LAND SUITABLILITY STUDY FOR AGRICULTURE IN NIGERIA

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Key words: Interpolate, Localized, Transition, Suitability

1. SUMMARY

Agricultural products have contributed over the years to food security and rural economic development of transition countries such as Nigeria particularly in the aspect of localized farming. The Fadama (Hausa name for irrigable, low-lying plains underlain by shallow aquifers found along major river systems) farming scheme was introduced for sustained crop yield to help Nigerian farmers but evidence of crop yield decline year to year. The Fadama concept has been an old tradition in Northern Nigeria, where flooded and land liable to flooding are used for growing a variety of crops and small-scale irrigation sites. This research was aimed at identifying land suitability at Bansara in Ogoja Local Government Area, Cross River State employing Remote Sensing and Geographical Information System. The datasets were collected on various themes including climate map, soil map and satellite dataset. Image processing and interpretation skills were used to analyze satellite dataset to produce a digital elevation model, land cover/ land use and soil map. GIS was used to produce thematic maps, weighted ranking of attribute data and it was produced in three classes of suitability land (High, Medium and Low) through weighted overlay. Results revealed that some area were found to be high suitability land of 51.54% of total area of 17,024.580 hectares, the medium suitability land is 32.30% which the total area is 10,669.32 hectares and the low suitability land is 16.15% which the total area is 5,335.47 hectares. The results also revealed the capability of GIS and remote sensing as tools to analyze, interpolate, combine and compare the spatial data for land suitability study of Bansara, Ogoja.

Słowa kluczowe: Interpolacja, Lokalizacja, Przejście, Przydatność

2. SUMMARY (Polish)

Produkty rolne przyczyniły się na przestrzeni lat do bezpieczeństwa żywnościowego i rozwoju gospodarczego obszarów wiejskich w krajach przechodzących transformację, takich jak Nigeria, szczególnie w aspekcie lokalnego rolnictwa. Fadama (nazwa Hausa dla nawadnialnych, nisko położonych równin pokrytych płytkimi warstwami wodonośnymi znalezionymi wzdłuż głównych systemów rzecznych) został wprowadzony w celu utrzymania plonów, aby pomóc nigeryjskim rolnikom, ale dowody na spadek plonów z roku na rok. Koncepcja Fadama jest starą tradycją w północnej Nigerii, gdzie zalane i grunty podatne na powodzie są wykorzystywane do uprawy różnych upraw i małych miejsc nawadniania. Badania te miały na celu identyfikację przydatności gruntów w Bansara w Ogoja Local Government Area, Cross River State z wykorzystaniem teledetekcji i systemu informacji geograficznej. Zbiory danych zostały zebrane na różne tematy, w tym mapa klimatu, mapa gleby i zestaw danych satelitarnych. Umiejętności przetwarzania i interpretacji obrazu wykorzystano do analizy zestawu danych satelitarnych w celu stworzenia cyfrowego modelu wysokości, pokrycia terenu / użytkowania gruntów i mapy gleby. GIS został wykorzystany do stworzenia map tematycznych, ważonego rankingu danych atrybutów i został wyprodukowany w trzech klasach przydatności gruntów (Wysoki, Średni i Niski) poprzez nakładkę ważoną. Wyniki ujawniły, że niektóre obszary uznano za grunty o wysokiej przydatności wynoszące 51,54% całkowitej powierzchni 17 024 580 hektarów, grunty o średniej przydatności wynoszą 32,30%, których całkowita powierzchnia wynosi 10 669,32 hektarów, a grunty o niskiej przydatności wynoszą 16,15%, a całkowita powierzchnia wynosi 5 335,47 hektarów. Wyniki ujawniły również możliwości GIS i teledetekcji jako narzędzi do analizy, interpolacji, łączenia i porównywania danych przestrzennych do badania przydatności gruntów Bansara, Ogoja.

