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Research article

SUITABILITY EVALUATION OF LAND RESOURCES ZONES OF NIGERIA FOR COCOYAM PRODUCTION.

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Abstract

In Nigeria, it ranks third after cassava and yam in importance. To increase the production of cocoyam (*Colocasia* and *Xanthosoma* spp) to enhance national food security and empowerment, a qualitative land suitability evaluation of Nigeria's land resources zones delineated by the Overseas Natural Resources Institute (ODNRI) was carried out. The output is a twin cocoyam map showing land suitability classification and important production areas in Nigeria. Results showed that semiarid zone is unsuitable while swamp zone and dry sub-humid zones are marginally suitable due to climatic constraints. Very humid, sub-humid, humid and plateau zones are moderately suitable, while only montane zone is highly suitable. The improved cocoyam map showed that potential cocoyam growing areas are grossly under cultivated and decreased from south to north. The map is recommended as a planning tool for scientists, present and potential cocoyam farmers and policy makers, as a guide to choice of site, to boost and sustain cocoyam production in Nigeria.

Key words: Cocoyam; land resources zones; land evaluation, cocoyam map, Nigeria

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Introduction

In Nigeria, cocoyam refers collectively to *Colocasia esculenta* (taro) and *Xanthosoma mafafa* (tannia). They are tropical herbaceous tuber crop, cultivated predominantly as annuals, mainly for their edible starchy storage underground stems called corms and cormels. Taro (*Colocasia esculenta*) is the fifth most harvested root crop in the world with production estimated at 9.0 million tonnes for 2011(FAO, 2012). Nigeria maintains the lead among cocoyam producing nations, with an annual production of 4.55 million metric tonnes in 2012, representing

61.2 and 43.1 % total production in West Africa and Africa, respectively (FAO, 2012). She also accounted for 34.3, 46.2 and 62.3 % of land area under cocoyam in the world, Africa and West Africa, respectively within the same period. In Nigeria, cocoyam ranks third after cassava and yam among staple roots and tubers crops, in terms of importance, total output and area under production. It has high economic potentials, not only as food (main meal, snacks and adjunct in thickening soup) but as an agro-industrial raw material for pharmaceutical, confectionery, and livestock industries (FAO, 1990, Kudu et al., 2012). In Nigeria, the bulk of cocoyam produced is consumed as food, either as a primary product (corm, cormel, leaves and the inflorescence) or as a secondary product (flour, cake, crisp, and chip) (Akomas et al., 1987). It is of interest to note that among root and tuber crops in Nigeria, cocoyam is the only tuber crops that all the parts are edible because the corms and cormels are eaten in various food forms while the leaves and flowers are commonly used as spice to garnish and flavour food (Chukwu, 2011; Plucknett et al., 1970). The corms are good sources of carbohydrates with easily digestible starch and they have a favourable protein-to-energy ratio (Standal, 1983). Cocoyam is nutritionally superior to major competitor roots and tubers like cassava and yam, in terms of digestibility, contents of crude protein and essential minerals, such as Ca, Mg and P. Table 1 shows that cocoyam contains over 80.0 and 240.0 % higher digestible crude protein than yam and cassava, respectively. It also contains higher appreciable amounts of essential minerals (Ca, Mg and P) than cassava and yam (Green, 2003). In phytomedicine, Ilonzo (1975) recommended daily consumption of roasted cocoyam with palm oil for three months as a cure for diabetes. Recently, Kundu et al., (2012) revealed its potential in the prevention of prostate and breast cancer. Increasing awareness and concern for environmental quality reveals that the small starch granules of cocoyam (1 – 4 µ) is superior to cassava (15- 17 µ), yam (10 – 70 µ) and potato (50 µ) as sources of starch in agro-industrial raw material for the production of biodegradable plastics (FAO, 1990).

Table 1: Selected Nutrient Contents of Cocoyam Compared with Yam and Cassava.

