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Land Suitability Evaluation and Mapping for Some Selected Crops in South Western, Nigeria

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ABSTRACT

Land suitability evaluation measures the degree of appropriateness of land for a certain use. Major causes of land degradation are as result of land mis-use and poor land management practices, which include agricultural crop cultivation, which is the mainstay economy in Nigeria. The aim of this study was to identify and map out the land that can best support some crops in south western Nigeria using GIS and remote sensing techniques. Three suitability criteria; soil, climate (rainfall, temperature) and topography were evaluated based on FAO guideline to classify the land based on their suitability ranked as highly suitable (S_1), moderately suitable (S_2), marginally suitable (S_3) and not suitable (N). The study employed an integrated methodology for the analysing and mapping of the land suitability using remote sensing and GIS techniques. Suitability maps were generated by overlaying these areas with available land cover map created from Land Satellite (LANDSAT) images through supervised classification. The suitability analysis revealed Ekiti State with 1969.43 Km^2 suitable for maize cultivation, Lagos State had 822.71 Km^2 suitable for cultivation of soya bean, Ogun State had 4024.75 Km^2 suitable for cultivation of guinea corn. In addition, Ondo State had 4024.75 Km^2 suitable of rice production, Osun State had 2982.79 Km^2suitable of cassava cultivation and Oyo State had 8726.19 Km^2 suitable for production of yam. The study developed land suitability evaluation maps for some selected crops in south western Nigeria, with varying results from state to state. The findings from the study will help governments and farmers to better plan crops production activities in order to address the problem of increasing food insecurity.

Keywords: Land suitability; evaluation; GIS; remote sensing.

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INTRODUCTION

The early historical occupation of a civilized man is agriculture; Mankind commenced their farming operation from shifting cultivation to intensive farming. With the improvement in farming activities, man start to know more about crop cultivation and land uses. The population of the planet is growing dramatically and in order to meet the increasing demand for food, the farming community has to produce more and more food. However, under the present situation where land is scarce, it is imposing to bring more area under cultivation to satisfy the growing demand (Teka and Haftu, 2002).Improper land use leads to land degradation and decline in agricultural productivity. However, in practice particularly in Nigeria, the use to which land is put is not often related to the land potential capacity for its use type, it is observed that much of the agricultural land used currently is below its optimal capability in different parts of the globe (Esa, 2014).

The ability of land to tolerate the production of crops in a sustainable manner is referred to as land suitability. In order to increase food security and production, crops need to be grown in areas where they are best suitable, to achieve this, land suitability analysis is required (Kihoro, *et al*., 2013).Suitability of land is assessed considering rational cropping system, for optimizing the use of a piece of land for a specific use (FAO, 1976, Sys *et al*.1991).According to Baniya (2008), GIS has the ability to perform many tasks utilizing both spatial and quality data stored in it. Remote Sensing provides the information about the various spatial yardstick/ factors under consideration. Remote Sensing can provide information like land use/cover, drainage density and topography. Kamau *et al,* (2015) carried out a study on the Crop-land Suitability Analysis Using GIS and Remote Sensing in Nyandarua County, Kenya. Baniya Nabarath (2008) conducted research on land suitability evaluation using GIS for vegetable crops in Kathmadu Valley, Nepal.

Esa (2014) investigated the land suitability assessment for sorghum and maize crops in dera wereda, ANRS, Ethiopia. Halder (2013) studied the qualitative evaluation of land to determine land suitability in Ghatal block, Paschim Medinipur district, West Bengal for rice and wheat cultivation based on four pedological variables, like Nitrogen-Phosphorus-Potassium (NPK) status, soil reaction (pH), Organic Carbon (OC) and soil texture that are mandatory input factors for crop cultivation. Mustafa *et al*. (2011) investigated land analysis for different crops; a multi criteria decision approach using remote sensing and GIS. Bhandari (2013) conducted a study on land capability classification and crop suitability assessment in Dehradun Uttara khand watershed. Based on the review of previous work, there is little work on land suitability evaluation for selected crops using GIS and remote sensing in south western, Nigeria. This study focused on evaluation of selected crops and classification of agricultural land into highly suitable (S1), moderately suitable (S2), marginally suitable (S3), and not suitable (N) in relation to FAO guideline.

