Bayero Journal of Pure and Applied Sciences, 7(1): 116 – 120
Received: November 2013
Accepted: February 2014
ISSN 2006 – 6996

LAND EVALUATION FOR IMPROVED RICE PRODUCTION IN WATARI IRRIGATION PROJECT KANO STATE, NIGERIA.

[1]Ya`u, S. L., [2]Manasseh, E. A. and [3]Sharifai, A.I.
[1]Kano State College of Arts, Science and Remedial Studies. P.M.B. 3145/Department of Soil Science/IAR, Ahmadu Bello University, P.M.B. 1044, Samaru, Zaria, Nigeria.
[2]Department of Soil Science/IAR, Ahmadu Bello University, P.M.B. 1044, Samaru, Zaria, Nigeria.
[3]Department of Agronomy/IAR, Ahmadu Bello University. P.M.B.1044, Samaru, Zaria, Nigeria.
*Correspondence: selyau@yahoo.com

ABSTRACT
This study aimed at raising irrigated rice production in Watari Irrigation scheme, in Kano state, as to bridge the gap between the demand for rice and its supply. The food and Agricultural Organization FAO, (1985) frame work for land evaluation for irrigated rice production was employed, and the soil map of the study area has already been produced by Haskoning Nigeria Limited in 1987 and only those mapping units identified as suitable for irrigation were considered for the study. Six (6) Land mapping units were delineated and twenty six(26) sampling points considered with a single profile from each mapping unit and various soil augerings.These were evaluated with respect to their land qualities and characteristics which are then matched with the requirements and limitations for irrigated rice using the FAO, (1985) rating for suitability. The results of the study revealed three (3) suitability classes via; moderately suitable, marginally suitable and not suitable classes with some degree of limitations. However, the area has been found to be moderately suitable" because of the larger area covered by the moderately suitable mapping units compare to the marginally suitable and not suitable mapping units. The limitations identified are those of stoniness, slope, texture, nutrient availability and drainability. The appropriate recommended management practices suggested to overcome these limitation and up-grade the suitability of the mapping units for increased rice production are; application of inorganic fertilizer, improve the low levels of nutrients and organic matter contents of the soil in the area and other recommendations include land leveling and conservation measures to control the effects of erosional hazards and slope steepness.
Keywords: Suitability, Evaluation and Irrigated rice.

INTRODUCTION

The concept of land suitability classification has been very controversial, even as it neither ensure that land use is suitable nor on and off site effects of particular land uses are environmentally acceptable (Raji,2004). Soil is fundamental natural resources on which civilization depends and agricultural production is directly related to quality and suitability of soil, and as soil degrades so also the crop yields. To ensure sustainable land management, land degradation has to be checked, through techniques that are cost effective for predicting the best future use, and for mapping and monitoring land use changes. The necessity for land use mapping and the evaluation of the consequences of land use/land cover changes is better demonstrated in area of intense agricultural activities. Where land use intensities are high, the risk to unsustainable management becomes higher. Irrigated agriculture falls within high intensity land use.

Land evaluation may include soil survey or soil survey data (Abdulkadir, 1986). This help to bridge the gap between soil survey and land use planning by comparing the land conditions (partly provided by planning authorities) and land use requirements. The importance of soil survey data in providing necessary information on soil, in irrigation evaluation has been emphasized by Ojanuga (1977), where he stated that soil survey is the examination, description, classification and mapping of soils. Survey provides information on the land surface characteristics as well as the morphological, physical, chemical and mineralogical characteristics of the soils occupying a land area. The identification and characterization of soils of an area to be irrigated is achieved only through a detailed soil survey of the area. He classified the failures of a number of irrigation projects in Nigeria which are based only on reconnaissance or semi-detailed soil surveys, and concluded by saying that any irrigation scheme established without the backing of a detailed soil survey runs the risk of failure or inadequate economic returns Ojanuga, (1977).

Food Agricultural Organization (1985) designed a framework for land evaluation to serve as a model for compares in which evaluation is carried out. The principle of the system assumes that when land use requirements and limitations are known and the land conditions in terms of land qualities and characteristics are also known, the components can be compared (matched), and the result forms a basis for suitability classification. The two key concepts involved are the concept of "land utilization type" and concept of "land quality" (Abdulkadir, 1986).

