide nutrients [24, 25]. The CEC value of this category provides more nutrients than the lower category. Base saturation ranges from 67% to 92%, which is included in the very high category. Soil with high base saturation indicates that there has been no serious nutrient leaching [26,27]. The C-organic content is between 1.58% to 3.28%. The C-organic content in land units 3 and 6 is included in the medium category. In general, soil dominated by sand fractions has a low C-organic content [28] [29].

3.2 Land suitability for coconut plants (*Cocos nicifera* L.)

Land suitability classes for coconut plants (*Cocos nicifera* L.) are presented in Table 2. Land unit 1 has an actual land suitability class according to marginal (S3) with a limiting factor of available nutrients (na) in the form of K_2O. Efforts or attempts to improve limiting factors that can be carried out on land units are presented in Table 3. The limiting factor of available nutrients can be improved by applying 282 K_2O/ha or 469 kg KCl/ha of fertilizer. Meanwhile, land unit 2 has an actual land suitability class that is quite suitable (S2) with limiting factors of water availability (wa), and nutrient retention (nr). The limiting factor of water availability (na) in the form of rainfall according to [14] can be improved with a moderate level of management in the form of making drainage channels aimed at reducing the availability of water or content in the land. The limiting factor of nutrient retention (nr) in the form of Soil CEC according to [14] can be improved with a low level of management, while on land 3 it can be done 3.01 tons/ha to moderate with the application of organic materials. Application of organic materials with a dose of 4.9 tons/ha can be done on land unit 2.

Land units 3 to 6 have an actual land suitability class that is quite suitable (S2) with limiting factors of water availability (wa), nutrient retention (nr), and available nutrients (na). The limiting factor of water availability (na) in the form of rainfall according to [14] can be improved with a moderate level of management in the form of making drainage channels aimed at reducing water availability or content in the land. This improvement process can increase the suitability class by 1 level. The limiting factor of nutrient retention (nr) in the form of Soil CEC according to [14] can be improved with a low level of management, while inland unit 3 it can be done 3.01 tons/ha to moderate with the application of organic materials.

Land units 2-6 have an actual land suitability class that is marginal (S3) with limiting factors of water availability (wa), nutrient retention (nr), and available nutrients (na). The limiting factor of water availability (na) in the form of rainfall according to [14] can be improved with a moderate level of management in the form of making drainage channels aimed at reducing water availability or content in the land. This improvement process can increase the suitability class by 1 level. The limiting factor of nutrient retention (nr) in the form of Soil CEC according to [14] can be improved with low to medium management levels in the form of adding organic materials of 3.01; 5.10; 3.98 and 2.09 tons/ha respectively. The limiting factor of nutrient availability (na) in the form of Total N, P_2O_5, and K_2O according to [14] can be improved with a low management level, namely the provision of fertilizers of 0.15 tons N/ha or 0.33 tons Urea/ha and 0.15 tons K_2O/ha or 0,26 tons KCl/ha (land 3); fertilizers of N 0.16 tons/ha or Urea 0.34 tons/ha, K_2O 0.25 tons/ha or KCl 0.41 tons /ha, P_2O_5 0.13 tons/ha or SP36 0.35 tons /ha (land 4); N 0,16 tons /ha or Urea 0.34 tons /ha (land 5); fertilizer N 0.14 tons/ha or Urea 0.31 tons /ha and K_2O 0.21 tons/ha or KCl0.35 tons /ha (land 6).