MATERIALS AND METHOD

Study Area

This study covered all the six states in South-western part of Nigeria which comprises of Lagos, Ogun, Oyo, Osun, Ondo and Ekiti States. It is also referred to as the south western geographical zone of Nigeria. It lies between longitude 2° 311' and 6° 001' E and Latitude 6° 211' and 8° 371' N with an absolute area of 77,818 km^{2}Popoola *et al*; 2015.The study area had 85 constituted forest reserves with a forest area cover of 842,499 ha. The climate of south-western Nigeria is tropical in nature and it is characterized by wet and dry seasons. The temperature measured between 21 and 34 °C while the yearly rainfall measures between 400 and 3000 mm.

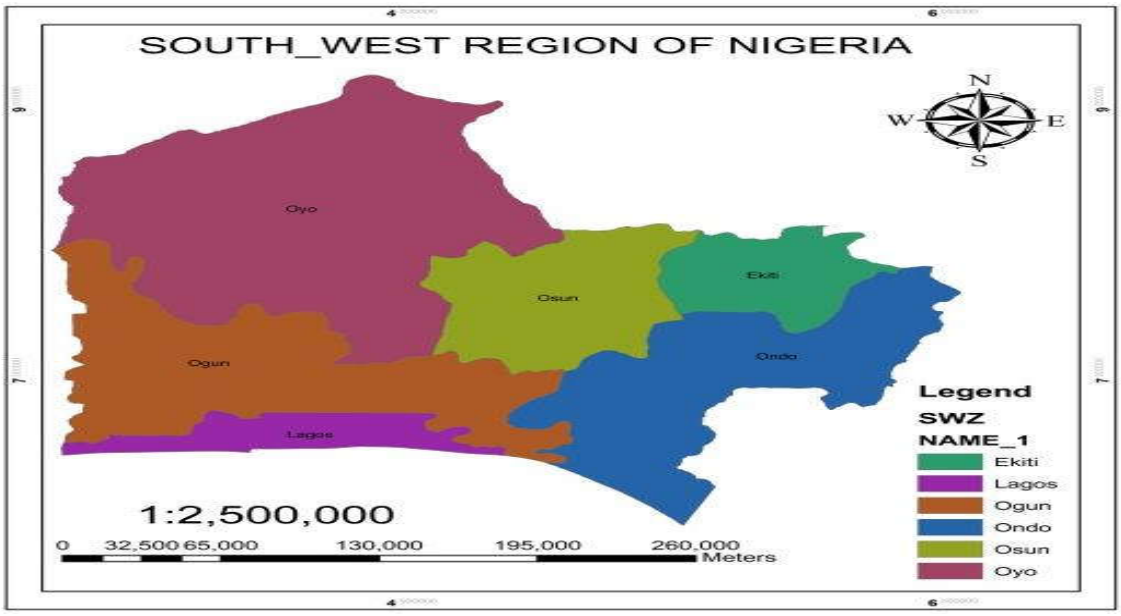

Figure 1: Map of the Study Area

DATA COLLECTION

The data acquired in achieving the objectives were;

i. **Soil data:** Soil data such as soil pH, soil texture, soil depth and soil drainage were obtained from International Institute of Tropical Agriculture (IITA) Ibadan.

ii. **Satellite data acquisition:** The satellite imageries (Landsat ETM) of each state in South-western of Nigeria for year 2015 were acquired from Global Land Cover Facility hosted by Maryland University USA (GLCF) with spatial resolution of 30m.

iii. **Field data:** Ground truth data of 10 sample points location at each state were obtained by using hand-held Global Positioning System (GPS) with an accuracy of 1 to 10 m

iv. **Weather data:** Weather data for the study area from 2011 to 2015 (5 years) were obtained from IITA meteorological station in Ibadan, Nigeria. The weather variables useful in the suitability evaluation to be derived are mean annual temperature and rainfall of the study area.

