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# Agricultural Land Uses In Wonosalam Village

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**Abstract**

Wonosalam Village is an area with diverse agricultural land use and intensive cultivation activities that have the potential to decrease in soil fertility, while the latest data on soil fertility levels in this area are not yet available. This study aims to assess the soil fertility index (SFI) across various land uses and identify key indicators influencing soil fertility in Wonosalam Village. Soil samples were selected from five land uses. These were mixed gardens, snake fruit gardens, coffee gardens, rice fields, and dry fields, at a depth of 0-60 cm using the purposive method of random sampling. Analysis was conducted on pH, organic C, total N, available P, exchangeable K, CEC, base saturation, and extra Al. The results showed a significant relationship between indicators, such as pH with available P (r = 0.586) and KB (r = 0.940), organic C with total N (r = 0.714), and extra Al with KB (r = -0.740). The SFI value was in the medium category (0.53–0.65), except for one dryland point, which was classified as low. The strength of this study lies in providing baseline data on index-based soil fertility across various land uses, a previously underreported area in the Wonosalam region. These results indicate that soil fertility remains moderate but is vulnerable to decline due to intensive land management. Therefore, this study recommends the implementation of sustainable soil management, particularly increasing organic matter and proper fertilizer management, as a reference for farmers and policymakers in Wonosalam Village.

**Keywords:** Land Management Intensity, Multivariate Analysis, Nutrient Availability, Soil Chemical Indicators, Sustainability Assessment

## 1. Introduction

Wonosalam Village is a village in Wonosalam District, Jombang Regency, with hilly topography and diverse soil types. Located at the foot and slopes of Mount Anjasmoro, with an average elevation of 500-600 meters above sea level, Wonosalam is classified as a volcanic hill geoformologically based on its topographic relief class. The region's abundant natural resources offer the potential for diverse agricultural uses. (Lasahari *et al.*, 2024). Some communities then exploit this land potential to develop various land-use patterns. Each land-use pattern is optimally utilized according to its potential, with intensive input and management to achieve maximum results.

Intensive land management in cultivation activities aims to meet production targets, considering that this sector is the main source of livelihood that supports the economy of most local people. Intensive agricultural practices implemented to meet food production targets often lead to decreased soil fertility. Intensive farming is typically accompanied by high agricultural input use, such as the application of high doses of chemical fertilizers for optimal yields and routine pesticide spraying to control pests and diseases. Intensified farming with high chemical inputs can gradually degrade soil quality, reduce organic matter content, and become highly dependent on external inputs (Soekamto *et al.*, 2023).

Intensive farming on agricultural land in Wonosalam Village is one of the problems in the area, especially with varied land uses and continuous planting. Previous research by Aji *et al.* (2024) explained that soil fertility in the Wonosalam District area, which includes Wonosalam Village, across all land uses has a low to moderate fertility status.

Decreasing soil fertility significantly impacts soil productivity, becoming a major constraint to crop production. Soil fertility is defined as the ability of a soil to provide essential nutrients in adequate and balanced amounts for plants (Ferry *et al.*, 2024). Soil fertility is

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assessed by its physical properties, including its ability to retain sufficient water and air for plants and its ease of root penetration. The soil's chemical properties must also be favorable, indicated by a sufficient amount of essential soil nutrients available for plant uptake.

Soil with high fertility can reduce input costs in agricultural operations, while soil with low fertility requires higher inputs, increasing farming costs. Therefore, maintaining stable soil fertility is crucial for agricultural development. An initial approach is to first determine the soil fertility level. The Soil Fertility Index (SFI *)* is one method for determining the soil fertility level on a plot of land. Without the application of the Soil Fertility Index (SFI), soil fertility assessments are less comprehensive because they are based solely on specific parameters, potentially resulting in inappropriate land management recommendations. Determining the soil fertility index is done by assessing the properties of the soil found on a plot of land so that its fertility level can be categorized from high to low based on the assessment that has been carried out on the land (Romadhon & Hermiyanto, 2021).

Previous research at the same location has assessed soil fertility using the *matching method. At the same time,* this study offers a novelty by applying the Soil Fertility Index (SFI), which can assess soil fertility quantitatively and in an integrated manner. Research on soil fertility index assessment is crucial given the lack of recent data on soil fertility indices for several land uses in Wonosalam Village. This study aims to analyze the soil fertility indices for several agricultural land uses in Wonosalam Village.

