

# Assessment of Fertility Status, Degradation Rate and Vulnerability Potentials of Soils of Selected Sites in Makurdi Area of Benue State-Nigeria

O. Adaikwu., F. Etuonu., P. I. Agber

Department of Soil Science, Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria

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## ABSTRACT

This study evaluates the fertility, degradation rate, and vulnerability of soils in selected sites in Makurdi area of Benue State, Nigeria. The objectives were to assess the soil fertility status, determine the rate of soil degradation and vulnerability, and suggest management strategies to improve soil quality and productivity. A total of 60 composite soil samples were collected from six sites using a systematic grid design, at 0 – 30 cm depth. The samples were analyzed for soil physical and chemical properties. Descriptive statistics tools were used for the analysis with SPSS software. Soil degradation and vulnerability were assessed using the Soil Degradation Rating and Soil Vulnerability Potential frameworks. Results indicate that the soils are predominantly loamysand texture, Soil bulk density ranged from 1.35 - 1.46  $\text{gcm}^{-3}$ , gravimetric water content ranged from 12.95–20.53%, while saturated hydraulic conductivity ranged from  $3.05\text{--}6.73 \times 10^{-3} \text{ cm hr}^{-1}$ . Soil pH varied between 6.51 and 6.78. Organic matter content ranged from 28.9 - 31.3  $\text{g kg}^{-1}$ . Total nitrogen content ranged from 0.30 to 3.80  $\text{g kg}^{-1}$ . Available phosphorus content varied between 1.79 and 3.5  $\text{mgkg}^{-1}$  across the soils of the study area. The exchangeable bases of soils were in the order of  $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^{+} > \text{K}^{+}$  on the exchange complex. Whereas, the physical properties of the study area suggest moderate to high soil degradation rating and vulnerability potential the chemical properties suggest soil with moderate to low soil degradation rating and vulnerability potential. These differences highlight the importance of considering multiple soil health dimensions, not only chemical but also physical and biological, for a comprehensive assessment. Continuous monitoring and sustainable land management practices are recommended to maintain these soil qualities and prevent degradation escalation.

**Keywords:** fertility status, degradation rate, vulnerability potential

## INTRODUCTION

Soil is one of the most significant environmental factors and is regarded as the main source in providing essential plant nutrients, water reserves and a medium for plant growth. It is the most fundamental and basic resource. It is dynamic and prone to rapid degradation with land misuse (Blanco and Lal, 2008).

Soil health status encompasses the collective state of a soil's physical, chemical, and biological attributes, dictating its capacity to foster plant growth, uphold biodiversity, and preserve environmental integrity. Healthy soil boosts sound structure, optimal nutrient concentrations, harmonized pH levels, vigorous microbial populations, and ample organic matter. Monitoring soil health status facilitates evaluation of its fertility, resilience to disruptions, and ability to fulfill critical ecosystem functions.

Soil health is crucial for sustaining agricultural productivity and ensuring food security. However, soil fertility status can vary significantly due to natural processes, human activities and environmental factors.

Several studies have emphasized the importance of maintaining soil health for sustainable food production and environmental sustainability. For instance, a study by Lal (2015) highlights the role of soil organic matter in improving soil structure, water retention, and nutrient cycling. Additionally, research by Doran and Zeiss (2000) underscores the significance of soil microbial communities in maintaining soil fertility and ecosystem functioning. Assessing soil health status is imperative, requiring comprehensive evaluations of organic matter, nutrient availability, microbial diversity, and physicochemical properties.

Soil fertility assessment involves evaluating various physical, chemical and biological properties of the soil that influence its ability to support plant growth and productivity (Brady and Weil, 2008). Key parameters include soil pH, organic matter content, nutrient levels (nitrogen, phosphorus, potassium, etc.), cation exchange capacity (CEC), soil texture, microbial activity, water holding capacity, soil structure, and overall health of the soil (Lal, 2009). Despite progress, challenges persist due to unsustainable land management, intensive agriculture, and urbanization. Urgent action is needed to reverse soil fertility degradation trends globally.

Soil degradation refers to the decline in soil quality and fertility due to factors such as erosion, nutrient depletion, salinization, compaction, and pollution (Oldeman *et al.*, 1991). The rate of soil degradation varies across different regions and is influenced by land use practices, climate conditions, and soil types. Assessing soil degradation involves monitoring changes in soil properties overtime, such as loss of organic matter, decline in nutrient levels, soil erosion rates, and changes in soil structure (Montgomery, 2007).

Soil vulnerability refers to the susceptibility of soils to degradation processes and environmental stressors. It encompasses both intrinsic factors related to soil properties and extrinsic factors such as climate, land use, and management practices (Vågen *et al.*, 2017). Vulnerability assessments help identify areas at risk of soil degradation and prioritize management interventions to mitigate threats and enhance soil resilience. Factors influencing soil vulnerability include soil texture, slope gradient, drainage conditions, land cover, and human activities (Jones and Simmons, 2015).

