FERTILITY CAPABILITY CLASSIFICATION OF SAMPOU SOILS IN BAYELSA STATE.

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ABSTRACT
Fertility capability classification was carried out to assess the native fertility status of the soils of sampou community in Bayelsa state. This study was intended to classify the soil and identify research areas needed to boost agriculture and sustainable food production. Different soils types were identified through soil survey procedures that produced four mapping units. Each mapping units were represented with one modal profiles. Profiles were sunk, described sampled and analyzed using standard laboratory methods. The result shows that the four FCC units were present in the study area. The FCC units are LLmg, LLmgk, LSmg and CCmg respectively. They include mapping unit 1 with FCC unit CCmg), 22% of the study area of the study area. The Type of the topsoil is Clay overlaying Clay subsoil. Mapping unit 2, LSmg covers 26% of the area with Loamy topsoil and Sandy subsoil. Mapping unit 3 LLmgk , Loamy topsoil Loamy subsoil Mapping unit 4 LLmg, Loamy topsoil Loamy subsoil. The pedons are all characterized by m (low Organic Carbon) g (soils saturated with water for >60 days in most years) constraints, expection of pedon 3 with k deficiency. This indicates that the soils of Sampou are quite fertile and application of Organic manure and balance fertilizers will be required. Drainage and flooding cannot be overcome rather management of the soils by understanding the flooding cycles for arable cropping.

INTRODUCTION
Fertility capability classification FCC according to Sanchez is a technical system of grouping soils according to the kind problems they present for agronomic management of their chemical and physical properties. It emphasizes quantifiable top soil and sub soil properties directly relevant to plant growth. Soil attributes based on fertility status bygrouping the soils into units with respect to its natural ability to support plant growth and production,. It`s also include features of soil that can change under management for a long period of years and inherent soil properties that are product of soil genesis and cannot be easily changed by management in less than a century. This system consist of two categorical levels (Sanchez, 2003) the first category describes. Four topsoil and four subsoil texture types and it is expressed in capital letters. For example S Sandy soil, S C sandy topsoil underlain by a clayey subsoil. The second category is the 17 Modifiers which explain the amounts and limits of specific soil properties and conditions affecting plant growth. Each condition modifiers is expressed in small letters with a positive or negative sign which indicates a greater or lesser expression of the modifier. The texture types and condition modifiers are the soil attributes in terms of their capability for plant growth. FCC unit is formed by the combination of the class designation from the two categorical levels.
The study area lies within the low-lying, broad and gently sloping upper deltaic plain of the Niger Delta. The Niger River divided into small branches which meander strongly in this plain which floods annually. Floodplains in rivers basins of many parts of the world have been use fro agriculture because of their natural fertility. (Verhnereand Setter, 2010). These plain soils are poorly drained and managed cultivation due to seasonal flooding and as a result abandoned by famers, this attributed to the farming system of the Sampou smallholder farmers. Community farmers which have not done any studies, large scale farming or fertilizers applications rather uses native fertility status to carry out their farming activities. This research will serve as a platform to guide the farmers the fertility management of Sampou soils. The FCC Version IV guidelines by (Sanchez, 2003) will be use to assess the soils, determine the FCC units of the soils and identify the soils types of the entire area.

MATERIALS AND METHODS
STUDY AREA
The Area lies between latitude 4500 to 5000 N and 6110 to 6250 E and lies between Yenegoa Local Government Area and Kolokuma/opokuma Local Government Area. It is a humid tropical climate and covers a land mass of about 9818 hectares, it lies within the low lying, broad and gently sloping upper deltaic plain of the Niger delta climate. It has two major seasons. The rainy season from April- October with annual rainfall of about 2539mm, the mean monthly temperature is lowest 28^{o}c during the period of heavy rainfall in July-September and the highest temperature of about 32^{o}c from December to march prior to the onset of rainfall. The vegetation of the study area consist of hydrophilic shrubs and elephant

grasses, raphia palms, oil palm and other species of tropical rainforest species.

FIELD STUDY

Four sites were identified and were examined along the toposequence by locating a representative profile pit at the levee crest, levee slope, floodplain/terrace and back swamp respectively. Soil profiles were sunk at the four location/ mapping units. Each profile pit was described according to FAO guidelines (2002) for soil description. Soil samples collected from diagnostic horizons from bottom to top of the pedons. Samples were collected into black labelled polythene for laboratory analysis, observation were also taken as to the current land uses in the area.