## 2. Material and Methods

### 2.1. Tools and materials

The tools used in this study consisted of laboratory analysis tools such as analytical scales, ovens, shakers, pH meters, spectrophotometers, and glassware (Erlenmeyer flasks, beakers, pipettes, burettes, test tubes, volumetric flasks, funnels, and filter paper). Field survey tools included hoes, meters, plastic bags, label paper, and GPS (Geographic Positioning System). Data processing used a computer with Microsoft Excel, Microsoft Office, and ArcGIS *software.*

The materials used in this study include chemicals as reagents for soil analysis, such as distilled water, 10% $H_2O_2$ , 2N HCl, 1N pH $NH_4$ OAc, alcohol, 50% NaOH, concentrated $H_2SO_4$ , and $K_2Cr_2O_7$ . In addition, a land use map from the 2024 Landsat 8 image of Wonosalam Village, a contour map of Wonosalam Village from the 30 m resolution SRTM 30 DEM data, and a map of Indonesian soil types were used.

### 2.2. Retrieval Soil Sample

The determination of soil sampling points in this study was carried out using the purposive random sampling method, namely sampling was carried out intentionally with certain considerations, namely based on different land uses and having different characteristics, and also applied to various land management practices (Figure 1). Sample points were taken from 5 land use units, including mixed gardens, kobi gardens, salak gardens, rice fields, and dry fields, with 4 points obtained. Each point will be taken with 5 replicate samples to represent the area with a depth of 0-20 cm, 20-40 cm, and 40-60 cm.

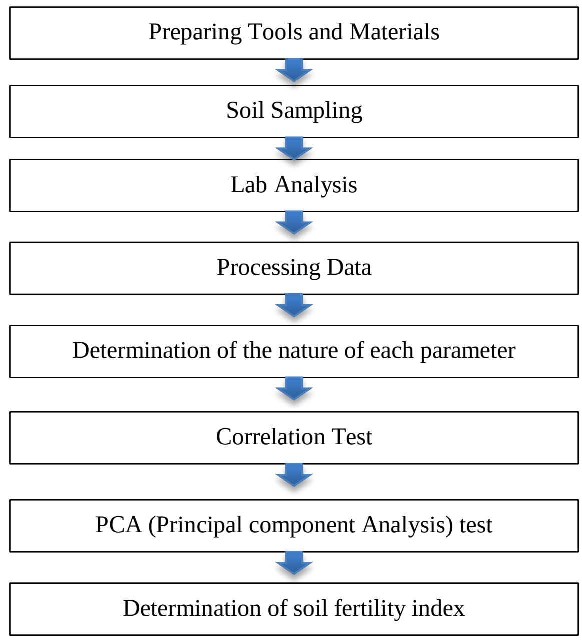


**Figure 1**Diagram channel study

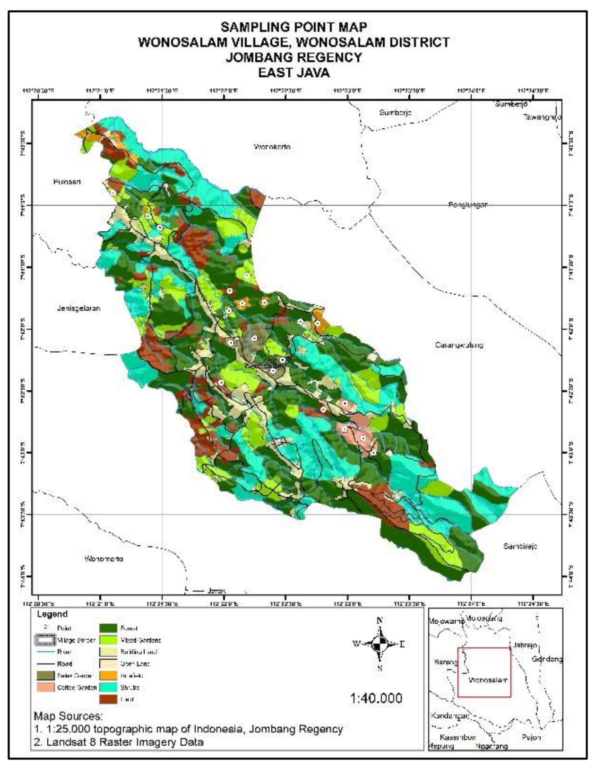


**Figure 2**Village Sampling Point Map Wonosalam

### 2.3. Soil Preparation and Analysis

The obtained soil samples were then analyzed in the Land Resources Laboratory of the Faculty of Agriculture, Veteran National Development University, East Java. The determined soil chemical properties were pH H2O (potentiometry), total nitrogen (Kjeldahl), available potassium (flame photometry), available phosphorus (Bray 1 and Olsen), CEC (NH4OAc pH 7 1N extraction), organic carbon content (Walkey and black), base saturation (ammonium acetate), and Al-dd (acid saturation). Meanwhile, the physical analysis carried out was texture (pipette). The results of the soil chemical properties analysis were then categorized based on the values of the soil chemical parameters, as in Table 1.

