

RESEARCH ARTICLE | MAY 30 2023

# Soil properties analyses combined with normalized difference vegetation index for investigating corn fields of Sendana district, West Sulawesi **FREE**

Andary; Muh. Jayadi; Asmita Ahmad 



AIP Conference Proceedings 2596, 080002 (2023)

<https://doi.org/10.1063/5.0120940>



View  
Online



Export  
Citation

CrossMark

## AIP Advances

Why Publish With Us?

-  **25 DAYS**  
average time to 1st decision
-  **740+ DOWNLOADS**  
average per article
-  **INCLUSIVE**  
scope

[Learn More](#)



# Soil Properties Analyses Combined with Normalized Difference Vegetation Index for Investigating Corn Fields of Sendana District, West Sulawesi

Andary<sup>1,a)</sup>, Muh. Jayadi<sup>1,b)</sup> and Asmita Ahmad<sup>1,c)</sup>

<sup>1</sup>*Department of Soil Science, Faculty of Agriculture, Hasanuddin University, Makassar, 90245 Indonesia.*

<sup>a)</sup>andarykd@gmail.com

<sup>b)</sup>jayaditanahunhas@gmail.com

<sup>c)</sup> Corresponding author: asmita.ahmad@agri.unhas.ac.id

**Abstract.** Majene Regency is part of West Sulawesi Province inhabited by people who depend on agriculture. One of the primary agricultural commodities in Majene Regency is corn. A conventional model is generally used to estimate long-term production. Remote sensing technology offers alternative information technology for estimating corn production. Nonetheless, it is necessary to determine the soil fertility level for cultivating corn from reflectance values classified using the Normalize Difference Vegetation Index (NDVI) method. This research was located in Sendana District, Majene Regency of West Sulawesi. Field surveys were carried out for soil sampling. Soil samples were taken on the top layer (0-30 cm). Soil properties data used were results from analysis data from soil texture with the hydrometer method, C-organic with the Walkley and Black method, pH with a pH meter, cation exchange capacity, and base saturation with the ammonium acetate extraction method (NH<sub>4</sub>CH<sub>3</sub>CO<sub>2</sub>). The data used in this research is Landsat 8 OLI/TIRS Collection 2 Level 1 image data in 2021. The results showed that NDVI of corn has a value in the range of -0.58 – 0.87. The range was indicated from the classification process for five land cover types using maximum likelihood classification (overall accuracy 93%, kappa index 0,9) in Sendana District. The soil characteristics of moderate vegetation density over various land cover classes were relatively similar. NDVI and soil characteristics give the best locations for cornfield development areas in the northern and southern parts of the Sendana District. This can be a reference that the area is generally potential for corn cultivation because of the soil characteristics suitable for growing conditions and potential land suitability.

## INTRODUCTION

BPS Majene data shows that the area of agricultural land in Majene Regency reaches 49.12% of the total area of Majene Regency [1]. One of the leading agricultural production commodities in Majene Regency is corn, with the best total production of 6,871/ton in 2015, but corn production in each sub-district is not always stable. One of them is in Sendana District, where corn production sometimes increases and also decreases due to poor management [2]

Proper agricultural management requires the right and more accurate information or data to increase production yields and economic efficiency [3]. Remote sensing is an important source of information for agricultural production management and supply and demand assessment. Remote sensing can be used to study vegetation, especially in agriculture which is used to determine the condition, amount, and availability of nutrients closely related to knowing or predicting the production yield of a plant with the application of GIS techniques [4].

One of the GIS techniques used for vegetation studies is NDVI (Normalized Difference Vegetation Index). The high and low vegetation density can be determined by using the NDVI technique, which is a spectral sharpening image transformation to analyze matters related to vegetation [5].

## MATERIALS AND METHODS

Sendana District is located in the southwest part of West Sulawesi, which lies between longitude 118°52'58.73" E and latitude 3°22'4.96" S with wide 82.24 km<sup>2</sup> (Fig. 1). Majene Regency is built by an area whose topography varies from flat to hilly and mountainous, with a slope of less than 3% to more than 70% [6]. Cornfields are identified based on ground check fields. Soil samples were taken using the field survey method.