Laboratory analysis

Soil samples were air dried and crushed and sieved through 2mm sieve for appropriate standard laboratory procedures (Udo, et al. 2009, Longanathan 1986). The following parameters were analyzed, particle size distribution, bulk density, % porosity. soil reaction (pH water), organic carbon, total nitrogen, available phosphorous, exchangeable bases, exchangeable acidity. The following were also determined; effective cation exchange capacity ECEC, percentage Base saturation.

Fertility Capability Classification

The results of the data obtained from morphological characteristics from the field and the laboratory analysis of the study area were used for the fertility capability classification. The data obtained were used in evaluating the soil as outlined by (Sanchez, 2003) version IV. The soils are classified according to whether a characteristic is present or not. Table1 to 3 shows various data and the aggregate classes of fertility capability classification units of the study area.

RESULTS AND DISCUSSION

General characteristics of the soils

The results of morphological physical and chemical characteristics of the laboratory analysis of Sampou soils are presented pedon by pedon. The data obtained of the study area were evaluated for FCC based on the Version IV by (Sanchez, 2003) which consist of two categories. The Type topsoil 0-20cm, subsoil within 50cm and 17 condition modifiers (soil constraints) are grouped into modifiers related to soil physical properties, soil reaction(pH), soil minearalogy and soil biological properties.

Morphologic characteristics

All Four soil profiles units are deep and are beyond 150 cm. Table 1 shows some morphological characteristics of the soils. The soils were poorly to moderately well drained soils are dominated by mottles and dark grey colour. The dominant hueis 10YR and 7.5YR and soil colours ranged from dark brown to yellowish brown in both surface and subsurface horizons. This is attributed to ground water conditions, due to flat and low lying topography in which these soils are formed making them liable to annual flooding (Anderson, 1967). Reddish Brown (5YR $^{4}/_{4}$) concretions were also observed, indicating these soils undergo alternate dry and wet cycles annually due to flooding (Anderson, 1967). The soil structure generally are massive, weak, thin and medium sub angular blocky and weakly developed structure in lower horizons (Soil Survey Staff, 2002). These may be attributed to the effect of ground water table reflecting the poor drainage condition of the profiles. The poorly drained soils shows some characteristics of accumulated silts content and the soil are mostly sandy clay loam and slightly sticky. With exception of pedon 1 which has a sticky consistence due to the accumulation of clay at the subsoil.

Horizon	Depth cm	Munsell colour (moist)	Textural class (hand feel)	Structure	Consistence (moist)	Roots	Boundary
A	0-18	7.5YR 4/2	Silty clay	Crumbs	Friable	Medium common	Smooth Wavy
Bt	18-28	7.5YR 5/3	Clay loam	Medium Sub Angular Blocky	Firm	Few medium	Wavy diffused
Bt_2	28-76	7.5YR 5/6	clay	Medium Sub Angular Blocky	Very firm	None	Gradual diffused
Bg	76-180	7.5YR 6/3	Sandy clay loam	Sub Angular Blocky	Very Firm	None	

Pedon 2	Depth cm	Munsell colour (moist)	Textural class (hand feel)	Structure	Consistence (moist)	Roots	Boundary
A	0-26	10YR 5/3	Loam	Thin Granular	crumbs	Medium Common	Wavy Clear
B	26-48	10YR 7/6	Loam Sand	Medium sub angular blocky	Hard	Few. Medium	Smooth diffused
Bw	48-67	10YR 6/6	Sandy Loam	Medium sub angular blocky	Hard	Few. Medium	Smooth diffused
Bw_2	67-102	7.5YR 6/6	Sandy Loam	Medium sub angular blocky	Hard	Very Few	Smooth diffused
Bw_g	102-128	10YR 7/3	loamy Sand	Thin sub angular blocky	Hard	None	Smooth diffused
Bcg	128-180	10YR 7/2	Sand	Thin sub angular blocky	Very firm	None	