### 2.4. Index Soil fertility

The results of the analysis of soil fertility index indicators were then analyzed using *Pearson Correlation Analysis* and *Principal Components Analysis* (PCA) to find *the Minimum Soil Fertility Indicators* (MSFI) using SPSS software. MSFI will help identify relevant indicators to evaluate the relationship between selected indicators in a soil type. The principal component (PC) used as MSFI is a PC with an eigenvalue ≥1, a cumulative percentage of >60%, or reaching 85%. Determination of SFI is obtained by dividing the total MSFI weight by the total number of indicators, as shown in equation (4). Scoring is based on Table 1, and the classification of soil fertility status is adjusted to (Bagherzadeh *et al* ., 2018) (Table 2). The calculation results are classified into soil fertility index classes. Assessment of soil fertility index (Mukashema, 2007; Dewi *et al*., 2024):

$$\boldsymbol{Cj = Wi \times Si} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\boldsymbol{Pc = \frac{1}{n_c}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\boldsymbol{SCi = Cj \times Pc} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\boldsymbol{SFI = \frac{(\sum_{i=1}^{n} SCi)}{N} \times 10} \ldots\ldots\ldots\ldots \quad (4)$$

Information:
Cj = Total weight of the score
Wi = Index weight
Si = Index score
Pc = Probability of SFI class for each MSFI
nc = Number of SFI classes
Sci = Scoring of each indicator included in the MSFI
W = Weight of each indicator included in the MSFI

**Table 1.** Soil Chemical Parameter Criteria Values

| Parameter | Dignity | | | | |
|---|---|---|---|---|---|
| | 1 (SR) | 2 (R) | 3 (S) | 4 (T) | 5 (ST) |
| N total | < 0.1 | 0.1 – 0.2 | 0.21 – 0.5 | 0.51 – 0.75 | > 0.75 |
| P Available | < 4 | 5 – 7 | 8 – 10 | 11 – 15 | > 15 |
| K-dd | < 0.1 | 0.1 – 0.3 | 0.4 – 0.5 | 0.6 – 1.0 | > 1.0 |
| C- Organic | < 1 | 1 – 2 | 2 – 3 | 3 – 5 | > 5 |
| KB | < 20 | 20 – 40 | 41 – 60 | 61 – 80 | > 80 |
| KTK | < 5 | 5 – 16 | 17 – 24 | 25 – 40 | > 40 |
| Al-dd | < 5 | 5 – 10 | 11 – 20 | 21 – 40 | > 40 |
| pH | < 5 | 5 – 5.4 | 5.5 – 5.8 | 5.9 - 6 | 6.7 |
| Texture | S, Si | LS | SL, L, SiL | SiC, CL, SCL | SiCL, SC, C |

Source: Balittan (2009) : Dewi *et al*., (2024)

**Table 2.** Soil Fertility Index Class

| No | Fertility Value | Fertility Class |
|---|---|---|
| 1. | 0.00 – 0.25 | Very Low |
| 2. | 0.25 – 0.50 | Low |
| 3. | 0.50 – 0.75 | Currently |
| 4. | 0.75 – 0.90 | Tall |
| 5. | 0.90 – 1.00 | Very high |

Source: Al Bagherzadeg *et al* . (2018)

## 3. Results and Discussion

### 3.1. Condition General Research Location

Wonosalam Village is located in Wonosalam District, Jombang Regency, which stretches from 112.354633 South Latitude to 7.708874 East Longitude. Wonosalam Village is a highland area with an average height of 500-600 meters above sea level, with undulating to hilly topography. Wonosalam Village covers 1,452 hectares, with land uses including rice fields, dry fields, gardens, and forests. The research locations, or soil sampling locations, were conducted across several land uses, including mixed gardens, dry fields, rice fields, snake fruit plantations, and coffee plantations.

### 3.2. Chemical Properties of Soil

Soil chemical properties are one of the main indicators that determine the level of soil fertility and productivity because they are directly related to the availability of nutrients. Analysis of soil chemical properties provides an overview of the soil's ability to provide essential nutrients for plants and prevent nutrient loss due to leaching or certain chemical reactions. Soil chemical properties: Parameters observed in this study include pH, organic carbon, total nitrogen, available phosphorus, available potassium, CEC, base saturation (KB), and extra-alkali. The results of the chemical analysis that has been carried out can be seen in Table 3.