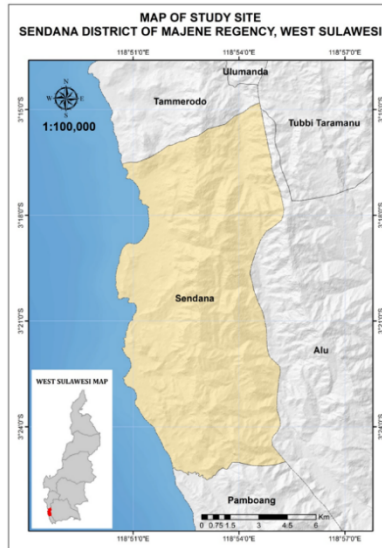


FIGURE 1. Research Site Map.

### Data

The data used in this research is Landsat 8 OLI/TIRS Collection 2 Level 1 image data in 2021. Landsat 8 OLI/TIRS Collection 2 Level, 1 imagery for the research area in Majene Regency was downloaded from the United States Geological Survey (USGS) website. The purpose of using Landsat 8 OLI/TIRS image data is for further analysis in the mapping process.

Soil properties data used in this research is result analysis data from soil texture with the hydrometer method, C-organic with the Walkley and Black method, pH with a pH meter, cation exchange capacity, and base saturation with the ammonium acetate extraction method (NH<sub>4</sub>CH<sub>3</sub>CO<sub>2</sub>).

### Radiometric Correction

The radiometric correction was performed to improve the pixel value in the cornfields recorded by satellite sensors. The spectral response in the cornfield has the same value according to the reflection of objects on the earth's surface. Radiometric correction of Landsat 8 imagery is considered the angle of elevation of the sun. This is necessary because the difference in the angle of elevation of the sun can cause the lighting on the earth's surface to be not the same. It affects the amount of energy received by the satellite sensor from the reflectance value of each object on the earth's surface. The equation used to perform radiometric correction is as follows [7]:

$$\rho\lambda' = M_p Q_{cal} + A_p \quad (1)$$

Information:

$\rho\lambda'$  = the result of the previous processing, without correction of the shooting angle. ' does not contain correction for sun angle

$Q_{cal}$  = pixel value (DN)

$M_p$  = rescaling constant (Reflectance\_Mult\_Band\_x, where x is the band used)

$A_p$  = incrementing constant (Reflectance\_Add\_Band\_x, where x is the band used)

It must be corrected for the sun angle to get the reflectance value. Reflectance correction can be generated in the equation below:

$$\rho\lambda = \frac{\rho\lambda'}{\cos\theta_{SE}} = \frac{\rho\lambda'}{\sin\theta_{SE}} \quad (2)$$

Information:

$\rho\lambda'$  = TOA planetary reflectance (without units),  
SE = Sun elevation angle when recording (sun elevation)

### Normalized Difference Vegetation Index (NDVI)

Normalized difference vegetation index (NDVI) is a spectral sharpening image transformation to analyze matters related to vegetation. The vegetation index is the value greenness of the vegetation obtained from digital signal processing from the brightness value data of several satellite sensor data channels. Referring to Table 1, the NDVI is close to, or a value of 1 indicates that it has a high vegetation density and vice versa if it is close to or a value of -1 has a low divided vegetation density [8]. NDVI calculation value can be calculated by the following formula, where NIR is Near Infrared-band, and Red is Red band [9]:

$$NDVI = \frac{NIR-RED}{NIR+RED} \quad (3)$$

TABLE 1. Classification NDVI.

NDVI Value	Vegetation Density Class
-1 – 0	Non vegetation
0 – 0.25	Sparse
0.25 – 0.55	Low
0.55 – 0.78	Moderate
0.78 - 1	High

### Maximum Likelihood Classification

The Maximum Likelihood Classification method is based on the same pixel value and image recognition. One of the purposes of using the Maximum Likelihood Classification method in this study is to classify the parameter by assuming a normal distribution to represent each pixel in its class. Region Of Interest is used to obtain the characteristics of the pixel values in each object/class. Then all pixels that are not in the sample will be grouped by referring to the characteristics of the pixel values that have been taken by applying statistical calculations.