Table 3: Morphological Properties of Pedon 3 of Sampou soils

Pedon 3	Depth cm	Munsell Colour(moist)	Textural Class (hand feel)	Structure	Consistence (moist)	Roots	Boundary
Ap	0-30	10YR 4/3	Sandy clay loam	Medium granular	Friable	Common	Clear diffused
Bv	30-73	7.5YR 4/3	Loam	Thin sub angular blocky	Friable	Few Fine	Clear gradual
Bv_2	73-143	7.5YR 4/3	Loam	Thin sub angular blocky	Friable	Very Few	
Pedon 4	Depth cm	M. colour	Textural class	Structure	Consistence moist	Roots	Boundary class
Ap	0-16	10YR 4/6	loam	Crumbs	friable	Common Medium	Wavy Clear
B	16-37	10YR 5/4	Sandy loam	Thin sub angular blocky.	firm	Few	Wavy clear
Bt	37-63	10YR 6/3	Sandy loam	Thin sub angular blocky	firm	Very .few	Smooth clear
Bc	63-79	10YR 6/4	Sandy loam	Thin sub angular blocky	Firm	Very few	Smooth clear
Cg	79-124	10YR 7/6	sand	coarse Grains	Loose	None	Smooth clear
2Cg	124-160	10YR 7/3	sand	Fine Sand	Loose	None	

Physical and Chemical Properties of Sampou Soils

Partical size distribution varied from silty loam to sandy clay loam at the surface horizons . Subsurface texture is commonly sand clay to sandy loam.Pedon I has sandy clay from surface horizons and clay to sandy clay at the subsurface horizons. Soil textural class of Pedon 2 varied from loam to sandy loam while pedon 3 has sandy loam at surface soil and loam at subsurface horizons. Soil texture of pedon 4 is sandy loam in all horizons. These variations shows the features of floodplain soils due to differences in annual deposition of materials from flooding. Tables 5 to 8show the physical and chemical properties of the soils. The soils are slight to moderately acidic with pH values ranging from 4.5 to 6.0. They include the leached soils of floodplain with low to medium organic carbon content. The area is associated with heavy rainfall of about 2500 to 5000 mm in hot low land (Ojangua *et al*, 1981). Organic Carbon content varies from 1.50 to 7.18 g/kg at surface soils and 1.30 to 16.66 g/kg at subsurface soils. Total Nitrogen values ranged from 0.030 to 0.523 g/kg at surface soils and 0.009 to 1.201 g/kg at subsurface soils, the low values in pedon 2 and are relatively high values in pedon 3 could be due to the influence in soil texture. (Tabi *et al*, 2013). Available Phosphorous values are relatively moderate ranging from 11.3 to 33.7 mg/kg at surface soil and 14.0 to 39.2mg/kg at subsurface soils. In the soils, distribution of total bases, ECEC and % base saturation seem to be correlated with the distribution pattern of colloidal materials such as clay and organic carbon. The % base saturation values are high ranging from 75 to 97% in all pedons from surface soil to subsurface soils. These results agrees with other research of (Dickson and Ayolagha, 1998).

Table5 : Physical and Chemical properties of Pedon 1 of Sampou soils

Pedon 1		g/kg	g/kg	mg/kg	cmol/kg							%	g/kg			
Horizon Depth cm	**pH**	**Org. C**	**T N**	**Avl.P**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**TEA**	**ECEC**	**B S**	**Sand**	**Silt**	**Clay**	**Textural Class**
0--18	4.7	7.18	0.60	28.60	9.1	3.10	1.133	1.154	14.94	6.69	21.33	67	556.8	80	363.2	S C
18--28	4.8	2.19	0.22	30.1	5.9	1.17	1.219	1.307	9. 61	7.20	16.79	50	526.8	120	353.2	S C
28--70	5.5	5.59	0.46	39.2	2.8	2.31	2.315	1.931	9.36	1.24	10.59	72	364.0	60	576,0	C
70--180	5.0	4.59	0.46	11.9	1.4	1.25	1.230	0.854	4.73	6.88	11.42	62	544.0	60	396.0	S C