Table 2
Land Suitability Class for Coconut Plants in Airmadidi District, North Minahasa Regency

Land characteristics	Land Unit					
	1	2	3	4	5	6
Temperature (tc)						
Average temperature (mm)	S1	S1	S1	S1	S1	S1
Water aviability (wa)						
Rainfall (mm)	S2	S2	S2	S2	S2	S2
Length of dry months (month)	S1	S1	S1	S1	S1	S1
Humidity (%)	S1	S1	S1	S1	S1	S1
Oxygen aviability (oa)						
Drainage	S1	S1	S1	S1	S1	S1
Rooting content (rc)						
Texture	S1	S1	S1	S1	S1	S1
Coarse material	S1	S1	S1	S1	S1	S1
Soil depth (cm)	S1	S1	S1	S1	S1	S1
Peat						
Thickness (cm)						
Maturity						
Nutrient retention (nr)						
Soil CEC (cmol)	S1	S2	S2	S2	S2	S2
Base saturation (%)	S1	S1	S1	S1	S1	S1
pH H_2O	S1	S1	S1	S1	S1	S1
C-Organic (%)	S1	S1	S1	S1	S1	S1
Nutrient aviability (na)						
N-Total (%)	S1	S2	S2	S2	S2	S1
P_2O_5 (mg/100 g)	S1	59	S2	S2	S1	S1
K_2O (mg/100 g)	S3	S2	S1	S2	S1	S1
Toxicity (xc)						
Salinitty						
Sodiscity (xn)						
Alkalinity / ESP (%)	S1	S1	S1	S1	S1	S1
Sulfidic Danger (xs)						
Sulfidic depth (cm)	S1	S1	S1	S1	S1	S1
Erosion Hazard (eh)						
Slope (%)	S1	S1	S1	S1	S1	S1
Erosion hazard	S1	S1	S1	S1	S1	S1
Flood hazard (fh)						
Height (cm)	S1	S1	S1	S1	S1	S1
Duration (day)	S1	S1	S1	S1	S1	S1
Land preparation (lp)						
Rocks on surface (%)	S1	S1	S1	S1	S1	S1
Rocks outcrop (%)	S1	S1	S1	S1	S1	S1
ALS	S3na	S2wa,nr,na	S2wa,nr,na	S2wa,nr,na	S2wa,nr,na	S2wa,nr,na
PLS	S2na	S1	S1	S1	S1	S1

Information:
ALS: Actual Land Suitability
PLS Potential Land Suitability

The level of land improvement to overcome limiting factors can raise the class one level higher (S3 to S2) or (S2 to S1) can be done by farmers at low to moderate costs. Improvement of limiting factors to raise the class 2 levels higher can be done with assistance from the government or private parties because it requires high costs.

Tabel 3.
Recapitulation of Limiting Factor Improvement Efforts

Land Unit	Actual Land Suitability	Improvement effort	Potential Land Suitability
1	S3na	- Fertilization 145 kg N/ha or 315 kg Urea/ha - Fertilization 282 K_2O/ha or 469 kg KCl/ ha	S2na
2	S2wa,na	- Drainage channel construction - Provision of organic materials 4,9 ton/ha - Fertilization 157 kg N/ha atau 340 kg Urea/ha - Fertilization 234 K_2O/ha atau 389 kg KCl/ ha	S1
3	S2wa,nr,na	- Drainage channel construction - Provision of organic materials 3,01 ton/ha - Fertilization 153 kg N/ha or 333 kg Urea/ha - Fertilization 154 K_2O/ha or 256 kg KCl/ ha	S1
4	S2wa,nr,na	- Drainage channel construction - Provision of organic materials 5,10 ton/ha - Fertilization 157 kg N/ha or 340 kg Urea/ha - Fertilization 246 K_2O/ha or 410 kg KCl/ ha - Fertilization 126 P_2O_5/ha or 350 kg/SP36	S1
5	S2wa,nr,na	- Drainage channel construction - Provision of organic materials 3,98 ton/ha - Fertilization 156 kg N/ha or 338 kg Urea/ha	S1
6	S2wa,nr,na	- Drainage channel construction - Provision of organic materials 2,09 ton/ha - Fertilization 145 kg N/ha atau 315 kg Urea/ha - Fertilization 208 K_2O/ha atau 347 kg KCl/ ha	S1

4. Conclusion

The actual land suitability class in the Airmadidi District land unit is quite suitable (S2) and marginally suitable (S3) with the limiting factor of water availability (wa) in the form of rainfall, nutrient retention (nr) in the form of soil CEC and nutrient availability (na) in the form of N-Total, P_2O_5 and K_2O. The potential land suitability class in the Airmadidi District land unit is very suitable (S1) and quite suitable (S2) with the limiting factor of available nutrients (na).

