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Private sector participation in Agriculture - Limitations and Losses arising from Land acquisition; A case Study of a proposed Farm in Kwara State.

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ABSTRACT
Land allocated to private investors often fails to meet the requirements for profitable production. In most cases, the investors are in the dark concerning the quality of the allocated land until they have paid the obligatory cost of compensation and land evaluation. A land suitability evaluation of 450 hectares of land allocated to an investor for rice seed production in Kwara state showed that only 20% of the land was potentially moderately (S2) suitable for the specified purpose while between 20% and 25% of the land was not suitable for agricultural activities. The remaining 55% to 60% was potentially either moderately (S2) or marginally (S3) suitable for cowpea, maize or cassava. The limiting factors include low fertility, shallowness of soil, presence of plinthites at shallow depth, land degradation caused by gravel mining, rocky outcrop of various sizes and steep slope. The research concludes that the investor has lost substantially on land acquisition and evaluation and suggested that the State or Federal government should either provide a semi detailed soil survey map for area set aside for agriculture, or should indemnify the investor on all expenses incurred on land acquisition, compensation and survey, should such a land be found to be unsuitable for the purpose of its allocation.

Keywords: *Land allocation; Private sector; Land evaluation*

Introduction
The Federal Government of Nigeria has been clamouring for the repositioning of agriculture as the mainstream of Nigeria economy. There have been several policy statements and procedures put in place to fast-track private sector involvement in agriculture (FMARD, 2016.). However, there are several issues yet to be adequately addressed in order to protect the private sector investments in agriculture against losses. One key area of possible intervention is land acquisition and associated policies.

The Land Use Act (1978) confers the responsibility of land allocation for agriculture on the State government. The State government acquires land from the communities and allocates them to prospective investors who are expected to pay compensation to the local communities after the cost of economic trees and other infrastructures within the allocated land has been jointly determined by the communities and the State Ministry of Agriculture. Olaniyan and Ogunkunle (2007) reported that the degree of heterogeneity of soils within the mapping units of the current soil map of Nigeria is very high. As such, the current soil map of Nigeria cannot be used to predict accurately the suitability of the soils without further evaluation studies. Therefore, the prospective investors must carry out the relevant soil evaluation studies after the full payment of the compensation to determine the suitability of the allocated land for their desired uses. However, in most cases, land evaluation report conducted by investors after payment of required compensation often proves that a greater percentage of the acquired lands are not suitable for their intended investment option. The questions are: who bear the costs and the losses and what should be the role of the government in providing accurate soil information to prospective investors and which arm of the government should be saddled with this responsibility?

Except this policy issue is adequately addressed, the participation of private sector in agriculture, especially crop production will be a mirage.

In an attempt to show case the gravity of these problems, this paper characterized and evaluated the suitability of four hundred and fifty (450) hectares of plinthosol allocated to a private farm for rice seed production in Kwara State of Nigeria. We believe that this paper will motivate our readers, especially policy makers to have a second look on the policies regulating land allocation for agriculture such that relevant soil information can be provided for prospective investors at the point of land allocation.

MATERIALS AND METHODS

Field survey

The project site was located along Shao – Malete road in Moro Local Government Area of Kwara State, Nigeria(Fig. 1). The total area selected for the exercise was 450 hectares.

The perimeter survey map of the site was geo-referenced using the coordinates of some principal beacons provided by the Survey Department of Kwara State Ministry of Lands. The geo-referenced map was uploaded on the most recent Google Earth Imagery and this was interpreted to provide the base map of the site.

The base-map was then divided into regular polygon using Arc GIS software. The centre point of each polygon was designated as the sampling point (Fig.2). These sampling points were then uploaded into hand held GPS for mapping. The 'Grid' map was used as the basis of sampling. At each designated sampling point, augering was done at interval of 15 cm from the surface of the soil to 120 cm depth except in area were underground plinthite or stone limited the augering depth. The purpose of this augering was to delineate soil boundaries and for citing soil profile pits. Soil samples were collected from some designated points as well as from the profile pits.

At the end of the survey exercise, ten (10) soil profiles were dug in delineated mapping units. The profiles were described morphologically on the field using the FAO (2006) guideline on soil profile description. Soil samples were collected from the pedogenic horizons of these profile pits.

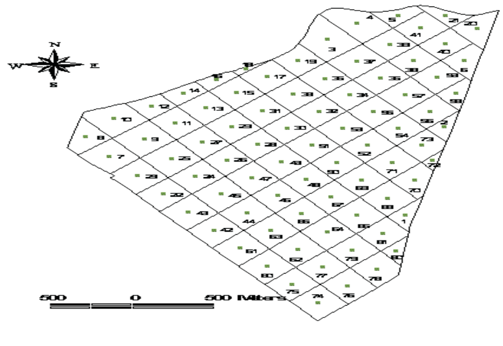

Fig.1: Location Map of Project site (Shao)

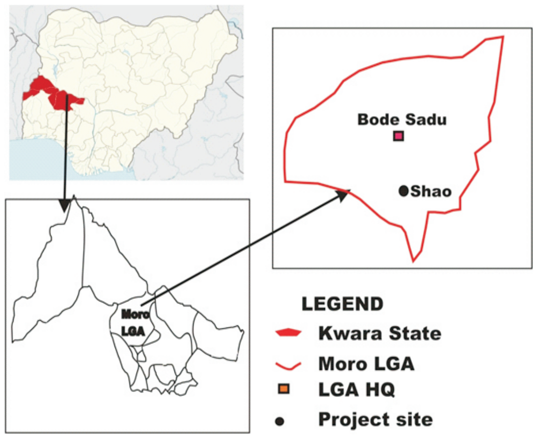

Figure 2: Sampling Points for mapping

Laboratory analyses

All the samples were air-dried and passed through 2 mm sieve before analysis. Sample fractions larger than 2 mm were assumed to be gravels and were collected, weighed and expressed as percentage gravel content of the soils. Particle size distribution was determined by the hydrometer method (Buoyoucos, 1962) after the removal of organic matter with hydrogen peroxide and dispersion with sodium hexametaphosphate (IITA, 1979). Determination of the particle size fractions, Organic carbon, exchangeable bases, exchangeable acidity, available phosphorus and pH were done as outlined in the manual of soil analysis by FAO (FAO, 2006). The micronutrients were extracted using 0.04MEDTA and their concentrations determined by atomic absorption spectrophotometer (AAS).

Also, core samples for the determination of bulk density, total porosity and saturated hydraulic conductivity were collected from each pedogenic horizon. The total porosity was calculated from the bulk density by assuming the particle density to be 2.65 g/cm^3.The saturated hydraulic conductivity (Ks) was determined by constant head soil core method of Reynolds (1993) by transposed Darcy's equation for vertical flow of liquid:

$$Ks = \frac{Qw \times d}{h \times A \times t}$$

where Qw is the volume of water (cm^3) that flowed through a cross-sectional area A (cm^2) in time (t), and h is the hydraulic head difference (cm) imposed across the sample length d (cm).