Table 6 Physical and Chemical Properties of Pedon 2 of Sampou soils

Pedon 2		g/kg	g/kg	mg/kg	cmol/kg							%	g/kg			
Horizon Depth cm	**pH**	**Org. C**	**T N**	**Avl.P**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**TEA**	**ECEC**	**B S**	**Sand**	**Silt**	**Clay**	**Textural Class**
0—26	5.1	4.09	1.18	289	2.24	2.35	0.282	3.301	8.173	0.459	8.63	94	490	302.8	207.2	L
26—48	5.0	1.50	0.30	337	2.28	1.24	0.574	0.263	4.367	1.122	5.47	79	746	206.8	47.2	L S
48—67	5.2	16.66	0.54	348	1.96	0.45	0.463	0.290	3.19	1.020	4.19	75	746	206.8	47.2	L S
67--102	5.7	1.30	1.54	355	0.96	0.81	0.459	0.320	2.55	2.004	4.55	54	728	134.8	117.2	S L
102--128	4.5	4.99	0.40	357	0.64	0.50	0.385	0.296	1.821	0.726	2.55	64	830	102.8	67.2	S
128--180	5.8	3.49	0.09	364	0.64	0.13	0.265	0.265	1.261	0.546	1.85	59	880	82.8	37.2	S

Table 7: Physical and Chemical Properties of Pedon 3 of Sampou Soils

		g/kg	g/kg	mg/kg	cmol/kg							%	g/kg			
Horizon Depth cm	**pH**	**Org. C**	**T N**	**Avl.P**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**TEA**	**ECEC**	**B S**	**Sand**	**Silt**	**Clay**	**Textural Class**
0--30	5.4	6.18	1.30	11.34	3.36	1.01	0.118	0.103	4.58	0.676	5.326	93	603.6	200	196.4	S L
30--73	5.6	2.18	1.30	14.00	10.28	4.02	0.086	0.057	14.44	1.020	15.460	94	453.6	330	176.4	S L
73--143	4.7	12.97	1.45	25.46	9.23	3.24	0.156	0.081	12.77	1..505	14.345	89	423.6	310	266.4	L

Table 8 Physical and Chemical Properties of Pedon 4 of Sampou soils

Horizon		**g/kg**	**g/kg**	**mg/kg**	**cmol/kg**							**%**	**g/kg**			
Depth cm	**pHw**	**Org. C**	**T N**	**Avl.P**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**TEA**	**ECEC**	**B S**	**Sand**	**Silt**	**Clay**	**Textural Class**
0--16	4.7	3.49	0.66	8.2	3 36	1.33	0.583	0.779	6.36	0.50	6.56	92	522.7	340	137.3	S L
16--37	5.1	0.740	0.18	10.6	2.72	1.08	0.528	0.283	5.29	0.90	5.51	84	650	222.8	127.2	S L
37--63	5.6	6.09	1.07	11.6	3.64	1.16	0.492	0.295	7.03	2.33	9.36	70	662.0	262.	75.2	S L
63--79	5.2	3.25	0.36	176	4.08	1.00	0.437	0.296	6.34	0.86	7.20	87	542.8	312	145.2	S L
79--124	6.3	0.68	0.12	28.5	1.20	0.94	0.437	0.259	3.64	1.07	4.71	71	928	5.2	2.0	S
124--160	6.1	2.19	0.28	36.4	2.68	1.25	0.257	0.293	4.89	0.48	5.37	87	862.8	62	75.2	LS

Table 9: Aggregate ClassesFertility Capability Classification of thePedons

Land characteristics	Pedon 1	Pedon 2	Pedon 3	Pedon 4
Type: texture of plow layer (0-20)	C	L	L	L
Substracta Type: if textural change encounter within 50cm	C	S	L	L
CONDITION MODIFIERS				
Slope %	<2%	<2%	<2%	<2%
High Erosion risks %	None	None	None	None
Low OrganicCarbon %	m	m	m	m
Low Potassium(K deficiency) cmol/kg	-	-	k	-
Waterlogged	g	g	g	g
FCC units/class	CCmg	LSmg	LLmkg	LLmg

Fertility Capability Classification (FCC) of the soils of the area.

The results of physical and chemical characteristics of the laboratory analysis and morphological properties of Sampou soils are shown in Tables 1 to 8 respectively. From the data obtained, the study area was evaluated for FCC based the Version IV by (Sanchez, 2003) consist of two categories. The Type topsoil 0-20cm, subsoil within 50cm and 17 condition modifiers (soil constraints) are grouped into modifiers related to soil physical properties, soil reaction (pH), soil mineralogy and soil biological properties are shown in the Table 9. The conversion data used in evaluating the soils are as outlined in (Sanchez, 2003). Fertility capability classification map and at the appendix.