A land quality is a complex attribute of land which in a specific way influences the performance of a specific kind of use. A land quality is characterized by one or more land characteristics which are attributes of land that can be measured or estimated (Dent and Young, 1981), while a land utilization type is a form of use of land including details about maintenance and management needs, costs and expectations, (Beek, 1981).

The ecology of the Watari Irrigation project is Sudan savanna, divided in to three main seasons.

These are:

i. The dry cool season from October to February.
ii. The hot dry season from March to May.
iii. The warm raining season from June to September.

The warm rainy season is traditionally the farming period for rain fed crops. Rainfall is highest in July and August during which precipitation exceeds potential evaporation. The average annual rainfall (30 years) is about 860mm (Owonubi *et al.,* 1983). During the rainy season, the cloudiness and the prevailing moist southwesterly winds have a moderately effects on the daily temperatures. By the onset of the cool dry season, most rain fed crops have been harvested and the northeastern dry, cool harmattan winds prevail. The winds sometimes carry fine dust from the Sahara desert, which reduces visibility and intercepts a great deal of solar radiation (Yayock and Owonubi, 1986).

Geologically, the Watari Irrigation project area belongs to the northern Nigeria Basement complex. The dominant rock types are the granitic gneisses and schist. The geology is highly weathered and dissected by many rivers. The original geology is covered in many places by alluvial and Aeolian materials. Soils of the Watari Irrigation project area belongs to the Eutric cambisols and is classified as Typic Ustropept (Owonubi *et al.,* 1993). Most of the soils are underlain by iron-pan at depth varying between 80 to 150cm.

In order to improve rice production and bridge the gap between rice demand and supply in Watari Irrigation project and Nigeria in general, there is need to evaluate the suitability of the mapping units produced by Haskoning Nigeria Limited since 1987 to ascertain the current suitability of each of the units. Therefore, the objective of the study is to evaluate the physical and chemical properties of the Watari Irrigation project and matching it with the requirements and limitations for rice production, using FAO, (1985) suitability rating.

MATERIALS AND METHODS

The Watari Irrigation Project lies between latitude $12^o05'$ and $12^o10'$ and longitude $8^o08'$ and 8^o17E in the savanna zone ecology and situated downstream of the dam across the river. The mean annual air temperature in the state is about 26^oC, though locally there may be considerable variations. Rainfall occurs generally in the months of June to September with some tight rains at the extremes, August being the wettest month. Mean annual rainfall is 797mm at Bichi. (Haskoning, 1981). The Watari River flows for about ten (10) kilometers south west of the town of Bichi in south eastern direction towards the Challawa River. The area falls within Bagwai Local Government Area of Kano state and cover a total of 4,574 hectares.

A ground truthing exercise was conducted in which all the mapping units produced by Ministry of Agriculture and Natural Resources (MANR, 1981) were confirmed with the help of a detailed soil survey map produced by MANR as a base map. The ground truthing exercise result was not in conflict with soil survey map as no new development was confirmed, and all the soil boundaries were properly fixed and identified so as to avoid any misrepresentation of the properties of the soil mapping units. The emphasis was on those mapping units identified as suitable for irrigation by the feasibility report of 1981.

Six (6) mapping units (S_1, S_2, T_1, T_3, T_2 and T_{1}-$_{2}$) were considered for detailed study. Viz:

S1: deep very gently sloping soils, slope 1-7%

S2:deep gently sloping soils, slope 7-15%

T1:flat deep light textured (loamy fine sand to loam) alluvial soils

T3:flat deep coarsed textured (sand) alluvial soils

T2: flat deep fine textured (clay loam to clay) alluvial soils

T_{1-2}:soil association of deep gently sloping and flat deep fine textured clay loam to clay soils.