Parameter	**Cocoyam**	**Yam**	**Cassava**	**Reference.**
Protein (Dry matter Basis) (%)	7.85	3.15	2.72	Green (2003)
Digestible crude protein (%)	6.88	3.68	1.99	Oyenuga (1968)
Carbohydrate (%)	19-21	15-23	32-35	Gooding (1987)
Energy (KJ $100g^{-1}$)	373-406	439	607	Gooding (1987)
Energy (KJ $100g^{-1}$)	393	452	568	Oyenuga (1968)
Minerals (% $100g^{-1}$): Ca	18.3	10.1	14.5	Green (2003)
P	99.4	88.3	98.5	Green(2003)
Mg	0.38	0.11	0.35	Green (2003)

In the colonial era and up to 1970's, the rain forest belt was the major zone for root and tuber crops production in Nigeria. The assertion is buttressed by the report by Agboola (1979) that the eastern states (Akwa Ibom, Anambra, Bayelsa, Cross River, Ebonyi, Enugu, Imo and Rivers States) dominated in root crop production from the pre-colonial era through 1970's. He delineated cocoyam production areas into four important categories based on percentage of cropland under cocoyam. However, macro characterization of West African farming systems by Mayong et al., (1996), and perspectives in yam research in Africa by Orkwor (2004) revealed that root and tuber crop production has significantly moved from the forest to savanna ecologies. The authors explained that yam cultivation has expanded into the savanna which has become the new major growing area in West Africa, due

to ecological, agronomic and socio-cultural factors such as better solar radiation, higher soil fertility, reduced intensity of accelerated soil erosion, etc. Consequently, it is expected that with the expansion of root crop belt northwards, the cocoyam cultivation map of Nigeria produced about 25 years ago by Agboola (1979), should be updated to reflect the present situation.

The current reconnaissance soil survey report of Nigeria (Federal Department of Agricultural Land Resources (FDALR, 1990), and soil fertility maps of various agro-ecological zones (Sobulo and Adepetu, 1987; FMANR, 1990) or States (Ohiri et al., 1989) did not provide information about the suitability of the soils for sustainable cocoyam production. The Overseas Development Natural Resources Institute (ODNRI, 1989) produced a profile of agricultural potential of Nigeria to provide a frame of reference for assessing existing and possible future strategies in the natural resources sector. They delineated Nigeria into eight land resources zones (semiarid, dry sub humid, humid, flood or swamp, plateau and montane), for the purpose of agricultural development. Rational and sustainable land use for crop production depends on correct interpretation of soil and environmental data. Van Diepen et al (1991) defined land evaluation as the various techniques to explain or predict the use potential of land. The absence of a land suitability classification map for cocoyam in Nigeria limits rational land use for increased cocoyam production and justifies the present study.

The National Root Crops Research Institute (NRCRI), Umudike, launched Cocoyam Re-birth Initiative in 2007 to increase awareness on nutritional, health and economic importance of cocoyam. This, aroused interest of many farmers to embark on large scale cocoyam production. The enlightenment campaign was so great that Akoroda (2012) remarked that "the re-birth programme from the NRCRI Umudike was initiated and the "*fire*" glows on". Thus, understanding the potentialities and the limitations of available land resources zones in Nigeria will enable current and potential cocoyam farmers to make judicious land use decisions to improve and sustain high yields to improve their livelihood.

The objectives of the study were to assess eight land resources zones of Nigeria delineated by the Overseas Development Natural Resources Institute (ODNRI, 1989) for sustainable cocoyam production and to provide an updated cocoyam production map of Nigeria.

Material and Methods

Land evaluation was based on Nigeria's land resources zones (ODNRI, 1989). The advantage of land resources zonation is the delineation of the country into six latitudinal divisions of low relief land surfaces based on gradual climate and vegetation changes, and two areas of greater elevation rising above 1,000 m above sea level. The agro climatic data of the zones are shown in Table 2.