References

[1] BPS Provinsi Sulawesi Utara. (2024). Provinsi Sulawesi Dalam Angkat 2024. BPS Provinsi Sulawesi Utara.

[2] Luntungan, A., & Kumaat., R. (2017). Analisis Potensi Ekonomi Kabupaten Minahasa Utara. *Jurnal Riset Bisnis dan Manajemen*, 5(4), 539-554.

[3] BPS Kabupaten Minahasa Utara. (2023). Kabupaten Minahasa Utara dalam Angka 2023. BPS Kabupaten Minahasa Utara.

[4] Willy, R. C K. (2013). Daya Saing Komoditi Minyak Kelapa Sulawesi Utara. *Jurnal EMBA*, 1(4), 1285-1405. Doi: https://doi.org/10.35794/emba.1.4.2013.2910

[5] Hidayat, M. (2014). Inequality across districts and cities in the Riau. *Econmic Journal of Emerging Markets*, 6(2), 106-108. Doi: https://doi.org/10.20885/ejem.vol6.iss2.art4

[6] Food and Agriculture Organization of The United Nations (FAO). (1976). A framework for land evaluation, soil resources development and concervation secvice land and water development division, Soils Bulletin, 32.

[7] Mubekti. (2012). Evaluasi karakteristik dan kesesuaian lahan untuk komoditi unggulan perkebunan: studi kasus kabupaten kampar. *Jurnal Teknik Lingkungan*, 13(1), 37-46.

[8] Badan Penelitian Pertanian dan Pengembangan Pertanian. (2012). Petunjuk teknis evaluasi lahan untuk komoditas pertanian. Bogor: Balai Besar Penelitian dan Sumberdaya Lahan Pertanian.

[9] Indrayani, R.A., Uska, P.J., Marten, U. N. (2022). Analisis kesesuaian lahan untuk pengembangan tanaman porang (*Amarphopallus ancophillus*) di kecamatan lewa kabupaten sumba timur. *Jurnal Tanah dan Sumberdaya Lahan*, 9(1), 49-55. Doi: https://doi.org/10.21776/ub.jtsl.2022.009.1.6

[10] Fidel, R. T., Franklin, J.C.P., Lingerid, L.M. (2018). Analisis peruntukan lahan pemukiman berdasarkan kesesuaian lahan di kecamatan airmadidi. *Jurnal Spasial*, 5(2), 162-170. Doi: https://doi.org/10.35793/sp.v5i2.20787

[11] Pusat Penelitian Tanah. (1983). Klasifikasi kesesuaian lahan. Proyek Pertanian Menunjang Transmigrasi. Bogor

[12] Oldeman, L.R. (1975). Contribution: An Agroclimatic map of Java and Madura. *Central Research Institute for Agriculture. Bogor*

[13] Braak, C. (1928). The Climate of The Netherlands Indies. Proceedings of Royal Meteorlogy Observation Batavia. No 14. 192

[14] Ritung, S., Nugroho, K., Mulyani, K., & Suryani, E. (2011). Petunjuk Teknis Evaluasi Lahan Untuk Komoditas Pertanian (Edisi Revisi). Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian. Badan Penelitian Pengembangan Pertanian. Bogor. 168

[15] Hardjowigeno, S. (2007). Ilmu tanah. Jakarta, ID: Akademika Pressindo.

[16] Djaenudin, D., Marwan H., Subagjo H. and Hidayat, A. (2003). Petunjuk Teknis Evaluasi Lahan untuk Komoditas Pertanian. BPT- P3TA. Badan Litbang Pertanian: Bogor.

