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Evaluation of Soil Fertility Status in Shifting Cultivation of Upland Rice in Tanah Merah Village, Warmare District, Manokwari Regency, West Papua

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ABSTRACT

This study was conducted on the agricultural land of Indigenous Papuan communities in Tanah Merah Village, Warmare District, Manokwari, where shifting cultivation is practiced in conjunction with a subsistence and semi-commercial farming system for upland rice (*Oryza sativa*). The research employed a descriptive method with a survey technique to determine the locations for composite soil sample collection in shifting cultivation fields planted with upland rice. The results showed that the soil in the study area has a clay texture with a yellowish-red to reddish-yellow color. The soil reaction (pH) is classified as acidic, slightly acidic, and neutral. Organic carbon content ranges from high to low. Total nitrogen content is classified as moderate in the upper soil layer and low in the lower soil layer across all land sections. Total phosphorus and available phosphorus contents are categorized as low to very low. Total potassium content is classified as moderate to low. Cation exchange capacity (CEC) and base saturation (BS) show varied values, leading to a low soil fertility status in the upper and middle land sections. In contrast, the lower land section has a moderate fertility status. The shifting cultivation system contributes to maintaining soil organic matter content. However, to improve land productivity, phosphorus (P) and potassium (K) fertilizers should be applied, along with soil conservation techniques such as terracing or ridging to reduce erosion risk and surface runoff.

Keywords: soil fertility, shifting cultivation, Manokwari, upland rice, Warmare.

INTRODUCTION

Shifting cultivation is a traditional agricultural technique that has been widely practiced in tropical countries (Borah *et al*., 2022). Shifting cultivation is practiced by utilizing a plot of forest land for cultivation. After the harvest season, the land is then abandoned or left fallow for a certain period of time, known as the fallow period. During the fallow period, the abandoned land is left untouched, with the hope that the soil fertility will increase naturally before it is used again (Chen *et al*., 2023). Shifting cultivation begins with the selection of forest land to be used as a garden. After determining the location, trees are cut down, branches and grass are cleared, and the land is dried and burned. The ash from the burning is believed to serve as a source of nutrients for the plants (Dhonanto *et al*., 2025). Once the land is ready, planting can begin (Temjen *et al*., 2022).

Shifting cultivation systems are often associated with the main cause of forest land deforestation; however, on the other hand, shifting cultivation supports food security for indigenous peoples (Dhonanto *et al*., 2025), as a symbol of indigenous

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cultural identity and mutual cooperation (Sriyana *et al*., 2025), spirituality (Kamakaula & Uria, 2025), and local wisdom (Tola *et al*., 2024). In addition, farmers generally do not cultivate the soil; planting is done by making holes using a tugal to plant seeds or seedlings (Dampa *et al*., 2024). Ecologically, this is considered a wise way to utilize the forest (Rahmadanih *et al*., 2024).

In Indonesia, shifting cultivation has long been practiced and is still applied today, such as in several areas on the island of Kalimantan by the Dayak indigenous people (Maring, 2020; Reneng, 2022; Sriyana *et al*., 2025); some areas in Banten by the Baduy indigenous community (Chairuman, 2024), on the island of Sumatra (Evizal, 2020), Sulawesi (Fauzia *et al*., 2023), Nusa Tenggara (Safe, 2024), Maluku (Matinahoru, 2023), and Papua (Dampa *et al*., 2024; Tola *et al*., 2024; Kamakaula & Uria, 2025; Kareth *et al*., 2025). West Papua is one of the provinces on the island of Papua, where most of the indigenous people still practice shifting cultivation in their agricultural activities, one of which is in the Warmare District. Warmare District is one of the districts (sub-districts) in Manokwari Regency, the capital of West Papua Province. Warmare District has a forest area that is used by the local community for agricultural activities using a shifting cultivation system (Dampa *et al*., 2024; Tola *et al*., 2024).

Forest land utilized for shifting cultivation is collectively owned by family/clan groups, which is referred to as *tanah ulayat* (customary land) (Dampa *et al*., 2024). Various types of crops, including food crops and horticultural commodities, are cultivated on this land. These include upland rice, corn, and tubers (taro, cassava, sweet potato, and yam), chili, banana, as well as vegetables such as kale, spinach, *gedi*, and mustard greens. Additionally, several rhizome crops, such as ginger, turmeric, and galangal, are intercropped within the shifting cultivation area. Upland rice is planted as a monoculture on a stretch of land, while other food crops, such as tubers, bananas, and other horticultural crops, are planted as a mixed polyculture on a stretch of land.

Farmers or indigenous communities in Tanah Merah Village, Warmare District, who practice shifting cultivation, also practice subsistence and semi-commercial agriculture. This means that most of their agricultural produce is used to meet household needs; however, if there is a surplus harvest or if the community needs cash for daily needs, then some of the harvest will be sold. In shifting cultivation systems, soil cultivation, fertilizer inputs, and pesticides and disease control chemicals are minimally applied or not used at all. Soil fertility depends solely on natural processes during the fallow period. Thus, the purpose of this study is to analyze nutrients and evaluate soil fertility in agricultural land using a shifting cultivation system, specifically for upland rice in Tanah Merah village, Warmare District, Manokwari Regency, West Papua Province. Upland rice fields were chosen as the object of this study because Tanah Merah Village is a rice-producing area in Manokwari Regency, and upland rice is grown exclusively as a monoculture, unlike other crops that are mixed with other crops in the same field. The results of this study are expected to provide benefits and information, as well as input for farmers and researchers to determine the nutrient content and fertility status of the soil in the shifting cultivation system at the research site.