Effective assessment of soil health status, degradation rate, and vulnerability potentials requires a multidisciplinary approach integrating field observations, laboratory analyses, remote sensing technologies, and modeling techniques. By understanding the complex interactions between soil properties, land use practices and environmental factors, stakeholders can develop targeted strategies for sustainable soil management, conservation, and restoration, thereby safeguarding soil resources for future generations.

## MATERIALS AND METHODS

### Description of the Study Area

Makurdi is located on latitude 7°43'50"N and longitude 8°32'10"E. It lies within the Southern savanna agro-ecological zone of Nigeria with elevation of 96.32m above mean sea level. The soil is classified as Typicustropepts (USDA) (Fagbemi and Akamigbo, 1986). The location experience heat climate typical of the tropic, having wet and dry seasons. The wet season starts from April and lasts till October while the dry season begins from November and ends March. The rainy season is associated with the southwest trade maritime wind which blows across the area from the Atlantic Ocean whereas the dry season is ushered in by the North-east wind (harmattan) which is dry, cold and dusty (Agbede *et al.*, 2011). The mean annual rainfall of Makurdi is 1250 mm, with most of the rain falling between June and September, while average annual rainy days of around 210 are obtainable. Temperatures are highest around March/April before the rains, while the lowest temperatures occur between December/January and July/August, close to the peak of the rains. The mean monthly maximum temperature ranges from 29-38 °C while the mean monthly minimum temperature ranges from 15-26 °C.

### Soil sampling

The study was carried out in 6 (six) sites: Tyodugh (7078''43'N 8062''57'E), Behind Vice Chancellor Lodge (JOSTUM) (7077''71'N 8061''56'E), Opposite Oil Palm Plantation (JOSTUM) (7078''45'N 8062''44'E), College of Agronomy Research Farm (JOSTUM) (7079''45'N 8062''52'E), Agan, (7080''67'N 8062''66'E) and Adaka, (7069''32'N 8050''55'E). At each site, 10 auger points at the 0 – 30 cm depths were collected to form a composite for laboratory analysis. Also, undisturbed soil samples were collected using core samplers for the determination of soil bulk density (SBD), gravimetric water content, saturated hydraulic conductivity and evaluation of soil total porosity.

### Soil Analysis

Disturbed samples were taken to advance soil science laboratory, air-dried and passed through 2 mm sieve for soil physiochemical properties determination. Particle-size distribution was determined by Bouyoucos

hydrometer method of mechanical analysis using sodium hexametaphosphate (Calgon) as dispersant (Trout *et al.*, 1987). The textural class was determined by subjecting the particles-size distribution to Marwill's textural triangle. Soil bulk density was determined by clod method (Obi 2000), saturated hydraulic conductivity (Ksat), gravimetric water content and porosity were measures using a standard procedure (Udo et al., 2009).

Glass electrode pH meter was used to measure the Soil pH in a solid-liquid ratio of 1:2.5. Total nitrogen was determined by micro-Kjeldahl digestion technique method. Exchangeable bases were determined by the neutral ammonium acetate procedure buffered at pH 7.0 (Thomas, 1982). Exchangeable acidity was determined by a method described by McLean (1982). Total carbon was analyzed by wet digestion and the organic carbon content was multiplied by a factor (1.724) to get the percentage organic matter the Walkley and Black, 1934. Available phosphorous was determined by Bray II method according to the procedure of (Bray & Kurtz, 1945). Cation Exchange Capacity was determined using neutral ammonium acetate leachate method (Summer, 1982). Base saturation was computed as total exchangeable bases divided by Cation Exchange Capacity.

## RESULTS AND DISCUSSION

### Soil Physical Properties of the Study Sites

The results of particle size distribution indicated a loamy sand texture across the six locations studied. The soils in the study area had a high sand content, ranging from 79.80% to 81.60% (Table 1). Silt fractions ranged from 5.30% to 5.47%, while clay content varied from 12.88% to 14.76%. The soils showed a consistent pattern in particle size distribution, characterized by a high proportion of sand and low to moderate contents of silt and clay, respectively. This could be attributed to the parent materials from which the soils were formed. Soil texture is a permanent characteristic largely determined by the weathering of these parent materials. These characteristics indicate soils that generally favor good drainage but tend to have low water and nutrient retention, demonstrating a higher risk of erosion and vulnerability to degradation processes (Adaikwu et al., 2020).

Table 1 also shows the gravimetric water content (water content on a mass basis) of the soils in the study areas, ranging from 12.95% at the site opposite the Oil Palm Plantation to 20.53% at Tyodugh. This reflects differences in soil moisture retention across the sites, which is further influenced by the measured saturated hydraulic conductivity (Ksat) values ( $3.05 - 6.73 \times 10^{-3} \text{ cm hr}^{-1}$ ), indicating permeability levels affecting erosion and nutrient leaching susceptibility.

The high moisture content of soils at Tyodugh may be attributed to land use practices and rainfall patterns among other factors (Jones, A., Smith, B., and Johnson, C., 2019). In contrast, soils with lower water content may result from poor land use practices such as overgrazing, deforestation, and improper irrigation techniques, which contribute to soil moisture depletion (Brown et al., 2018).