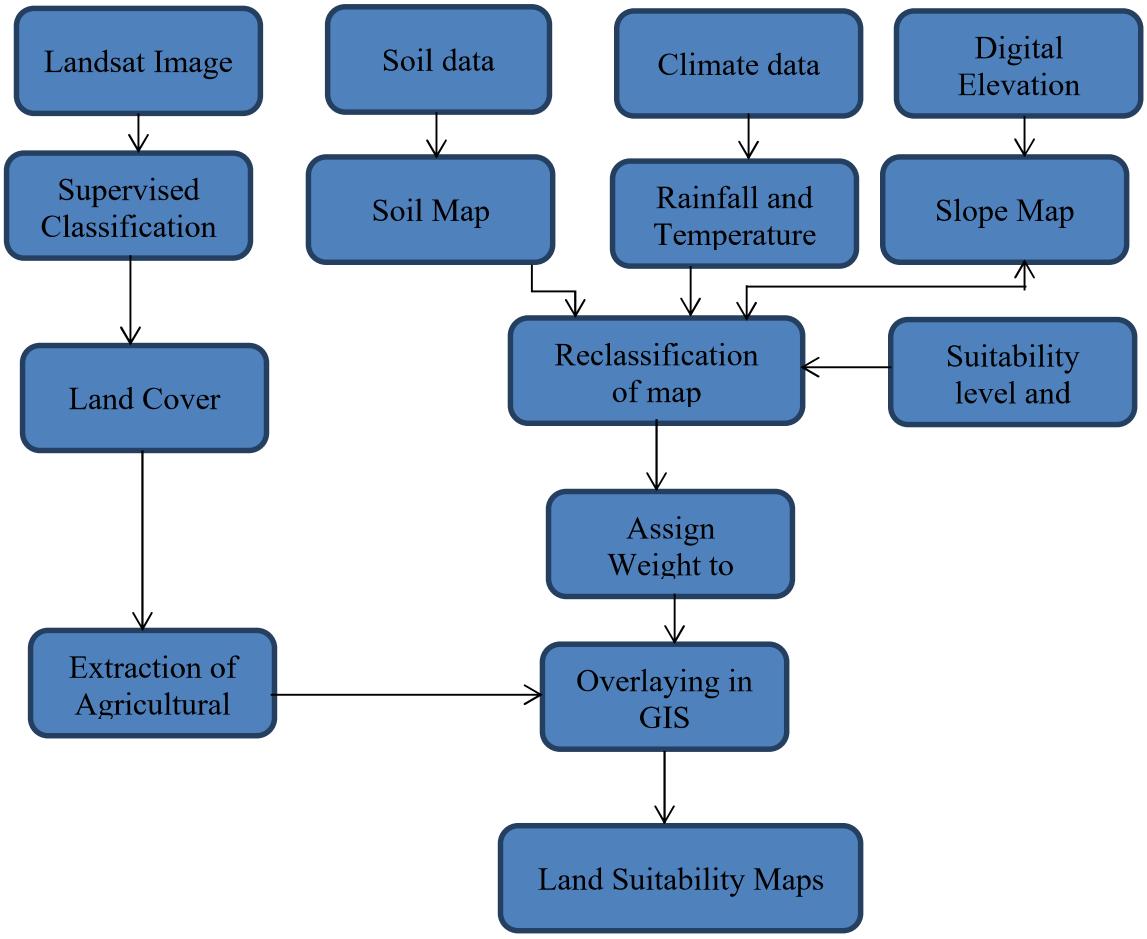

Figure 2: procedures for data collection and analysis

The procedures shown in Figure 2 were adopted to discuss the method and to maintain Geographical Information System (GIS) phenomenon in the evaluation of land suitability for selected crops in south western Nigeria. Firstly, the image was featured to amend errors; secondly the corrected image was classified by making use of the supervised classification. Agricultural land was removed and incorporated with soil data, weather data and digital elevation model, which were overlaid into ArcGIS environment to offer land suitability map. The level of suitability depend on the structure of Food and Agriculture Organization (FAO) land suitability classification and ranked as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N). Suitability levels for each of the sub-criteria were defined based on the FAO structure for Land suitability. Multi criteria evaluation was used to find out the agricultural land area that is best suitable for selected crop within each state. Suitability test was carried on all the agricultural land and non-agricultural land area within the south western region. This will serve as a guide for future purposes if government or other private body wishes to establish agricultural project within the area where agricultural land has not extended to. For example, conversion of forest land to agricultural land. After the suitability test for all the states had been analysed overlay of agricultural land to each suitability analysis for each state was done, these were used to know the extent of S1, S2, and S3 for all the states involved.