Table 2: Agro-climatic data of land resources zones of Nigeria in the wet season

Zones	Total Rainfall (mm)	Months*	Length (days)	Monthly temp (^{o}C)
Semiarid	400-600	Jas	90	22-32
Dry sub humid	600-1000	jJAs	90-150	21-31
Sub humid	1000-1300	mJJAS	150-200	23-30
Humid	1100-1400	amJJASO	200-250	26-30
Very humid	1200-2000	aMJJASO	250-300	24-28
Flood/Swamp	>2000	fMAMJJASON	300-360	25-28

Plateau	1400-1500	aMJJAS	200	20-24
Montana	1400-2000	mAJJASOn	200-300	14-29

Source: ODNRI (1989).

*Capital letter indicates months in which effective rainfall exceeds potential evapotranspiration.

The present study was based on secondary data collected from extensive literature review. Some sources of information include FAO (2000), Gooding (1987), Onwueme (1978), ODNRI (1989), and several others. The following major land use requirements (land qualities) for sustainable cocoyam production: soil fertility, temperature, soil reaction, length of growing season, flood hazard and moisture availability were identified and rated in Table 3, into nil (ideal or no limitation), moderate, severe and very severe, based on anticipated degree of limitation they are likely to pose in cocoyam production.

Table 3: Land Quality Rating for Sustainable Cocoyam Production Degree of Limitation Rating

Land Quality	Nil	Moderate	Severe	Very severe
Temperature (^{0}C)	21 – 27	25 – 30	30 – 35	>35
Moisture availability (Months Pe > ETo)	**≥ 5**	4	3	**< 3**
Total rainfall (mm)	≥ 2000	1300 – 1999	1000 – 1299	< 1000
Length of growth period (days)	≥ 200	150 – 200	100 – 150	< 100
Flood hazard (days)	≥ 2	3 – 7	8 – 14	> 14
Soil fertility (Base saturation) (%)	> 60	40 – 60	20 – 39	< 20
Soil pH	> 5 - 6.5	4.5 – 5	4 – 4.4	< 4.0

Sources: Gooding (1987); ODNRI (1989); FAO (2000); Onwueme (1978).

Where Pe = Effective rainfall; ETo = potential evapotranspiration

However, in delineating land suitability classes, the numbers coded on the map (Figure 1) in descending order (4, 3, 2, 1) were translated into the FAO (1983) land suitability classification classes thus:

4 = S1 (highly suitable), 3 = S2 (moderately suitable), 2 = S3 (marginally suitable), and 1 = N (unsuitable). The interpretation is as follows:

S1 = highly suitable: Land having no significant limitation for sustained cocoyam production.

S2 = moderately, suitable: Land having limitations that are moderately severe for sustained cocoyam production.

S3 = marginally suitable: Land having limitations, which in aggregate are severe to preclude profitable and sustained cocoyam production. A farmer can manage to break even.

N = not suitable: Land having significant limitations production would be at a loss.

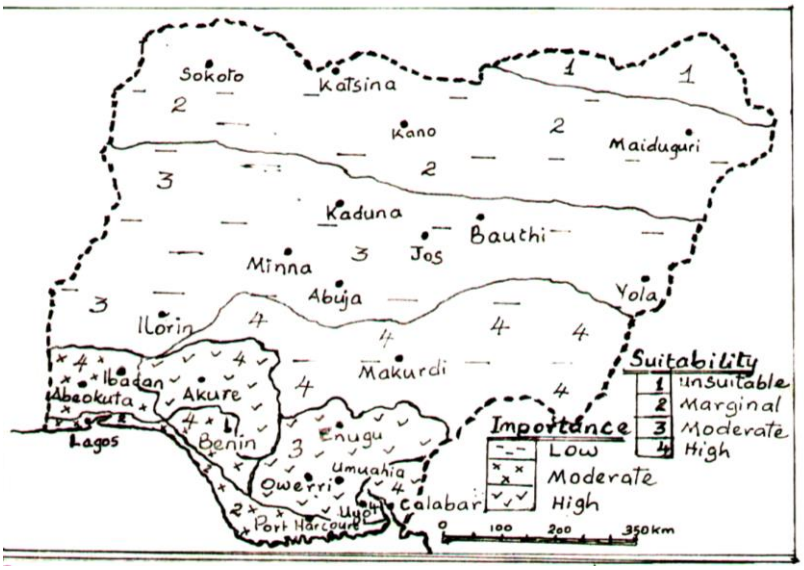

Figure 1: Cocoyam map showing land suitability classification and important growing areas in Nigeria.