Stratified random sampling technique was employed in collection of the soil samples from the soil mapping units (Peterson and Calvin, 1986). A total of twenty six (26) sampling sites were considered with the help of a grid of equal squares (25m) imposed at each sampled sites. Six profiles were dug with a single profile from each of the mapping units considered. Samples were collected up to 80cm from the surface of the soil. This is because the effective rooting depth of most rice varieties ranges from 75-80cm.The disturbed soil samples were air dried and pass through 2mm sieve for the following analysis below using a standard procedures (Udo and Ogunwale, 1986; IITA, 1979; 1981). Particle size distribution, Soil reaction (pH), Organic carbon, Cation exchange capacity (CEC), Exchangeable bases (Ca, Mg, K and Na), Available phosphorus, Percentage base saturation, Total nitrogen and Electrical conductivity.

All the data collected on soils were used in comparing the land use with the land qualities and characteristics to determine those mapping units that would support better rice production under irrigation management among the mapping units identified as suitable for irrigation by feasibility report of the study area.

RESULTS AND DISCUSSION

Tables 1 and 2 presents the results of physical and chemical properties of the representative mapping units. The texture of the soils ranges from sandy loam to loamy texture with some exeptions from mapping units T_{1-2} and T3 where there was a predominance of clay and sandy texture(Table 1), thus indicating the heavy nature of the T_{1-2} soils and excessively drained nature T3 soils. The clayey texture of the T_{1-2} soils may not be unconnected with the location of the unit around the lower main terrace of the river. For high yield in rice, Sys (1991, 1993) stated that upland rice requires a loamy soil, while a texture of loamy clay to sandy loam was considered as most adequate for the production of low land rice.

The soil chemical properties which could affect their suitability for rice production are acidity, salinity and fertility (Ajiboye *et al.*, 2011). The soil reaction ranges from 5.6-7.8 (Table 2) from strongly acidic to neutral. The acidic nature of the soils can be ascertained as a result of the influenced it has on growth of many plants. This is because of its influence on certain trace elements and their availability in the soil.

The CEC of the study area is generally low to moderate for all the mapping units (5.0-16.1CmolKg^{-1}). This is because FAO (1979), have quoted a value of 8-10 CmolKg^{-1} of soil has indicative minimum value in the top 30cm of soil for satisfactory production under irrigation. The soils of the upland and low land slopes represented by (S) in the study area have values ranges from 5.5-8.5 CmolKg^{-1} which contrast with the terrace soils (T) in the range of 3.5-13.5 CmolKg^{-1}. However rice slightly tolerant of lower CEC values (FAO,1979).

The levels of exchangeable cations in a soil are usually of more immediate value in advisory work than the CEC. Because, they not only indicate existing nutrients status but can also be used to asses balances amongst cations (Landon, 1984). All the mapping units studied have indicated lower values for all the exchangeable cations (Table 2). Calcium levels has been found to be higher compared to potassium and sodium in almost all the mapping units while magnesium is higher than calcium.

The base saturation percentage (BSP) values are used in soil classification by FAO-unesco (1990) as indicators of soil fertility status; where they used a value of < 50% to be considered as less fertile. The values of the BSP are very high in all the mapping units (Table 2). Higher base saturation in general reflects an appreciable supply of bases and or/ limited removal of bases by leaching (Abdulkadir, 1986). Electrical conductivity measurements are used as indicators of total quantities of soluble salts in the soil. Salinity has not been found to be problem in the study area because it is found at a very low level (Table 2). Rice been a salt tolerant crop records an electrical conductivity of < 3mmho/cm compared with other cereals (IRRI, 1995).

Land Suitability Classification for the Mapping Units

One important aspect of the FAO framework for land evaluation is the comparison of the land utilization type with the land qualities and characteristics dubbed matching, which refers to as reconciliation of information about the land qualities with the information on crop requirements which takes place through a medium of chosen criteria, usually land characteristics or diagnostic criteria. A diagnostic criteria is an attribute of land that serves to locate the boundary of land classes and it usually must have a powerful influence on not only the use but the input and benefit that may be derived from using the land in the manner specified (FAO, 1979). The matching activities were carried out with respect to each mapping unit to determine which mapping unit among those identified as suitable for irrigation in the study area are capable of supporting economic rice production under irrigation management.

