Soil Suitability Analysis for Cultivation of Cassava in Ibarapa Central LGA, A GIS Approach

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ABSTRACT

In this study, Geographic Information Systems techniques were applied to identify suitable area of land in Ibarapa Central Local Government Area in Oyo state, Nigeria for cassava cultivation and optimum production. Data acquisition include; geological map, use map and soil type map of Oyo state, and topography map of the study area for the purpose of identifying and classifying soil type, nutrients and moisture content, and also selecting slope and relief to reduce soil erosion that washed away top soil. The acquired data were converted into digital format for the purpose of georeferencing in GIS environment using ARCGIS 9.3. The database was created for different entities and their attributes, on this spatial analyzes were carried out that determine suitable soil SITE for cassava production. The result showed that Idere and part of Igbo-Ora is suitable for the cultivation and production of cassava.

Keywords: Soil Suitability, Database, Map, Cassava, Geographical Information Systems, Georeferencing, Nigeria.

1. INTRODUCTION

Soil suitability for cassava, each cassava varieties require definite soil and climatic conditions for optimum growth. Since the availability of both water and plant nutrients is largely controlled by the physico-chemical properties, micro-environment of soils, the success and failure of any species of a particular area is, therefore, governed by soil characteristics (Shahbazi, 2008).

The Cassava (*Manihot esculenta*) is generally described as a perennial subshrub or shrub or forb/herb, and has its most active growth period in the year round. The greatest bloom is usually observed in the indeterminate, with fruit and seed production starting in the year round and continuing until year round. Leaves are retained year to year. The Cassava (*esculenta)* has a short life span relative to most other plant species and a rapid growth rate. At maturity, the typical Cassava (*esculenta*) will reach up to 10 feet high. The Cassava (*esculenta)* is easily found in nurseries, garden stores and other plant dealers and distributors. It can be propagated by bare root, cutting stem, seed. Note that cold stratification is not required for seed germination and the plant cannot survive exposure to temperatures below 17°F. Has low tolerance to drought and restricted water conditions (Enwenzor, 1989).

Developing sustainable agricultural management systems is complicated by the need to consider their utility to humans, their efficiency of resource use, and their ability to maintain a balance with the environment that is favorable both to humans and most other species. More simply stated by Tom Franzen, a midwestern farmer in the USA, a sustainable agriculture sustains the people and preserves the land". We are challenged to develop management systems that balance the needs and priorities for production of food and fibre with those for a safe and clean environment. Assessment of soil quality or health is invaluable in determining the sustainability of land management systems. Soil quality is conceptualized as the major linkage between the strategies of conservation management practices and achievement of the major goals of sustainable agriculture (Acton and Gregorich,1995; Parr *et al.*, 1992). In short, the assessment of soil quality or health, and direction of change with time, is the primary indicator of sustainable land management. Although soil's contribution to plant productivity is widely recognized, soil condition also impacts water and air quality. The quality of surface and sub-surface water has been jeopardized in many parts of the world by intensive land management practices and the consequent imbalance of Carbon, Nitrogen, and water cycling in soil. Agriculture is considered the most widespread contributor to non-point source water pollution in the USA (National Research Council, 1993).

According to Tomlin (1983), the term cartographic modeling mean the use of basic GIS manipulation functions in a logical sequence to solve complex spatial problems. It was developed to model land use planning alternatives, an application that requires the integrated analysis of multiple geographically distributed factors.

Ministry of Food and Agriculture explained analytical capability of GIS that GIS is used to group detailed land cover and land use classes into constraint categories appropriate for the route selection analysis. According to ESRI definition in 1998, GIS is an organized collection of computer hardware, software, and geographic data designed for capturing, storing, updating, manipulation, analyzing and displaying all forms of geographically referenced information. A report on strategies to improve Africa's agriculture, and food security was presented at UN headquarters (2004) stated that since problem facing Africa's agriculture, there should a number of concrete steps that the scientist should be working closely with farmers.