MATERIALS AND METHODS

Research time and location

This research was conducted from August to October 2022 in Tanah Merah village (0059'38.54“ S - 133058'39.81” E to 1002'49.41“ S - 133058'51.97” E), Warmare District, Manokwari, West Papua, on upland rice fields using a shifting cultivation system (Figure 1).

Research tools and materials

The tools used were field equipment and laboratory equipment. For field equipment, soil drills, Munsell soil color charts, and mobile phones with Avenza Maps installed were used to collect coordinate points, as well as laptops equipped with Microsoft Office and ArcMap 10.8 software. The laboratory equipment used consisted of equipment for soil sample preparation, namely drying trays, mortars (for grinding/pounding soil), sieves (for separating fine and coarse soil particles), and plastic clips for storing soil samples ready for analysis. The materials used in this study were soil samples from the research location.

Soil sampling

The method used in this study was a descriptive method with field survey techniques. The research location was surveyed to determine the location for taking composite soil samples on shifting cultivation land cultivated with upland rice. The upland rice cultivation land found was generally located on sloping land, so soil samples were taken based on the slope gradient.

Soil sampling was conducted across a single expanse of upland rice cultivation, considering different slope gradients, specifically the upper, middle, and lower sections of the slope. The collected soil samples were coded US (Upper Slope), MS (Middle Slope), and LS (Lower Slope). For each section, sampling was performed by taking five bore soil samples to be composited into a single sample ready for analysis.

At each drilling point where soil samples were taken, surface rocks and litter were first cleared. At each sampling point, two soil layer depths were taken, namely at depths of 0-20 cm and 20-40 cm. Thus, 6 (six) composite soil samples were obtained, each weighing 1 kg, namely LA 0-20; LA 20-40; LT 0-20; LT 20-40; LB 0-20; LB 20-40.

Observation of soil physical properties

Observation of soil physical properties is conducted in the field at the same time as soil sampling. This observation includes field texture and soil color. Field texture is determined using the pirit method, but to obtain a comparison of three fractions, texture is also analyzed in the laboratory. In addition to texture, soil color is observed by matching the color of the soil with the colors listed in the Munsell soil color chart.

Analysis of soil chemical properties

The soil chemical properties analyzed included: pH H2O; total N; available P (ppm);

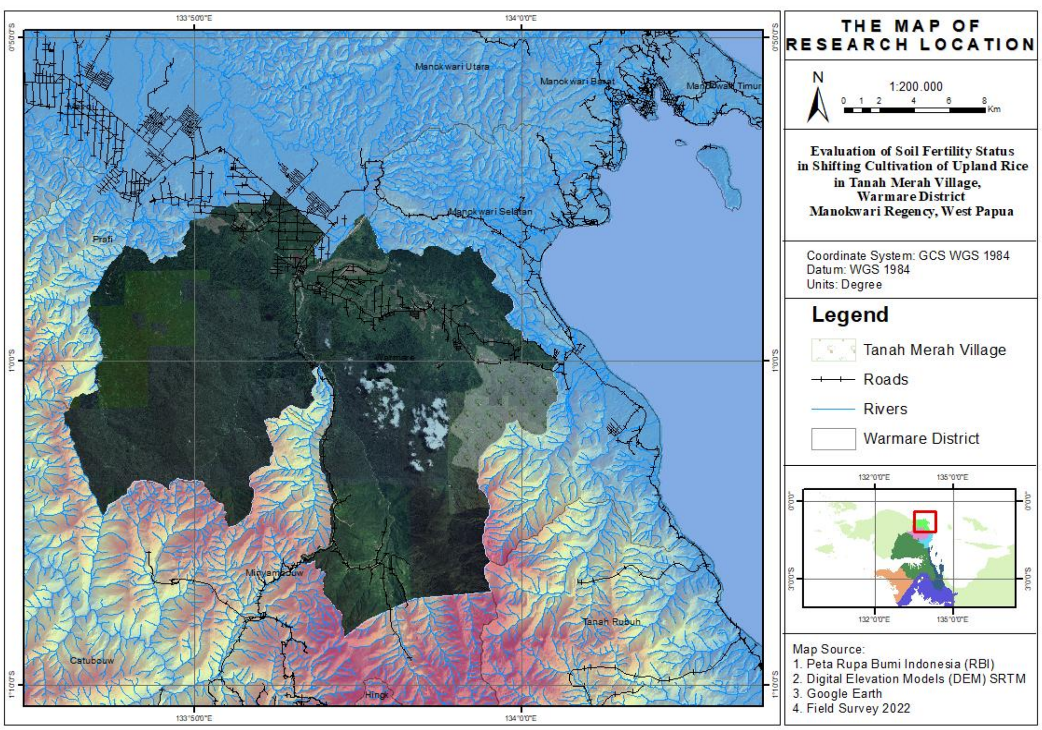

Figure 1. Research location map.

organic C; cation exchange capacity (CEC); base saturation (BS); and base cations Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}; as well as the texture of the three fractions. Soil samples were prepared at the Soil Laboratory of the Faculty of Agriculture, University of Papua, including cleaning of litter, plant roots, and gravel that were included during drilling; followed by drying (air drying), grinding, and sieving until the samples were ready for further analysis of their chemical properties at the Soil Laboratory, Department of Soil Science and Land Resources, IPB University.