Land Suitability Evaluation procedures

The suitability of the land for production of rice, maize, cassava and cowpea was conducted using the parametric linear model of land evaluation (Stories 1933, Ajiboye et al., 2011) and the square root models (Ogunkunle, 1993; Uddoh and Eyo, 2006; Uddoh, 2008). Each profile was assigned to a suitability class by matching its characteristics and qualities with the land requirements for maize (Adesemuyi, 2014)), cowpea (Ogunwale et al, 2009), cassava (Ande, 2011) and upland rice production (Ajiboye *et al.,* 2011). The land requirement for the various crops was modified from the general land requirement for arable crops(Table 1) proposed by Sys et al (1993). According to Liebig's Law of minimum, the most limiting characteristic in a group determines performance of the group and this applies to the performance or suitability of a soil type.

The land qualities considered for evaluation are those that have direct bearing with the yield of rice and include the climate (c), topography (t), drainage characteristics (w), soil physical characteristics (s) and soil chemical fertility (f). The soil fertility (f) was assessed using the soil reaction, level of macro and micro nutrients. In computing the potential suitability for the production

of the selected crops, the fertility factors that can be amended by fertilizer additions and management practices were excluded. These factors include the level of available micro-nutrients (Fe, Zn and Mn), the levels of N, P, K and the organic matter content of the soil. However, the soil CEC, percent base saturation and pH were considered.
The current suitability was computed linearly using index of current (actual) productivity (IPC) of Storie (1933)

$IP_C = A \times B/100 \times S/100 \times C/100 \times \ldots.. F/100$ ----- (i)

Where, IP_C is index of current (actual) productivity, A the overall least rating characteristic and B, C..... are the least rating characteristic for each land quality group.

The potential suitability (IP_P) was similarly computed using the potential index of productivity.

Results

Climate

Climatic data for the area was not available anywhere at the time of this survey. Therefore, data from Meteorological stations that were close to the village were used to estimate the climatic condition for the area. The data presented here were collected from Lower Niger River Basin Development Authority (LNRBDA), Ilorin Meteorological station.

The area lies within the Guinea savanna ecology of Nigeria. The atmospheric climate of the project sites falls within the group described by Strahler (1970) as low latitude, tropical wet-dry climate.

Rainfall in the area generally begins in April and ends in October, and with a break of about two weeks occurring either in July or August. Ilorin, (using data from LNRBDA) has a range of 1000mm to 1600mm rainfall per annum and with a dry season occurring between November and March/April (Fig. 3). The average monthly rainfall ranges between 0mm (November to March) and 206 mm (August-September). Rainfall distribution is highly unpredictable both in terms of total rainfall and distribution (quantity and intensity). Generally, the total number of rainy days in a month rarely exceeds 15 days. On the average, there are about 11 rainy days per month between May and October.

Soil temperature, as earlier mentioned, is the aspect of climate that has direct bearing on soil physico-chemical processes. However, this data is seldom available outside research stations, Airports and Universities. As a result, ambient temperature is usually adopted as an indication of soil temperature bearing in mind the relationship between the two.

The coldest months have mean temperatures range of 21^{o}C to 24^{o}C and a minimum of 16^{o}C to 18^{o}C. However in Ilorin, the mean monthly minimum temperature is between 18^{o}C in January and 25^{o}Cin March while the mean maximum temperature is between 27^{o}C in August and 36^{o}C in March (Fig. 4). The mean annual temperature ranged between 29^{o}C and 31^{o}C. August usually has the lowest mean monthly maximum temperature and this ranges between 25^{o}C and 28^{o}C. In most years, January has the lowest minimum temperature. This is as a result of harmattan. It is well known that in tropical areas, inadequacy of sunshine does not pose any limit on crop performance. However, it is worthy of mentioning since soil temperature is a function of the solar radiation reaching the ground surface at any point in time. Mean monthly sunshine hours vary from 5.00 hours to about 8 hours (Fig.

Table 1: Land Requirement classes modified for suitability evaluation

Land Qualities	$S1_1$	$S1_2$	S2	S3	N1	N2
Climate (c)						
Annual Rainfall (mm)	>1000	900-1000	800-900	600-800	600-500	<500
Mean annual temperature (°C	>25	22 – 25	20 – 22	18 – 20	16 – 18	<16
Relative humidity (%)	>75	70 – 75	65 – 70	60 – 65	<60	
Topography (t): Slope (%)	<2	3-4	5 – 6	7 - 8	9 – 10	>10
Drainage (s):						
Wetness	WD (ID)†	MWD (ID) †	MD	ID (WD) †	PD (WD) †	PD (WD) †
Flooding	Fo	Fo	F1	F1	F2	F3
Soil physical properties (s)						
Texture	L (LC)†	Lfs (SLC) †	LS (SL) †	S	S	S
Structure	Cr (SAB) †	C (SAB) †	SAB (Cr) †	SAB (Cr) †	Col (Cr) †	Col (Cr) †
Coarse fragments (%) (0-45cm)	<3	3 – 5	5 – 10	10 – 15	>15	
Soil depth (cm)	>75	65 -70	50 – 65	35 – 50	30 – 35	<30
Fertility (f)						
pH	5.5 – 6.5	5.0 - 5.5	4.5 – 5.0	4.0 -4.5	<4.0	
Cation Exchange Capacity (cmol kg^1)	>16.0	12.0 - 16.0	8.0 - 12.0	5.0 – 8.0	<5.0	
Base saturation (%)	>80	70 – 80	50 -70	40 – 50	25 -35	<25
Organic carbon (%) (0-30 cm)	>2.0	2.0 – 1.5	1.2 – 1.5	1.0 – 1.2	1.0	<1.0
Macro- nutrients						
Nitrogen (%)	>2.0	1.5 – 2.0	1.0 – 1.5	0.5 – 1.0	<0.5	
Phosphorus (mg kg^{-1})	>20	15 – 20	8 – 15	5 – 8	3 – 5	<3
Potassium (cmolkg^{-1})	>0.5	0.3 -0.5	0.2 – 0.3	0.1- 0.2	<0.1	
Micro-nutrient (0.5 N HCl)						
Iron (Fe) (mg kg^{-1})	>4.5	3.5 – 4.5	2.5 – 3.5	1.5 – 2.5	1.0 – 1.5	<1.0
Zinc (Zn) (mg kg^{-1})	2.0-2.5	1.5 – 2.0	1.0 – 1.5	0.8 – 1.0	0.6 -0.8	<0.6
Manganese (Mn) (mg kg^{-1})	1.5 – 1.7	1.0 – 1.5	0.8 – 1.0	0.6 – 0.8	0.5 – 0.6	<0.5

Source: Sys et al (1993) and De Datta (1989.) modified for the different crops

† = ratings for lowland rice production; SAB =Sub Angular Blocky; Col = Columnar; Cr = crumb; WD = Well Drained; MWD = Moderately Well Drained; ID= Imperfectly Drained; PD = Poorly Drained; L= Loamy; SL= Sandy Loam; LS= Loamy Sand; Lfs = Loamy fine sand; SCL= Sandy Clay Loam; Fo =Rarely flooded; F1= Flooding expected; F2= Irregularly Flooded; F3 = regularly Flooded