Pedon 1 to 4 represent mapping unit 1 to 4. The aggregate FCC of the pedons of the study area are shown in Table 9 Fertility Capability Classification units CCmg,2204(ha), 22% of the study area . The texture Type of the topsoil is Clay overlaying Clay subsoil with >35 % of clay content in both topsoil and subsoil. There is low infiltration rate, moderate water holding capacity due to moderate clay content (table 1)with limitation in Condition Modifier m (low organic carbon) and g (soil saturated with water for >60 days in most years). For low organic carbon organic manure could be incorporated during farming activities. The water logging conditions indicates that soil are formed in floodplain so they are flooded during the rainy seasons. Mapping unit 2 fall into LSmg. 2632 (ha), 26%. of the study area. Texture Type of the topsoil is Loam overlaying Sandy subsoil. The slope gradient of the land is <2% (Anderson, 1967) which is low and no influence of erosion hazard. Condition modifiers m (low organic carbon) and g (soil saturated with water for >60 days most years); (Sanchez, 2003). The soils of mapping unit 2 shows that the topsoil is good for arable crop production but there is high filtration rate at subsoil and low water holding capacity due to high sand content. Organic manure could be incorporated into soil during farming. The soils are saturated with water due to annual flooding, due to low lying gentle sloping topography of the study area. (Tabi et al.,2013). Mapping unit 3 fitted into FCC unit of LLmkg 4002 (ha), 40.7% indicating that Loamy topsoil overlaying Loamy subsoil with condition modifiers of m (low organic carbon), k(low nutrient capital reserves, K deficiencies) and g (soil saturated with water for >60 days in most years).And mapping unit 4 represents FCC unit LLmg 980 (ha), 9.98% and of the study area. The texture Type is Loamy overlaying Loamy subsoil with limitations m (low organic carbon) and g (soil saturated with water for >60 days most years). Base on the Type and condition modifiers the study area have four Fertility Capability Units LLmg, LLmkg, CCmg, and LSmg.

CONCLUSION

Sampou soils were evaluated for fertility capability classification, using the guideline by (Sanchez, 2003). In spite of low Organic Carbon and soils saturated with water in most years and K deficiency, there is high agricultural potential. To raise the productivity of the soils, management techniques should be adopted to enhance the nutrient, application of organic manure and balance fertilizers would enhance soil productivity. Appropriate drainage facilities should be put in place to take care of the excessive soil moisture and check the rising water table. Where drainage cannot be overcome planting of arable crop should be carry out during the dry season and planting of rice and other water tolerance crops can be grown. These results shows fertility capability classification

as a technical system is efficient in grouping the soils of Sampou according to the kind of problems they represent for agronomic management of their chemical and physical properties.