More than 80 percent of the site studied falls into S_1- Suitability class for soil depth in irrigated rice, which requires a depth of more than 50cm for efficient production, and about 75 percent of the soil of the study area have indicated a sandy loam texture, for adequate rice production, sufficient quantity of water is to be applied.

Table 1: Some physical properties of Watari soils.

Mapping Unit	**Horizon designation**	**Depth (CM)**	**Particle size distribution (%)**			
			Sand	**Silt**	**Clay**	**Textural class**
S_1	AP	0 – 12	82.24	6.00	11.76	Sand
	B1	12- 45	45.00	25.00	30.00	Loam
	C	45 - 67	43.65	24.00	23.35	Loam
S_2	AP	0 – 20	59.00	24.00	17.00	Loamy sand
	BE	20 – 35	62.00	27.00	11.00	Sandy loam
	Bt	35 – 55	59.24	19.76	21.00	Loamy sand
	C	55 - 85	71.24	12.00	16.76	Loamy sand
T_1	AP	0-18	54.24	28.00	17.76	Sandy loam
	BE	18-35	89.24	23.00	17.76	Sandy loam
	C	35-82	59.24	20.00	20.76	Sandy loam
T_2	AP	0-22	43.36	31.00	25.64	Loam
	B1	22-50	74.75	13.25	12.00	Loamy sand
	C	50-80	90.35	4.65	5.00	Sand
T_3	AP	0-8	72.05	13.00	14.95	Sandy loam
	BE	8-43	72.00	13.00	15.00	Sandy loam
	C	43-79	48.00	24.00	28.00	Loam
T_{1-2}	AP	0-20	32.24	17.76	43.76	Clay
	Bt1	20-40	34.24	14.00	51.76	Clay
	Bt2	41-85	70.44	12.56	17.00	Loamy sand

Table 2: Some chemical properties of Watari soils

Mapping Unit	Horizon designation	Depth (CM)	Ph	OC %	EC	CEC	Avai.P	Exchangeable Bases cmolKg^{-1}				%N	PBS
								Ca	Mg	Na	K		
S_1	AP	0 – 12	6.6	3.56	0.04	6.00	1.30	2.30	2.6	.01	1.3	.08	82.5
	B1	12- 45	6.8	2.80	0.09	4.90	0.85	2.00	2.0	.03	0.9	.05	82.5
	C	45 - 67	7.1	2.10	0.10	6.18	0.80	2.28	2.2	.02	0.8	.07	73.3
S_2	AP	0 – 20	6.5	0.50	0.10	6.89	1.50	1.90	1.9	.03	1.5	.05	56.3
	BE	20 – 35	6.3	0.60	0.12	5.79	1.30	1.60	2.1	.04	1.3	.04	62.1
	Bt	35 – 55	6.2	0.40	0.85	5.86	0.85	1.30	2.3	.02	0.9	.07	62.8
	C	55 - 85	6.0	1.00	0.06	5.06	0.80	1.50	1.7	.02	0.8	.09	63.2
T_1	AP	0-18	7.8	1.85	0.08	7.01	2.30	1.60	2.6	.02	2.3	.17	60.8
	BE	18-35	6.8	0.50	0.03	7.00	1.80	2.10	2.1	0.4	1.8	.10	61.0
	C	35-82	6.5	0.45	0.06	6.23	1.90	1.85	1.8	0.3	1.9	.90	58.8
T_2	AP	0-22	6.5	2.76	0.02	8.80	1.40	1.60	3.2	0.4	1.4	.10	55.7
	B1	22-50	6.5	3.08	0.02	6.15	0.51	0.40	3.0	0.2	0.5	.07	56.4
	C	50-80	6.5	2.70	0.06	9.71	0.53	3.20	2.7	.03	0.5	.09	61.5
T_3	AP	0-8	6.0	1.50	0.12	10.50	0.58	1.20	4.8	.05	0.6	.05	58.3
	BE	8-43	6.5	1.25	0.02	9.80	0.54	1.00	4.9	0.4	0.5	.05	61.2
	C	43-79	7.0	0.98	0.01	8.62	0.56	1.30	3.4	.03	0.6	.08	55.3
T_{1-2}	AP	0-20	5.9	2.86	0.01	13.00	1.49	3.20	6.4	.02	1.5	.07	74.4
	Bt1	20-40	6.0	2.60	0.01	16.10	0.58	5.60	8.6	0.2	0.6	.07	88.6
	Bt2	41-85	6.2	1.95	0.03	12.15	0.53	4.50	5.3	.01	0.5	.08	80.6