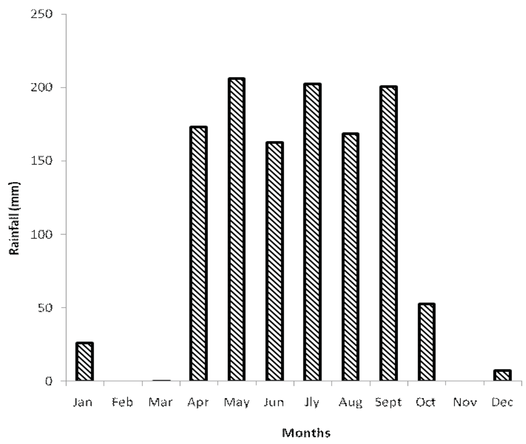

Fig. 3: Total Monthly Rainfall

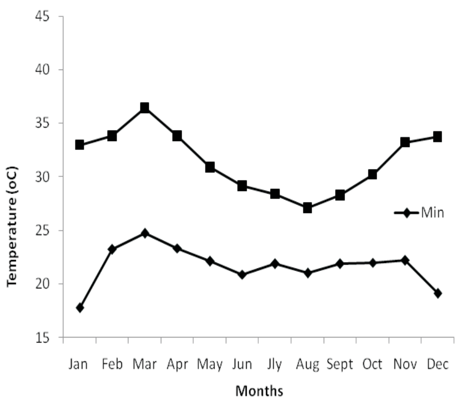

Fig. 4: Mean monthly minimum and maximum temperature.

5). The minimum daily sunshine hours are usually recorded between the months of June and August, while the maximum daily total occurs either in December or January.

A total of nine mapping units were encountered within the area of survey. These mapping units include BL1, BL2 to BL9 (Fig.6).

Description of the mapping units

Mapping unit BL1 (profiles P1 and P8) was fairly deep soil (>70 cm in depth) with loamy sand (LS) surface horizons overlying sandy clay loam/sandy clay (SCL/SC) subsurface horizons (Table 2). The colour ranged from dark reddish brown (5 YR 3/2) on the surface to dark red (2.5 YR3/6) in the subsurface horizons.

Mottling occurred at depth below 75 cm.

The mottles were many in abundance, yellowish brown (10 YR 6/8), medium–coarse in size, prominent and distinct. Also, the mapping unit had moderately formed medium subangular blocky structure with firm to very firm consistency. In addition, the soil of this mapping unit had iron – manganese concretion (plinthite) at depths below 70 cm.

This mapping unit has moderate to high saturated hydraulic conductivity (Ks)(59.62 – 132.99 cm h^{-1}) in the first horizon of the profiles (Table 2). However, the Ks decreased drastically in the last horizons indicating a highly reduced infiltration rate with increasing soil depth. This phenomenon is by the clayey nature of the soil subsurface horizon.

The bulk density (BD) of this mapping unit ranged from 1.91 g cm^{-3} on the surface to 2.26 g cm^{-3} in the sub surface horizon. The gravelly nature of this soil is probably the cause of the high bulk densities observed in the soil of this mapping unit.

The organic carbon content of the soil of this mapping unit was low and ranged from 0.33% to 0.68% (Table 3). In the same vein, the phosphorus (P) and potassium (K) contents of the soils were very low. While the P content ranged from 2.06 mg kg^{-1} to 2.88 mg kg^{-1}, the K content ranged from 0.06 cmol kg^{-1} to 0.17 cmol kg^{-1}. Similar to most savanna land in Nigeria, the total nitrogen (N) content of this mapping unit

Table 2: Soil physical and morphological properties

Profile	*Horizon (cm)*	*Sand (%)*	*Silt (%)*	*Clay (%)*	*Gravel (%)*	BD (g/cm3)	Ks (cm/hr)	*Texture*	*Structure*	*Cons.*	*Colour*
P- 1	0 – 18	80	9	11	27.11	2.08	132.99	SL	We, Me, Sbk	FR	5 YR 3/3
	18 – 42	78	7	15	41.78	2.17	134.83	SL	We, Fi, Sbk	FR	2.5 YR 3/6
	42 – 76	60	7	33	764.34	2.26	233.89	SCL	We, Fi, Sbk	VFI	2.5 YR 3/6
	76 – 140	60	19	21	51.87	2.16	134.83	SCL	MA	EFI	2.5 YR 3/6
P-2	0 – 38	78	11	11	60.37	2.1	392.25	SL	We, Me, Sbk	FR	10 YR 3/4
	38 – 50	78	7	15	76.03	2.19	91.41	SL	We, Me, Sbk	VFI	10 YR 3/6
P-3	0 – 13	79	9	12	36.66	2.23	15.59	SL	We, Me, Sbk	FR	10 YR 4/3
	13 – 31	79	9	12	24.12	2.08	36.99	SL	We, Me, Sbk	FR	10 YR 4/3
	31 – 59	69	13	18	43.26	2.13	7.77	SL	St, Me, Abk	FR	5 YR 4/6
	59 – 122	49	9	42	65.16	2.24	0.61	SC	St, Co, Abk	VFI	5 YR 4/6
	122 – 183	47	11	42	78.92	2.29	2.23	SC	St, Co, Abk	EFI	5 YR 4/6
P-4	0 – 13	73	15	12	41.13	1.95	148.28	SL	We, Fi, Sbk	VFR	10 YR 2/1
	13 – 46	79	8	13	74.85	2.09	369.32	SL	We, Me, Sbk	FI	10 YR 3/4
	46 – 124	67	4	29	81.3	2.12	345.48	SCL	We, Fi, Sbk	VFI	5 YR 4/6
	124 – 180	69	10	21	78.4	2.2	50.75	SCL	We, Fi, Abk	VFI	10 YR 5/3
P-5	0 – 34	83	8	9	45.97	2.13	32.71	LS	We, Me, Sbk	FR	10 YR 3/4
	34 – 75	80	7	13	56.13	2.01	81.94	SL	We, Me, Sbk	FR	10 YR 4/3
	75 – 100	78	7	15	68.29	2.07	31.8	SL	We, Me, Sbk	FR	10 YR 4/4
P-6	0 – 12	70	15	15	53.62	1.82	61.15	SL	Mo, Me, Sbk	FR	5 YR 3/2
	12 – 43	58	11	31	78.98	2.3	417.94	SCL	Mo, Me, Sbk	FI	2.5 YR 3/6
	43 – 80	54	11	35	8.41	2.18	239.08	SCL/SC	Mo, Me, Sbk	FI	2.5 YR 3/6
P-7	0 – 10	79	10	11	60.21	2.07	82.55	SL	We, Fi, Sbk	FR	10 YR 3/ 4
	10 – 35	71	8	21	49.83	2.18	56.87	SCL	We, Fi, Sbk	FR	10 YR 4/6
	35 – 64	49	10	41	66.13	2.19	169.99	SC	Mo, Me, Sbk	FI	2.5 YR 4/6
P-8	0 – 40	75	10	15	53.76	1.91	59.62	SL	Mo, Me, Sbk	FI	5 YR 3/2
	40 – 68	59	8	33	48.57	2.11	49.83	SCL	Mo, Me, Sbk	FI	2.5 YR 3/6
	68 – 92	59	10	31	61.63	2.19	33.63	SCL	Mo, Me, Sbk	FI	2.5 YR 3/6
P-9	0 – 18	59	20	21	72.48	2.02	22.32	SCL	Mo, Me, Sbk	FI	2.5 YR 3/ 3
	18 – 33	45	14	41	59.38	2.22	475.72	CL/SC	Mo, Me, Sbk	FI	2.5 YR 3/ 4
	33 – 108	39	12	49	58.42	2.29	9.17	CL	Mo, Me, Sbk	VFI	2.5 YR 3/ 4
P-10	0 – 52	84	6	10	62.12	2.15	107.01	LS	We, Me, Sbk	FR	10 YR 3/6
	52 – 104	84	4	12	79.77	2.11	140.33	LS	We, Me, Sbk	FI	10 YR 4/6
	104 – 150	76	4	20	77.91	2.07	134.52	SL/SCL	We, Me, Sbk	FR	10 YR 5/3
	150 – 180	68	8	24	67.4	1.96	68.18	SCL	Mo, Me, Sbk	FR	10 YR 5/3
	180 – 200	64	16	20	78.86	2.04	0.9172	SL/SCL	Mo, Me, Sbk	FR	10 YR 5/3