Making a guided classification using the maximum likelihood classification method can be displayed in ArcMap software. Composite settings by inputting RGB bands as needed. Then, creating a training area to determine the land cover type that will be classified later, and finally classifying it using the maximum likelihood method where the value of the training area will be displayed.

### Confusion Matrix

The classification accuracy test aims to see classification errors to know the accuracy percentage (accuracy). The accuracy of the classification results is tested by making a contingency matrix which is often referred to as an error matrix or confusion matrix.

The level of mapping accuracy is determined by using the classification accuracy-test referring to the formula [10]:

$$MA = \frac{X_{cr} \text{ pixels}}{X_{cr} \text{ pixels} + X_o \text{ pixels} + X_{co} \text{ pixels}} \times 100\% \quad (4)$$

Information:

MA = mapping accuracy  
 $X_{cr}$  = number of corrected class X  
 $X_o$  = number of Class X who enter another class (omission)  
 $X_{co}$  = number of additional X classes from other classes (commission)

## RESULTS AND DISCUSSION

### Vegetation density analysis of Sendana District using NDVI

The results of processing the distribution of vegetation density values in Sendana District obtained based on NDVI analysis has a range with a value of -0.580711 to 0.877651 (Fig. 2a). This shows that most of the districts in Sendana have high greenness vegetation values.

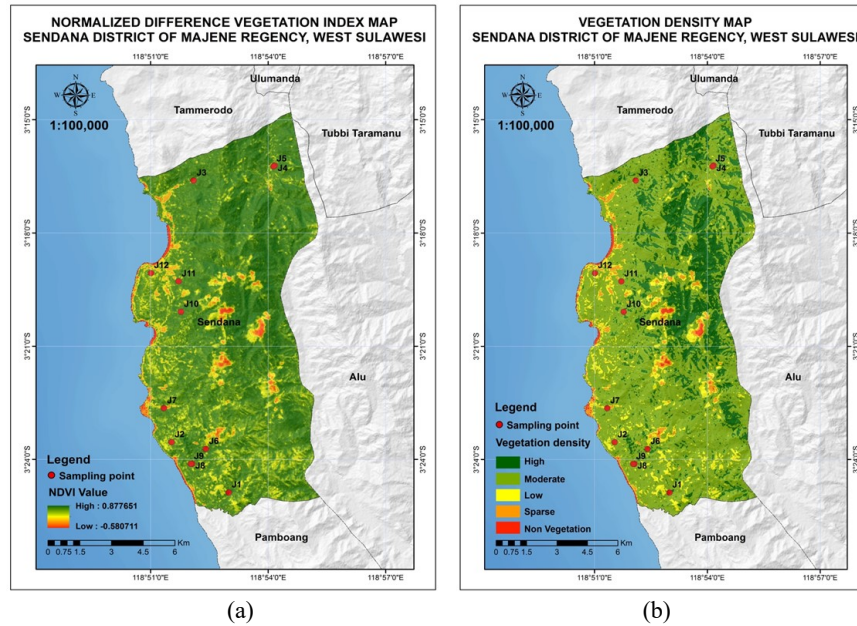


FIGURE 2. (a) NVDI Map; (b) Vegetation Density Map.

Sendana District is divided into five classes of vegetation density, namely non-vegetation, sparse, low, moderate, and high (Fig. 2b), and the area of each class is listed in Table 2. The lowest value is in the range of -0.58 – 0.03 with an area of 111.25 ha, which indicates the area is not overgrown by vegetation. In contrast, the highest value is in the range of 0.74 – 0.87 with an area of 2,762.82 ha, which indicates the area has a lot of vegetation. The lowest density values were clouds and water bodies, while the highest was a forest [11].

TABLE 2. Classification NDVI in Sendana District, 2021.