RESULTS AND DISCUSSION

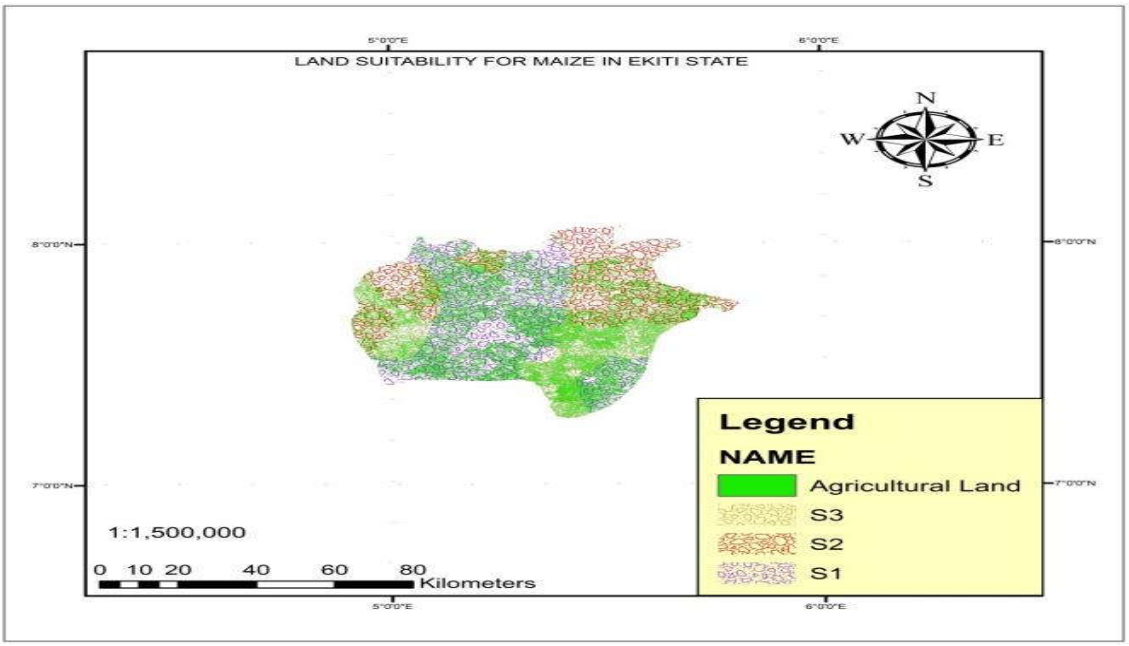

Figure 3: Land Suitability Map for Maize in Ekiti State

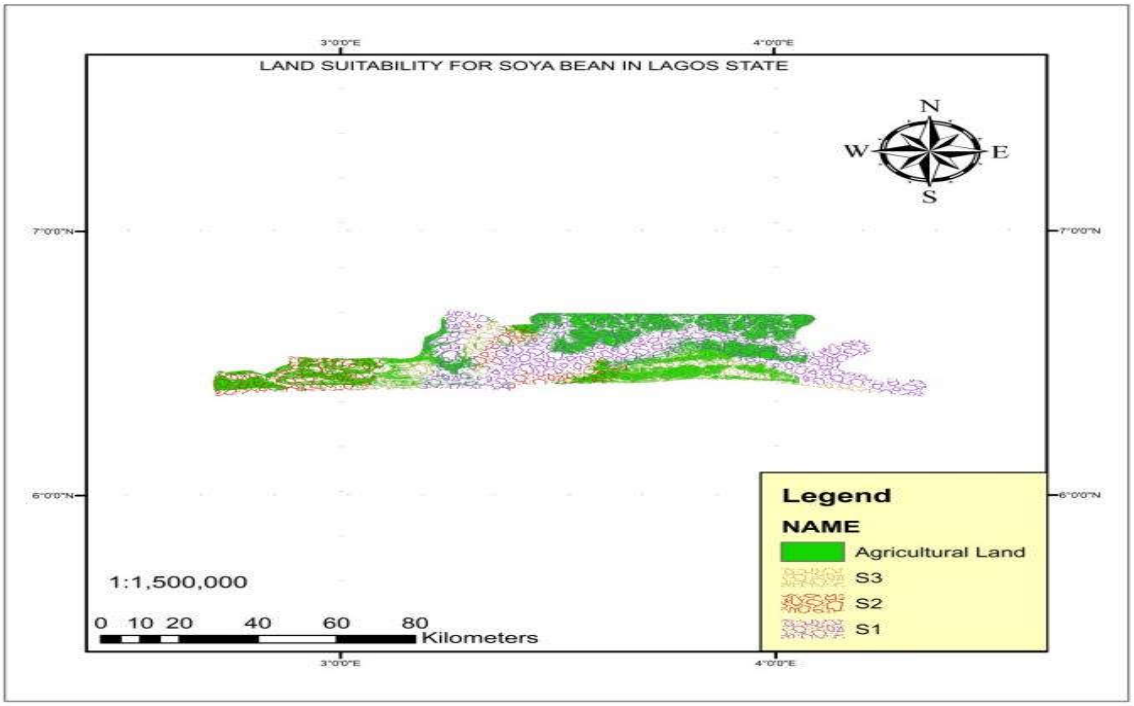

Figure 4: Land Suitability Map for Soya Bean in Lagos State

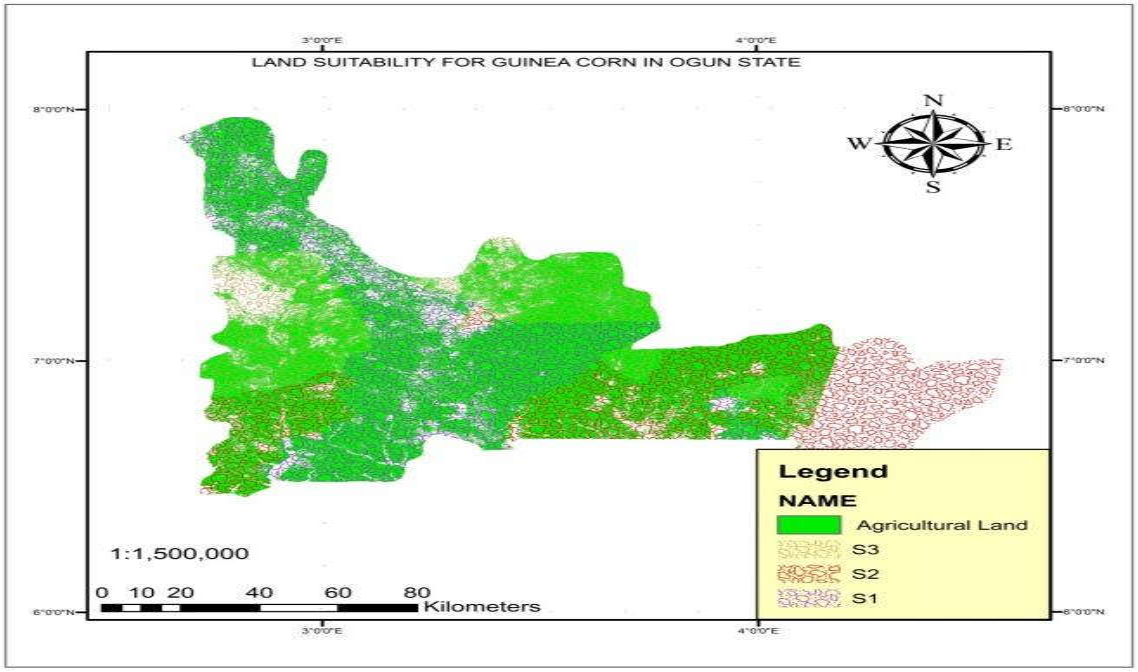

Figure 5: Land Suitability Map for Guinea Corn in Ogun State