Data analysis

Data analysis in this study was conducted by comparing the measurement results with the criteria in the technical guidelines for physical, chemical, and soil fertility properties. The data in this study were divided into three categories, namely data on physical soil properties, which will be described based on the technical guidelines for physical soil properties (Kurnia *et al*., 2023); data on the results of soil chemical property analysis, conducted by comparing the analysis results with the criteria for each property in the technical guidelines for soil chemical property assessment (Eviati *et al*., 2023), and for soil fertility evaluation, the data on the results of soil chemical property criteria were compared with the soil fertility status based on the technical guidelines for soil fertility evaluation (PPT, 1995). The analysis results are presented in tables and graphs and described in narrative form.

RESULTS AND DISCUSSION

Physical properties of soil

The physical properties of soil in this study consist of soil texture and color. Texture indicates the ratio of sand, silt, and clay fractions present in the soil. Texture greatly influences important soil properties, such as water-holding capacity,

Table 1. Physical properties of soil.

No	Sample codes	%			Texture	Class	Colour
		Sand	Silt	Clay			
1.	US 0 – 20	7.02	19.25	73.74	Clay	Fine	5 YR, 5/6 *Yellowish red*
2.	US 20 – 40	4.73	18.59	76.68	Clay	Fine	5 YR, 5/8 *Yellowish red*
3.	MS 0 – 20	12.38	34.14	53.47	Clay	Fine	5 YR, 5/6 *Yellowish red*
4.	MS 20 – 40	4.50	22.93	72.56	Clay	Fine	5 YR, 6/6 *Reddish yellow*
5.	LS 0 – 20	27.00	31.69	41.31	Clay	Fine	7,5 YR, 7/6 *Reddish yellow*
6.	LS 20 – 40	13.58	33.56	52.84	Clay	Fine	7,5 YR, 7/6 *Reddish yellow*

Table 2. Soil fertility status of research locations.

No	Sample codes	CEC	BS	Organic carbon	P_2O_5	K_2O	Fertility status
1.	US 0 – 20	27.12 (H)	50.21 (M)	4.23 (H)	14.97 (VL)	14.01 (L)	Low
2.	US 20 – 40	22.23 (M)	42.65 (M)	1.76 (L)	18.0 (L)	13.80 (L)	Low
3.	MS 0 – 20	40.29 (VH)	60.06 (M)	2.06 (M)	9.07 (VL)	37.65 (M)	Low
4.	MS 0 – 40	28.13 (H)	33.80 (L)	1.35 (L)	13.96 (VL)	11.04 (L)	Low
5.	LS 0 – 20	45.34 (VH)	78.16 (H)	2.62 (M)	10.71 (VL)	31.79 (M)	Moderate
6.	LS 20 – 40	42.71 (VH)	53.24 (M)	1.37 (L)	8.49 (VL)	13.83 (L)	Low

Notes: VL = very low; L = low; M = moderate; H = high; VH = very high.

infiltration, drainage, tillage properties, and nutrient retention capacity (Kurnia *et al.*, 2023). The texture and color classes of the soil at the study site are shown in Table 1.

The texture class of all soil samples at the research site is classified as clay with a fine texture. Soils with a high clay fraction tend to have higher water content and cation exchange capacity. This is due to the large specific surface area of the clay fraction, which is around 800 m^2/g, resulting in soils with a clayey texture being able to adsorb water molecules and other cations (Hartanto *et al*., 2022). However, soils with a texture dominated by clay fractions can make it difficult for plant roots to penetrate the soil because the soil consistency tends to be stickier when wet and harder (firmer) when dry.

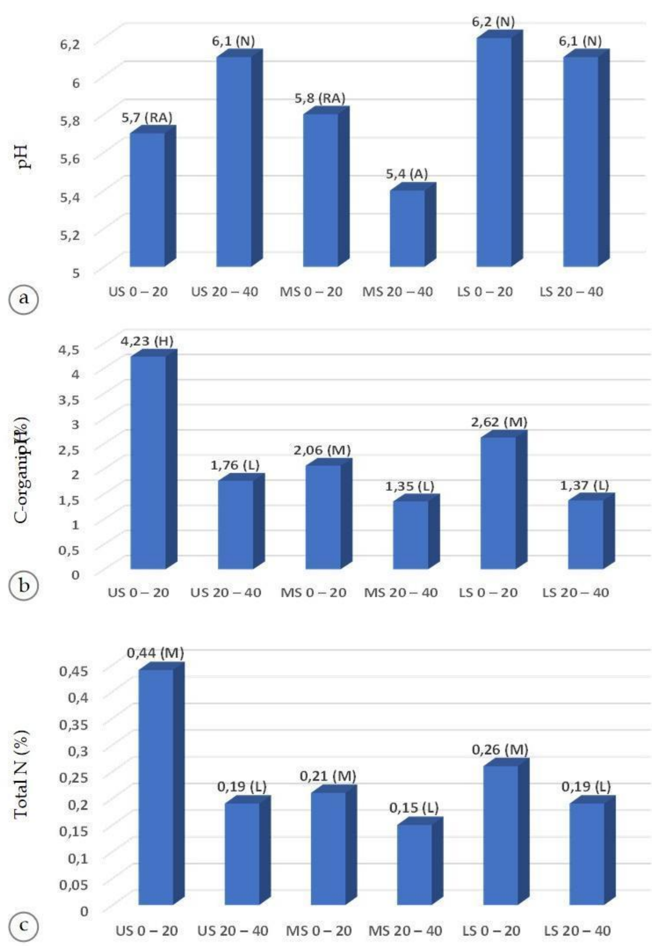

Figure 2. Distribution of values for pH (a), organic carbon (%)(b), and total N (%) (c).