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1.1 Background to the Study

Inappropriate agricultural land uses and management practices had contributed to the decline in land quality and crop yield. This phenomenon is enhanced as a result of the increasing rates of wind and water erosion and accelerated rates of soil acidification, nutrient decline, and carbon losses FAO (2000). The federal agricultural development and management agencies (FADAMA) arable land mapping and management practices will be major approach for improving the management of land resources for FADAMA farming. In this era, a key developmental agenda for many developing countries is the development of their agricultural base through irrigation. The irrigated landscape remains very dynamic. There remain considerable uncertainty about the exact extent, area and cropping intensity of irrigation in different parts of the world, due to the dynamics and systematic problems of under reporting and over reporting of irrigation in different contexts and country (FAO, 2000). FAO (2000) identified Nigeria as a nation technically unable to meet their food needs from rain fed production at a low level of inputs and appears likely to remain so even at intermediate levels of inputs at some point in time between 2000 and 2025. The Nigerian farming systems are still mainly small holder-based and agricultural land holdings are scattered and simple, low-input technology is employed, resulting in low-output labour productivity.

Farm sizes in most countries ranges from 0.5 hectare in the densely populated high-rainfall South to 4 Hectares in the dry northern part of the country (FAO, 2000). FADAMA/ wetlands have been used for dry season farming in Nigeria and it has contributed greatly to food crop production in the semi-arid and arid regions of Nigeria. Over the years many farmers cultivates small areas in FADAMA during the dry season, using water directly obtained from streams and rivers manually or using electrical power generators to pump water into their lands. There are actually FADAMA areas in the Cross River State, but they have been observed not to be common or not developed, just as in other part of the Niger-Benue trough of the middle belt of the country (Balogun, 2001). The major FADAMA areas are located along the flood plains of the major rivers. FADAMA farming in Cross River State has traditionally depended on rainfall in the wet season as well as residual moisture during the dry season. The wet season recession crops they depend on is mostly rice. Over the years, farmers are encouraged to engage in FADAMA farming by Cross River State Agricultural Development Programme (ADP) with strong financial push coming from World Bank.

Remote Sensing (RS) technology produces an authentic source of information for surveying, identifying, classifying, mapping, monitoring and planning of natural resources and disasters mitigation, preparedness and management as a whole. Multispectral, temporal and spatial satellite imaging has been extensively used in developed countries for water resources studies, monitoring and management of agricultural lands (Pramanik et. al., 1992). Geographic Information System (GIS) can integrate RS and different data sets to create a broad overview of potential FADAMA area. This approach to FADAMA farming planning enables communities and concern agencies to potent and increases their productivity. One of the potential approaches of doing this involves the use of Digital Terrain Modelling (DTM) to map out areas that are favourable for FADAMA farming. The DTM presnts a bare-earth model, devoid of landscape features. A DTM is a quantitative representation of the topography of the earth (or any surfaces) in a digital format. The DTM is also a valuable component in analyses involving various terrain characteristics such as profile, cross-section, line of sight, aspect and slope. The uses of DTM also encourages, flood mapping, Urban planning, agricultural planning etc (Natale et. al., 2007).

Data for FADAMA potential areas either in statistical form or map that could help to propose short and long term planning for FADAMA farming in Cross River State are not readily available, as such it is essential to have reliable maps showing areas favourable for FADAMA farming. Such maps will also be a prerequisite for land development strategy and action plan towards FADAMA farming development and agricultural crop production at large. Researchers are therefore needed that demonstrates how RS and GIS techniques can be useful in mapping areas that are favourable for FADAMA farming and the need for such studies constitutes the main aim of this study. Thus, implementing a GIS analysis will be part of a larger, long term effort to gain a better understanding of flood plains favourable to FADAMA farming.

1.2 Aim and Objectives of the Study

This study is aimed at land suitability study for FADAMA Farming in Bansara, Cross River state. The particular objectives include:

1. Create land suitability map of the study area
2. Determine low, moderate and high suitability land of the study area
3. Identify and analyze crops suitable for the study area

1.3 Study Area

Bansara is situated in Ogoja, Cross River, Nigeria, its geographical location is between longitude 8°30'19.058"E and 8°36'40.887"E and latutude 6°25'29.393"N and 6°30'9.401"N (See Figure 1). Ogoja is a big town in Cross River State, Nigeria. The name Ogoja is wildly used in Northern Cross River it is one of the Local Government Area (LGA), Cross River with its headquarters is Ogoja town. It has an area of 972 km² and a population of 171,901 at the 2006 census, (NPC, 2006).