LS= Loamy sand; SL=Sandy loam, SCL=Sandy clay loam; CL= Clay; S= Sand; We = weak; Mo = moderate; St = strong; Fi = fine; Me = medium; Co = coarse; Sbk= sub-angular blocky; Abk= angular blocky; VFR = very friable; FR = friable; FI = firm; VFI = very firm; EFI = extremely firm

Table 3: Soil Chemical properties

Profile	Horizon Depth (cm)	pH	OC (%)	N (%)	Ca	Mg	K	Na	EA	ECEC	Av. P	Zn	Cu	Mn	Fe
					← cmol+/kg →						← (mg kg^{-1}) →				
P-1	0 - 18	6.7	0.68	0.042	1.67	0.49	0.17	0.03	ND	2.36	2.47	2.31	1.46	175.40	71.86
	18 - 42	6.2	0.34	0.017	0.40	0.24	0.06	0.05	ND	0.74	2.06	0.63	1.46	179.39	83.86
	42 - 76	6.2	0.33	0.034	0.91	1.13	0.17	0.09	ND	2.29	2.67	0.78	1.71	156.21	58.53
	76 - 140	6.2	0.33	0.010	0.43	0.66	0.15	0.04	ND	1.28	2.47	12.09	0.96	131.24	77.20
P-2	0 - 38	6.7	0.61	0.035	2.21	0.75	0.06	0.04	ND	3.06	1.85	2.31	1.21	205.17	101.19
	38 - 50	6.7	0.49	0.015	1.13	0.46	0.00	0.08	ND	1.66	2.47	1.09	2.45	187.79	134.52
P-3	0 - 13	7.6	0.54	0.020	1.13	0.25	0.02	0.04	ND	1.45	2.67	1.39	1.46	152.42	91.86
	13 - 31	7.1	0.43	0.014	0.94	0.22	0.02	0.04	ND	1.21	1.65	1.39	1.96	186.99	113.19
	31 - 59	6.7	0.28	0.013	0.75	0.56	0.15	0.06	ND	1.51	2.47	1.85	2.45	195.58	129.19
	59 - 122	6.0	0.23	0.021	2.30	0.65	0.31	0.08	ND	3.34	2.26	2.31	1.46	113.45	70.53
	122 - 183	6.3	0.32	0.018	2.74	0.68	0.19	0.06	ND	3.67	3.08	0.47	0.96	95.87	63.86
P-4	0 - 13	6.8	1.22	0.074	2.68	1.21	0.39	0.07	ND	4.35	5.33	7.20	1.71	153.22	149.19
	13 - 46	6.6	0.62	0.043	1.25	0.40	0.13	0.06	ND	1.84	11.48	2.92	1.96	56.70	91.86
	46 - 124	6.3	0.43	0.036	2.21	1.10	0.19	0.07	ND	3.57	11.48	1.70	0.46	99.26	65.20
	124 - 180	6.9	0.34	0.040	2.49	0.95	0.15	0.07	ND	3.65	2.06	3.23	2.95	180.19	81.20
P-5	0 - 34	6.2	0.41	0.039	0.87	0.36	0.19	0.06	ND	1.48	2.47	0.63	1.96	118.05	55.87
	34 - 75	6.3	0.27	0.024	1.10	0.45	0.23	0.08	ND	1.85	1.65	0.32	1.96	113.45	94.53
	75 - 100	6.4	0.19	0.010	1.29	0.53	0.04	0.08	ND	1.94	2.06	0.47	2.70	113.05	94.53
P-6	0 - 12	6.8	1.38	0.099	3.92	1.27	0.08	0.08	ND	5.35	2.47	9.04	1.96	212.57	173.19
	12 - 43	6.1	0.62	0.075	0.87	1.10	0.80	0.08	ND	2.86	1.85	2.31	3.20	185.99	93.20
	43 - 80	6.3	0.50	0.078	1.38	1.96	0.43	0.05	ND	3.82	4.93	1.09	1.96	202.37	62.53
P-7	0 - 10	6.8	0.68	0.051	1.73	0.66	0.19	0.07	ND	2.64	2.67	3.23	2.45	84.88	191.85
	10 - 35	6.1	0.46	0.029	0.68	1.23	0.25	0.03	ND	2.19	2.47	1.24	2.45	139.83	179.85
	35 - 64	7.1	0.24	0.020	1.73	3.57	0.37	0.09	ND	5.76	2.67	4.76	0.46	158.21	62.53
P-8	0 - 40	6.6	0.64	0.044	2.33	0.89	0.17	0.08	ND	3.48	3.49	6.28	2.70	185.19	142.52
	40 - 68	6.1	0.53	0.047	1.95	0.91	0.13	0.08	ND	3.07	2.88	5.83	3.20	181.39	127.86
	68 - 92	6.1	0.39	0.040	1.79	0.88	0.08	0.08	ND	2.85	2.67	6.59	2.95	223.76	122.53
P-9	0 - 18	6.7	1.97	0.165	6.20	2.10	0.58	0.08	ND	8.96	2.88	14.39	5.69	198.78	161.19
	18 - 33	6.5	0.76	0.069	2.21	1.78	0.64	0.08	ND	4.71	2.67	6.13	2.95	230.55	123.86
	33 - 108	5.9	0.38	0.036	1.92	1.79	0.70	0.09	ND	4.50	2.88	7.51	3.70	91.87	119.86
P-10	0 - 52	6.6	0.38	0.020	0.81	0.33	0.11	0.07	ND	1.32	2.67	17.29	0.09	59.30	81.20
	52 - 104	6.4	0.18	0.011	0.46	0.24	0.13	0.08	ND	0.90	1.85	64.39	0.71	38.92	54.53
	104 - 150	6.2	0.24	0.019	1.25	0.57	0.25	0.09	ND	2.16	2.47	55.98	0.46	31.52	34.53
	150 - 180	6.5	0.24	0.019	2.27	0.68	0.21	0.07	ND	3.22	2.06	52.46	0.71	22.53	31.87
	180 - 200	6.6	0.22	0.023	2.68	0.66	0.15	0.06	ND	3.54	2.67	32.89	0.22	123.44	27.87