NDVI Value	Vegetation Density Class	Area (ha)
0.74 – 0.87	High	2,762.82
0.62 – 0.74	Moderate	8,201.82
0.42 – 0.62	Low	973.91
0.03 – 0.42	Sparse	315.29
-0.58 – 0.03	Non Vegetation	111.25

Vegetation density analysis using satellite imagery illustrates that some parts of Sendana District have not been used as residential areas, so they still have a good vegetation index value (Fig. 2b) with colors dominated by green to dark green. This is caused by the value of the resulting vegetation canopy having a large reflection so that the resulting color is dark/green. If the reflection from a vegetation canopy is small, the resulting color is bright/red.

Based on the ground check, it was found that 8 of the 9 sample points, namely samples J1 to J8, were dominated by corn plantations with moderate vegetation density class, and sample J9 was classified as low vegetation density. This shows that corn plantations are very well cultivated in areas with moderate vegetation density classes and low vegetation.

## Maximum Likelihood Classification

Based on Fig. 3., the map results from the guided classification of the maximum likelihood method, it is found that five land-cover classes consist of agricultural land, paddy field, settlement, primary dryland forest, and water body/river. Landsat 8 image interpretation results show that Sendana District is dominated by primary dryland forest symbolized in green. It is known that Sendana District is one of the parts of Majene Regency, which is still developing. Most of its territory still does not exist.

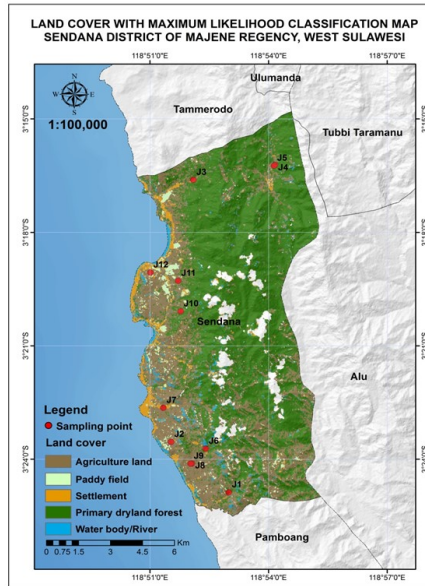


FIGURE 3. Land Cover Map using Supervised Maximum Likelihood.

## Confusion Matrix Accuracy

The results of the calculation of overall accuracy and kappa accuracy for five land classes using the maximum likelihood classification method can be seen in Table 3. as follows:

TABLE 3. Land Cover Classification Accuracy Test for Landsat 8 Data Using Maximum Likelihood Classification.

Class	Agriculture land	Paddy field	Settlement	Vegetation	Waterbody/river	Total
Agriculture land	9	0	1	0	0	10
Paddy field	0	6	0	0	0	6
Settlement	0	0	10	0	1	11
Primary dryland forest	1	0	0	8	0	9
Waterbody/river	0	0	0	0	5	5
<b>Total</b>	10	6	11	8	6	41

Overall accuracy = 93%, Kappa accuracy = 0.9

Table 3 shows that the accuracy values obtained from the five land cover classes are settlement, waterbody/river, primary dryland forest, paddy field, and agriculture land, with an accuracy test value of 93% with a kappa value of 0.9, which is categorized as high. The land mapping process can be said to be good if the total accuracy received is more than 70%, while the use of kappa values which has a value range of 0 to 1 which indicates that the higher the kappa value obtained, the more accurate the classification results in the field [12]. Classification errors occur in the results because the class has a color and hue almost the same as the color and hue of other classes.