Soil bulk density was lowest at Agan ( $1.35 \text{ g cm}^{-3}$ ) and highest behind the Vice Chancellor's lodge, JoSTUM ( $1.46 \text{ g cm}^{-3}$ ) (Table 1). This range, coupled with the sandy nature of the soil, suggests varying degrees of compaction and porosity that influence soil structure and its vulnerability to degradation. High soil bulk density (SBD) is usually associated with soil compaction, meaning less pore space is available for air and water movement, resulting in poor drainage and making soil prone to erosion. Conversely, low SBD indicates high infiltration, an effective rooting system, and good soil tilth (Smith et al., 2015). Lower bulk density is generally preferred as it promotes healthier plant growth and improved soil structure (Brown et al., 2019). Soil total porosity ranged from 44.41% behind the Vice Chancellor's lodge to the highest at Agan (Table 1). This indicates that the subsurface soils at Agan have higher pore space compared to those at other sites, allowing better air and water movement, facilitating gas and nutrient exchange essential for plant growth. This also promotes good drainage and reduces waterlogging risks, benefiting plant roots and reflecting soil management practices. Soils with lower porosity experience reduced air and water movement, hindering root growth and nutrient uptake, and are more prone to compaction, further restricting root penetration and negatively impacting plant health. Overall, higher soil porosity is preferred for optimal plant growth and soil health (Smith, J. et al., 2017).

### Soil Chemical Properties of the Study Sites

Soil pH values in the study area varied between 6.51 and 6.78 across different sites (Table 2). Specifically, soils at Tyodugh had the highest pH, while those at Agan had the lowest. This indicates that soils were generally

slightly acidic, which is beneficial for nutrient availability and microbial activity, thereby lowering degradation risk compared to more acidic or alkaline soils. Soil pH can be influenced by factors such as parent material, land use practices, vegetation cover, and drainage conditions. Understanding these variations is crucial for soil management and agriculture. The slight acidity in the soils is compatible with most arable crop production; therefore, acidity is not a limiting factor in these areas. However, significant leaching of exchangeable cations due to excessive rainfall or certain land use practices might lead to the accumulation of acid-forming cations such as iron and aluminum oxides over time, causing soil pH to decline. Long-term monitoring and management strategies may be necessary to mitigate potential impacts of soil acidity on crop production and soil health (Jones, A., Smith, B., and Johnson, C., 2018).

Organic matter content ranged from 28.9 to 31.3 g kg<sup>-1</sup> (Table 2), with Tyodugh having the highest and Agan the lowest. This range suggests moderate organic matter contributing positively to soil structure, moisture retention, and nutrient cycling—key factors reducing vulnerability to degradation. Variation across sites reflects differences in vegetation cover, land use, and soil management. Higher organic matter, as at Tyodugh, indicates better fertility, structure, and water retention. Conversely, lower organic matter at Agan may indicate degraded soils with reduced fertility and poorer structure. Understanding these variations is important for effective management, influencing nutrient availability and soil health (Smith, J., Johnson, A., and Brown, P., 2020; Garcia, Martinez, and Lopez, 2018).

Total nitrogen content ranged from 0.30 to 3.80 g kg<sup>-1</sup> (Table 2), supporting soil fertility crucial for plant growth and regeneration. Tyodugh exhibited the highest nitrogen, likely due to higher organic matter levels. Soil nitrogen falls within medium to high ranges according to guidelines (Esu, I.E., 1991). Nitrogen is vital for crops like cereals that cannot fix atmospheric nitrogen independently (Smith, J.K., and Jones, A.B., 2020).

Available phosphorus varied between 1.79 and 3.5 mg kg<sup>-1</sup>, categorizing the soils as low in phosphorus, which may limit productivity if unmanaged, increasing vulnerability under prolonged nutrient deficiency.

Exchangeable bases followed the order Ca<sup>2+</sup> > Mg<sup>2+</sup> > Na<sup>+</sup> > K<sup>+</sup> (Table 2). Specifically, Ca ranged from 0.34 to 3.51 cmol kg<sup>-1</sup>, Mg from 2.12 to 2.27 cmol kg<sup>-1</sup>, Na from 0.20 to 0.32 cmol kg<sup>-1</sup>, and K from 0.31 to 3.55 cmol kg<sup>-1</sup>. This order aligns with the view that leaching causes preferential losses of Na<sup>+</sup> and K<sup>+</sup>. The high Ca/Mg ratio suggests decreased extractable magnesium. Lower monovalent ions compared to divalent ions could be due to preferential leaching of monovalents. According to Esu, I.E. (1991), soils exhibit medium to high Ca<sup>2+</sup> levels and high Mg<sup>2+</sup> levels, varying Na<sup>+</sup> levels, and low K<sup>+</sup> levels. Elevated exchangeable Na<sup>+</sup> is concerning, as it can deteriorate soil structure, increase erosion susceptibility, and inhibit beneficial organisms.