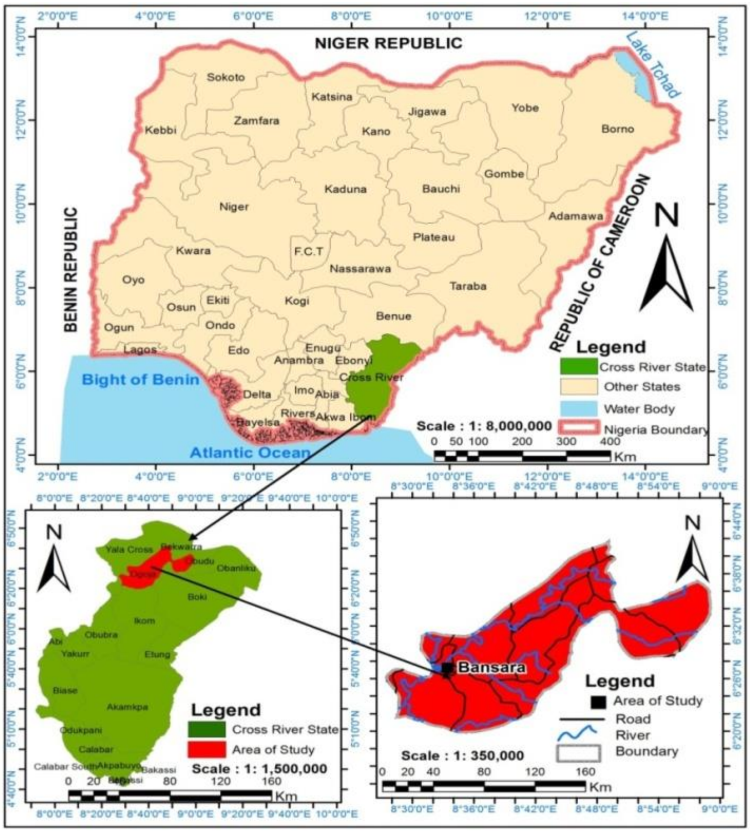

Figure 1: Showing the map of the Study Area obtained from OSGOF (2018)

The people of Ekoi are the major habitants of the city, the town was one of the provinces during pre-colonial independence. The area consists of many tribes, which includes: Ishibori (This village has different clans like Uhmuria, Ikaptang, Ikajor, Ishinyema, Ikariku, Imerakorm) and Igoli as the central town. Mbube being one of the major tribes consist of different villages which includes: Odajie, Adagum, Ekumtak, Idum, Ojerim, Egbe,Nkim, Ogberia Ogang & Ogberia Ochoro, Oboso, Benkpe, Edide, Bansan, Aragban etc. Ekajuk is one of the major clan in Ogoja Local Government Area. Divided into Ward I and Ward II, and includes major Communities such as Nwang, Ekpogrinya, Esham, Egbong, Nnang, Ewinimba and Bansara. The major source of livelihood in Ogoja LGA of Cross River State Nigeria is subsistence agriculture, basically farming of cassava, yams, palm oil, palm wine etc. The desire to maintain the food basket status of Ogoja has prompted the council to do all within the limits of its resources to promote agriculture. The area also have food crops and very rich trees of different species. Consequently, to boost farming, the council has assisted farmers in planting over 10,000 oil palm trees have so far been planted (Rilwani and Gbakeji, 2009).

2.1 Literature review

Several studies have been undertaken to assess land suitability and various methods to integrate spatial and land characteristics in land evaluation studies for agriculture. GIS and remote sensing provide a platform which allows for manipulation of data using fuzzy logic (Baja et. al., 2001). Therefore GIS and remote sensing have become modern tools which can aid in bottom-up planning for a variety of problems confronting rural dwellers (Rasmussen et al., 1999; Twumasi et. al., 2003; Twumasi, 2005).

2.2 Land suitability and Suitability Criteria

Land suitability is the fitness of a given type of land for a defined use. The land may be considered in its present condition or after improvements. The process of land suitability classification is the appraisal and grouping of specific areas of land in terms of their suitability for defined uses. Each plant species requires definite soil and site conditions for its optimum growth. Most of the plant species need well drained, moderately fine to medium texture soils, free of salinity and having optimum physical environment. Soil resource maps based on several parameters, can aid in predicting the behavior and suitability of soils for growing field crops, horticultural crops, forest species and other plantation crops once the suitability criteria is established. Within limits, it may also find application in transfer of technology to other areas with comparable soil-site characteristics. Several systems of land evaluation have been proposed for use in different regions, the important being that of Storie (1954) and Ricquier et. al. (1970).