The soil pH values in all samples ranged from 5.02 to 6.98, indicating soil conditions ranging from acidic to slightly acidic with varying management systems. Pamenang *et al*, (2025) mention that soil pH conditions in Wonosalam are classified as acidic enough. Land with an organic and inorganic fertilizer management system (KC 1) showed a pH of 6.09, which is categorized as slightly acidic, higher than land using only NPK fertilizers such as KC 3 (5.66) and KC 4 (5.60). This result indicates that the application of organic matter can increase soil pH through the release of base cations and the formation of buffer compounds (Rusli *et al*., 2022). Land managed with single inorganic fertilizers such as NPK or urea tends to have a lower pH because nitrogen fertilizers can produce $H^+$ ions through the nitrification process, which causes a decrease in soil pH (Wang et al., 2018).

The manure management system at KK 4 and TG 4 locations showed a relatively high organic C content ranging from 1.46-1.57% because manure is a source of carbon-rich organic matter and can significantly increase soil organic C. The management system with single inorganic fertilizers such as NPK fertilizer at KC 3, KC 4, TG 3, and SW 4 showed a lower organic C content ranging from 0.95-1.60%. The low organic C was due to the absence of external organic matter addition, so that soil organic C only came from the decomposition of plant residues and roots. Increasing soil organic C content can increase cation exchange capacity, improve soil aggregation, and increase the soil's ability to retain water (Ramos *et al*., 2018).

The total N value in all samples ranged from 0.12% to 0.31%, which is included in the low to moderate category. Land with an organic and inorganic fertilizer management system in KC 1 showed the highest total N (0.31%) with the use of combined fertilizers (organic and inorganic fertilizers). The combination of organic fertilizers provides slow-release nitrogen, and inorganic fertilizers provides rapidly available nitrogen, thereby increasing nitrogen accumulation in the soil. Land managed with urea fertilizers such as in TG 2, KS 2, and SW 3 showed varying total N content (0.13-0.22%) because urea fertilizer is easily leached and experiences volatilization, so that not all applied nitrogen accumulates in the soil (Wan *et al*., 2024). Nitrogen availability is closely related to soil organic matter content and microbial activity (Bao *et al*., 2024).

**Table 3.** Results of the Analysis of the Chemical Properties of the Soil in Wonosalam Village

| Code Sample | pH $_{H2O}$ | C-Org (%) | N-Total (%) | P-Ter (ppm) | K-dd (me/100g) | KTK (me/100g) | KB | Al-dd (me/100g) |
|---|---|---|---|---|---|---|---|---|
| KC 1 | 6:09 AM | 1.39(R) | 0.17(R) | 12.57(S) | 0.83(T) | 32.24(T) | 44.34(R) | 0.12(SR) |
| KC 2 | 5.78 AM | 1.38(R) | 0.12(R) | 9.80 (R) | 0.20(R) | 31.14(T) | 46.9(R) | 0.22(SR) |
| KC 3 | 5.85 AM | 1.62(R) | 0.14(R) | 7.15 (R) | 0.49(S) | 25.39(T) | 42.59(R) | 0.15(SR) |
| KC 4 | 5.66 AM | 1.60(R) | 0.14(R) | 7.67 (R) | 0.58(S) | 26.27(T) | 43.77(R) | 0.19(SR) |
| KS 1 | 5.60 AM | 1.12(R) | 0.20(R) | 9.29 (R) | 0.48(S) | 27.85(T) | 47.80(S) | 0.14(SR) |
| KS 2 | 5.48(M) | 1.18(R) | 0.18(R) | 4.09(SR) | 0.77(T) | 24.80(S) | 49.11(S) | 0.23(SR) |
| KS 3 | 5.81 AM | 1.46(R) | 0.16(R) | 14.04(S) | 1.25(ST) | 25.38(T) | 51.91(S) | 0.07(SR) |
| KS 4 | 5.98 AM | 0.93(SR) | 0.12(R) | 13.17(S) | 2.24(ST) | 24.06(S) | 53.54(S) | 0.23(SR) |
| KK 1 | 5.60 AM | 1.57(R) | 0.24(S) | 9.90(R) | 2.50(ST) | 29.06(T) | 47.81(S) | 0.11(SR) |
| KK 2 | 5.19(M) | 1.07(R) | 0.16(R) | 2.28(SR) | 0.81(T) | 19.89(S) | 46.69(S) | 0.19(SR) |
| KK 3 | 5.23(M) | 1.60(R) | 0.22(S) | 4.62(SR) | 1.22(ST) | 31.96(T) | 29.06(R) | 0.27(SR) |
| KK 4 | 5.12(M) | 0.07(SR) | 1.51(R) | 0.21(S) | 2.61(ST) | 30.82(T) | 31.02(R) | 0.58(SR) |
| SW 1 | 5.15(M) | 0.06(SR) | 2.57(S) | 0.31(S) | 1.03(ST) | 33.28(T) | 40.30(S) | 0.18(SR) |
| SW 2 | 5.39(M) | 0.07(SR) | 3.02(S) | 0.31(S) | 1.07(ST) | 33.47(T) | 29.04(S) | 0.16(SR) |
| SW 3 | 5.18(M) | 0.05(SR) | 1.80(R) | 0.20(R) | 0.68(T) | 26.80(T) | 37.63(S) | 0.47(SR) |
| SW 4 | 5.29(M) | 0.05(SR) | 1.96(R) | 0.23(S) | 0.92(T) | 33.29(T) | 36.99(S) | 0.26(SR) |
| TG 1 | 5.38(M) | 0.05(SR) | 1.66(R) | 0.17(R) | 0.32(R) | 31.20(T) | 35.72(R) | 0.12(SR) |
| TG 2 | 5.61 AM | 0.07(SR) | 1.33(R) | 0.13(R) | 0.12(R) | 32.81(T) | 32.54(R) | 0.15(SR) |
| TG 3 | 5.80 AM | 0.12(SR) | 1.42(R) | 0.15(R) | 0.43(S) | 29.14(T) | 30.85(R) | 0.18(SR) |
| TG 4 | 5.45(M) | 0.06(SR) | 1.77(R) | 0.09(R) | 0.43(R) | 27.81(T) | 34.38(R) | 0.15(SR) |