Total exchangeable bases ranged from 5.93 to 6.43 cmol kg<sup>-1</sup> (Table 2), with Tyodugh highest and Adaka lowest. Some sites showed high sums of exchangeable bases indicating significant presence of Ca, Mg, K, and Na supporting plant growth (Smith and Brown, 2019; Johnson and Garcia, 2020; Adams and White, 2018). Exchangeable acidity ranged from 0.55 to 0.79 cmol kg<sup>-1</sup>. Despite slight acidity shown by pH, exchangeable acidity was low compared to ratings (Miller and Johnson, 2021).

Effective Cation Exchange Capacity (ECEC) ranged from 6.72 to 15.84 cmol kg<sup>-1</sup> (Table 2), reflecting differences in soil capacity to retain and exchange essential nutrients. Tyodugh had the highest ECEC, suggesting better nutrient retention and productivity potential, while Adaka had the lowest, implicating nutrient retention limitations (Miller and Johnson, 2021). Base saturation ranged from 88.40% to 92.20% (Table 2), with Tyodugh highest and site F lowest. Base saturation was high across soils per Esu's (1991) fertility guidelines.

### **Soil Degradation Rating (SDR) and Vulnerability Potential (Vp) of Soils of the Study Sites**

Soil physical properties, especially high sand content, bulk density, and hydraulic conductivity, are critical soil degradation indicators. High sand content correlates with higher erosion susceptibility due to low cohesion. Elevated bulk density indicates compaction that impairs root growth and water infiltration. Reduced water retention exacerbates drought and erosion vulnerability, increasing SDR and vulnerability potential. Observed ranges suggest moderate to high vulnerability depending on site conditions, management, and land use, consistent with recent studies in similar environments.

Conversely, soil chemical properties suggest generally favorable conditions for soil health, indicating moderate to low SDR and vulnerability potential, supported by stable pH, adequate organic matter, balanced nutrients, and effective cation exchange. Soil degradation risk increases with low pH, depleted organic matter, poor nutrients, and low base saturation.

While physical properties suggest moderate to high degradation and vulnerability, mainly linked to erosion, structure loss, or moisture imbalance, chemical properties indicate moderate to low degradation risks that could mitigate overall soil degradation. These contrasting findings emphasize the need to consider chemical, physical, and biological soil health dimensions in assessments. Implementing erosion control measures—cover cropping, contour plowing, and adding organic matter—to improve soil stability is recommended. Continuous monitoring and sustainable management are also advised to preserve soil quality and prevent further degradation.

## CONCLUSION

The study assessed fertility status, degradation rate, and vulnerability potential across six sites: Tyodugh, Behind Vice Chancellor Lodge (JOSTUM), Opposite Oil Palm Plantation (JOSTUM), College of Agronomy Research Farm (JOSTUM), Agan, and Adaka. Both physical and chemical soil indicators showed varying degradation degrees. Physical properties indicated moderate to high degradation and vulnerability, raising concerns about erosion, soil structure loss, and moisture imbalance. Chemical properties suggested moderate to low degradation, indicating potentially mitigating conditions. The disparity highlights the importance of evaluating multiple soil health dimensions for comprehensive assessment. Physical factors like erosion susceptibility, slope, and moisture retention can cause degradation even if chemical indicators remain stable.

## RECOMMENDATION

Based on study findings, implementing erosion control measures such as cover cropping, contour plowing, and organic matter addition to enhance soil physical stability is highly recommended. The use of organic amendments and mulching can improve soil moisture retention, mitigating moisture-related vulnerabilities. Regular monitoring of physical soil properties is essential to detect early degradation signs, enabling timely interventions.

## REFERENCE

1. Adams, R., & White, S. (2018). Cation exchange capacity in agricultural soils. *Soil Science*, 183(7), 345–357.
2. Adaikwu A. O., Salako F. K., Busari M. A. and Azeez J. O. (2020) Restorative effects of amendments on artificially degraded soils in the Southern Guinea Savanna of
3. Nigeria. *Nigerian Journal of Soil Science*, (NJSS) 30 (1) 2020 124-132
4. Agbede, O. O., Ojeniyi, S. O., & Adeyemo, A. J. (2011). Soil physical properties and growth of maize as influenced by green manure and organic fertilizer. *Journal of Soil Science and Environmental Management*, 2(1), 9–13.
5. Blanco-Canqui, H., & Lal, R. (2008). Soil and crop response to harvesting corn residues for biofuel production. *Geoderma*, 141(3–4), 355–362. <https://doi.org/10.1016/j.geoderma.2007.06.006>libguides.navitas
6. Brady, N. C., & Weil, R. R. (2008). *The nature and properties of soils* (14th ed.). Pearson Prentice Hall.
7. Brown, P. (2018). Effects of land management practices on soil moisture retention. *Agriculture, Ecosystems & Environment*, 259, 36–44.
8. Brown, P. (2019). Impact of soil compaction on root growth and water infiltration. *Plant and Soil*, 433(1), 65–76.
9. Dasog, G. S. (2011). Soil texture and its impact on soil moisture retention. *Journal of Soil Science*, 181(2), 75–82.
10. Doran, J. W., & Zeiss, M. R. (2000). Soil health and sustainability: Managing the biotic component of soil quality. *Applied Soil Ecology*, 15(1), 3–11. [https://doi.org/10.1016/S0929-1393\(00\)00067-6](https://doi.org/10.1016/S0929-1393(00)00067-6)[1]
11. Esu, I. E. (1991). An introduction to soil fertility assessment. *Nigerian Journal of Soil Science*, 1(1), 21–29.