2.3 GIS and land evaluation for agriculture in Nigeria

Despite the utilitarian value of GIS and remote sensing in land evaluation for sustainable agriculture which has been emphasized, the practice is still relatively an emerging technique in Nigeria. Nuga (2001) reviewed the application of GIS for sustainable land resource management in Nigeria. Nuga (2001) reported that the current methods of land evaluation for agriculture in Nigeria suffer from a number of inherent deficiencies that limit their usefulness as a tool for effective land use planning. Rilwani and Gbakeji (2009) examined the challenges and prospects of geomatics in agricultural development in Nigeria. A critical analysis of the prevailing situation in Nigeria revealed the shortcomings of the current methods of data collection, analysis and management. The challenges of agricultural development highlighted in Rilwani and Gbakeji, (2009) include technological development, inconsistency and inept implementation of government policies, low level of investment, small land assets, diversity of cultivation systems and market imperfection. The study emphasized the need to adopt RS and GIS to improve agricultural productivity to meet the nutritional need of the teeming Nigerian masses as well as for export income. The study showed that there are numerous crop-yield prediction models that relate crop yields to a single set of factors. These models have been inadequately applied, largely because they are specifically located.

Most of the models are factors of crop production such as socioeconomic factors and climate are held constant. There is, therefore, a need to utilize comprehensive land evaluation methods for crop farming in Nigeria in line with the new concept of precision farming. The need for the integration of GIS with processes of land evaluation, for improved quality of land decisions and sustainable land use and management was emphasized. Uchua et. al. (2012) mapped and analyzed agricultural systems in the lower river Benue basin in Nigeria using various GIS software to identify relationships between variables responsible for agricultural systems in the lower river Benue basin. Uchua et. al. (2012) analyzed the locational characteristics of various agricultural systems such as upland cereal, tuber-based, plantation or tree crop, and agro-forestry. Uchua et. al. (2012) acknowledged the recession of the Lower River Benue which has led to some adverse ecological changes and the decline of agricultural production in the face of rapid population growth in the area. Mustafa et. al. (2011) in the study of land suitability analysis for different crops using Multi Criteria Evaluation (MCE) approach, remote sensing and GIS, found that Analytical Hierarchy Process (AHP) is a useful method to determine the weights. Khoi and Murayama (2010) used a GIS based MCE of biophysical factors and LANDSAT imagery to delineate the areas suitable for cropland in protected area-buffer zone of Tam Dao National Park region, Vietnam. Other studies using this approach include; Suitability analysis for rice growing sites using a MCE and GIS approach in great Mwea region, Kenya (Kihoro et. al., 2013) and land suitability analysis using MCE approach and GIS for Tabriz County, Iran, (Feizizadeh and Blaschke, 2012).

3.1 Methods and Materials

The data utilized in carrying out this research work will be collected from secondary sources and manipulated to produce required data. The materials, data and software to be used in this study will include the following: Data on climatic parameters (2000 - 2014) were collected from The Nigerian Meteorological Agency. The LANDSAT Satellite imagery was obtained from Global Land cover Facility (GLCF) through the earth explorer platform. LANDSAT 8 OLI-TIRS of 30 metres (m) resolution acquired on 23rd September, 2018 data was obtained for the study area which had ortho-rectified the systematic radiometric, atmospheric and geometrical distortions of the imagery to a quality level of 1G before delivery (USGS, 2015). The LANDSAT Scene covered a region of approximately 181km x 185km and had a spatial resolution of 30m. The LANDSAT scences of Path/ Row (188/ 055) covers the study area while the topographic maps of the study area were obtained from the Office of the Surveyor General of the Federation in Abuja. The topographic map sheets were at a scale of 1:50.000 for more details to be captured. The NASA's Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) GDEM has provided digital elevation data for over 80% of the globe. This data was downloaded from the National Map Seamless Data Distribution System (www.http://gdex.cr.usgs.gov/gdex/). The elevation details was obtained from the ASTER using the Global Mapper 15 software and compared with the contour extracted from the topographic map using the ArcMap10.1 software. To have a full understanding of the topography, maps were derived for theme such as climate, drainage and soil.