## Analysis of Physical and Chemical Properties

The results of the analysis of physical and chemical properties for evaluation of soil fertility status of the study area are texture, pH H<sub>2</sub>O, C-Organic, Cation Exchange Capacity (CEC), Base Saturation (BS), Nitrogen (N) can be seen in Table 4 and Table 5 as follows:

**TABLE 4.** Results of Analysis of Physical and Chemical Properties in Some Corn Soil Samples.

Sample	Parameter							
	Texture				pH H <sub>2</sub> O	C-Organic	CEC	BS
	Sand	Silt	Clay	Texture Class		%	cmol/kg	%
% %								
J1	46	41	14	loam	6.20	1.60	17	35
J2	19	56	25	silty clay loam	6.98	1.30	16	38
J3	20	39	41	clay	6.30	0.75	23	27
J4	43	28	29	clay loam	5.30	1.35	21	27
J5	32	33	35	clay loam	5.16	1.40	18	19
J6	55	28	18	sandy clay loam	5.75	1.20	20	23
J7	30	28	42	clay	6.35	1.15	23	34
J8	45	32	23	loam	5.45	0.75	22	38
J9	37	36	27	clay loam	6.01	1.40	18	37

### *Soil Texture*

Based on the soil texture analysis in Table 4, the soils in Sendana District have a dominant clay loam texture class. Soil texture is one of the soil properties that greatly determines the ability of the soil to affect plant growth and can indirectly improve the circulation of water, air, and heat, the activity of living organisms in the soil, the availability of nutrients for plants, the overhaul of organic matter, and the ease with which roots can penetrate deeper ground [13].

Following the requirements for growing corn plants, corn plants have quite optimum growth and development if the soil used has a soil texture such as loam, sandy loam, clay loam, silty clay loam, and also silt loam with an effective depth of about 25 to 60 cm [14].

### *pH Level*

Based on the results of the analysis in Table 4, it is shown that the soil pH meter in Sendana District has the lowest pH in sample J5 with a value of 5.16 with slightly acidic criteria and the highest pH in sample J2 of 6.98 with neutral criteria. pH is one of the important indicators in determining soil fertility, which can affect the availability of nutrients in the soil, including macro and micronutrients [15].

Corn is a plant that can be cultivated because it has uncomplicated growing conditions. Corn plants can grow at an optimal temperature of around 21 – 34 °C with a soil pH between 5.6 – 7.5 with an altitude of 1000 – 1800 m above sea level [16]. Evaluation of land for agricultural commodities, land characteristics that are good for planting corn have a pH of 5.8 – 7.8 for the S1 land suitability class while the pH with a range of 5.5 – 5.8 has an S2 land suitability class [17]. Based on the study results, the soil contained in the cornfield in Sendana District has met the requirements for growing corn with a pH range of 5.6 – 7.5.

### *C-Organic*

Based on the analysis results obtained in Table 4, the c-organic content in corn soils in the Sendana District area has very low to low criteria, namely 0.75 to 1.60%. The soils in Sendana District are inceptisol-type soils. In general, inceptisol-type soils have a fairly low organic matter content [18].

Requirements for land use for corn plants if the c-organic content has a value of  $> 0.4\%$ , then the land suitability class is very suitable [19]. That way, the criteria for c-organic in cornfields in Sendana District have entered the criteria that have been mentioned. C-organic is an essential element in the soil. Therefore it is necessary to meet standards so that the resulting production increases.

#### *Cation Exchange Capacity*

Based on the analysis results in Table 4, the lands in Sendana District have the lowest value of 16 with low criteria and the highest value of 23 with medium criteria. It is known that the type of soil that dominates in the Sendana District area is an inceptisol soil type with the sub-order Typic Eutrudepts where the Typic Eutrudepts type has characteristics of a fairly low to moderate CEC. Typic Eutrudepts type is a soil that has developed with soil characteristics with low cation exchange capacity and base saturation below  $<50\%$  [20]. Land suitability class S1 for good maize has a CEC above  $>16$  cmol [17]. Based on the study results, the soil contained in the cornfield in the District of Sendana has met the requirements for growing corn with CEC  $> 16$  cmol.

#### *Base Saturation*

The analysis results obtained in Table 4 show that the soil sample shows a base saturation value below  $<50\%$ . Base saturation generally has a low criterion due to intensive washing, and also, bases are easily washed [21]. Potential land suitability for corn plants with a base saturation value of  $>50\%$  is in the S1, 35 – 50% category for the S2 category, and  $<35\%$  in the S3 category [17]. This shows that the land potential in Sendana District with a base saturation value of 19 – 38% is included S2 and S3 categories.

