**ABSTRACT**

Based on the basic principles and assumptions of FAO evaluation approach, suitability evaluation is always for a specific kind of use, meaning that different kinds of land use have different requirements. In this study, the land use suitability is specifically for the production of cocoyam in Benue State, Nigeria. This study aims to identify and delineate areas that best support the growth of cocoyam within the area. In this study, Land-Sat image of 2014 covering the study area was used to classify different land use types in ArcGIS 10.3 software. SRTM data was used to generate slope of study area, soil map of Nigeria was used, and different soil types within the study area was digitized. Multi-Criteria Evaluation was done in order to generate weightage for different factors that were used to produce the suitability map. The various factors that were used include soil, slope, and land use and the weight derived from each of the factors are 0.5, 0.3, and 0.2 respectively. Rainfall is regarded as constant in the area because of the single climatic type covering the small area. The classes established under the soil types include fluviosols, acrisols, alisols, gleysols, and nitisols, which were assigned the relative weights of 0.2667, 0.2, 0.1333, 0.0667 and 0.3333 respectively. The classes established under the slope include steep slope, strong slope, moderate slope, gentle slope, and nearly level, which were assigned the relative weights 0.0677, 0.13, 0.2, 0.27 and 0.3333 respectively and the classes established under the land-use factors include settlements, bare-surfaces, cultivated land, vegetation, and wetland, which were assigned the relative weights 0.0667, 0.13, 0.2, 0.27 and 0.3333 respectively. The result of the computation was classified into four quarters namely 0-25%, 26-50%, 51-75%, and 76-100%. The results were updated to a newly created field in the attribute data of the GIS layer containing the entire factor data used for suitability evaluation. After computation, SAVMACE sent the results into ArcGIS for symbolization and visualization.

**KEYWORDS**

FAO, Suitability, cocoyam, land use, MCE, and SAVMACE.

**1. INTRODUCTION**

The world's population is increasing dramatically, and in order to meet the increasing demand for food, the farming community has to produce more, in order to increase food production and provide food security; crops need to be grown in areas where they are best suited in order to get optimum yields, and this can be done with the aid of land suitability analysis. Based on a study, land suitability analysis is a method of land evaluation, which measures the degree of appropriateness of land for a certain use [1].

Cocoyam otherwise known as Taro is a herbaceous perennial plant belonging to the family Araceae and grown primarily for its edible roots. They are actually of two species namely Colocasia which is basically cultivated as food crops and Xanthosoma species which is comprised of a large spherical corm from which a few large leaves emerge. Cocoyam grows best in fertile, well-draining, sandy loam soil with a pH between 4.2–7.5. It can be grown in a wide variety of conditions including wetland areas using a system similar to that of rice. Xanthosoma species require temperatures above 21°C (69.8°F) to grow properly. Unlike Colocasia spp, they will not tolerate waterlogging and grow best in deep, well-draining loams with a pH between 5.5 and 6.5 in partial shade. Cocoyam will thrive when planted in full sunlight or partial shade. The plants can survive for short periods at temperatures of 10°C (50°F) but will be damaged or killed by lower temperature.

According to research, the global production of cocoyam has been estimated to be approximately 60 per cent in Africa and 40 per cent in Asia, with little quantities in the Caribbean and Oceania, over an area of 983 million hectares with an average yield of 5.314 mt/ha [2]. In a lot of developing countries, roots and tubers such as cocoyam, yam, cassava, and sweet potatoes are important crops that generate income and provide food security for the populace.

In Nigeria, cocoyam is cultivated mainly predominantly as annuals, mainly for their edible starchy storage underground stems known as corms and cormels. Cocoyam corms are good sources of carbohydrates with starch that is easily digestible and it's nutritionally superior to its 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. The country 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, respectively [3]. Also, in Nigeria cocoyam ranks third after cassava and yam among staple root and tuber crops in terms of importance, total output and production area. It has high economic potential not only as food but also as an agro-industrial raw material for pharmaceutical and livestock industries. This crop is very important and can generate income and provide food security for the populace.
1.1 Statement of Problem

Food is one of the people’s basic necessities of life, and government’s food production and supply in the State and as such posing threat to food security to the country at large. Cocoyam is actually under-exploited in Benue State in as much as it has enormous health benefits over its competitor root crops such as cassava and yam which are eventually given more emphasis. These health benefits are in terms of certain minerals such as Ca, Mg, and P. Also, it aids digestion more than its competitor crops which include cassava and yam.