Information on important areas of cocoyam production was elicited from surveys on cocoyam germplasm collection (Mbanaso et al, 2006; Okoye et al. 2007), and from cocoyam production map of Nigeria (Agboola, 1979). Land area under cocoyam production in Nigeria was modified and delineated into three categories based on percentage of cropland under cocoyam, as in Agboola (1979) thus: low = ≤ 9 % of cropland, moderate = 10 – 29 % of cropland and high = ≥ 30 % of cropland (Figure 2).

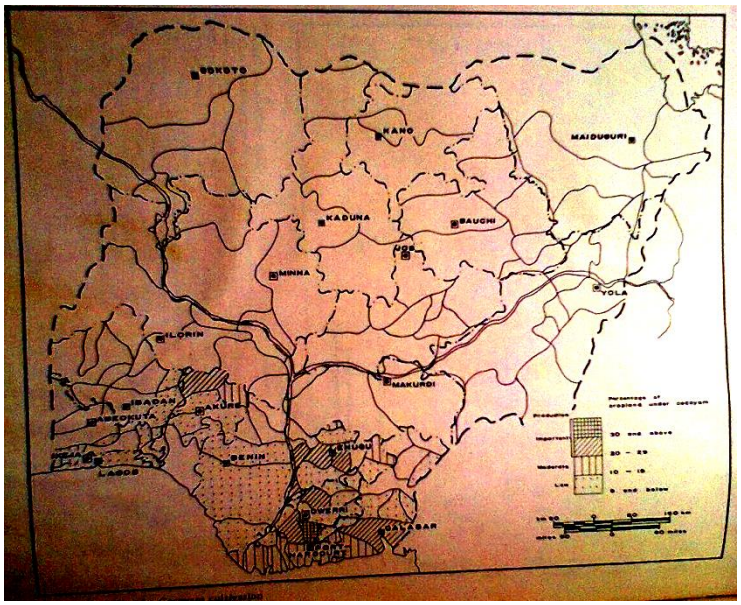

Figure 2: Nigeria: cocoyam cultivation.

Source: Agboola (1979)

Results and Discussion

Table 2 revealed the semiarid and dry sub-humid zones typical of north of Maiduguri (Borno State), Sokoto, Kano States (Figure 1), aridic and torric moisture regimes predominate. As a consequence, soil moisture is likely to be held at ≥ 1,500 KPa tension for at least for 90 days out of 180 – 240 days of growth period for cocoyam (ODNRI, 1989). Similarly, total annual precipitation in these land resources zones ranged from 400 – 1,

000 mm (ODNRI, 1989). This amount of rainfall (precipitation) cannot sustain cocoyam production withoutirrigation. These environmental challenges explained why semiarid zones were rated not suitable (N) based on current knowledge for sustained cocoyam production. Table 2 also showed that flood swamp had the highest number of rainy days (300 - 360). Effective rainfall is likely to exceed evapotranspiration for nine months, out of 12 calendar months in a year, indicating that it is likely to suffer moisture stress due to excessive moisture. Appreciable portions of the flood swamp soils are characterized by endosaturation of aquic moisture regime, whereby the soils are saturated with water in all layers from the upper surface to a depth of 200 cm (Soil Survey Staff, 2003). Concomitantly, flood hazards, Thionic Fluvisols (Chukwu and Olufumihan, 2003) and problems of access to the swamps for cultivation and application of necessary agronomic management, characterize such deltaic micro-ecologies. This explained the down-graded land suitability class for this zone to marginally suitable (S3). Typical sites include parts of Akwa Ibom, Bayelsa, Cross River, Edo, Lagos and Rivers States Table 4). The sub humid zone (parts of Kaduna, Bauchi, Plateau, Adamawa and Niger States) and humid zone (parts of Oyo, Kogi, Kwara, Benue, Ondo, Plateau and Cross Rivers States and Federal Capital Territory) are moderately suitable for cocoyam production. The soils are fertile with a base saturation ranging from 60 – 80 % (FAO, 2000). They are derived essentially from basement complex rocks and newer basalts (FDALR, 1990) and are naturally endowed with weatherable minerals, especially white mica (muscovite) which is a potassium aluminum silicate (Ahn, 1970), the soils are less prone to accelerated soil erosion because of appreciable amounts of gravel and presence of occasional rock out crops (FDALR, 1985; 1990). All these confer higher structural stability to the soils of the zone. However, it is surprising to note that sub humid and humid zones, which are moderately suitable for cocoyam are where less than ≤ 9 % of cropland is under cocoyam (Figure 1), indicating evidence of under utilization of the area for cocoyam production. Similar observation was made by Sgoe et al (2004) in Ghana where they observed that a vast low lying ecology suitable for cocoyam production is not put to effective use.