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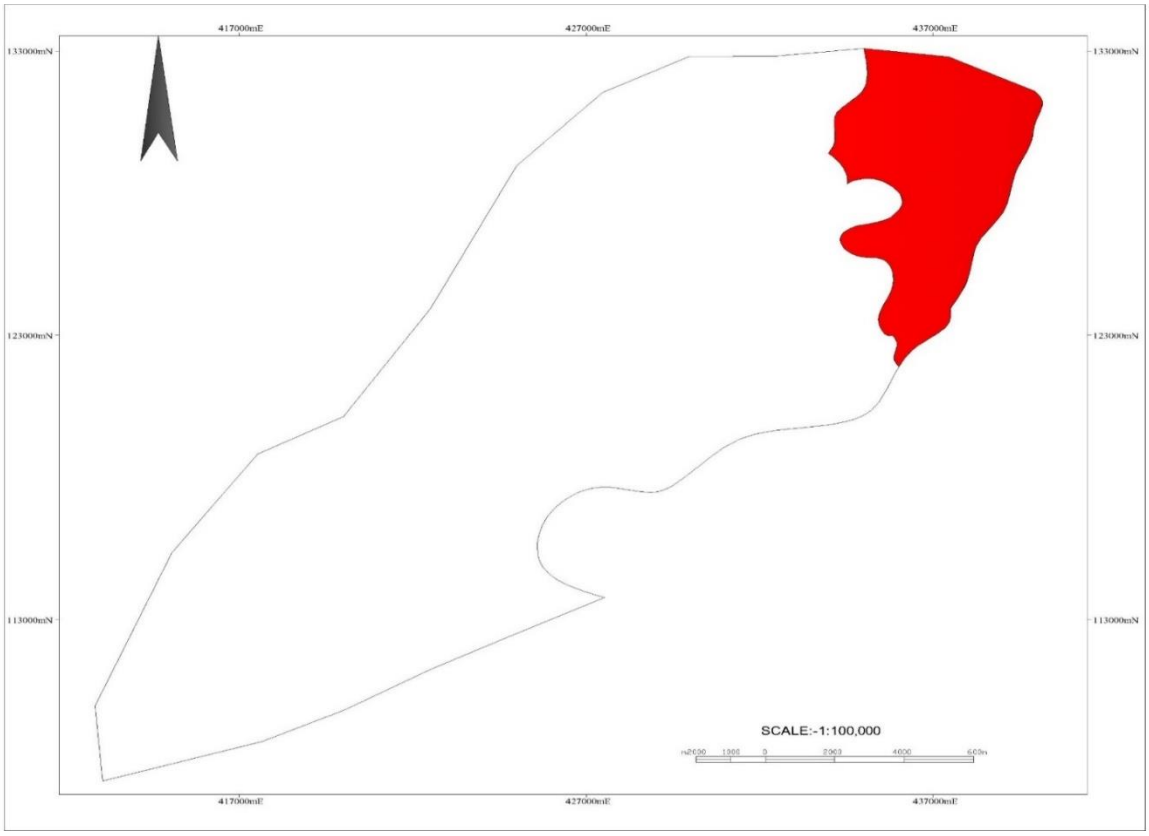
Fig. 1. Map of Kolokuma/Opokuma Local Government Area indicating the study Area