The color of the soil at the research site ranges from yellowish red to reddish yellow. Soil color is an indication of several properties contained in the soil, one of which is organic matter content. Darker soil colors indicate high organic matter content, while lighter soil colors indicate low organic matter content (Hardjowigeno, 2010). The reddish color of the soil in this village is also the reason why it is called Tanah Merah village.

Chemical properties of soil

The chemical properties of soil in this study consisted of: soil reaction (pH), organic carbon, total nitrogen, phosphorus, potassium, base cations (Ca^{2+}, Na^{+}, Mg^{2+}, K^{+}), cation exchange capacity (CEC), and base saturation (BS). The results of the chemical property analysis of soil at the study site are described as follows.

Soil pH, organic carbon, total-N

The soil pH distribution at the research site was classified as rather acidic (RA), neutral (N), rather acidic (RA), acidic (A), neutral (N), and neutral (N) (Figure 2a). At neutral pH, nutrient availability is optimal in terms of both quantity and balance of nutrients in the soil solution, whereas at low or too high pH, nutrients are unavailable (Hardjowigeno, 2010). Upland rice requires a pH of around 5.5–7.5 (Ritung *et al.*, 2011). Thus, the pH at the research site is quite good in supporting plant growth, although in the middle slope at a depth of 20–40 cm, the pH is lower, namely 5.4 (Acidic).

The organic carbon content affects soil fertility and the amount of organic matter. Organic carbon content at the study site ranged from high to moderate in the topsoil and low in the subsoil (Figure 2b). This is because organic matter content decreases with soil depth. In addition to soil depth, slope length and steepness also affect organic matter content. Arsyad (2010) found that the longer and steeper the slope, the greater the surface runoff, so that soil containing a lot of organic matter will be carried away to lower places. At the study site, the upper land had a high organic C-organic content (4.23%), but it decreased in the middle (2.06%) and lower (2.62%) areas.

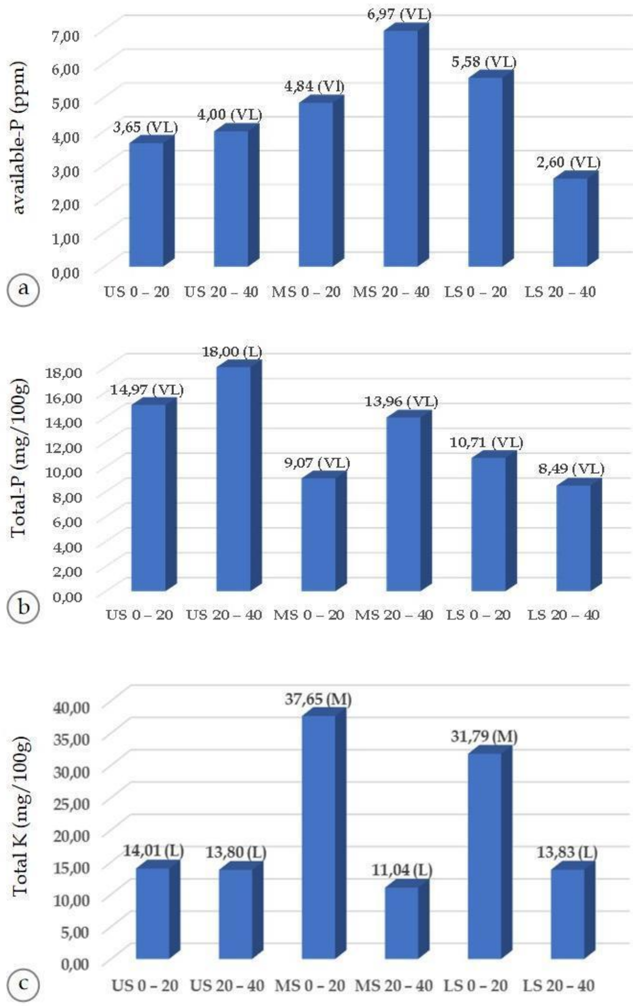

Figure 3. Distribution of values for available-P (a), total-P (b) , and total-K (c).

However, for upland rice, the required C-organic content is more than 1.2% (Ritung *et al*., 2011), so the C-organic value at the study site is very good for the growth and development of upland rice.

Nitrogen is a major plant nutrient that stimulates vegetation growth. The higher the total N content of the soil, the better the effect on plant growth. The total N content at the study site was moderate (0.44, 0.21, and 0.26%) in the topsoil and low (0.19, 0.15, and 0.19%) in the subsoil. Upland rice requires a moderate level of nitrogen for its growth; thus, the N content at the study site is considered sufficient to support the growth of upland rice.

Phosphorus (P) and potassium (K)

In addition to nitrogen (N), phosphorus (P), and potassium (K) are important macro nutrients for plant growth. NPK nutrients are essential for plants, meaning that plant's need for NPK cannot be replaced by other elements. The status of P in the soil is expressed in total and available forms. The total form indicates the reserve (potential) content, while the available (actual) form is the form that can be absorbed by plant roots (Hardjowigeno, 2010).