Anthony, 2001 stressed the uses of GIS in Agricultural Sector of the economy including cultivation, inventory, vegetation cover, soil study, land use monitoring. This gives rise to what is referred to as precision agriculture. Usually the information gotten is stored in a database having an order or arrangement. This makes the location and retrieval of data / information easier.

Geographic Information System has a persuasive reach into everyday life, it provides a means to convert data from tables with locational information into maps. Subsequently, GIS generated maps are the basis for spatial data decision making in government, business, community groups and others (Rowe, 1981)

As GIS answer the question “what is where and where is what” this illustrates what we eat, where it comes from, and how it gets to reach the market, where we eventually buy, all depends on GIS technology. Nigerian should readily have the database about its soils, the nutrient status, the crop requirements, rainfall distribution pattern in digital form to suite the new age of computer advancement for the purpose of sustainable development and food security.

The study of Agricultural sustainability focuses on using techniques such as digital terrain model (DTM), geographic information system (GIS), and decision support system (DSS) for arable land ecosystem classification and suitability analysis of the Tropical Experimental Forest. The content includes the delineation of ecosystem units using DTM, the development of a hierarchical ecosystem classification system using GIS and multivariate statistical analysis, and the establishment of a forestland classification DSS with an application on site selection. From the work reviewed results indicate that DTM is a fast, easy, feasible, and automatic approach for delineating ecosystem units of different spatial scales. The developed hierarchical ecosystem classification is a satisfactory scheme for Liukuei’s forestland classification because the developed scheme coincides with the terrain characteristics along a continuum. The established DSS can effectively and feasibly analyze forestland classification under different spatial scales. Meanwhile, the system can easily perform site selection for any arable land. From the results, it is concluded that techniques such as DTM, GIS, and DSS are useful for farm managers in the reasonable planning of land classification and management practice. (Salwasser, 1992).

In addition to the use of DTM and GIS, the DSS that helps forest managers manage and assess forests has grown tremendously and is commonly used for many aspects of forest management, for example, to provide support in the complex process of problem formulation and task analysis; to make effective use of available data and knowledge bases; and to support rational use of the results. As for the DSS, Renolyds *et al*, (1998) had developed an ecosystem management decision support (EMDS) system for ecological assessment, proposed a DSS using a combination of linear programming and GIS for formulating Agricultural land use strategies to improve sustainability.

Cassava production has been limited in so many ways caused by limiting factors such as wrong site selection, un-identification of suitable soil, unavailability of database that contain detail records of nutrients requirement for each crop and available soil nutrients. As a result of these aforementioned factors, we have not got a reasonable percentage of cassava production. We therefore, need soil analysis for suitability assessment.

Majorly there are available works on soil type, soil analysis, rainfall record, nutrients status of many areas around the country, as well as which crop can thrive most there, most of these data exist in analogue form. It is therefore necessary to transform such information particular to a location into digital format such that it can be easily accessed, retrieved, edited and queried. This will actually assist anyone who desire to invest into cassava production to know which soil to choose, particular time to grow cassava, what to do in case of soil deficiencies, and what named fertilizer should be added to soil and in what quantity.

The main objective of this research work is to apply Geographic Information System to select best site for the cultivation and production of cassava Performing some spatial analysis such as query and buffering to determine the appropriateness and suitability of the soil sample compatible with crop nutrient requirement in Ibarapa Central LGA.

2. METHODOLOGY

The study area was Ibarapa Central LGA, is geographically lies between latitude 3^0 24^1 34^{11} North of the Greenwish meridian and longitude 7^0 32^1 0^0East of the top right Equator, and 3^0 31 25East, 7^0 18^1 23^{11} of Oyo state, Nigeria. Ibarapa central LGA of Oyo state has a humid tropical climate with a bimodal rainfall, distinct wet and dry seasons. The average annual rainfall figures could be as high as 2550mm. The average maximum level of temperature was 38C. The relative humidity is influenced by the temperature and rainfall, thus, its pattern of distribution is similar to those of temperature and rainfall. It was high throughout the year with an annual mean of 81.04% with the highest record during the rainy season.