The State can increase the production of this root and tuber crop in order to provide food security especially for the teeming population within Benue State and the country at large. This can, however, be done with the aid of a land suitability analysis in order to identify most suitable land for the production of cocoyam within the state.

1.2 Study Area

Benue is a state in the Mid-belt-region of Nigeria with a population of about 4,253,641 in 2006 census, the State lies on latitude 7º 20’ N and Longitude 8º 45’ E and has a total area coverage of 34,059km². The Study area actually cuts across parts of Gwer South, Gboko, Ad)]; Guma, Taraba, Gogo, and Buruku Local Government Areas of the State and it lies on Latitudes 8º 0’ 40.87”, 7º 23’33.46” N and Longitudes 7º 40’ 50.87” E, 8º 7’ 35.97” E. The State is a very rich agricultural region and, some of the crops grown there include potatoes, cassava, soy beans, guinea corn, sesame, maize, rice, groundnuts, yam etc.

1.3 Aim and Objectives

To identify and delineate areas that can best support the growth of cocoyam within the study area

1.4 Objectives

1. Identify the various factors responsible for cultivation of cocoyam within the area.
2. To provide thematic maps of land suitability for the production of cocoyam.
3. Integrate Multi-criteria Evaluation method and GIS to produce a suitability map for cocoyam production.
Table 1: Data and Data Sources

<table>
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<th>S/no</th>
<th>Data Type</th>
<th>Format</th>
<th>Scale</th>
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<th>Acquisition Date</th>
<th>Source</th>
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<td>2</td>
<td>Soil Map</td>
<td>Analogue</td>
<td>1:1,300,000</td>
<td>30m</td>
<td>1997</td>
<td>Wageningen, The Netherlands</td>
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<tr>
<td>3</td>
<td>SRTM</td>
<td>Digital</td>
<td>30m</td>
<td>30m</td>
<td>2016</td>
<td>Earthexplorer.usgs.gov</td>
</tr>
</tbody>
</table>

3.1 Identification of Soil Types within the Study Area.

This was done with the aid of the Soil map of Nigeria on the scale of 1:1,300,000 sourced from Wageningen, the Netherlands. The map was imported into ArcGIS (10.3) environment, it was geo-referenced, and the study area of interest (AOI) was digitized and delineated. The soil types that were identified and digitized include Acrisols, Alisols, Fluvisols, Gleysols, and Nitosols.

3.2 Classification of Land Use and Land Cover within the Study Area.

Classification of Land Use/Land Cover was carried out using Land-Sat Image of 30m resolution covering the study Area of Interest (AOI). The satellite image was layer stacked colour composite was done in order to assign different bands to the image in order to enhance clarity, the image was imported into Envi 4.3 environment where it was eventually classified. The image was further exported to ArcGIS 10.3 for further analysis.

The map was reclassified, and the various classes used for the study were ranked accordingly. These classes include settlement, bare surfaces, cultivated land, Shrubland, and wetland. And they were ranked 1, 2, 3, 4, and 5 respectively according to their various significance. One has to be the least favourable and five been the most favourable.

3.3 Generation of Thematic Maps

Various thematic maps of the study were generated using ArcGIS 10.3. These thematic maps were rasterized and reclassified into five suitability classes based on the crop requirement using the spatial analyst tool in ArcGIS 10.3. They include soil map, slope, and LULC map. The slope information was obtained from Digital Elevation Model (DEM) using GIS software package Arc GIS 10.3 derived from SRTM (Shuttle Radar Topographic Mission) data with 30m spatial resolution. TIN to raster operation was carried out in spatial analyst tool in ArcGIS 10.3, and the slope was finally generated. The DEM and slope were also rasterized and reclassified into five suitability classes based on the crop requirement.

3.4 Image Processing

The land use land cover information was generated using the Land-Sat image acquired in 2014 with a spatial resolution of 30m pixel size and processed using ENVI 4.3 and ArcGIS 10.3. Supervised classification was done using the maximum likelihood algorithm for 3 spectral bands corresponding to 5, 4, 3 combinations. Green, red, and blue (G, R, B). The image was exported to ArcGIS 10.3 after classification in Envi 4.3 environment. The image was further exported to ArcGIS 10.3 for further analysis.

The map was reclassified, and the various classes used for the study were ranked accordingly. These classes include settlement, bare surfaces, cultivated land, Shrubland, and wetland. And they were ranked 1, 2, 3, 4, and 5 respectively according to their various significance. One has to be the least favourable and five been the most favourable.