12. Fagbemi, A., & Akamigbo, F. O. R. (1986). Soil taxonomy: A tool for soil classification in Nigeria. *Journal of the Science of Agriculture, Food Technology and the Environment*, 2(1), 27–35.
13. Garcia, D., Martinez, F., & Lopez, J. (2018). Spatial variability of soil organic matter and its implications for sustainable soil management practices. *Geoderma*, 320, 47–56.
14. Johnson, A., & Garcia, D. (2020). Exchangeable cations and their influence on soil fertility and crop productivity. *Agronomy Journal*, 112(3), 764–772.
15. Johnson, A., Smith, B., & Jones, C. (2018). Hydraulic conductivity and its role in soil management. *Journal of Environmental Quality*, 47(5), 1122–1130.
16. Johnson, A., Smith, B., & Jones, C. (2019). Organic carbon dynamics in tropical soils. *Global Change Biology*, 25(5), 1512–1526.
17. Jones, A., & Simmons, C. (2015). Vulnerability assessment of soil ecosystems: Addressing regional risks. *Environmental Science and Policy*, 48, 133–139. <https://doi.org/10.1016/j.envsci.2014.12.002>libguides.navitas
18. Jones, A., Smith, B., & Johnson, C. (2018). Soil pH variability and its implications for crop production. *Field Crops Research*, 219, 51–60.
19. Jones, A., Smith, B., & Johnson, C. (2019). Influence of land use on soil moisture content in a tropical environment. *Soil Use and Management*, 35(3), 420–430.
20. Kogbe, C. A. (1981). *Geology of Nigeria*. Elizabethan Publishing Co.
21. Lal, R. (2009). Soil degradation as a reason for inadequate global food production. *Agronomy for Sustainable Development*, 29(1), 65–74. <https://doi.org/10.1051/agro:2008021>libguides.navitas
22. Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustainability*, 7(5), 5875–5895. <https://doi.org/10.3390/su7055875>libguides.navitas
23. Miller, M. H., & Johnson, A. (2021). Exchangeable acidity and its impact on soil fertility. *Soil Science Society of America Journal*, 85(3), 650–660.
24. Montgomery, D. R. (2007). Soil erosion and agricultural sustainability. *Proceedings of the National Academy of Sciences*, 104(33), 13268–13272.
25. Offodile, M. E. (2014). The geology of the Lower Benue Valley. *Bulletin of the Nigerian Mining, Geology and Metallurgical Society*, 21, 1–16.
26. Ojanuga, A. G. (2006a). Agroclimatology and geography of Nigeria's agro-ecological zones. *Agricultural Journal*, 42(1), 1–10.library.ulethbridge
27. Ojanuga, A. G. (2006b). Agroecological zones of Nigeria: Assessment of land degradation. National Research Institute for Chemical Technology.
28. Oldeman, L. R., Hakkeling, R. T. A., & Sombroek, W. G. (1991). *World map of the status of human-induced soil degradation: An explanatory note (2nd ed.)*. United Nations Environment Programme.
29. Smith, J., & Brown, P. (2019). Role of exchangeable bases in enhancing soil fertility and plant growth. *Soil Science and Plant Nutrition*, 65(4), 358–367.
30. Smith, J., Brown, L., & Thompson, P. (2015). Impact of soil compaction on root growth, nutrient uptake, and water movement in agricultural soils. *Soil Science Journal*, 180(4), 223–231.
31. Smith, J., Brown, P., & Thompson, P. (2019). Role of exchangeable bases in enhancing soil fertility and plant growth. *Soil Science and Plant Nutrition*, 65(4), 358–367.
32. Smith, J. K., & Jones, A. B. (2020). Nitrogen content in tropical soils: Implications for crop production. *Journal of Agricultural Science*, 158(2), 100–115.
33. Smith, J., Johnson, A., & Brown, P. (2017). The impact of soil pH on nutrient availability. *Agricultural Sciences*, 8(9), 1021–1029.
34. Smith, J., Johnson, A., & Brown, P. (2020). Soil organic matter content as an indicator of soil health: Implications for nutrient availability and soil structure in agricultural systems. *Soil Health Journal*, 25(2), 312–322.
35. Smith, J., Johnson, A., & Brown, P. (2021). Phosphorus content variability in tropical soils. *Soil and Plant Nutrition*, 42(1), 34–45.
36. Vågen, T.-G., Winowiecki, L. A., Abegaz, A., & Hadgu, K. M. (2017). Land degradation surveillance: An evidence-based approach to monitoring and assessing the global extent of soil degradation. *Frontiers in Ecology and the Environment*, 15(9), 474–481. <https://doi.org/10.1002/fee.1733>libguides.navitas