2.1 Data Acquisition

The data of realities used were spatial and non-spatial (attributes) that were sourced for as primary and secondary data. The data model type used here was vector data. The main primary data used were the coordinates of the study area. This was done using handheld GPS for raster data. The data was downloaded into the computer system for further processing. The secondary data used were Soil type map of the study area, Land use map, Rainfall data and Temperature data (I.A.R.&T.2005).

2.2 Data Processing

The data used in GIS analysis were in digital format, however some of them were in analogue format. Topographical map (and any hardcopy map) was an example of analogue data, the conversion of GIS involved scanning, geo-referencing, digitizing. This was achieved in this project by digitizing a scanned map using ArcGIS 9.3 software, this same software was also used for analysis. Having designed a data structure and ensuring that the basic spatial datasets were in place, the attribute database was created. The database for this project was created according to the condition and criteria favourable to cassava cultivation, that is; table for different level of nutrients available, table temperature data collected for the study area, table for rainfall data collected for study area, table for available crops on land, and table for different types of soil.

2.3 Analysis and Product Generation

Cartographic Modeling is developed to model land use planning alternatives-an application which requires the integrated analysis multiple geographically distributed factors. It is a systematic approach to define the information needed and also designing the analysis procedure to meet them. To tackle many analytical problems in Geographic information processing, there is a need of linking the geographic primitives, point, region, and neighborhoods commands together in sequence, where the command sequences or map algebra becomes the cartographic modeling. GIS analysis are performed base on the nature of the data and the end user requirement, such analytical operations include: Buffering, Spatial Query, Overlay, and Intersection, Connectivity and Neighbourhood.

In this study the application of buffering for analysis was applied to water bodies (water logged area, swamp area, mangrove), and major roads of 50m and 20m respectively to satisfy the set criteria for distance, according to the report from I.A.R.&T, 2008.

3. Discussion of Result

Table 1 shows physical declaration for soil entity and its attributes, table 2 shows physical declaration for river entity and its attributes, table 3 shows Physical Declaration for Built up Area Entity and its Attributes, table 4 shows physical declaration for road entity and its attributes. The result shows different level of soil nutrient and this is used to determine the portion that is low, medium, and high in nutrient.

The results had shown the significance of Geographic Information Systems in Agricultural sector (Crop Production), in that it provides analytical capability of identifying the major soil series, selecting suitable soil for crop production, and suggesting measures of improvement on less productive SITE. The designed database was queried to give useful information on type of soil that best suit (base on texture, moisture content, physical properties, and fertility) cassava optimum production. Couple with the other queries that analyzed the needed soil nutrients and topography of SITE which will adequately support the plant growth. The result from query observed that part of Igbo-Ora and Idere Arable land satisfied the condition.

4. Conclusion

The result has shown the importance of Geographic Information Systems in the creation of a database for different soil types and their soil nutrient status in order to determine their suitability for cassava production. This work resulted into diversities of land qualities suitable for cassava production with. Climate and topography revealed that elevation could be an issue in Igbo-Ora where flooding or water rises to rooting zone. However, the range of rainfall suitable for cassava production contributed to growth of cassava in the rain forest and dried savanna with comparable yield was recorded in Idere where we have light texture, well drained soil with sufficient amount of nutrients. The report from Obasanjo farm in Igbo-Ora recorded that cassava yield has dropped from 22tones to 12tones. The response could be attributed to low N in all the soils. The suitability rate may be more than 76% in all soils, but yield disparity may occur which shows that good yield is a function of other parameters like appropriate farming system and cultural practice. The more suitable the land quality with adequate input and appropriate management, the higher the yield of cassava will be.

x. REFERENCES

Acton, A. F. and Gregorich, W.C, (1995). "Ecological Intensification of Cereal Production Systems: Yield Potential, Soil Quality, and Precision Agriculture"

Anthony, (2001). A GIS-Based Plant Prediction Model for Wetland Ecosystems.