ND = below detection limit

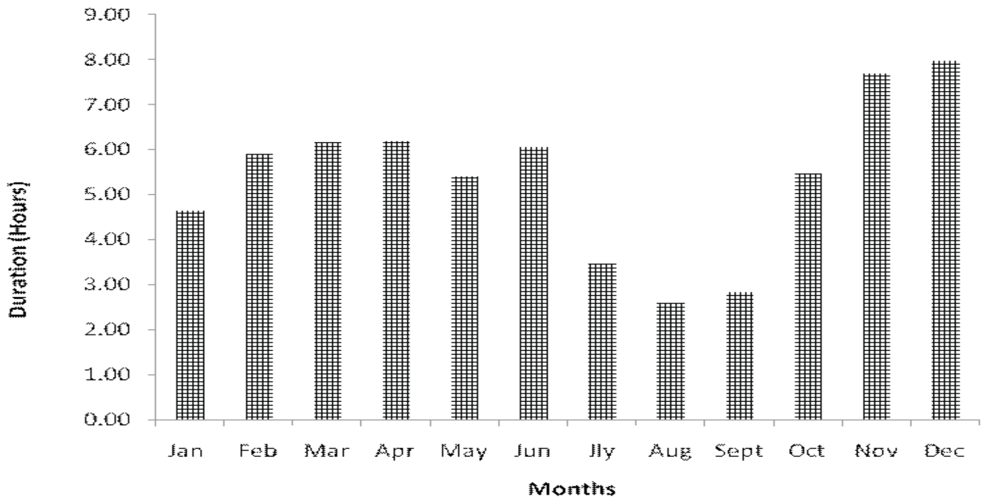

Fig. 5: Mean monthly Sunshine hours

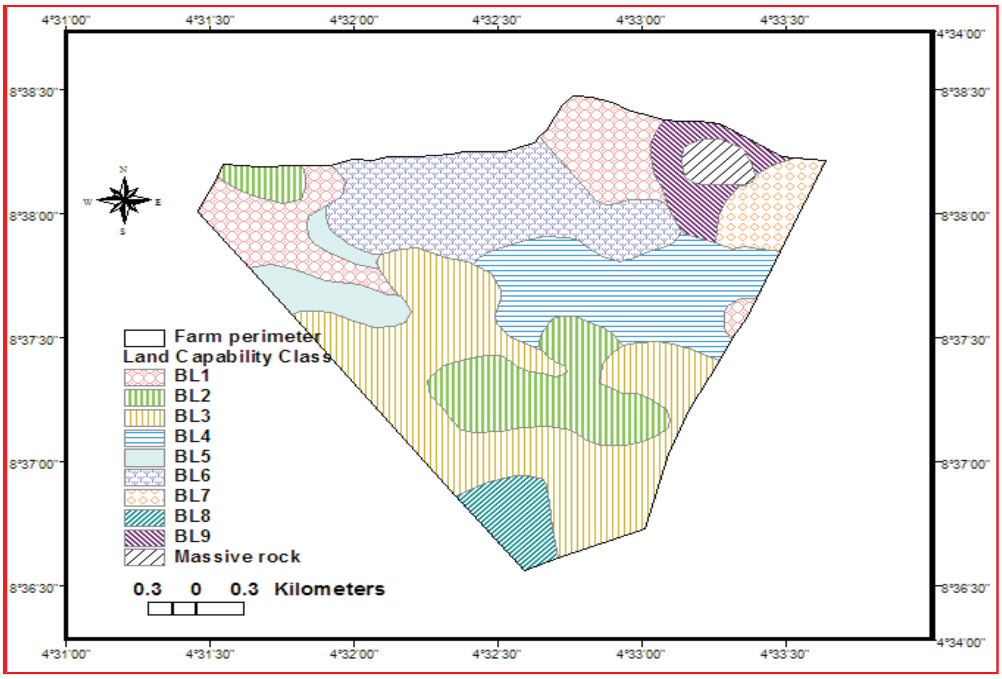

Fig.6: Soil map showing the mapping units

was lower than the critical requirement for most arable crop grown within this ecological zone. The N content of the soil ranged from 0.010% to 0.047%. The soil pH ranged from slightly acid (6.1) to neutral (6.7) while the effective cation exchange capacity (ECEC) was also very low and ranged from 0.74 cmol $kg^{-1}$to 3.84 cmol kg^{-1}. However, the micronutrients content of the soils were all high. While the values of available copper (Cu) ranged from 0.96mg kg^{-1} to 3.20mg kg^{-1}, those of zinc (Zn) ranged from 0.63 mg $kg^{-1}$to 12.09 mg kg^{-1}. The concentration of iron (Fe) and manganese (Mn) in the soils were excessively high and could be toxic. While the soil content Fe ranged from 58.53 mg kg^{-1} to 142.52 mg kg^{-1}, the Mn content of the soils ranged from 131.24 mg kg^{-1} to 230.55 mg kg^{-1}.

Mapping unit BL2 (profiles P3 and P5) was moderately deep (>100 cm). This soil type has sandy loam (SL) textured surface overlying sandy clay loam or sandy clay (SCL) textured subsurface. Furthermore, the soil has weakly formed medium sub-angular blocky structure on the surface (< 30 cm depth) and moderate to strongly formed medium sub-angular blocky structure in the subsurface (>30 cm depth).The consistency ranged from friable (FR) in the surface to very firm (VFI) in the subsurface horizons, while the soils ranged in colour from dark yellowish brown (10 YR 3/4) in the surface to yellowish red (5 YR4/6) in the subsurface. At the fringe of some rivulets where the soil is somewhat imperfectly drained, the last horizon of the profile (P5) has many, fine, diffuse, faint and dark yellowish brown (10 YR 3/4) mottles.

BL2 has Ks that ranged from 15.99 to 32.71 cm h^{-1} in the surface horizons but there was drastic reduction in the Ks depth after the second horizon. This reduction in the rate of infiltration increasing soil depth correlated negatively and significantly with the percentage gravel and clay content of the soil which increased with increasing soil depth.

The BD ranged from 2.13 g cm^{-3} on the surface to 2.29 g cm^{-3} in the sub surface horizons. It was also observed that the second horizons of BL2 had the lowest bulk density.

The OC content of BL2 was low and decreased with increasing soil depth, ranged from 0.19% to 0.54%. Also, the P and K contents of the soils were very low. The P content of BL2ranged from 1.65 mg $kg^{-1}$to 3.08 mg kg^{-1} while the K content ranged from 0.02cmol $kg^{-1}$to 0.31 cmol kg^{-1}. In BL2, the K content was lowest in the surface horizons and highest in the subsurface horizons. The pH ofBL2 ranged from moderately acid (6.0) to slightly alkaline (7.6) while the ECEC was very low and ranged from 1.21cmol kg^{-1} to 3.67cmol kg^{-1}.