Figure 3a shows that the total P content (mg/100g) at the study site was low to very low, ranging from 18 to 8.49 mg/100g of soil. The low category ranges from 15 to 20 mg/100g, while below 15 mg/100g is classified as very low (Eviati *et al*., 2023). The available P content (ppm) was also low to very low, ranging from only 6.97 to 2.6 ppm (Figure 3b). Upland rice plants require P_2O_5 (mg/100g) that is classified as high to moderate (Ritung *et al*., 2011).

According to Maulidan & Putra (2024), the P element in rice plants plays a role in supporting growth and panicle formation, triggering flowering, and grain maturation, especially in low climatic conditions. Optimal P supports more tiller or seedling formation and supports better grain formation and better nutritional content in relation to the P content in the seeds. Additionally, Khan *et al*. (2023) explain that phosphorus plays a crucial role as a regulator of physiological responses to important plant processes such as root interception, nutrient absorption, photosynthesis, and the opening and closing of stomata.

Potassium (K) functions to accelerate carbohydrate formation, strengthen cell walls, and especially improve seed quality in food crops such as rice, tubers, and corn (Putri & Pinaria, 2021). The total potassium content at the research site was low in the upper soil layer at both depths and moderate in the upper layer of the middle and lower soils (Figure 3c), while in the lower layer of both of these soils (middle and lower soils), it is classified as low (Eviati *et al*., 2023). Upland rice requires at least a moderate amount of K_2O (mg/100g) to support plant growth and development (Ritung *et al*., 2011). Low K content will greatly affect the quality of upland rice grains.

Basic cations (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+})

Calcium (Ca^{2+}) at the research site was classified as moderate to very high (6.16–27.45 cmol/kg). Magnesium (Mg^{2+}) was classified as moderate to high (1.79–7.81 cmol/kg). Potassium (K^{+}) was classified as low to high (0.34–0.97 cmol/kg), and sodium (Na^{+}) was classified as very low to low (0.08–0.39 cmol/kg) (Figure 4a; 4b; 4c; 4d). In general, base cations had higher or better values in the middle and lower parts of the land and tended to be low in the upper parts. This is because the soil is located on a sloping area. On sloping land, erosion generally occurs, so surface runoff will carry and transport soil particles containing nutrients and bases to lower areas (Arsyad, 2010), in this case, the lower soil. Specifically, low Na levels indicate that the soil does not experience salinity, as good soil has Na <1.0 cmol/kg., or is classified as low.

Cation exchange capacity (CEC) and base saturation (BS)

Cation Exchange Capacity (CEC) indicates the maximum number of cations that can be adsorbed by soil, while Base Saturation (BS) indicates the ratio between the number of base cations and the total number of cations present in the soil adsorption complex (Hardjowigeno, 2010). The CEC at the study site was high in the upper soil layer and very high in the middle and lower soil layers. High CEC values are greatly influenced by the amount of clay. The finer the soil texture and the higher the amount of clay fraction, the higher the CEC (Zainudin & Kesumaningwati, 2021). This proves that the high CEC at the study site (Figure 5a) is closely related to the soil texture (Table 1), which is dominated by the clay fraction.

Base Saturation (BS) is classified as moderate in the upper soil, moderate in the topsoil layer, but low in the lower layer in the middle soil, while in the lower soil it is classified as high in the upper layer and moderate in the lower layer. KB is relatively determined by the amount of base cations and soil reaction (pH). The relationship between KB and soil pH is generally positive, meaning that as soil pH increases, KB also increases, and conversely, if pH is low, KB will also be low (Zainudin & Kesumaningwati, 2021). This is clearly seen in the pH value (Figure 2a) of the soil in the middle area in the second layer, which has a slightly acidic pH (5.4), so that the KB