Only 5 percent of the soils are classified under suitability of the textural suitability classification while 30 percent have been classified as N-suitable class. But as far as sufficient quantity of water is to be applied, texture may not be a serious problem to irrigated rice production in the study area. So also, about 65 percent of the mapping units studied was classified into S_1 and S_2 Suitability classes of the FAO rating for soil fertility status (Table 3). The fertility status has been found to be at a low level, so the use of inorganic fertilizers has been recommended.

The result of the land suitability assessment exercise in (Table 3) distinctively shows three suitability classes, viz; "moderately suitable" (S_2), "marginally suitable" (S_3) and currently not suitable (N_1) with different kinds of limitations to give the suitability sub-classes. Mapping units termed as "moderately suitable" are those with little or no limitations with regards to physical characteristics but with significant limitation in chemical soil fertility or available soil nutrients. These are mapping units T_{1-2}, T_2, S_1 and $T_{1.}$ (Table 4). The nutrients limitation is very important because of the need rice have for certain elements e.g. Carbon, Nitrogen, Phosphorus e.tc for nutrients and proper growth, and these elements are found in a very low quantity in the mapping units. These mapping units are moderately suitable because limitations are moderately severe for sustained irrigated rice production, yielding a moderate benefit sufficiently high to justify the required inputs. While the "currently not suitable" mapping units in the study area is mapping unit T_3. It is termed so, because of its severe deficiency. The multiple force of the limiting factors here (excessive drainage and sandy texture) do not favour the use of the land for irrigated rice production, but conservation techniques can be adopted to improve on the utilization of the mapping unit.

Table 3: Suitability rating using the FAO, 1985 framework

Land quality	Land characteristics	FAO rating	Suitability classification	Observed level	Critical value
Workability	Soil depth	50cm	S_1	50-60	10-20
		30-50cm	S_2	35-40	5-9
		20-30cm	S_3	-	2-4
		0-20cm	N	-	<2
Particle size distribution	Texture	Silty clay loam, clay, Silty clay & sandy clay. Loam & clay loam Sandy	S_1 S_2 S_3 N	Clay Loam Sandy loam Sandy	20-25 15-19 10-14 <10
Chemical soil fertility	Rated on CEC, O.C and available Phosphorus	High-medium	S_1		7-10
		High-medium low	S_2		5-6
		Medium-low	S_3		3-5
		Very low	N		<3

Note: S_1=Highly suitable, S_2=Moderately suitable, S_3=Marginally suitable and N=Not suitable

Table 4: Suitability classification for the mapping units

Mapping units	Nutrients Availability	Acidity	Drainability	Texture	Order	Class	Sub-class
S_2	S_2	S_2	S_1	S_2	S	S_3	S_{3nst}
S_1	S_2	S_1	S_1	S_2	S	S_2	S_{2es}
T_{1-2}	S_2	S_1	S_1	S_1	S	S_2	S_{2n}
T_2	S_2	S_2	S_1	S_2	S	S_2	S_{2et}
T_1	S_2	S_2	S_1	S_2	S	S_2	S_{2se}
T_3	S_2	S_2	N	S_3	N	N_1	N_{1-d}

Note:
S_{3nst}=Marginally suitable with nutrients, stoniness and texture as limitations
S_{2es}=moderately suitable with erosion and slope as limitations
S_{2n}=moderately suitable class with nutrients availability as limitations
S_{2et}= moderately suitable class with erosion and texture as limitations
S_{2se}= moderately suitable class with stoniness and erosion as limitations
N_{1-d}=currently not suitable with drainage as limitation

CONCLUSION AND RECOMMENDATIONS

The Watari soils have been found to be moderately suitable for irrigated rice.