Available copper (Cu) content of BL2 was high and ranged from 0.96 mg kg^{-1} to 2.70 mg kg^{-1} while Zn content ranged in value from low (0.32 mg kg^{-1}) to high (2.31 mg kg^{-1}) high. The concentration of Fe and Mn in BL2 were excessively high and could become toxic especially when the pH of the soils falls below 4.0. While the Fe ranged from 55.87 mg kg^{-1} to 129.19 mg kg^{-1}, the Mn content ranged from 95.87 mg kg^{-1} to 195.58 mg kg^{-1}.

The third mapping unit (BL3) (profile P4) consist of deep soils (>100 cm depth) with iron-manganese concretions (plinthite), prominent manganese nodules and quartz gravels. The soil of BL3 was well drained with black (10 YR 2/1) to dark yellowish brown (10 YR 3/4) sandy loam (SL) surface horizons overlying brown (10 YR 5/3) to yellowish red (5 YR 4/6) sandy clay loam (SCL) subsurface horizons. Mapping unit BL3 was highly gravelly, containing both plinthite and quartz gravel. The surface horizon had average gravel content of 41.13% and this increased drastically to 81.30% in the subsurface horizons.BL3 has very weakly to weakly formed fine sub-angular blocky structure throughout the profile depth. The consistency of BL3 ranged from friable (FR) in the surface to very firm (VFI) in the subsurface horizons.

The BD of BL3 ranged from 1.95 g cm^{-3} in the surface to 2.20 g cm^{-3} in the subsurface horizons and generally increased with increasing depth from the surface. However, the Ks of BL3 averaged148.28 cm hr^{-1}on the surface, increased to 369 cm hr^{-1} between 13 cm and 124 cm depth before declining to 50.75 cm hr^{-1}.

The OC, N, P, K as well as the ECEC of BL3 were low. The OC ranged from 0.34% to 1.22% while N ranged from 0.036% to 0.074%. Similarly, the values of K ranged from 0.13cmol kg^{-1} to 0.39cmol kg^{-1}but the ECEC values ranged from 1.84cmol kg^{-1} to 4.35cmol kg^{-1} and P ranged from 2.06 mg kg^{-1} to 11.48 mg kg^{-1}.The nutrient content of BL3was lower than the critical requirements for most crops. The available Cu which ranged from 0.46 mg kg^{-1} to 2.95 mg kg^{-1} and the Zn content that ranged from 1.70 mg kg^{-1} to 7.20 mg kg^{-1} were moderately high but not toxic to most crops. However, the Fe (65.20 mg kg^{-1} – 149.19 mg kg^{-1}) and Mn (56.70 mg kg^{-1} – 180.19 mg kg^{-1}) were excessively high and could become toxic.

Mapping unit BL4 holds the worst soil within the selected area in terms of the physical properties of the soil. This area was mapped but there was no profile pit dug in it because it was regarded as highly degraded soil that is not useful for agriculture.BL4was an extensive gravel mine with both surface and subsurface stoniness exceeding 90%. The gravel ranged in sizes from fine, sub-rounded, coarse angular gravels to boulders.

Surface (0-30 cm) samples collected from this mapping unit indicated that the soil had loamy sand (LS) texture, well drained with 53.27% gravel. The soil was slightly (acid 6.50) to neutral (7.0). The average OC content was 0.70 %, 0.049% N, 8.20 mg kg^{-1}P and 0.27 cmol kg^{-1}K.

Mapping unit BL5 depicted by profile P2 represent shallow soils (<50 cm) with plinthiteout crop, iron-manganese concretions (plinthite) and impenetrable layer at less than 50 cm depth. The soils which were well drained, had dark yellowish brown (10 YR ¾ or 3/6) colour, loamy sand texture, moderately formed fine subangular blocky structure and friable to very firm consistency.

BL5 has very high saturated hydraulic conductivity that ranged from 392.25cm hr^{-1} in the surface to 91.41cm hr^{-1} in the subsurface horizon. The bulk densities ranged from 2.10 g cm^{-3}in the surface to 2.19 g cm^{-3}in the subsurface horizons.

The soil of this mapping unit had neutral reaction (pH 6.7). The OC, N, P and K content of the soil as well as the ECEC were low. The average of values of these nutrient elements were 0.55%, 0.020% and 2.16 mg kg^{-1} respectively for OC, N and P while those of K and ECEC were 0.03 cmol

kg^{-1} and 2.36 cmol kg^{-1} respectively. The available Zn (1.09 – 2.31) and Cu (1.21 – 2.45) content of the soil were moderately high but not considered toxic, but the Fe and Mn contents were very high and could become toxic under low pH.

The soils of the hilly area of the farm was mapped together as mapping unit BL6 and depicted with profile P9. This mapping unit in practical terms cannot be used for agriculture because of the steepness of the slope. Profile P9 that depicts this mapping unit was dug at the bottom of the slope and could in all respect be regarded as hill-washed soils. The soil of this mapping unit was deep (>100 cm), clayey and gravelly but not plinthic.BL6 was well drained, very dusky red (2.5 YR 2.5/2) on the surface and dark reddish brown (2.5 YR 3/4) in the subsurface horizons. The soil had the sandy clay loam texture on the surface and sandy clay – clay texture in the subsurface horizons. The surface horizons of the soil of this mapping unit had strongly formed coarse subangular blocky structure while the subsurface horizons had strongly formed medium angular block structure. In term of the consistency, the surface horizons were slightly sticky and slightly plastic or very firm while the subsurface horizons were sticky and plastic. Apart from the clayey nature of the soils of this mapping unit, the soils had rounded and sub-rounded quartz stones of various sizes throughout the profile. The percentage gravel content of the soils of the mapping unit ranged from 58.42% to 72.48%. The gravel content of the soil was highest in the surface horizons and decreased linearly with increasing soil depth. Furthermore, the saturated hydraulic conductivity of this mapping unit was moderately high in the Surface horizon (22.32 cm hr^{-1}), very high in the second horizon (475.72 cm hr^{-1}) and moderately high in the other subsurface horizons (9.17 cm hr^{-1}). The bulk density of the soils of the mapping unit ranged from 2.02 g cm^{-3}in the surface horizon to 2.29 g cm^{-3} in the subsurface horizon.