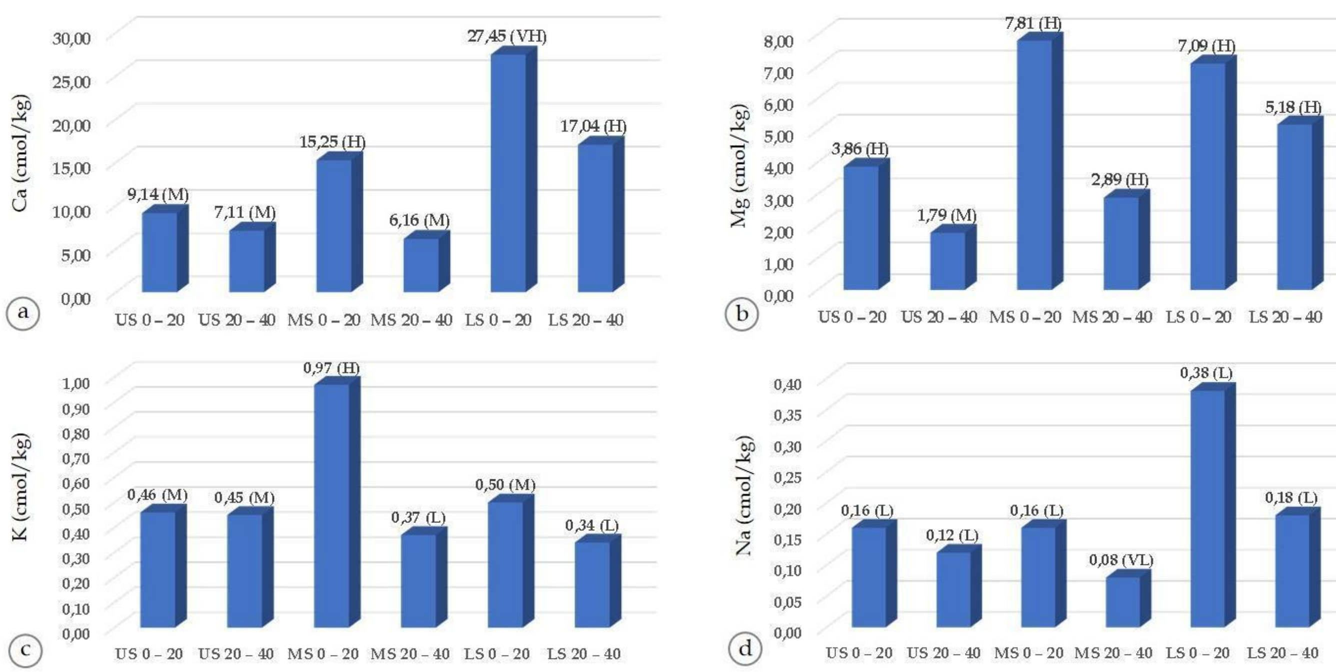

Figure 4. Distribution of base cation values. (a) calcium, (b) magnesium, (c) potassium, (d) natrium.

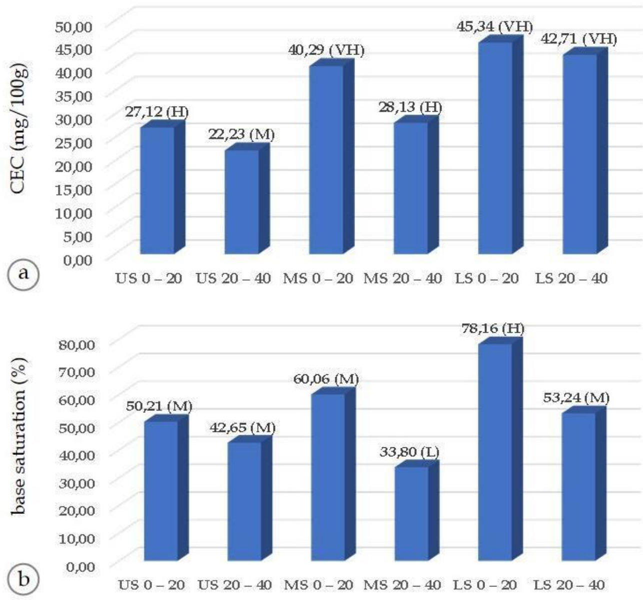

Figure 5. Distribution of values for available-P (a), total-P (b) , and total-K (c).

(Figure 5b) in this area is also relatively low compared to other soils. The soil pH in the lower slope (LS) of the field is classified as neutral in both soil layers (Figure 2a), consequently leading to a moderate to high CEC value (Figure 5b) for the soil in this lower field section (LS).

Soil fertility status

Based on the results of soil chemical analysis, soil fertility status is determined by comparing five parameters, namely KTK (cmol.kg^{-1}), KB (%), C-organic (%), P_2O_5 (mg/100g), and K_2O (mg/100g) with the criteria for determining soil fertility status (PPT, 1995) (Table 2).

The assessment results show that soil fertility at the research site is low in upland and mid-slope areas where upland rice is cultivated, moderate in lower areas in the upper layer, but low in the lower soil layer.

Topography affects soil fertility through drainage, infiltration, surface runoff, and soil erosion. Soil on upper slopes is generally less fertile than soil on lower slopes due to changes in soil chemical characteristics. The frequency of leaching and erosion is higher on upper slopes than on lower slopes. Surface runoff and leaching of organic matter, along with nutrients and base cations, will be washed away with the topsoil to flatter areas. The longer and steeper the slope, the greater the speed and volume of surface water flow that transports soil particles. Rainfall impacting the soil surface causes the breakdown of soil aggregates. These fragmented soil aggregates consequently clog the soil pores, which reduces the amount of infiltrated water and results in an increase in surface runoff (Arsyad, 2010).

In general, the limiting factor found in all three plots is the low P and K content of the soil, so it is necessary to add P and K. P and K fertilization can help provide P and K in the soil, thereby increasing crop productivity. In addition to P and K fertilization, adding organic matter to the soil can increase nutrient content, but based on the results of organic C analysis at the research site, the upper layer is still in fairly good condition. The maintenance of organic C content at the research

Table 2. Soil fertility status of research locations.