Description: KC = Mixed Garden, KS = Salak Garden, KK = Coffee Garden, SW = Rice Field, TG = Dry Field, M = Sour, AM = Slightly Sour, SR = Very Low, R = Low, S = Medium, T = Very High

Available P content showed a wide variation, ranging from 2.62 ppm to 14.04 ppm, with low to moderate criteria depending on the land management system. Land with SP-36 fertilizer management systems at TG 1, KS 1, and KS 4 showed high available P content ranging from 9.20-13.17 ppm because SP-36 fertilizer is a source of phosphorus that is easily soluble and quickly available to plants (Syers *et al*., 2020). Management systems with NPK fertilizers at several locations such as KC 3, KC 4, and TG 3 showed relatively low available P ranging from 2.62-7.67 ppm. These values indicate the occurrence of phosphorus fixation by Al and Fe, which usually occurs in land with acidic conditions (Bao *et al*., 2024).

The K-DD value ranged from 0.30 cmol(+)/kg to 2.61 cmol(+)/kg, with low to moderate criteria, with land use with the NPK fertilizer management system in KC 2 showing the highest K-DD (2.30 cmol(+)/kg). This result is because NPK fertilizer contains potassium in a soluble form, which can directly increase exchangeable potassium in the soil (Amoakwah *et al*., 2024). Land managed with manure in TG 4, KK 4, and several other locations showed a relatively low K-DD ranging from 0.43-0.81 cmol(+)/kg because the potassium in the manure is partly still in organic form that needs to be mineralized, and some is easily leached. The availability of potassium in the soil can be reduced due to several things, namely being transported by plants with the harvest, being leached, eroded and fixed (Rahmayanti *et al*., 2021).

The soil CEC value ranges from 19.89 cmol(+)/kg to 46.69 cmol(+)/kg, which is categorized as medium to high. Land with organic and inorganic fertilizer management systems at KC 1 shows the highest CEC (46.30 cmol(+)/kg) because the continuous addition of organic matter can increase soil organic colloids that have a high negative charge to bind cations. Management systems with single inorganic fertilizers such as NPK, SP-36, or urea in several locations show a relatively lower CEC ranging from 19.89-31.96 cmol(+)/kg. A decrease in the soil CEC value occurs when the organic matter content in the soil decreases due to physical activity that occurs in the soil (Sarah *et al*., 2024).

Base saturation values ranged from 11.02% to 53.54% with low to moderate criteria, with land use KC 1 showing the highest KB value (46.30%), including moderate. The management system with SP-36 fertilizer in KS 1 and TG 1 showed a relatively high KB ranging from 47.81-49.11% because phosphate fertilizers such as SP-36 contain calcium, which can increase the content of base cations in the soil. Land managed with urea fertilizer or NPK fertilizer in several locations such as KC 3, KC 4, SW 2, SW 4, and KK 1 showed low KB ranging from 11.02-36.99% because nitrogen fertilizers can cause a decrease in pH and leaching of base cations. In soils with low base saturation, most of the soil adsorption complexes are filled with acid cations such as Al3+ and H+ (Sefano and Hakim, 2024).