Base saturation can identify the fertility of the soil. Soil is categorized as fertile if it has a base saturation value above  $>80\%$ , moderate 50 – 80%, and low,  $<50\%$ . The nature of the soil will more easily liberate exchange base cations when it has reached 80% [22].

#### *Nitrogen*

From the analysis results, the value of N in Table 5 shows that the results obtained are quite diverse, namely very low to high, namely 0.04 to 0.70%. There are several reasons for the low value of N content, one of which is the leaching of drainage water. This is supported by data from chirps (2021) that Sendana District has had rainfall ranging from 2001 to 2500 mm/year for the last ten years. Nitrogen is an element that is easily lost in the soil. Nitrogen in the soil can be lost because plants and microorganisms absorb it, evaporate, and are washed away by rainwater [23].

**TABLE 5.** Results of Analysis of Chemical Properties of Some Samples of Corn Plants.

Sample	N-Total
J1	0.18
J2	0.70
J3	0.46
J4	0.32
J5	0.04
J6	0.46
J7	0.18
J8	0.18
J9	0.32

## Potential Development of Corn Fields

Development mapping is the final stage in determining the development area through technology development. The data showed that the northern and southern parts have good potential for corn plant development (Fig. 4). In the western part, the Mosso and Mosso Dua village have quite a good potential compared to the northern part. This is because the villages of Mosso and Mosso Dua have the best quality of soil.

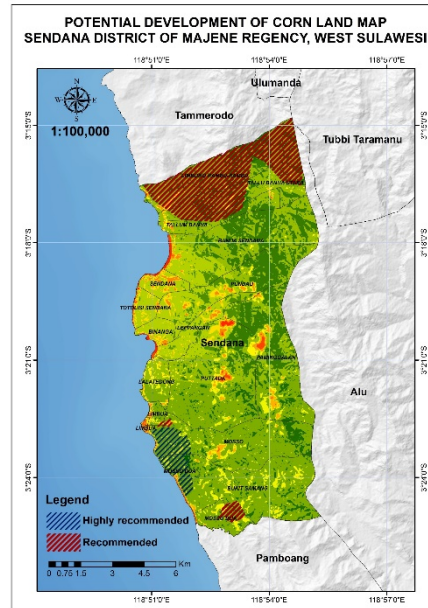


FIGURE 4. Potential Development of Corn Fields.

## CONCLUSION

NDVI and soil characteristics give the best locations for cornfield development areas in the northern and southern parts of the Sendana District. The best place highly recommended for developing corn fields is in the Mosso and Mosso Dua village.

## REFERENCES

1. BPS, *Majene dalam Angka 2013* (Statistic Indonesia, Majene, Indonesia, 2013).
2. BPS, *Produksi/Ton Tanaman Pangan* (Statistic Indonesia, Majene, Indonesia, 2017).
3. S. Skakun, E. Vermote, J. C. Roger, and B. Franch, "Combined Use of Landsat-8 And Sentinel-2a Images For Winter Crop Mapping And Winter Wheat Yield Assessment At Regional Scale," *AIMS Geoscience* **3**, 163–186 (2017).
4. L. M. Irsan, S. H. Murti, and P. Widayani, "Estimasi Produksi Jagung (*Zea Mays L.*) Dengan Menggunakan Citra Sentinel 2a Di Sebagian Wilayah Kabupaten Jeneponto Provinsi Sulawesi Selatan," *J. Teknosience* **8**, 93 (2019).
5. E. H. Putra, *Penginderaan Jauh Dengan Ermapper* (Gajah Mada University Press, Yogyakarta, 2011).
6. I. Bali, A. Ahmad, and C. Lopulisa, "Identifikasi Mineral Pembawa Hara Untuk Menilai Potensi Kesuburan Tanah," *J. Ecosolum* **7**, 81-100 (2018).
7. Rahayu and D. S. Candra, "Koreksi Radiometrik Citra Landsat-8 Kanal Multispektral Menggunakan Top Of Atmosphere (Toa) Untuk Mendukung Klasifikasi Penutup Lahan," in *Prosiding Seminar Penginderaan Jauh 2014* (IPB, Bogor, 2014), pp. 762–768.