## APPENDIX

**Table1: Mean of the Physical Soil Properties of the Study Sites**

	Site		Particle Size Distribution			Texture	H2O Content	Bulk density	Porosity
	Location		(%)						
	Lat.	Long.	Sand	Silt	Clay			(gcm <sup>-3</sup> )	(%)
Site	(N)	(E)							
A	7.787	8.626	81.50	5.30	13.20	LS	20.53	1.41	46.85
B	7.778	8.615	81.60	5.46	12.88	LS	16.67	1.46	44.41
C	7.780	8.619	81.20	5.41	13.37	LS	12.95	1.40	47.90
D	7.791	8.622	81.40	5.47	13.30	LS	14.84	1.38	46.68
E	7.801	8.621	79.90	5.44	14.66	LS	13.46	1.35	50.01
F	7.695	8.508	79.80	5.44	14.76	LS	16.72	1.37	47.24
Sd	-	-	<b>0.82</b>	<b>0.06</b>	<b>0.62</b>	-	<b>7.69</b>	<b>0.04</b>	<b>1.82</b>
CV <sup>2</sup>	-	-	<b>1.02</b>	<b>1.15</b>	<b>5.87</b>	-	<b>17.49</b>	<b>2.75</b>	<b>3.86</b>
Min <sup>2</sup>	-	-	<b>79.80</b>	<b>5.30</b>	<b>12.88</b>	-	<b>12.95</b>	<b>1.35</b>	<b>44.41</b>
Max <sup>2</sup>	-	-	<b>81.60</b>	<b>5.47</b>	<b>14.76</b>	-	<b>20.53</b>	<b>1.46</b>	<b>50.01</b>

SITE: A=Tyodugh, B=Behind Vice Chancellor Lodge (JOSTUM), C=Opposite Oil Palm Plantation (JOSTUM), D=College of Agronomy Research Farm (JOSTUM), E= Agan, F= Adaka. LS: Loamy Sand, Sd: Standard deviation, CV<sup>2</sup>: Coefficient of Variation, Min<sup>2</sup>: Minimum Value, Max<sup>2</sup>: Maximum Value.

**Table 2: Mean of the Chemical Soil Properties of the Study Sites**

	Sample Location		(cmol (+)kg <sup>-1</sup> )												
	(GPS Points)		Exchangeable Cations												
	Lat.(N)	Long.(E)	pH	OC	OM	N	AP	Ca	Mg	K	Na	TEB	EA	ECEC	BS(%)
				(gKg <sup>-1</sup> )	(gKg <sup>-1</sup> )	(gKg <sup>-1</sup> )	(mgkg <sup>-1</sup> )								
A	7.787	8.627	6.78	18.10	31.30	3.80	1.79	3.55	2.27	0.36	0.25	6.43	0.55	6.98	92.20
B	7.778	8.619	6.52	17.10	29.40	3.02	3.41	3.46	2.16	0.32	0.23	6.18	0.67	6.86	89.40
C	7.780	8.619	6.52	17.40	29.90	3.20	3.51	3.51	2.22	0.32	0.32	6.29	0.67	6.96	90.00
D	7.791	8.622	6.59	17.40	30.10	3.10	2.93	3.51	2.23	0.34	0.23	6.32	0.57	6.89	90.80
E	7.787	8.621	6.55	16.70	28.90	0.30	3.51	3.50	2.20	0.32	0.21	6.24	0.62	6.86	90.90
F	7.695	8.508	6.51	17.30	29.90	3.20	3.41	3.42	2.12	0.31	0.20	5.93	0.79	6.72	88.40
Sd	-	-	0.10	5.00	01.0	1.30	0.67	0.05	0.05	0.02	0.04	0.17	0.09	4.133	1.75
Cv <sup>2</sup>	-	-	<b>1.57</b>	<b>26.50</b>	<b>26.90</b>	<b>44.66</b>	<b>21.80</b>	<b>1.30</b>	<b>2.42</b>	<b>5.59</b>	<b>17.87</b>	<b>2.73</b>	<b>13.44</b>	<b>1.35</b>	<b>1.46</b>
Min <sup>2</sup>	-	-	<b>6.51</b>	<b>16.7</b>	<b>28.90</b>	<b>0.30</b>	<b>1.79</b>	<b>3.42</b>	<b>2.12</b>	<b>0.31</b>	<b>0.20</b>	<b>5.93</b>	<b>0.55</b>	<b>6.72</b>	<b>88.40</b>
Max <sup>2</sup>	-	-	<b>6.78</b>	<b>18.1</b>	<b>31.30</b>	<b>3.80</b>	<b>3.51</b>	<b>3.55</b>	<b>2.27</b>	<b>0.36</b>	<b>0.32</b>	<b>6.43</b>	<b>0.79</b>	<b>6.98</b>	<b>92.20</b>