The Aluminum Saturation Content (Al-dd) ranges from 0.11 cmol (+)/kg to 0.58 cmol (+)/kg, which is included in the very low category. Aji *et al.* (2024) mention that in the Wonosalam area, Alfisol land is rich in aluminum and iron, so the term "Alf" refers to aluminum (Al) and iron (Fe). Land with organic and inorganic fertilizer management systems at KC 1 shows low Al-dd (0.12 cmol(+)/kg) because organic matter can form complex compounds with aluminum, thereby reducing exchangeable aluminum, which is toxic to plants. The compost management system also shows low Al-dd because compost can increase soil pH and bind aluminum into a non-toxic form (Cahyono, 2021). Land managed with single inorganic fertilizers such as NPK fertilizers shows relatively higher Al-dd ranging from 0.19-0.47 cmol(+)/kg because nitrogen fertilizers can lower soil pH, thereby increasing aluminum solubility and saturation (Rahman *et al*., 2022). Al-dd is related to soil pH where if soil pH increases, Al-dd will decrease, and vice versa (Butar *et al*., 2024).

### 3.3. Soil Texture

Soil texture is a basic physical property that describes the relative proportions of sand, silt, and clay in a soil sample. This property significantly influences the soil's ability to retain water, air, and nutrients needed by plants. The soil textures for each land use in this study are shown in Table 4.

Soil texture analysis in Wonosalam Village shows variations in clay, dusty clay, and dusty clay loam texture classes with a dominance of clay and dust fractions, and low sand content (5–11%). Mixed gardens (KC) have a dusty clay to dusty clay loam texture with a clay content of 40–47% and dust 46–53%, snake fruit plantations (KS) show a clay to dusty clay loam texture with a clay content of 31–68%, coffee plantations (KK) are dominated by clay texture with a clay fraction of 57–68%, irrigated rice fields (SW) have a dusty clay to dusty clay loam texture with a clay fraction of 32–51%, and dry fields (TG) have a clay to dusty clay texture with a clay content of 40–59%. Clay-textured soils, because they are finer, have a larger surface area, so that can retain water and provide high nutrients. This result indicates that fine-textured soil has better soil chemical properties than coarse-textured soil (Hilungka *et al*., 2020).

### 3.4. Index Soil Fertility and Recommendations Management Land

The Soil Fertility Index *(SFI) is a useful value for determining resource management due to changes in soil* productivity of a soil. The results of the correlation analysis (Table 5) indicate positive and negative correlations between several variables and the SFI. A positive correlation means that if one variable increases, the other variable will also increase. On the other hand, a negative correlation means that if one variable increases, the other variable decreases (Dewi *et al*., 2024).

Correlation values show an existing connection between inter-indicator fertility and soil. pH correlates significantly with organic C (r = –0.326), total N (r = –0.348), and available P (r = 0.586), indicating that pH plays a role in the availability of nutrients and organic material

(Kabala *et al*., 2025; Arumtanzia *et al*., 2024). C- organic correlated significantly with N-total (r = 0.714) and K-dd (r = 0.515), indicating that organic material followed an increase in total nitrogen as well as the capacity to trap cations (Chaudhary *et al*., 2025). N-total correlated negatively with pH (r = –0.531) and KB (r = –0.464), indicating nitrogen accumulation in the soil as well as its decrease at a lower pH, with a faster consequence ofmineralization (Nopsagiarti et al., 2025). P-available correlated significantly with K-dd (r = 0.449) and KB (r = 0.648), indicating that phosphorus is more available on the ground with dominant cation exchange (Alwi *et al*., 2023).

**Table 4.** Analysis Results: Soil Texture

| Sample Code | Faction | | | Texture |
|---|---|---|---|---|
| | Sand (%) | Dust (%) | Clay (%) | |
| KC 1 | 7 | 46 | 47 | Dusty Look |
| KC 2 | 8 | 53 | 40 | Dusty clay loam |
| KC 3 | 7 | 50 | 43 | Dusty Look |
| KC 4 | 6 | 51 | 44 | Dusty Look |
| KS 1 | 8 | 61 | 31 | dusty clay loam |
| KS 2 | 5 | 31 | 64 | clay |
| KS 3 | 6 | 40 | 54 | clay |
| KS 4 | 5 | 27 | 68 | clay |
| KK 1 | 8 | 35 | 57 | clay |
| KK 2 | 7 | 30 | 63 | clay |
| KK 3 | 7 | 35 | 58 | milk |
| KK 4 | 6 | 26 | 68 | clay |
| SW 1 | 9 | 59 | 32 | dusty clay loam |
| SW 2 | 5 | 44 | 51 | Dusty Look |
| SW 3 | 8 | 54 | 38 | dusty clay loam |
| SW 4 | 7 | 45 | 48 | Dusty Look |
| TG 1 | 6 | 54 | 40 | dusty clay loam |
| TG 2 | 10 | 37 | 54 | clay |
| TG 3 | 4 | 37 | 59 | clay |
| TG 4 | 11 | 43 | 46 | dusty clay |