The most severe limitation in the scheme is soil texture, chemical fertility and erosion. In order to raise the productivity of the soils to optimum for irrigated rice production, management practices to be employed should enhance the nutrients and moisture holding capacity of the soils. The use of organic / inorganic fertilizers, incorporation of crop residues as well as land levelling and conservation measures would raise the productivity of the soils. However, occasional assessment of the current land use is very vital to increase the output of rice production and prevent the adverse effect of land degradation, which may lead to decrease in rice yield.

REFERENCES

Abdulkadir, A. (1986). Land Evaluation for Irrigation in Bauchi State. Ph.D. Thesis (Unpublished) B.U.K. pp 187

Ajiboye, G.A., Alabi, K.O., Aiboni, V.U., Okeleye, K.A., and Adesodun, J.K. (2011). Classification and suitability evaluation of the soils of a toposequence at Odeda, Ogun State for the production of rice (Oryza sativa). *Nigerian Journal of Soil Science.* 21(2):142-155

Beek, L.K. (1981). Land Evaluation for Agricultural Development: Publication No. 23 Inter Institute for Land Reclamation and Improvement. Wagenning the Netherlands.

Dent, D.L. and Young (1981). Soil Survey and Land Evaluation, George Allen and Urwin, London.

FAO (1979). Land evaluation criteria for irrigation, report of an expert consultation world soil resources report 50, FAO, Rome.

FAO (1985). Guidelines: Land Evaluation for Irrigated Agriculture, FAO Bulletin No. 55, Rome, pp45

FAO-UNESCO-ISRIC. (1990) Soil map of the world. Revised legend reprinted with corrections. *World soil resources report*, 60, FAO, Rome, 119p

IITA (International Institute of Tropical Agriculture) (1979). Selected methods for soil and plant analysis. IITA manual series, I, IITA, Ibadan Nigeria, 60pp

IITA (International Institute of Tropical Agriculture) (1981). Automated and semi-automated methods for soil and plant analysis manual series. No. 7, IITA, Ibadan, 33pp.

IRRI (International Rice Research Institute) (1995). Rice: IRRI Bulletin Vol. 19 No. 3 March, 1995

Landon, J.R. (1984).Booker Tropical Soil Manual. XIV+450pp., Booker Agricultural International Limited., London, and Longman, Burnt mill, U.K.

MANR (Ministry of Agriculture and Natural Resources, Kano State) (1981): Reconnaissance study of Watari River Project: Haskoning Engineering Consultants (Nigeria) LTD.

Ojanuga, A.G. (1977). Soil Survey as a Tool in Planning on Development Proceedings of the First Annual Conference of Soil Science Society of Nigeria, Nsukka.

Owunubi, J.J; P.R. Muarya; V. Kumar; J.Y. Yayock and S. Abdulmumin (1983). Farmers Managed Irrigation system. Final technical report (phase 1). IAR-ABU, Zaria, 122pp

Petersen, R.G. and Calvin, L.D. (1986). Sampling. Methods of Soil Analysis 1, Physical and Mineralogical Methods (Soil Science Society of America). *Agronomy*, 9:33-51.

Raji, B.A. (2004). Agricultural land use planning and management in Kadawa Irrigation scheme, Kano state. Paper presented at the 1st National workshop on satellite remote sensing (Nigeria sat 1) and GIS: A solution to sustainable National Development Challenges, which held at Abuja Le meridian Hotel, Nigeria: GEOSON/NARSDA, June 15-17, 2004

Sys. C., Ranst. V and Debaveye. J. (1991). Land Evaluation Part 111, crop requirements. Agricultural publication No. 7, ITC Ghent. 247pp

Sys. C., Ranst. V and Debaveye. J. and Beemanrt. F. (1993). Land Evaluation Part 111, crop requirements. Agricultural publication No. 7, ITC Ghent. 199pp

Udo, E.J, and Ogunwale, J.A (1986). Laboratory manual for the analysis of soil plant and water samples. Dept. of Agronomy, University of Ibadan, Nigeria.

Yayock, J.Y. and Owunubi, J.J. (1986). Weather-sensitive agricultural operations in groundnut production: The Nigeria situation In: Agrometerology of groundnut (Proc. Int. symp. Niamey, Niger, August (1985) 213-226 ICRISAT, Niamey, Niger.