Table 4: Land suitability classification of cocoyam production in Nigeria.

Land resource zones	Temp. (^oC)	Moisture availability (months)	Annual rainfall (mm)	Growth period (days)	Flood hazard (days)	Soil pH	Base saturation (%)	Overall
Semiarid	S2	N	N	N	S1	S1	S1	N
Dry sub humid	S3	S3	S3	S2	S1	S1	S1	S3
Sub humid	S1	S2	S2	S1	S1	S1	S1	S2
Humid	S2	S1	S2	S1	S1	S2	S2	S2
Very humid	S1	S1	S1	S1	S2	S1	S1	S2
Flood/swamp	S2	S1	S1	S1	S3	S2	S2	S3
Plateau	S1	S1	S2	S1	S1	S2	S2	S2
Montane	S1	S1	S2	S1	S1	S1	S1	S1

The montane zone (Obubra and Mambilla) is highly suitable for sustainable cocoyam production. Soil reaction is favourable with a good weather to guarantee optimum growth period and maximum yield. While Obubra in Cross River State is among the important cocoyam cultivation areas identified by Agboola (1979), Mambilla plateau in Adamawa State is among the areas unimportant for cocoyam production. However, the

present study showed that both areas are highly suitable for sustained cocoyam production taken into cognizance climatic and edaphic factors for sustainable cocoyam production. However, parts of the very humid zone especially in the southeastern states (Anambra, Enugu, Ebonyi, Abia and Imo) are underlain by acidic soils derived essentially from Coastal Plain Sands, Sandstone and Shale parent materials, with low base saturation (Chukwu, 2007). The soils are characterized by sandy to loamy textural classes at the epipedon, underlain by medium to heavy loam, to clay textural classes at the endopedon (Lekwa et al, 1994). Consequently, they are moderately (S2) suitable for sustainable cocoyam production (Table 4) and are currently among the major cocoyam cultivation areas earlier reported by Agboola (1979). The study revealed that the potentialities of Nigeria land resources zones are not effectively utilized for cocoyam production (Figure 1).

Conclusion

It is concluded that all the land resources zones of Nigeria are not suitable for cocoyam production. The potentialities of the land resources zones and suitable soils for cocoyam in Nigeria are currently underutilized for cocoyam production. It is recommended that the land suitability/importance cocoyam map should be used as a basis for site selection to expand cocoyam production and increase total output.

References

[1] Agboola, S.A. (1979). An agricultural atlas of Nigeria Oxford University Press, Great Britain, 248 pp.

[2] Ahn, P (1970). West African Soils. Oxford University Press, London, 332 pp.

[3] Akoroda, M. (2012). Better co-ordinated root crop systems for food and cash in Nigeria. In: Root and Tuber Crops Research for Food Security and Empowerment. Amadi, C.O. Ekwe, K.C, Chukwu, G.O, Olojede, A.O and Egesi, C.N. eds. NRCRI, Umudike, pp 3 - 32.