Description : KC = garden mixed (4 points ), KS = Garden salak (4 points ), KK = coffee plantation (4 points ), SW = rice fields (4 points ), TG = dry fields (4 points )

**Table 51**Results of Pearson Correlation Analysis

| | pH | C-Org | N-Total | P-Available | K-dd | KTK | KB | Al-dd |
|---|---|---|---|---|---|---|---|---|
| **pH** | 1 | | | | | | | |
| **C-org** | -0.415 | 1 | | | | | | |
| **N-Total** | **-,531*** | **,714**** | 1 | | | | | |
| **P-Available** | **,745**** | -0.267 | -0.175 | 1 | | | | |
| **K-dd** | **,523*** | **,515*** | 0.189 | **,449*** | 1 | | | |
| **KTK** | **-,543*** | 0.329 | 0.388 | -0.258 | -0.147 | 1 | | |
| **KB** | **,940**** | -0.275 | **-,464*** | **,648**** | **,613**** | **-,586**** | 1 | |
| **Al-dd** | **-,530*** | 0.003 | 0.142 | -0.231 | **-,492*** | 0.367 | **-,740**** | 1 |

K-dd correlated significantly with organic C- (r = 0.515), KB (r = 0.472), and negatively with Al-dd (r = –0.492), confirming that domination language lowers aluminum availability (Lisa et al., 2022; Puja et al., 2018). KTK correlates negatively with pH (r = –0.543) and KB (r = –0.586), indicating that capacity trap tall No always followed saturation alkaline (Faery *et al*., 2024). Al-dd correlated negatively with pH (r = –0.601), K-dd (r = –0.492), and KB (r = –0.740), indicating Al dominance in the soil under saturation and its decline as saturation increases (Sahfiitra, 2023).

Furthermore, a PCA analysis was conducted of selected MSFI indicators (Table 5). PCA was used to select the SFI calculation parameters. Based on the PCA analysis, there were eight indicators including pH, Organic C, Total N, Available P, Extra K, CEC, KB, and Extra Al. Each indicator was assigned a weight and a score calculated using the procedure described in (Mukashema; Dewi *et al*., 2024). PCA analysis was performed with the indicators selected in MSFI, namely indicators that are correlated with each other. Table (6) shows that the cumulative index obtained is 0.914.

The main components with eigenvalues ≥ 1 or cumulative percentages > 60% are PC1 to PC4. These components also explain approximately 91.4% of the total variation, which is quite good, as can be seen from the cumulative total, namely by adding up the proportions of each component (Dewi *et al*., 2024).

**Table 6.** Principal Component Analysis Results

| **Eigenvalue** | **2,841** | **1,801** | **1,511** | **1,159** |
|---|---|---|---|---|
| Proportion | 0.355 | 0.225 | 0.189 | 0.145 |
| Cumulative | 0.355 | 0.580 | 0.769 | 0.914 |
| Eigenvectors | | | | |
| **Variable** | **PC1** | **PC2** | **PC3** | **PC4** |
| pH | **-0.495** | 0.050 | -0.358 | -0.191 |
| C-Organic | **0.453** | 0.116 | -0.385 | 0.103 |
| N-Total | **0.461** | 0.381 | -0.176 | 0.116 |
| P-Ter | -0.362 | **0.410** | -0.232 | -0.407 |
| K-DD | 0.042 | **0.606** | 0.281 | -0.323 |
| KTK | 0.346 | -0.057 | **-0.477** | -0.445 |
| KB | -0.125 | 0.547 | 0.020 | **0.552** |
| Al-DD | 0.260 | 0.028 | **0.576** | -0.408 |

The selection of these indicators is based on the largest absolute value for each PC (positive or negative) because it indicates the strongest relationship. Loading values can be positive or negative and are selected based on magnitude (absolute value) because the greater the value, the greater the influence of the variable on the component. A positive loading value for a variable indicates that the variable is related in the same direction as the principal component (PC), meaning that when the variable increases, the PC value also increases. A negative loading value for a variable indicates that the variable is related in the opposite direction to the principal component (PC), meaning that if a variable increases, the PC value will decrease (Chen *et al.*, 2021) .