3.5 Suitability and Vulnerability Modelling and Computation Environment (SAVMACE)

Based on a study, SAVMACE is a generic spatial decision support system that provides an environment for the modelling and computation of suitability and vulnerability scenarios [11]. It was used in this study to model the factors that contribute positively to the growth of cocoyam in the study area which includes soil, slope, and land use. Relative weights were assigned to the factors accordingly and used to produce the suitability map.

4. RESULT AND DISCUSSION

Cocoyam suitability evaluation was carried out by first modelling the factors that contribute positively to the growth of the crop which includes soil, slope, and land-use, which were assigned relative weights of 0.5, 0.3, and 0.2 respectively. Soil types would define the nature of the medium in which the crop would grow; thus defining many important conditions such as nutrient availability and supply to the crop, soil aeration and water retention capacity. The slope factor defines how steep the landscape is, thus affecting processes such as soil and nutrient erosion. The land-use factor is used to distinguish areas of potential and/or pre-existing crop cultivation from areas that cannot be used for crop cultivation. Rainfall was also considered in the study as a factor for the crop growth, but because the study area does not cover a national or regional scale, it is therefore assumed that the climatic condition of the small area covered is of a single type [12].

Figure 3: Methodological Flow Chart

Figure 4: Land-Sat image of Benue State showing study area.
From the analysis above, the study shows that the delineated study area is predominantly covered with shrub land with about 959.1650 km², representing 71.46%, followed by wetland, cultivated land, bare surface and settlement with 332.3210 km², 24.76%, 45.1564 km², 3.36%, 5.4180 km², 0.40%, and 0.2318 km², 0.02% respectively. Nitisol soil is the dominant soil type within the study area with a percentage of 85.66%.
followed by acrisols, alisols, fluvisols and then gley soils with a percentage of 9.91%, 1.53%, 1.50% and 1.39% respectively. This implies that Nitisol soils favour the production of cocoyam more than any other soil type within the study area as cocoyam can only thrive very well in a well-drained soil type. It produces optimum yields when planted in fertile soil with a good water retention capacity. Nitosols are well-drained soils with a clayey sub-surface horizon that is deeply stretched and has nutty or polyhedric blocky structure elements with shiny faces. Gley soils, on the other hand, are wetland soils that unless drained, are saturated with groundwater for a long period to develop a characteristic gleyic colour pattern. Gley soils are mostly planted to rice; it doesn’t favour the production of cocoyam at all.

Figure 9: Slope Map of study area.

The study area shows that there are no adequate settlements within the area, this is because the area is mainly a basin; the area is relatively suitable for the cultivation of cocoyam except areas around Gwer-East LGA close to Moi-Igho and Aliade all in Gwer-East LGA. Within these areas, you will find places of steep and strong slopes which are not suitable for cultivating cocoyam.

Table 3: Suitability Analysis

<table>
<thead>
<tr>
<th>Area Km²</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Suitable</td>
<td>400.38</td>
</tr>
<tr>
<td>Suitable</td>
<td>537.30</td>
</tr>
<tr>
<td>Moderately Suitable</td>
<td>389.05</td>
</tr>
<tr>
<td>Slightly Suitable</td>
<td>10.96</td>
</tr>
<tr>
<td>Not Suitable</td>
<td>2.23</td>
</tr>
<tr>
<td>Total</td>
<td>1339.92</td>
</tr>
</tbody>
</table>

Figure 10: Area in Km² and percentage for Suitability Analysis.

Figure 11: Cocoyam Suitability Map of Study Area

The modelling technique adopted in the suitability process here is Weighted Linear Combination (WLC) which makes use of factors and constraints in the multi-criteria modelling of the scenario. However, the suitability map was produced using Suitability and Vulnerability Modelling and Computation Environment (SAVMACE) where all the datasets were compressed in one single file, and then the suitability model was run to produce the final suitability map using the generated weightage for each factor. The results were updated to a newly created field in the attribute data of the GIS layer containing the entire factor data used for the suitability evaluation. After the computation, SAVMACE sent the results into ArcGIS for symbolization and visualization.

5. CONCLUSION

The results obtained from this study indicate that the use of remote sensing data and GIS application together with multi-criteria Evaluation using Suitability and Vulnerability Modelling and Computation Environment (SAVMACE) could provide a database for cocoyam production. Although, cocoyam is not really cultivated in the area but based on the findings in this study, it is recommended that cultivation of the crop should be carried out within the area and Benue State at large, where it’s actually suitable in order to increase food production.

REFERENCES