Due to none usage (because of steepness of the slope), the nutrient content of the soils of mapping unit BL6 were higher than those of the other mapping units. Apart from the available phosphorous content of the soils which were very low, the organic carbon, total nitrogen and exchangeable potassium content of the soils were moderate especially in the surface horizons. The reaction of the soils in distilled water ranged from moderately acid (pH 5.9) in the sub surface horizons to neutral (pH 6.7) in the surface horizons. The organic carbon content of the surface horizon was high (1.97%) but low (0.38% - 0.76%) in the subsurface horizon. Also, the values of the available phosphorus (2.67 mg kg^{-1} – 2.88 mg kg^{-1}) and the cation exchange capacities of the soils (4.50cmol kg^{-1} – 8.96cmol kg^{-1}) were very low. However, the values of the exchangeable potassium (0.58cmol kg^{-1} – 0.70cmol kg^{-1}) were high. Similarly, the values of the available micronutrients (Zn, Cu, Fe and Mn) were high. While the values of the Zn 6.13 mg kg^{-1} – 14.39 mg kg^{-1}) and Cu (2.95 mg kg^{-1} – 5.69 mg kg^{-1}) were high but not considered toxic, the values of Fe (119.86 mg kg^{-1}–161.19 mg kg^{-1}) and Mn (91.87 mg kg^{-1}– 230.55 mg kg^{-1}) were excessively high and could become toxic especially with increase in the soil acidity.

Mapping unit BL7 consists of soils with

subsurface plinthite pan as well as surface plinthite outcrops. The soil of this mapping unit is represented by profile P6 (plate xvii). This mapping unit consist of shallow plinthitic and gravelly dark reddish brown black (5 YR 3/2), well-drained, loamy sand (LS) surface horizon overlying dark red (2.5 YR 3/6/), sandy clay loam/sandy clay (SCL/SC/) subsurface horizons. The first two horizons have abundant (> 40%), medium - coarse, sub-rounded and angular quartz gravels while the last horizons of this mapping unit had little gravelly (<10%). The surface horizon has moderately high hydraulic conductivity (61.15 cm h^{-1}) while the subsurface horizons have very high saturated hydraulic conductivity that ranged from 239.08 cm $h^{-1}$to 417.94 cm h^{-1}. The bulk density of the pedon ranged from 1.82 g cm^{-3} to 2.30 g cm^{-3}. This mapping unit had moderately formed medium subangular blocky structure with a friable (FR) consistency on the surface horizon while the subsurface horizons had coarse, strongly formed medium subangular blocky structure with firm (FI) consistency. Mapping unit BL7 has slightly acid (pH 6.1) to neutral (pH 6.8) reaction with moderate (1.38%) surface but low (0.50%) subsurface organic carbon. The total nitrogen (0.075 -0.099%) and available phosphorus (1.85 – 4.93) were equally very low. While the surface horizons had very low exchangeable potassium (0.08 cmol kg^{-1}), the exchangeable K content of the subsurface horizons (0.43cmol kg^{-1} - 0.80cmol kg^{-1}) were moderate. The values of the Zn which ranged from 1.09 mg kg^{-1}to2.31 mg $kg^{-1}$and those of Cu that ranged from 1.96 mg kg^{-1}to3.20 mg kg^{-1} were high but not considered toxic. However, the values of Fe (62.536 mg kg^{-1} – 173.19 mg kg^{-1}) and Mn (185.99 mg kg^{-1} – 212.57 mg kg^{-1}) were excessively high.

Profile P10 depicts the soils of mapping unit BL8. This mapping unit consists of very deep soils (>180 cm) with subsurface iron- manganese concretion (Fe-Mn concretion or plinthite) and occasional outcrop of banded and granite gneiss. The soils occur around the prominent outcrop of granite/banded gneiss situated at the northern part of the farm. The soil of this mapping unit has plinthite from 50 cm down the whole soil depth.

The soil of this mapping unit had loamy sand (LS) surface texture overlying a sandy clay loam (SCL) subsurface. Apart from the first surface horizon which had a friable (FR) consistency, all other horizons were firm to very firm (FI - VFI) in consistency. Also, apart from the fourth horizon that had angular blocky (AB) structure, the remaining horizons had subangular blocky (SB) structure.

The soil of this mapping unit had colour variation between dark yellowish brown (10 YR 3/6) on the surface and brown (10 YR 5/3) in the subsurface.

Water infiltration rate as indicated by the saturated hydraulic conductivity (Ks) was very high in the surface horizon of this mapping unit (107.01 cm h^{-1}). However, the subsurface horizons of this mapping have Ks that ranged from low to very high (0.92 - 140.33 cm h^{-1}). Generally, the Ks decreased steadily from the second horizon through to the last horizon. Also, the bulk density of the soil of this mapping unit was high in the surface (1.75 g cm^{-3}) probably due to the compaction effect of grazing livestock but decreased in the subsurface horizons from 1.39 – 1.28 g cm^{-3} with increasing soil depth.

The soil of this mapping unit had

slightly acid (pH 6.2) to neutral reaction (pH 6.6) in distilled water. The average organic carbon (0.25%), total nitrogen (0.18%), available phosphorus (2.34mg kg^{-1}), exchangeable potassium (0.17cmol kg^{-1}) content of the soil as well as the effective cation exchange capacities (2.02cmol kg^{-1}) were low. The available zinc (173 – 6.44mg kg^{-1}) content of the soil was excessively high and could become toxic, but the copper (0.09 – 0.71mg kg^{-1}) was very low in the surface horizons and moderate in the subsurface horizon. Furthermore, the level of available iron and manganese in the soil of this mapping unit was very high as observed for other mapping units. The values of these elements ranged from 27.87mg kg^{-1} to 81.54mg kg^{-1} and from 22.53mg kg^{-1} to 123.44mg kg^{-1} respectively for iron and manganese.

Mapping unit BL9 soils limited by high water table, but not hydromorphic. The high water table of the mapping unit is the result of impervious subsurface layers caused mainly by the presence of partially weather rock (gneiss). This mapping unit is represented by profile P7. This mapping unit exists south of the granite gneiss outcrop. The soil had impervious partially degraded granite gneiss material at about 60 cm depth where water table was encountered. The soils had loamy sand (LS) surface horizon overlying a sandy clay (SC) subsurface horizon. The surface horizon had dark yellowish brown (10 YR 4/4) colour while the subsurface horizons had red (2.5 YR 4/6) colour. The last horizons of the mapping unit had common, medium, distinct, clear and brown (10 YR 5/3) mottles. Also, the surface horizons had friable (FR) consistency while the subsurface horizons had firm (FI) consistency. The soils of this mapping unit had no plinthite in any part of the horizon. The soil of this mapping unit has very high saturated hydraulic conductivity that ranged from 82.55 cm hr^{-1} in the surface to 169.99cm hr^{-1} in the subsurface horizon. The bulk densities ranged from 2.07 g cm^{-3} in the surface to 2.19 g cm^{-3} in the subsurface horizons.

In term of nutritional elements and reactions, the soil of the mapping unit had slightly acid to neutral pH (6.1 – 7.1), but the average organic carbon (0.46%), total nitrogen (0.033%), available phosphorus (2.60mg kg^{-1}), exchangeable potassium (0.06cmol kg^{-1}) and effective cation exchange capacity (3.35cmol kg^{-1}) content of the soils were very low. The available zinc and copper were moderate to high while the iron and manganese contents of the soils were extremely high.