3.2 Drainage pattern from Digital Terrain Model

The 30m spatial resolution digital elevation model ASTER GDEM will be obtained from Aster Global Digital Elevation Map (http://gdex.cr.usgs.gov/gdex/) and will be used to generate slope, altitude and aspect. The ARC GIS 10.1 (Extension spatial analyst) was used for the data analysis. After the point map was generated, contour map was created which shows the joining of the areas with equal elevations. Grid interpolation was carried out which resulted to digital elevation model (DEM).

The DEM is in grid from which is in pixels that is in block form or in rows and columns. This is called raster. From the DEM, slope map was created. The contour map was interpolated at 10m interval and two dimensional (2D) formats, signifying the variations in height and x, y co-ordinates. Aspect map of the DEM was also generated, which defines the direction of the flow. The flow accumulation which defined the drainage pattern was also created.

3.2.1 Digitization of Soil Map

The Nigeria soil map was collected from Soil Survey Division, Federal Department of Agricultural Land Resources (FDALR), Kaduna and will be used to extract the soil information of the study area. Field capturing of data was done based-on basic survey principles and techniques. The map was geo-referenced and digitized in ArcGIS 10.1. The vector soil map was then converted to raster for further processing.

3.2.2 Image Classification

The remote sensing analyses for the research included Land cover and Land use analysis and Normalized Difference Vegetation Index (NDVI) evaluation. These two (2) analyses were achieved using a combination of software (Erdas Imagine 9.2 and ArcGIS 10.1) and geo-processing operations. The spatial analyses were done in ERDAS software while the cartographic processing was achieved using the ArcGIS 10.1 software.

3.2.3 Land Cover/ Land Use

The current LCLU will be determined from LANDSAT satellite image downloaded from USGS website (https://earthexplorer.usgs.gov/). LANDSAT 8 OLI-TIRS of 30m resolution acquired on 23 September 2018. The image will be preprocessed and classified by using supervised classification method with the support of unsupervised classification in ERDAS Imagine 9.2 software. In preprocessing stage, radiometric and geometric correction will be performed to correct and enhance the image spectral quality. During image preprocessing, image will also be layer stacked and create a subset later image classification will be performed by collecting signatures from each class. The LANDSAT imagery was ortho-rectified, after which, a subset of the study area was made from the scenes of LANDSAT imagery downloaded. This subset was done using the ArcGIS 10.1. From empirical analysis and Principal Component Analysis (PCA), it has been proven that the bands that carry the greatest information about natural environment are the visible (Near Infra-red, Red, Blue and Green) wavelength bands. Classification involved labeling the pixels belonging to particular spectral classes using the spectral data available. The supervised method of classification was used which gave rise to the training sets. Using the Erdas Imagine 9.2 a true colour composite was made in Red, Green and Blue (RGB) representing Bands 3, 2 and 1 respectively. The tool considered both the variance and covariance of the class signatures as it assigned each cell to one of the classes represented in the signature file. With the assumption that the distribution of a class sample was normal, classes were characterized by the mean vector and the covariance matrix. Given these two characteristics for each cell value, the statistical probability was computed for each class to determine the membership of the cells to the class.

3.2.4 Vegetation Index

The NDVI is expressed as the difference between the Near-Infrared and Red bands normalized by the sum of those bands. This is the most commonly used vegetation index as it retains the ability to minimize topographic effects while producing a linear measurement. The NDVI was calculated using the empirical format by Rouse et. al. (1973). NDVI, the normalized difference vegetation index, is a quantity used to assess the presence of live green vegetation. NDVI is computed using the formula:

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)} \quad 3.1$$

The RED and NIR stand for the spectral reflectance measurements acquired in the red and near-infrared regions of electromagnetic spectrum, respectively, where NIR is near infrared Band and RED is Red edge data NDVI takes values from -1 to 1. The higher the NDVI, higher the fraction of live green vegetation present. LANDSAT band 4 (0.77 - 0.90µm) measures the reflectance in NIR region and band 3 (0.63 - 0.69µm) measures the reflectance in the Red region. To calculate NDVI is to use the ‘reflectance’ of bands 3 and 4. Reflectance is defined as the fraction of incoming radiation that is reflected back to the surface. Using ArcGIS 10.1 the Image analysis tool was tool can convert the digital numbers of LANDSAT bands into the apparent surface reflectance. That reflectance’s can then be used in the NDVI computation to produce a more consistent value for NDVI that does not change with time of year and sun angle.