Edward, W. A. (1980) "Integrating Precision Farming Tools to Achieve Sustainability," 830-838 in proceeding of the forth International Conference

Enwenzor, W. O. (1989) World Food Programme and Ministry Disaster and Relief

International Institute of Tropical Agriculture (2005), *International Journal on Evaluation of Crop and Soil Nutrient (IITA).* Publication on Cassava Cultivation management.

Karlenet et al, (1997). Spatial Analysis of Agronomic Properties in Two Production Cotton Fields in West Texas. pp. 1286-1290 in *1999* Proceedings Beltwide Cotton Conferences.

National Research Council, (1993); *International Publication on Sustainable Agriculture*: How to Sustain a Production System in a Changing Environment. (1999) 29(1): 1-5

Reynolds S. J., Merchant J. A., Stromquist A. M., Burmeister L. F., Taylor C., Lewis M. Q., Kelly K. M. (1998). *Journal of Agricultural Safety and Health.* Special Issue (1):67-77.

Rowe, J. S. (1981). Evaluation of the Effect of Climatic Changes on Agricultural Production in Nigeria. African crop science conference proceedings vol. 8 pp 423-424.

Salwasser, (1992). Key to Soil Taxonomy. Tenth Edition. The 18th World Congress of Soil Science. USDA. (2006) 19-25.

Shahbazi, (2008). Multilingual Soil Profile Database for Using in Soil Monitoring and Evaluation System Sand Software, 17:721-730.

Tomlin, Y. L. (1983). Essential of Cartographic Modeling in Principle of Information System for Land Resources Assessments. Pp 107-115.

www.iart-ngonline.org/ibadanstation.html

Table 1. Physical Declaration for Soil Entity and its Attributes

Name	**Data type**	**Width**
S_Id	Short integer	10
S_type	Text	30
S_property	Text	30
S_fertility	Text	30
S_location	Text	30

Table 2. Physical Declaration for River Entity and its Attributes

Name	Data type	Width
R_Id	Integer	15
R_type	Text	30
R_location	Text	30
R_name	Text	30
R_size	Double	40

Table 3. Physical Declaration for Built up Area Entity and its Attributes

Name	Data type	Width
S_Id	Integer	15
S_type	Text	40
S_area	Double (both integer and text)	50
S_location	Text	40
S_name	Text	40

Table 4. Physical Declaration for Road Entity and its Attributes

R_Id	Short integer	10
R_Type	Text	30
R_condition	Text	30
R_length	Double	15
R_name	Text	30

Table 5. The Result of Soil Analysis of Different Portion of Land

Parameter	Igbo-Ora	Igbole	Abolonko	Towobowo	Idere
Sand	75.9	75.9	71.9	82.8	65
Clay	14.5	5.8	13.6	11.2	25
Silt	9.6	18.2	11.3	9.8	20
Ca	1.92^{m}	0.96^{l}	0.86^{l}	1.02	2.15^{m}
Mg	0.85^{m}	0.75^{m}	1.57^{h}	1.37^{h}	1.0^{m}
K	0.92	0.88	0.76	0.45	.27
Na	1.0^{m}	0.9^{m}	0.8^{m}	1.20^{m}	0.8^{m}
N	0.08	0.04	0.06	.10	0.02
P	4.5	2.83	4.3	2.6	9.95
C	0.26	0.19^{l}	0.22	0.30^{l}	1.40^{m}
Zn	7.1	7.6	6.5	6.9	7.5
Cu	3.5	2.86	3.02	3.12	4.10
H^+	0.65	0.09	0.13	0.56	.10

Approximate classification of soil chemical characteristics according nutritional requirement of cassava.

l- low, m- minimum, h- high

The result shows different level of soil nutrient and this is used to determine the portion that is low, medium, and high in nutrient.