[4] Chuklwu, G.O. (2007). Soil fertility capability classification for seed yam (Dioscorea rotundata Poir) on acid soils of Southeastern Nigeria, Unpublished Ph.D thesis submitted to Federal University of Technology, Minna, Niger State, Nigeria

[5] FAO (1983). Guidelines: land evaluation for rain fed agriculture. FAO Soils Bulletin, No 52, FAO, Rome, Italy, pp. 237

[6] FAO (2000). Simple Soil water and plant testing technique for soil resources management.AGL/MISC/28/2000, IITA Ibadan, FAO Rome, Italy, 158 pp.

[7] Food and Agriculture Organization of the United Nations (FAO). (2012). 18 Mar. 2013. ttp://faostat3. fao.org/home/index.html>.

[8] Gooding, E.G. B. (1987) Tonnia (Xanthosama spp) and Taro (Colocasia esculenta) in : Root Crops second edition. Tropical Development and Research Institute, London pp 200 – 251.

[9] Green, B.O. (2003). Taxonomic and nutritional analysis of certain tuber crops in the Niger Delta of Nigeria. African Journal of Environmental Studies 4(1/2): 120-122

[10] Ilonzo, F.I.N. (1995). You and your health with phytomedicine (healing remedies from plants). The Centre for Psychic and Healing Administration. Nobel Publication, Enugu, Nigeria, 26 pp.

[11] Manyong, V. M., Smith, J, Weber, G, Jagtap, S.S and Oyewole, B. (1996). Macro characterization of agricultural systems in West Africa: An overwiew. Resource and Crop Management Monograph, No. 21, IITA, Ibadan.

[12] Mbanaso, E.N.A., Echendu, T.N.C, Chukwu, G.O. and Okoye, B.C. (2005) Cocoyam collection in south-south geopolitical zone of Nigeria. Proc. 39th Annual Conference of Agricultural Society of Nigeria, Benin City, pp. 399 – 401

[13] ODNRI (1989). Nigeria profile of agricultural potential. Overseas Development Natural Resources Institute, United Kingdom, 15 pp.

[14] Okoye, B.C., Obasi M.N., Chukwu, G.O., Olojede A.O., Mbanaso, E.N.A. and Echendu T.N.C. (2006). In-country germplasm collection of cocoyam in southeastern Nigeria. Proc. 40th Annual Conference Agric. Soc. of Nigeria, NRCRI, Umudike, pp 3 – 38.

[15] Okwor, G.C. (2004). Perspectives in yam research in Africa. Proc. 8th ISTRC-AB Symposium, Ibadan, Nigeria, pp 5 – 8.

[16] Onwueme, I.C .(1978). The tropical root and tuber crops: yams,cassava,sweetpotato and cocoyam. John Wilsey and Sons, New York, 234 pp.

[17] Oyenuga,V.A (1968). Nigeria's food and feeding stuff, their chemistry and nutritive value(3rd edition).University press, Ibadan, pp 31-35.

[18] Plucknett, D.L., R.S. de la Pena, and F. Obrero. (1970). Taro (Colocasia esculenta). Field Crops Abstr. 23:413–426.

[19] Sagoe, R., Ban, R., Manu-Adueing, J., Haleegoah, J., Dedzoe, D., Tetteh., J.P., Osei, J . K., Safo-Kantanka, O and MOFA Staff. (2004). Improving taro cropping systemin Ghana: A participatory research - farmer- extension approach. Proc. 8th ISTRC-AB Symposium, Ibadan, Nigeria, pp 321 – 324.

[20] Standal, B.R. (1983). Nutritive value, p. 141–147. In: Wang, J.K. (ed.). Taro: A review of Colocasia esculenta and its potentials. University of Hawaii Press, Honolulu, HI.

[21] Van Diepen, C.A, Van Keulen, H., Wolf, J. and Berks hout, J.A.A. (1991). Land evaluation: from intuition to quantification. In: Advances in Soil Science B.A.Stewart (ed), Springer, New York, pp 139 – 204.