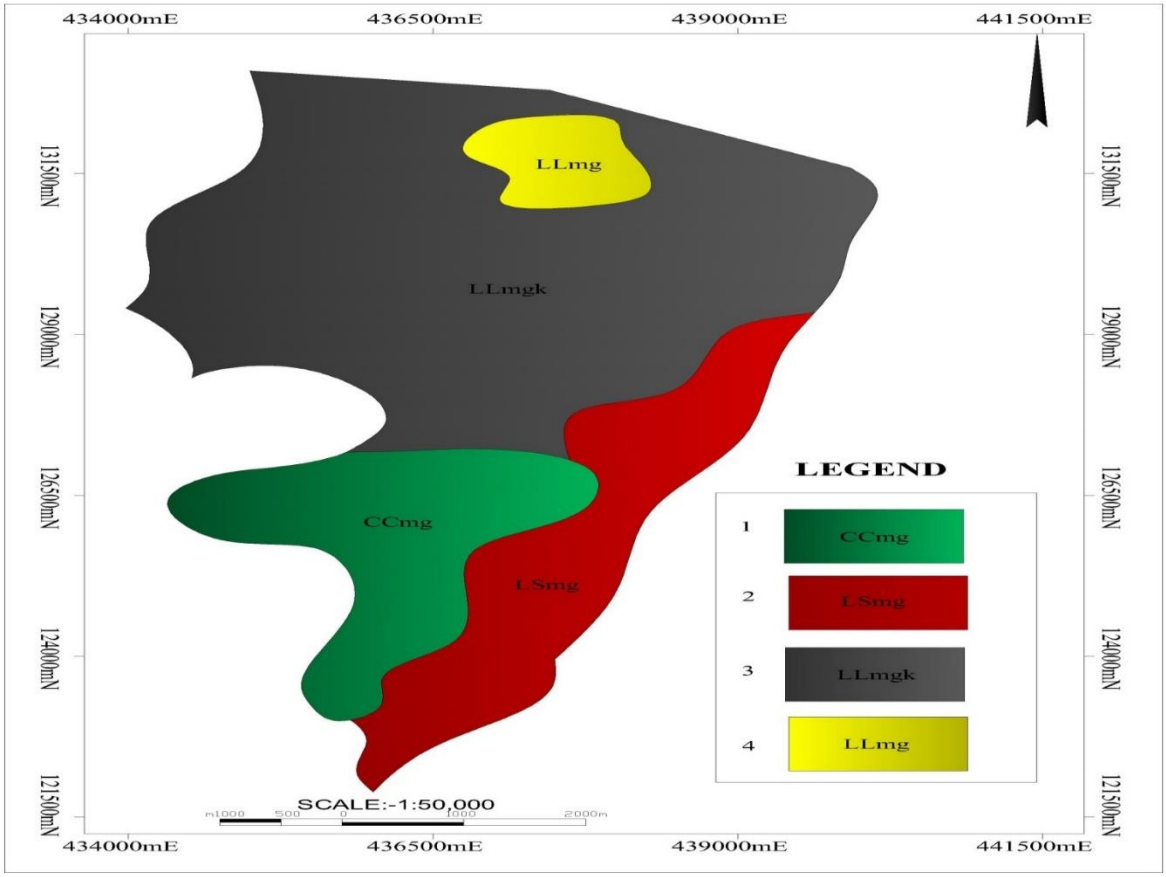

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Table 8: Fertility Capability Classification System, Version 1V

FCC Class/ descriptions	Symbols	Definitions and Interpretation
Type: 0-20cm depth or plow layer	S	Sandy topsoil >35% sand, loamy sands and sands
	L	Loamy topsoil <35% clay but not loamy sand or sand
	C	Clayey topsoil >35% clay
	O	Organic soil =12% organic carbon to a depth of 50cm or more
Subtype: used if textural change is encountered within 50cm	S	Sandy Subsoil – texture as in type
	L	Loamy subsoil-texture as in type
	C	Clayey subsoil- texture as in type
	R	Rock or other hard root restrictions layer within 50cm depth
	R	As in above, but layer can be plowed to increase rooting depth.

Condition Modifiers: In plow layer or top 20 cm are grouped into modifiers related to soil physical properties, soil reaction (pH), soil mineralogy and soil biological properties.

Condition Modifiers	Symbols	Identifying Criteria (If More Than One, They are listed in decreasing desirability)
Waterlogging	g	Soil saturated with water for >60 days in most years.
	g^+	Prolonged waterlogging, soil saturated with water either naturally or by irrigation for >200 days.
Strong Dry Season(Moisture Stress)	d	>3 months dry season
	d^+	Too dry to grow crops without irrigation.
Low Soil Temperature	t	<8^{o}C mean annual
	t^+	temperature too low, no cropping is possible.
Gravel	r^+	10-35% by volume of gravel
	r^{++}	≥35% by volume in top 50cm of the soil
Slope	%	Where desirable place range in % slope (0-15%, 15-30%, >30%)
High Erosion Risk	SC, LC, CR, LR, SR, >30%	Soil with high erodibility due to sharp textural contrasts (SC and LC), shallow depth (CR, LR, SR) and steep slope (>30%).
Aluminium Toxocity	A	>60% aluminium saturation within 50cm
	a^{--}	10-60%: aluminium saturation within 50cm for extremely acid sensitive crops such as cotton and alfalfa
Sulfidic Clays	C	pH<3.5 after drying
No Major Chemical, No Symbols, Limitations (Includes Formal H Modifiers)		<60% Al saturation of ECEC within 50cm and pH between 5.5 and 7.2
Calcareous (Basic Reactions)	B	Free $CaCO_3$ within 50cm, (fizzing or effervescence with HCl or pH>7.2
Salinity	S	>0.4dsm^{-1} of saturated extract
	S^{--}	0.2-4 dsm^{-1} of saturated extract
Alkalinity	n	>15Na saturated of ECEC within 50cm
	n^{--}	6-15% Na saturated of ECEC
Low Nutrient Capital Reserve (K-Deficiencies)	K	Exchangeable <0.20 cmol/kg
High P Fixation	I	Clay ratio >0.2
By Sesquioxides	i^{--}	As above but soil have been recapitalized with P fertilizers to supply long term P to crops
	I^+	As above potential Fe toxicity if soils is waterlogged for a long time.

Amorphous Volcanic (High P Fixation By Allophone)	x -	x-	pH >10 within 50cm or 90% P retention retention between 30% and 90%	P
Cracking Clays	V		>35% clay and >50% of 2:1 expanding clays	
High Leaching Potential	E		<4.cmol/kg^{-1} soil as ECEC	
Low Organic Carbon	m		<12% total organic carbon saturation in topsoil.	

Source: (Sanchez, 2003)