8. D. O. Anim, A. T. Kabo-Bah, P. N. Nkrumah, and R. T. Murava, "Evaluation of Ndvi Using Spot-5 Satellite Data For Northern Ghana," *Environment. Manag. Sustain. Dev.* **2** (2013).
9. M. Indrayanti, "Transformasi Ndvi." *Academia* (2013) Available at Academia.Edu.
10. N. Nawangwulan, B. Sudarsono, and B. Sasmito, " Analisis Pengaruh Perubahan Lahan Pertanian Terhadap Hasil Produksi Tanaman Pangan Di Kabupaten Pati Tahun 2001- 2011," *J. Geod. Undip* **2**, 84015 (2013).
11. R. E. Burgan, and R. A. Hartford, General Technical Report: Monitoring Vegetation Greenness With Satellite Data INT-297 (University of Minnesota, 1993).
12. S. H. Purwadhi, *Interpretasi Citra Digital* (Grasindo Publishing, Jakarta, 2001).
13. M. Mustawa, S. H. Abdullah, and G. M. D. Putra, " Analisis Efisiensi Irigasi Tetes Pada Berbagai Tekstur Tanah Untuk Tanaman Sawi (Brassica Juncea)," *J. Ilm. Pertan Engineering. dan Biosist.* **5**, 408–421 (2017).
14. N. Dibia and R. Suyarto, *Budidaya Jagung Manis* (Udayana University, Bali, 2017).
15. N. Hakim, Y. Nyakpa, A. M. Lubis, S. G. Nugroho, M. R. Saul, M. A. Diha, G. B. Hong, and H. H. Bailey, *Dasar-Dasar Ilmu Tanah* (Lampung University Press, Lampung, 1986).
16. Badan Ketahanan Pangan Dan Penyuluh Pertanian Aceh, "Budidaya Tanaman Jagung," *Badan Peneliti dan Pengembangan Pertanian* 1–21 (2009) Available at <http://Nad.Litbang.Pertanian.Go.Id/Ind/Images/Dokumen/Modul/27-Brosur Jagung1.Pdf>.
17. S. Ritung, K. Nugroho, A. Mulyani, and E. Suryani, *Petunjuk Teknis Evaluasi Lahan Untuk Komoditas Pertanian Edisi Revisi* (Agency for Research and Development of Agricultural Land Resources, Bogor, Indonesia, 2011).
18. E. A. Sihite, M. M. Damanik, and M. Sembiring, "Perubahan Beberapa Sifat Kimia Tanah, Serapan P Dan Pertumbuhan Tanaman Jagung Pada Tanah Inceptisol Kwala Bekala Akibat Pemberian Pupuk Kandang Ayam Dan Beberapa Sumber P," *Agroecotechnology* **4**, 2082–2090 (2016).
19. D. Djaenudin, H. Marwan, H. Subagjo, and A. Hidayat, *Petunjuk Teknis Evaluasi Lahan Untuk Komoditas Pertanian* (Agency for Research and Development of Agricultural Land Resources, Bogor, Indonesia, 2011).
20. E. D. Waas, J. Ayal, and S. Kaihatu, "Evaluasi Dan Penentuan Jenis Tanah Di Kabupaten Seram Bagian Barat," *Agros* **16**, 336–348 (2014).
21. S. Hardjowigeno, *Ilmu Tanah* (Akademika Pressindo, Jakarta, 2010).
22. D. Widyantari, K. Susila, and T. Kusmawati, " Evaluasi Status Kesuburan Tanah Untuk Lahan Pertanian Di Kecamatan Denpasar Timur, " *J. Trop. Agroecotechnology* **4**, 293–303 (2016).
23. D. D. Ramadhana, D. Donantho, and R. R. Paranoan, "Penilaian Status Kesuburan Tanah Pada Lahan Pascatambang Di Areal PT . Trubaindo," *J. Agroekoteknologi Trop. Lembab.* **2**, 24-28 (2019).