[17] Hendrico, F., H., Willem, A., Siahaya., Rafael, M.O. (2020). Evaluasi kesesuaian lahan tanaman jagung dan kelapa pada lahan praktek sekolah pertanian pembangunan kota Ambon, provinsi Maluku. *Jurnal Budidaya Pertanaian*, 16(2), 157-166. Doi**:** https://doi.org/10.30598/jbdp.2020.16.2.157

[18] Bambang, S. (2018). Sebaran unsur hara N, P, K dan pH dalam tanah. *Buana Sains*, 18(2), 109-124. Doi: https://doi.org/10.33366/bs.v18i2.1184

[19] Yuliani, A., Damayanti, M., Nur, D.M. (2019). Efek pupuk organik dan pupuk N, P, K terhadap C-Organik, N-Total, C/N, serapan N, serta hasil padi hitam pada inceptisol. *Jurnal Pertanian Presisi*, 3(2), 90-105. Doi: http://dx.doi.org/10.35760/jpp.2019.v3i2.2205

[20] Azurianti., Restu, W., Faris, N. F. A., Sungeng, P. (2022). Kajian hubungan hara tanah terhadap produktifitas tanaman teh produktif di perkebunan teh Pagar Alam, Sumatera Selatan. *Jurnal Tanah dan Sumberdaya Lahan*, 9(1), 153-161. Doi: https://doi.org/10.21776/ub.jtsl.2022.009.1.17

[21] Rudy, S., Fitra, S.H., Abdul, R., Rahmawaty, Simon, H.S., (2018). Evaluasi kesesuaian lahan pada areal penggunaan lain di kecamatan Sitellu Tali Urang Julu kabupaten Pakak Bharat untuk pengembangan tanaman cabai merah (*Capsicum annuum* L). *Jurnal Tanah dan Sumberdaya Lahan*, 5(2), 829-839.

[22] Sukmawati. (2015). Analisis ketersediaan C-Organik di lahan kering setelah diterapkan berbagai model sistem pertanian hedgerow. *Jurnal Galung Tropika*, 4(2), 115-120. Doi: https://doi.org/10.31850/jgt.v4i2.103

[23] Hanafiah, K.A. (2007). Dasar-dasar Ilmu Tanah. Jakarta: PT. Raja Grafindo Persada. Jakarta.

[24] Syofiani, R., Putri, S.D., Karjunita, N. (2020). Karakteristik sifat tanah sebagai faktor penentu potensi pertanian di Nagari Silokek Kawasan Geopark Nasional. *Jurnal Agrium*, 17(1), 1-6. Doi: https://doi.org/10.29103/agrium.v17i1.2349

[25] Firnia, D. (2018). Dinamika fosfor pada tiap horison profil tanah masam. *Jurnal Agroekotek*, 10(1), 45-52. Doi: http://dx.doi.org/10.33512/j.agrtek.v10i1.5464

[26] Tarigan, A., Abdul, R., Rahmawaty. (2019). Evaluasi kesesuaian lahan cabai merah di kawasan relokasi sosial kabupaten Karo. *Jurnal Tanah dan Sumberdaya Lahan*, 6(2), 1229-1235. Doi: https://doi.org/10.21776/ub.jtsl.2019.006.2.3

[27] Hidayah, A.N., Susilo, B., Endang, D.P. (2022). Evaluasi kesesuaian lahan kecamatan karangreja kabupaten purbalingga jawa tengah sebagai upaya peningkatan produktivitas komoditas sayuran. *Jurnal Tanah dan Sumberdaya Lahan*, 9(2), 395-404. Doi: https://doi.org/10.21776/ub.jtsl.2022.009.2.20

[28] Darlita, R.R., Ben, J., Rija, S. (2017). Analisis beberapa sifat kimia tanah terhadap peningkatan prokduksi kelapa sawit pada tanah pasir di perkebunan kelapa sawit selangkun. *Jurnal Agrikultura*, 28(1), 15-20.

[29] Zhang, Z., Hu, L., Liu, Y., Guo, Y., Tang, S., Ren, J. (2024). Land use shapes the microbial community structure by altering soil aggregates and dissolved organic matter components. *Journal of Integratuve Agriculture*. Doi https://doi.org/10.1016/j.jia.2024.07.018.