No	Sample codes	CEC	BS	Organic carbon	P_2O_5	K_2O	Fertility status
1.	US 0 – 20	27.12 (H)	50.21 (M)	4.23 (H)	14.97 (VL)	14.01 (L)	Low
2.	US 20 – 40	22.23 (M)	42.65 (M)	1.76 (L)	18.0 (L)	13.80 (L)	Low
3.	MS 0 – 20	40.29 (VH)	60.06 (M)	2.06 (M)	9.07 (VL)	37.65 (M)	Low
4.	MS 0 – 40	28.13 (H)	33.80 (L)	1.35 (L)	13.96 (VL)	11.04 (L)	Low
5.	LS 0 – 20	45.34 (VH)	78.16 (H)	2.62 (M)	10.71 (VL)	31.79 (M)	Moderate
6.	LS 20 – 40	42.71 (VH)	53.24 (M)	1.37 (L)	8.49 (VL)	13.83 (L)	Low

Notes: VL = very low; L = low; M = moderate; H = high; VH = very high.

site is related to the shifting cultivation system practiced by the community in their agricultural activities. The shifting cultivation system utilizes fallow periods and the burning of litter to restore the organic matter and nutrients that have been removed from the soil, so that the land can naturally restore its fertility through the decomposition of litter. However, due to the low levels of P and K nutrients, fertilization with these nutrients is highly recommended. In addition to K and P fertilization, another recommendation is to implement land conservation measures on sloping land, namely by creating terraces or ridges in the planting area to protect the land from erosion and surface runoff.

CONCLUSION

The soil properties of the shifting cultivation fields for upland rice in Tanah Merah village, Warmare District, Manokwari Regency, have a clayey (fine) texture with a reddish-yellow to yellowish-red color. The chemical properties of the soil in terms of soil reaction (pH) are classified as acidic, slightly acidic, and neutral. Organic carbon in the topsoil is classified as high, but low in the middle and lower layers. Total nitrogen content is classified as moderate in the topsoil and low in the lower layers in all parts of the field. Total phosphorus and available phosphorus content are classified as low to very low. Total potassium content is low in the upper layer at both depths, moderate in the upper layer of the middle and lower layers, and low in the lower layer. For base cations, Ca is moderate to very high, Mg is moderate to high, K is low to high, and Na is very low to low. KTK was classified as high to very high. KB was classified as moderate in the upper slope, moderate to low in the middle slope, and high to moderate in the lower slope. The soil fertility status at the research site was classified as low in the upper and middle slopes. Conversely, in the lower slope, the status was classified as moderate in the topsoil but remained low in the subsoil layer. The shifting cultivation system practiced by the community greatly helps to maintain the soil's organic carbon content. However, to enhance crop productivity, phosphorus (P) and potassium (K) fertilization are highly recommended. In addition to fertilization, implementing terraces or ridges in the planting area is also recommended to protect the land from erosion and surface runoff.

REFERENCES

Arsyad, S. 2010. *Konservasi tanah dan air*. Edisi ke-2. IPB Press. Bogor.

Borah, J.R., J.J. Gilroy, K.L. Evans, and D.P. Edwards. 2022. The value of shifting cultivation for biodiversity in Northeast India. *Diversity and Distributions.* 28(9): 1979–1992. Doi: 10.1111/ddi.13605.

Chairuman, M. 2024. Konservasi sebagai landasan perencanaan lansekap berbasis tempat pada masyarakat Baduy Dalam di Kabupaten Lebak Provinsi Banten. *ULIN:Jurnal Hutan Tropis*. 8.1: 67-77 Doi: 10.32522/ujht.v8i1.13201.

Chen, S., P. Olofsson, T. Saphangthong, and C.E. Woodcock. 2023. Monitoring shifting cultivation in Laos with Landsat time series. *Remote Sensing of Environment.* 288: 113507. Doi: 10.1016/j.rse.2023.113507

Dampa, D., S. Bulkis, and A. Widati. 2024. Tuber-based farming management to increase household food availability: A case research of shifting cultivation among the Arfak Tribes. *Nongye Jixie Xuebao/Transactions of the Chinese Society of Agricultural Machinery.* 55(11): 2024. Doi: 10.62321/issn.1000-1298.2024.11.2

Dhonanto, D., S. Darma, Mulyadi, N. Imang, Fahrunsyah, Nurhasanah, R. Paranoan, G. Salsabila, and B.A. Nugroho. 2025. Solusi pangan berkelanjutan atau ancaman ekologi? Menimbang praktik perladangan berpindah. *Jurnal Tanah dan Sumberdaya Lahan*. 12(2): 301-310. Doi: 10.21776/ub.jtsl.2025.012.2.8.

Eviati, Sulaeman, L. Herawati, L. Anggria, Usman, H.E. Tantika, Prihatini, and P. Wuningrum. 2023. *Petunjuk Teknis Edisi 3 Analisis Kimia Tanah, Tanaman, Air, dan Pupuk*. Balai Pengujian Standar Instrumen Tanah dan Pupuk. Balai Besar Pengujian Standar Instrumen Sumberdaya Lahan Pertanian. Badan Standarisasi Instrumen Pertanian. Kementrian Pertanian. Jakarta.

Evizal, R. 2020. Review: Etnoagronomi perladangan pangan di Indonesia. *Jurnal Agrotropika.* 19(1): 1-10.

Fauzia, N.C., Hayari, and S. Effendi. 2023. Perladangan berpindah masyarakat Muna di Desa Wakadia Kecamatan Watopute Kabupaten Muna dan dampaknya terhadap lingkungan. *Journal Idea of History.* 6(1): 1975-2022.

Hardjowigeno, S. 2010. *Ilmu tanah.* Akademika Pressindo. Jakarta.

Hartanto, N., Zulkarnain, and A.A. Wicaksono, 2022. Analisis beberapa sifat fisik tanah sebagai indikator kerusakan tanah pada lahan kering. *Jurnal Agroekoteknologi Tropika Lembab*. 4(2): 107-112.