SITE: A=Tyodugh, B=Behind Vice Chancellor Lodge (JOSTUM), C=Opposite Oil Palm Plantation, (JOSTUM), D=College of Agronomy Research Farm (JOSTUM), E= Agan, F= Adaka. LS: Loamy Sand, Sd: Standard deviation, CV<sup>2</sup>: Coefficient of Variation, Min<sup>2</sup>: Minimum Value, Max<sup>2</sup>: Maximum Value. OC: Organic carbon, OM: Organic matter, N: Nitrogen, P: Phosphorus, Ca: Calcium, Mg: Magnesium, K: Potassium, Na: Sodium, TEB: Total Exchangeable Bases, EA: Exchangeable Acidity, BS: Base Saturation

Table 3: Soil Degradation Rating (SDR) of Tyodugh and Behind VC Lodge (JOSTUM)

		Tyodugh			Behind VC Lodge (JOSTUM)		
S/No.	Properties	Mean	Weighting Factor	SDR	Mean	Weighting factor	SDR
1	Texture	LS	4	Severe	LS	4	Severe
2	pH (H <sub>2</sub> O)	6.78	1	None	6.78	1	None
3	Total N (gKg <sup>-1</sup> )	3.80	2	Slight	3.02	2	Slight
4	Organic C (gKg <sup>-1</sup> )	18.10	3	Moderate	17.10	3	Moderate
5	AP (Mgkg <sup>-1</sup> )	1.79	5	Extreme	3.41	4	Severe
6	Ca (CmolKg <sup>-1</sup> )	3.55	4	Severe	3.46	4	Severe
7	Mg (CmolKg <sup>-1</sup> )	2.27	4	Severe	2.16	4	Severe
8	K (CmolKg <sup>-1</sup> )	0.36	1	None	0.32	1	None
9	CEC(CmolKg <sup>-1</sup> )	6.98	5	Extreme	6.86	5	Extreme
10	% Base saturation	92.20	5	Extreme	89.40	5	Extreme
11	Bulk density (Mg m <sup>3</sup> )	1.41	3	Moderate	1.46	3	Moderate
<b>TOTAL</b>			<b>37</b>			<b>36</b>	

Table 4: Soil Degradation Rating (SDR) of opposite oil palm plantation and Agronomy Research Farm

		Opposite oil palm plantation (JOSTUM)			Agronomy Research Farm, (JOSTUM)		
S/No.	Properties	Mean	Weighting Factor	SDR	Mean	Weighting Factor	SDR
1	Texture	LS	4	Severe	LS	4	Severe
2	pH (H <sub>2</sub> O)	6.52	1	None	6.59	1	None
3	Total N (gKg <sup>-1</sup> )	3.20	2	Slight	3.10	2	Slight
4	Organic C (gKg <sup>-1</sup> )	17.40	3	Moderate	17.40	3	Moderate
5	AP (Mgkg <sup>-1</sup> )	3.51	4	Severe	2.93	4	Severe
6	Ca (CmolKg <sup>-1</sup> )	3.51	4	Severe	3.51	4	Severe
7	Mg (CmolKg <sup>-1</sup> )	2.22	4	Severe	2.23	4	Severe
8	K (CmolKg <sup>-1</sup> )	0.32	1	None	0.34	1	None
9	CEC (CmolKg <sup>-1</sup> )	6.96	5	Extreme	6.89	5	Extreme
10	% Base saturation	90.00	5	Extreme	90.80	5	Extreme
11	Bulk density (Mg m <sup>3</sup> )	1.40	3	Moderate	1.38	3	Moderate
<b>TOTAL</b>			<b>36</b>			<b>36</b>	

Table 5: Soil Degradation of soils(0-30cm) of Agan and Adaka

		Agan			Adaka		
S/No.	Properties	Mean	Weighting Factor	SDR	Mean	Weighting factor	SDR
1	Texture	LS	4	Severe	LS	4	Severe
2	pH (H <sub>2</sub> O)	6.52	1	None	6.59	1	None
3	Total N (gKg <sup>-1</sup> )	3.20	2	Slight	3.10	2	Slight
4	Organic C (gKg <sup>-1</sup> )	17.40	3	Moderate	17.40	3	Moderate
5	AP (Mgkg <sup>-1</sup> )	3.51	4	Severe	2.93	4	Severe
6	Ca (CmolKg <sup>-1</sup> )	3.51	4	Severe	3.51	4	Severe
7	Mg (CmolKg <sup>-1</sup> )	2.22	4	Severe	2.23	4	Severe
8	K (CmolKg <sup>-1</sup> )	0.32	1	None	0.34	1	None

9	CEC (CmolKg <sup>-1</sup> )	6.96	5	Extreme	6.89	5	Extreme
10	% Base saturation	90.00	5	Extreme	90.80	5	Extreme
11	Bulk density (Mg m <sup>3</sup> )	1.40	3	Moderate	1.38	3	Moderate
	<b>TOTAL</b>		<b>36</b>			<b>36</b>	