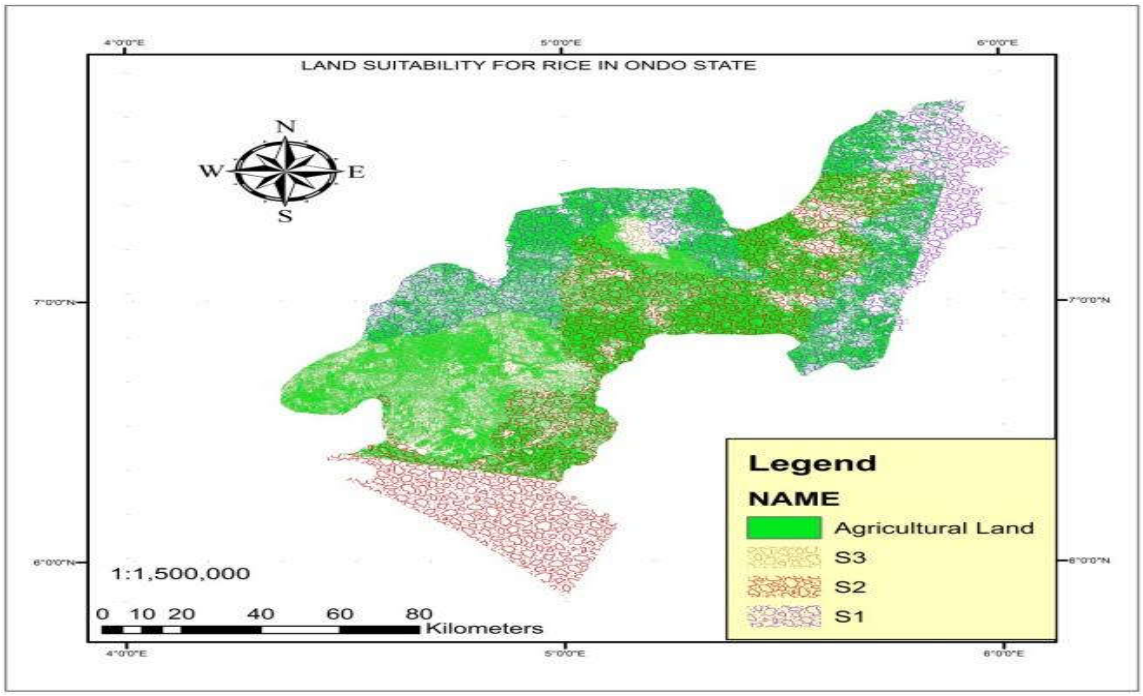

Figure 6: Land Suitability Map for Rice in Ondo State

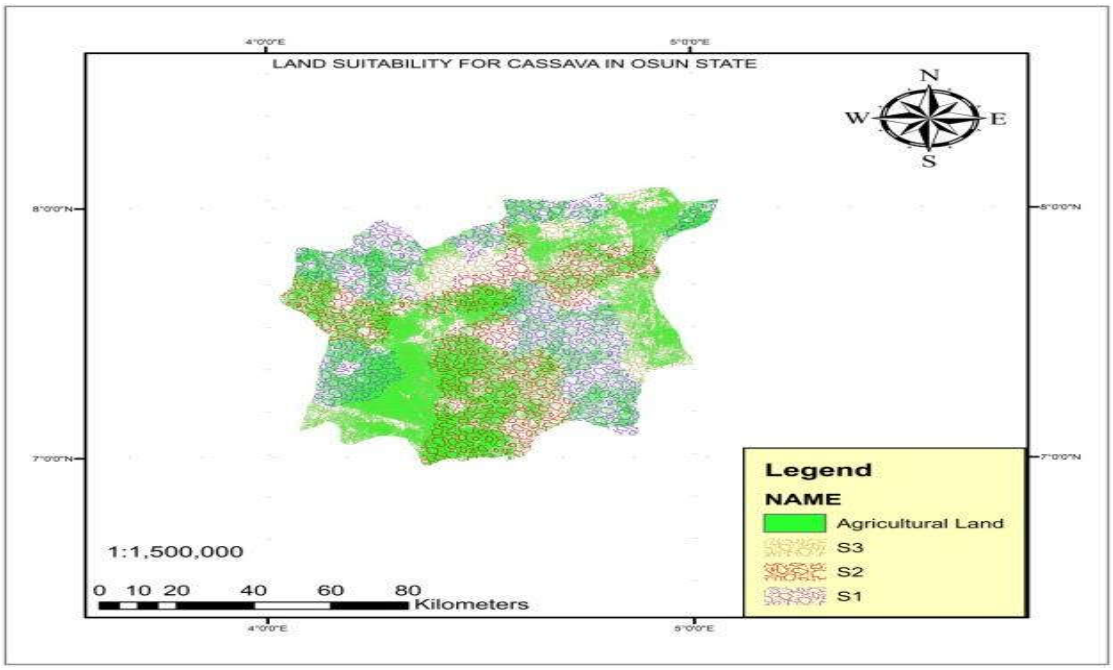

Figure 7: Land Suitability Map for Cassava in Osun State

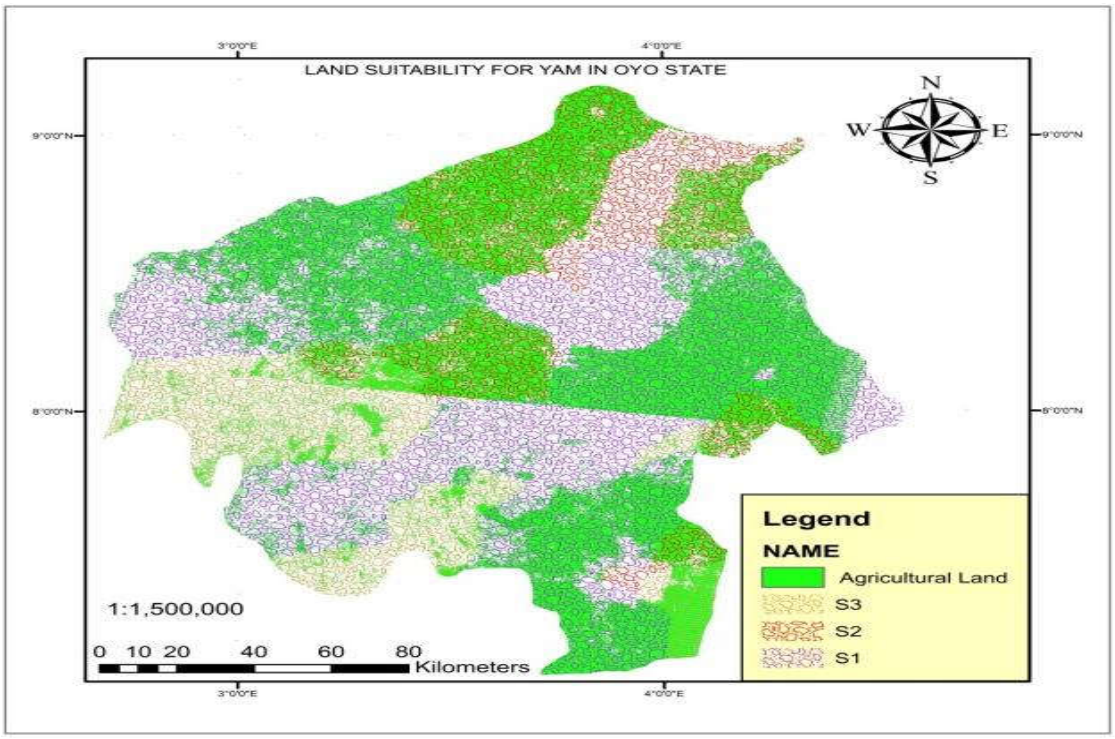

Figure 8: Land Suitability Map for Yam in Oyo State

Table 1: Crops analysed for in the study area

States	Crop
Ekiti	Maize
Lagos	Soya bean
Ogun	Guinea corn
Ondo	Rice
Osun	Cassava
Oyo	Yam

Table 2: Suitability areas in south western states for the selected crops

Suitability Class	Ekiti Area (Km^2)	Area (%)	**Lagos Area** (Km^2)	Area (%)	Ogun Area (Km^2)	Area (%)	Ondo Area (Km^2)	Area (%)	**Osun** Area (Km^2)	Area (%)	**Oyo** Area (Km^2)	Area (%)
S1	1260.44	64	444.26	54	1972.13	49	1424.51	33	984.32	33	4537.62	52
S2	531.75	27	279.72	34	1328.17	33	1683.51	39	1282.60	43	3228.69	37
S3	374.17	17	98.71	12	724.46	18	1208.68	28	715.87	24	959.88	