Kamakaula, Y., and D. Uria. 2025. Sistem pertanian ladang berpindah dalam perspektif etnoekologi. *Hidroponik: Jurnal Ilmu Pertanian dan Teknologi dalam Ilmu Tanaman*. 2(1): 294-308. Doi: 10.62951/hidroponik.v2i1.310.

Kareth, N., R.M. Osok, A.M. Kalay, and A. Talahaturuson. 2025. Karakteristik tanah dan status kesuburan tanah ladang berpindah di Kabupaten Maybrat Provinsi Papua Barat Daya. *Agrologia.* 14(1): 79-93. Doi: 10.30598/agrologia.v14i1.18675.

Khan, F., A.B. Siddique, S. Shabala, M. Zhou, and C. Zhao. 2023. Phosphorus plays key roles in regulating plants' physiological responses to abiotic stresses. *Journals Plants.* 12(5): 2861. Doi: 10.3390/plants12152861.

Kurnia, U., F. Agus, A. Adimihardja, A. Rachman, S. Sutono, H. Suganda, Yusrial, M.S. Djunaedi, N. Sutrisno, T. Vadari, Haryono, H. Kusnadi, R.L. Watung, H. Erfandi, I. Juarsah, A. Dariah, Haryati, U. Nurida, Maswar, Irawan, S. Marwanto, R. Yustika, Jubaedah, A. Budiyanto, Sudirman, T. Budhyastoro, S.H. Talaohu, R. Ariani, J.A. Santri, and L.N. Fahmi. 2023. *Sifat fisik tanah dan metode analisisnya.* Edisi 2. Balai Pengujian Standar Instrumen Tanah dan Pupuk. Balai Besar Pengujian Standar Instrumen Sumberdaya Lahan Pertanian. BSIP. Kementrian Pertanian. Jakarta.

Maring, P. 2020. The strategy of shifting cultivators in West Kalimantan in adapting to the market economy: empirical evidence behind gaps in interdisciplinary communication. *Journal of Political Ecology.* 27(1): 1015-1035. Doi: 10.2458/v27i1.23757.

Matinahoru, J.M. 2023. Socialization of the impact of switching facining for forest ecosystems in Imabatai Village, Inamosol Sub-District, West Seram District. *Jurnal Pengabdian pada Masyarakat: Abdi Dosen*. 7(2): 542. Doi: 10.32832/abdidos.v7i2.1780.

Pusat Penelitian Tanah (PPT). 1995. *Petunjuk teknis evaluasi kesuburan tanah.* Bogor: Laporan Teknis No. 14. Versi 1,0. 1. REP II Project, CSAR.

Putri, R.S., and Pinaria, A.G. 2021. Penggunaan kompus *Chromollaena odorata* untuk meningkatkan kalium tanah. *Jurnal Agroekoteknologi Terapan*. 1(1): 15-17.

Rahmadanih, Mikhael, M.S. Ali, E.B. Demmallino, D. Salman, N.M. Viantika, S.H. Syam, 2024. The sustainability of the farming system transformation and its relation to household food access. *Universal Journal of Agricultural Research.* 12(2): 376-390. Doi: 10.13189/ujar.2024.120217.

Reneng, W.A. 2022. Suksesi vegetasi pada areal bekas perladangan berpindah di Desa Bengkuang Kecamatan Kelam Permai Kabupaten Sintang. *Jurnal Lingkungan Hutan Tropis.* 1(2): 476-483.

Ritung, S., K. Nugroho, A. Mulyani, and E. Suryani. 2011. *Petunjuk teknis evaluasi lahan untuk komoditas pertanian*. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian, Badan Penelitian dan Pengembangan Pertanian, Bogor.

Safe, Y., E.V. Muhammad, A.U,K. Ngaji. 2024. Ketersediaan pangan pada keluarga petani lahan kering yang menerapkan pola perladangan berpindah. Prosiding Seminar Nasional Politani Kupang ke 7. https://ejurnal.politanikoe.ac.id/index.php/psnp/article/view/434/343.

Sriyana, A.R. Al Husein, and S. Arianti. 2025. Sosiokultural perladangan tradisional masyarakat Dayak Kalimantan Tengah. *Anterior Jurnal.* 24(2): 58–68.

Temjen, W., M.R. Singh, and T. Ajungla. 2022. Effect of shifting cultivation and fallow on soil quality index in Mokokchung District, Nagaland, India. *Ecological Processes.* 11: 42. Doi: 10.1186/s13717-022-00386-w.

Tola, K.S.K., S. Baja, Rismaneswati, and A. Admad. 2024. Remote sensing for shifting cultivation land evaluation: An idea of maintaining local wisdom in West Papua. *IOP Conf. Series: Earth and Environmental Science.* 1525 (2025): 012032 Doi: 10.1088/1755-1315/1525/1/012032.

Maulidan, K., and B.K. Putra. 2024. Pentingnya unsur hara fosfor untuk pertumbuhan tanaman padi. *Journal of Biopesticide and Agriculture Technology*. *JBIOGRITech.* 1(2): 47–54. Doi: 10.61511/jbiogritech.v1i2.2024.1163.

Zainudin, and R. Kesumaningwati. 2021. Penilaian status kesuburan tanah pada beberapa penggunaan lahan di Samarinda. *Jurnal Agroekoteknologi Tropika Lembab*. 3(2): 106-111.