PC1, with an *eigenvalue of* 2.84 with a proportion of 35% consists of three indicators, namely pH, C-Organic, and N-Total. PC2 with an eigenvalue of 1.80 and a proportion of 22% consists of two indicators, namely P-Available and K-dd. PC3 with an eigenvalue of 1.51 and a proportion of 18% consists of two indicators, namely CEC and Al-dd. PC4 with an eigenvalue of 1.15 and a proportion of 14% consists of one indicator, namely KB. Based on the results of the Soil Fertility Index (SFI) analysis conducted on various land uses in Wonosalam Village ( Table 7), it shows that the level of soil fertility is generally in the moderate category with values ranging from 0.53 to 0.65.

Table 7. Index Soil fertility

| **Land Use** | **Point** | **SFI Values** | **SFI Class** |
|---|---|---|---|
| (Mixed Garden) | 1 | 0.68 | Currently |
| | 2 | 0.56 | Currently |
| | 3 | 0.59 | Currently |
| | 4 | 0.59 | Currently |
| | **Average** | 0.60 | Currently |
| (Salak Fruit Garden) | 1 | 0.63 | Currently |
| | 2 | 0.57 | Currently |
| | 3 | 0.72 | Currently |
| | 4 | 0.70 | Currently |
| | **Average** | 0.65 | Currently |
| KK (Coffee Plantation) | 1 | 0.72 | Currently |
| | 2 | 0.57 | Currently |
| | 3 | 0.62 | Currently |
| | 4 | 0.68 | Currently |
| | **Average** | 0.65 | Currently |
| SW (Rice Field) | 1 | 0.66 | Currently |
| | 2 | 0.72 | Currently |
| | 3 | 0.60 | Currently |
| | 4 | 0.63 | Currently |
| | **Average** | 0.65 | Currently |
| TG (Tegalan) | 1 | 0.50 | Currently |
| | 2 | 0.56 | Currently |
| | 3 | 0.59 | Currently |
| | 4 | 0.49 | Low |
| | **Average** | 0.53 | Currently |

Mixed Gardens (KC) have an average SFI value of 0.60, which is classified as moderate. Mixed vegetation consisting of snake fruit, cloves, oranges, mahogany, durian, and bananas makes a positive contribution to soil fertility through the diversity of organic matter inputs from the resulting litter. According to Octavia *et al.* (2023) agricultural systems such as mixed gardens contribute to increasing CEC and base saturation (KB) of the soil through the addition of organic matter and binding of base cations.

The Salak Plantation (KS) showed an average SFI value of 0.65, which is one of the highest values among other land uses. This land is managed with the application of SP-36 fertilizer, NPK fertilizer, and compost on a land slope of 13.3-15.6% with salak monoculture vegetation. The high SFI value in the salak plantation indicates that the management system with a combination of inorganic fertilizers and compost is quite effective in maintaining soil fertility, as stated by Zhuang *et al.* (2024) that fertilization that combines organic substrates (compost/litter) with inorganic fertilizers increases soil C-Organic, CEC, and NPK availability compared to the use of single inorganic fertilizers. The Coffee Plantation (KK) has an average SFI value of 0.65, the same as the salak plantation. The management system implemented includes the application of compost, NPK fertilizer with compost, and manure on land with a slope of 12.3-13.9% planted with coffee as the sole vegetation. The advantage of coffee plantations lies in their relatively higher potassium content compared to other land uses, which supports the growth and production of coffee plants.

Paddy fields (SW) showed an average SFI value of 0.65 with a management system using N fertilizer (urea and ZA), straw, and NPK fertilizer. The content of C-Organic and P-Available is very low in paddy fields. However, the SFI value is quite high because a continuous irrigation system and a regular planting cycle support it. Utilization of straw as a source of organic matter is a good practice to support soil fertility (Zhao *et al*., 2019). Dry fields (TG) have the lowest average SFI value of 0.53, although it is still classified as a medium category. The lowest SFI value in dry fields is caused by several main limiting factors such as very acidic soil pH, very low organic carbon content, and very limited phosphorus and potassium.

## 4. Conclusion

The soil fertility index value in Wonosalam Village is classified as low to moderate in each land use; dry land use has the lowest value with an average of 0.53 (moderate), and salak plantations, coffee plantations, and rice fields have the same average SFI value of 0.65 (moderate). In contrast, coffee plantations have an average SFI value of 0.59 (moderate). Based on these results, more sustainable land management efforts are needed, especially in dry land and coffee plantations, through increasing organic matter and balanced nutrient management to improve and maintain soil fertility.

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