Land Suitability

In term of the suitability of the soils for the production of maize, the evaluation result (Table4)showed that all the mapping units were currently not suitable for maize, cassava, cowpea and upland rice production. This stems from the low fertility status of all the mapping units, shallowness of depth and excessive stoniness of most of the mapping units. However, with adequate application of appropriate fertilizer, all the mapping units except mapping units BL4 and BL6 can support maize production marginally. This may require ridging in some of the mapping unit (BL5) because of shallowness of the soil. However, the cost of production may be so high as to reduce the profit margin of such production venture drastically. For cassava cultivation, evidence from literatures indicates that soils that are suitable for maize production, especially those with sandy loam and loamy sand textures, will equally be suitable for cassava production. However, the fertility requirement of cassava is lower than that of maize. Since the major limitations for cassava production in all the mapping units are low fertility and coarse fragments (gravels) in the soil, improving the fertility of the soils by fertilizer application will improve the suitability of mapping units BL1, BL3, BL5, BL7, BL8 and BL9 from currently not suitable(N1) to moderately (S2) suitable. However, mapping unit BL2 will be marginally suitable for cassava production (Table 4).

Evaluation of the potential suitability of the soil for production of cowpea, a nitrogen fixing crop (legume) indicated that with amendment of the soil fertility status mapping units BL1, BL3, BL5, BL7, BL8 and BL9 which are currently not suitable (N1) for cowpea production will become moderately (S2) suitable, while mapping units BL2 will be marginally suitable (S3). Since cowpea is a nitrogen fixing plant, adequate application of phosphorus fertilizers will be of uttermost importance in the production of cowpea or any other leguminous crop in the project site.

The evaluation of the site for upland rice production showed that all the pedons had index of current productivity (IPc) less than 25 and were classified as currently not suitable (N1) for the production of upland rice. The limiting factors were mainly low levels of available macro-nutrients, organic matter and low cation exchange capacity. Also, the soil texture, structure and coarse fragment (gravel) contents were sub-optima for rice production. However, when the potential suitability of the soils (without considering the levels of organic carbon, macro- and micronutrients which is regarded as temporary limitation) was computed, the results indicated that all the mapping units except mapping units BL4

Table 4: Overall Suitability of the mapping units

	Maize		Cassava		Cowpea		Rice		PMSC*
Over all Suitability	**Actual Suitability**	**Potential Suitability**	**Actual Suitability**	**Potential Suitability**	**Actual Suitability**	**Potential Suitability**	**Actual Suitability**	**Potential Suitability**	
BL1	15.6	39 (S3)	24 (N1)	60 (S2)	24 (N1)	60 (S2)	21.6 (N1)	54 (S2)	Cassava/ Cowpea
BL2	10.14 (N2)	25.35 (S3)	24 (N1)	39 (S3)	24 (N1)	39 (S3)	21.6 (N1)	54 (S2)	Upland Rice
BL3	13 (N1)	32.5 (S3)	20 (N1)	50 (S3)	20 (N1)	50 (S3)	20 (N1)	50 (S2)	Cassava/ Cowpea
BL5	13 (N1)	32.5 (S3)	20 (N1)	50 (S3)	20 (N1)	50 (S3)	21.6 (N1)	54 (S2)	Upland Rice
BL6	6.5 (N2)	16.25 (N1)	20 (N1)	25 (N1)	20 (N1)	25 (N1)	2.92 (N1)	13.25 (S3)	Not Suitable
BL7	14.3 (N1)	35.75 (S3)	22 (N1)	55 (S2)	22 (N1)	55 (S2)	21.6 (N1)	54 (S2)	Cassava/ Cowpea
BL8	17.94 (N1)	44.85 S3)	24 (N1)	60 (S2)	24 (N1)	60 (S2)	21.6 (N1)	54 (S2)	Cassava/ Cowpea
BL9	6.69 (N2)	25.35 (S3)	24 (N1)	60 (S2)	24 (N1)	60 (S2)	21.6 (N1)	54 (S2)	Cassava/

PMSC = potentially most suitable crop* and BL6 had index of potential suitability that ranged from 50 to 54.This suggests that mapping units BL1, BL2, BL3, BL5, BL6, BL8 and BL9 could become moderately (S2) suitable for the production of upland rice with application of the appropriate types and quantity of fertilizers.

In term of comparative suitability of all the mapping units, mapping unit BL4 was considered none arable while mapping unit BL6 was not also suitable for crop production because of the steepness of the slope. Comparatively, mapping units BL2 and BL5 were the most suitable for upland rice production while mapping units BL1, BL3, BL7, BL8 and BL9 were the most suitable for cassava and cowpea production. Mapping units BL1, BL2, BL3, BL5, BL7, BL8 and BL9 were marginally suitable for maize and therefore cassava, cowpea and upland rice were likely to give high yields/unit input than maize (Fig 7).

Discussion

Agricultural production requires premium land with good soil quality characteristics (Tommy et al., 2014).

The observed fragile nature of the soil with nutrient status well below the critical requirements for most of the evaluated crops could have resulted from over utilization of the soil (Parfitt, 1992; Kirkman *et al.,* 1994; Al-Zubaidi *et al.,* 2008; FFD, 2011). Due to over-cropping and over grazing, the surface vegetal covers was sparse and this could lead to soil compaction, low aggregate stability and water infiltration and this may expose the soil to erosion as a result of direct raindrop impact (Lal, 2001).Serious rehabilitation and conservative practices is required before the soil could be used for sustainable agricultural production(Eswaran and Dumanksi, 1998). Therefore, preservation of the surface soil with its all-important organic matter will be of utmost importance in conservation and management of these soils(Nia et al., 2012)

Stoniness as observed in mapping units BL4, BL5 and BL7 affects several soil physical properties including the bulk density, root penetrometer resistance, saturated hydraulic conductivity as well as tillage practices especially by mechanization (Beckers *et al.*, 2016). Shallow soil depth resulting from the stony sub surface horizons make mechanization practically impossible and also limited the choice of crops that can be planted in mapping unit BL5 and rendered mapping units BL4 and BL7 non arable. Although shallow stony soils are classified as unproductive (Blake *et al*., 2012), mounding, minimum and zero tillage practices are the only tillage options that can be used to manage mapping unit BL5 productively (Agbede, 2006). Soil fertility management should combine organic and inorganic fertilizer amendments in an integrated system. Sound management of organic residue should be adopted and cropping systems such as crop rotation and intercrops including legumes should be encouraged (Ojeniyi, 2010).

Since some of the areas are rated as not suitable for cropping or marginally suitable for cropping, the affected area can be put into other none agricultural uses like mining and recreational activities.

Only about 20% of the land is potentially moderately suitable for rice seed production while another 20-25% of the land is unsuitable for agricultural activities.

Conclusion

In this present study, the investor cannot realize one-quarter of the money (more than

N30,000,000.00) he has invested on land acquisition, payment of compensation, perimeter survey, soil survey and land evaluation by cropping the 20% suitable land. Thus, the investor will either abandon the project or be forced to change his investment plan by considering the production of other suitable crops on the land. The question now is who should bear the losses: the investor or the government? We suggest that the State or Federal government should either provide a semi detailed soil survey map for area set aside for agriculture, or should indemnify investors for expenses on land acquisition, compensation and survey should such a land be found to be unsuitable for the purpose of its allocation. Except this is done, agricultural activities will continue to be dominated by the peasant farmers in Nigeria.

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