In this study, a total of six crop were evaluated and analysed, out of which three important cereal crops were rice, maize and guinea corn whereas yam, cassava belong to root crops and soya beans belong to annual legume. The choice of the crop in each assigned state was based on the prevalent land uses of the study area. The results are similar to that obtained by Esa, (2014) on land suitability assessment for sorghum and maize crops using a SLA and GIS approach in Dera Wereda, ANRS, Ethiopia. The suitability classes of agricultural land area covered by each crop in the study area were analysed and the figures were discussed in figures as land suitability map and table as area covered in percentage. Table 1 Shows the crop evaluated in each state of the study area.

Suitability analysis for maize in Ekiti State

Ekiti State with Agricultural land cover of 1969.43 Km^2 was evaluated with maize and the result shown the following suitability classes: 64% of agricultural land area was highly suitable (S_1) for maize production followed by 27% moderately suitable (S_2) while 19% was marginally suitable (S_3) the whole agricultural land area cover in Ekiti state was suitable for maize production as presented in Figure 3and Table 2.

Suitability analysis for soya beans in Lagos State

Lagos State has Agricultural land area cover of 822.71$km^2$and it was evaluated with annual legume of soya beans and results showed that the whole agricultural land was suitable for soya beans production and the suitability classes indicate that 54% of the agricultural land was highly suitable for soya beans (S_1) while 34% of the Agricultural land in Lagos was moderately suitable (S_2) as represented in Figure 4 and Table 2.

Suitability analysis for guinea corn in Ogun State

Ogun State has Agricultural land area cover of 4024.75 $km^2$and it was evaluated with guinea corn which belong to cereal crops, the analysis for suitability classes showed that 49% of the land cover; 1972.13 km^2 was highly suitable for guinea corn (S_1) while 33% of the land area was moderately suitable (S_2) for the crops in Ogun State each which accounted for 1328.17 km^2 as presented in Figure 5 land suitability map and Table 2 Suitability classes.

Suitability analysis for rice in Ondo State

Ondo State has agricultural land cover of 4028.75 Km^2 and it is the second large land area cover south-western Nigeria. The analysis was evaluated with rice which was cereals crop, the suitability classes show that 33% of agricultural land area is highly suitable (S_1), followed by 39% of the Agricultural land area which was moderately suitable (S_2) for rice production in Ondo State which is presented in Figure 6 and Table 2.

Suitability analysis for cassava in Osun State

Osun State was evaluated to have 2982.90km^2 Agricultural land area cover and cassava which belong to root crops was analysed and the results showed the following suitability classes 33% of the land was suitable for cassava production (S_1) followed by 43% was moderately suitably (S_2) for cassava production while 24% was marginally suitable (S_3). The land area cover is suitable for production as presented in Figure 7and Table 2

Suitability analysis for yam in Oyo State

In this study, yam was highly suitable (S_1) over 4537.62 km^2 land area cover, which accounted for 52% of the total area available for cultivation in Oyo State, only 37% was moderately suitable (S_2) which was 3228.69 km^2out of total Agricultural land area which was 8726.19 km^2, 11% was marginally suitable. Oyo State is very suitable for yam production from the evaluation carried out which revealed that 88% of the totals Agricultural land areas are highly and moderately suitable as represented in Figure 8 and Table 2. The result is similar to the study conducted by Udoh (2006) Land Suitability Evaluation for Banana (*Musa* spp.) Cultivation in Akwa Ibom State of Nigeria.

CONCLUSION

The land suitability evaluation of selected crops in south western, Nigeria has been determined and the suitability class had been defined. The study areas showed that south western, Nigeria agricultural land areas are all suitable for the cultivations of the selected crop in all the state in south western, Nigeria. Thus the land suitability evaluation for selected crops conducted will help the government, agricultural extension, planners and policy makers on the land that is suitable for the selected crop. The information and data generated by the study will help in climate change adaptation in order to plan smart agriculture. Therefore, a GIS based method cannot be overlooked in the study as a useful tool in land suitability evaluation for agricultural planning.

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