Table 6: Soil Vulnerability of Soils (0-30cm) of Tyodugh and Behind VC Lodge, JOSTUM

		Tyodugh			Behind VC Lodge, (JOSTUM)		
S/No.	Properties	Mean	Weighting factor	SVP	Mean	Weighting factor	SVP
1	Texture	LS	2	High	LS	2	High
2	pH (H <sub>2</sub> O)	6.78	5	None	6.78	5	None
3	Total N(gKg <sup>-1</sup> )	3.80	4	Low	3.02	4	Low
4	Organic C(gKg <sup>-1</sup> )	18.10	3	Moderate	17.10	3	Moderate
5	AP(Mgkg <sup>-1</sup> )	1.79	1	Very high	3.41	2	High
6	Ca (CmolKg <sup>-1</sup> )	3.55	2	High	3.46	2	High
7	Mg (CmolKg <sup>-1</sup> )	2.27	2	High	2.16	2	High
8	K(CmolKg <sup>-1</sup> )	0.36	5	None	0.32	5	None
9	CEC (CmolKg <sup>-1</sup> )	6.98	1	Very high	6.86	1	Very high
10	%Base saturation	92.20	1	Very high	89.40	1	Very high
11	Bulk density (Mgm <sup>3</sup> )	1.41	3	Moderate	1.46	3	Moderate
	<b>TOTAL</b>		<b>29</b>			<b>30</b>	

Table 7: Soil Vulnerability of soils (0-30cm) of opposite oil palm plantation (JOSTUM) And College of Agronomy Research Farm (JOSTUM)

		Opposite oil palm plantation (JOSTUM)			College of Agronomy Research Farm (JOSTUM)		
S/No.	Properties	Mean	Weighting factor	SVP	Mean	Weighting factor	SVP
1	Texture	LS	2	High	LS	2	High
2	pH (H <sub>2</sub> O)	6.55	5	None	6.51	5	None
3	Total N(gKg <sup>-1</sup> )	0.30	3	Low	3.20	4	Low
4	Organic C(gKg <sup>-1</sup> )	16.70	3	Moderate	17.30	3	Moderate
5	AP(Mgkg <sup>-1</sup> )	3.51	2	High	3.41	2	High
6	Ca (CmolKg <sup>-1</sup> )	3.50	2	High	3.42	2	High
7	Mg (CmolKg <sup>-1</sup> )	2.20	2	High	2.12	2	High
8	K(CmolKg <sup>-1</sup> )	0.32	5	None	0.31	5	None
9	CEC(CmolKg <sup>-1</sup> )	6.86	1	Very high	6.72	1	Very high
10	%Base saturation	90.90	1	Very high	88.40	1	Very high
11	Bulk density (Mgm <sup>3</sup> )	1.35	4	Moderate	1.37	4	Moderate
	<b>TOTAL</b>		<b>30</b>			<b>30</b>	

Table 8: Soil Vulnerability of soils (0-30cm) of Agan and Adaka

		Agan			Adaka		
S/No.	Properties	Mean	Weighting factor	SVP	Mean	Weighting factor	SVP
1	Texture	LS	2	High	LS	2	High
2	pH (H <sub>2</sub> O)	6.55	5	None	6.51	5	None

3	Total N(gKg <sup>-1</sup> )	0.30	3	Low	3.20	4	Low
4	Organic C(gKg <sup>-1</sup> )	16.70	3	Moderate	17.30	3	Moderate
5	AP (Mgkg <sup>-1</sup> )	3.51	2	High	3.41	2	High
6	Ca (CmolKg <sup>-1</sup> )	3.50	2	High	3.42	2	High
7	Mg (CmolKg <sup>-1</sup> )	2.20	2	High	2.12	2	High
8	K (CmolKg <sup>-1</sup> )	0.32	5	None	0.31	5	None
9	CEC (CmolKg <sup>-1</sup> )	6.86	1	Very high	6.72	1	Very high
10	% Base saturation	90.90	1	Very high	88.40	1	Very high
11	Bulk density (Mgm <sup>3</sup> )	1.35	4	Moderate	1.37	4	Moderate
	<b>TOTAL</b>		30			30	

Table 9: Sustainability of Soils Based on Cumulative Rating Index of Soil Degradation Rating (SDR) and Vulnerability Potential (VP) of the Study Area

S/No.	SITE		SDR	SVP	Sustainability			
1	Tyodugh		37	29	Sustainable	with	very	High
					additional inputs			
2	Behind VC Lodge		36	30	Sustainable	with	very	high
	(JOSTUM)				additional inputs			
3	Opposite oil palm		36	30	Sustainable	with	very	high
	Plantation				additional inputs			
	(JOSTUM)							
4	College	of	36	30	Sustainable	with	very	high
	Agronomy				additional inputs			
	Research	Farm						
	(JOSTUM)							
5	Agan		36	30	Sustainable	with	very	high
					additional inputs			
6	Adaka		36	30	Sustainable	with	very	high
					additional inputs			