3.2.5 Analysis of the rainfall and temperature quantity

Rainfall data was collected from Centre for Basic Space Science (CBSS) and the National Space Research and Development Agency **(**NASRDA**)** in Port Harcourt River State, the SPSS Statistical software was used to calculate the Sum of Rainfall, and the annual average precipitation. The thermal band 6 of LANDSAT ETM^+ was downloaded from United State Geological Survey and was processed to obtain surface temperature using Map Algebra Raster Calculation of ArcGIS 10.1.

3.2.6 Multi-criteria parameter for land suitability

Multi Criteria Parameter for land suitability is a process of integrating multiple layers of date set. Matching crops with their specified requirement which is suitability evaluation, this method takes the most limiting factors to define the land suitability classes. Selected parameters were placed in suitability classes by matching with the requirements of selected crops. All the suitability parameter was listed in tabular form for GIS weighting. Data will be measured on different units as well as on different scales of measurements. Operations such as vector to raster conversion, reclassification, weighted overlay etc. were performed at this stage using the ArcGIS 10.1 software and its geo-processing tools in Arc Toolbox. A "Weighted Overlay Operation" was adopted using GIS techniques for identification of areas of the different crop suitability depending on a number of thematic layers and based on the principle of Multi-Criteria Evaluation. The ArcGIS 10.1 software was used to create the various thematic maps from available data. The maps (rainfall, drainage, temperature, DEM, Land Cover Land Use and soil) were converted from vector format to raster format using the conversion tools in Arc Toolbox for use in the GIS weighted overlay operation. Using the spatial analyst tools in Arc Toolbox, the various raster maps were reclassified. A scale of 1 to 3 was adopted to indicate the level of importance. Value 3 represented highly suitability while Value1 represented not important. The crop suitability maps were created through the weighted overlay geo-processing tool in ArcGIS 10.1 Arc Toolbox by using the weights assigned to each of the parameters (climate, soil, Land Cover, and DEM). The multi criteria steps adopted are setting the goals, determine the criteria, standardize the factor, determine the weight by ranking or by rationing and aggregating the criteria using formula is;

$$S = \sum wi\, Xi\, x\, \pi cj \quad 3.2$$

Where: S = Composite suitability score

X_i = Factor score (cella)

W_i = Weight assigned to each factor

C_j = Constraints (or Boolean factors)

πc = Product of constraints (1 - low, 2 - moderate and 3 - high suitable)

3.2.7 Classification of land suitability

The selections of crop varieties was made based on their dominant grown, their importance and low productivity as explained by experts and farmers in the studied area. The GIS multi criteria parameter are expressed by defining optimal, marginal and unsuitable conditions for each land attribute that directly or indirectly influences plant growth, performance and biomass production (Sarkar, Ghosh & Banik, 2014). All the vectors data was convert in raster data for proper integration of Logical and arithmetical statement for suitability analysis using the raster calculation tool in ArcGIS10.1. All the parameters were compared against each other in a pair-wise comparison matrix which was a measure of the relationship between the parameters in order to rule out bias, subsequently, a numerical value expressing the level of importance of one parameter against another was assigned. After the preparation of all the thematic layers, reclassification as well as preparation of the table of weights, the weighted overlay operation was performed on the ArcGIS10.1 software using five (5) classes, the various layers were classified from very high suitability to very low suitability. Suitability maps were created for certain selected crops. Each raster was assigned a percentage of influence according to its importance derived for each crop.

4.1 Digital Terrain Model (DTM) and the Relief Maps of the Study area

From figure 2 below, the legend indicate the elevation ranging from 21m to 152m. The elevation plays a large role in the health and growth of crops. Elevation may affect the type and amount of sunlight that plants receive, the amount of water that plants can absorb and the nutrients that are available in the soil. As a result, certain plants grow very well in high elevations, whereas others can only grow in middle or lower elevations. From 152m to 108.33m the elevation is high. The crops in higher elevations typically receive more direct sunlight than plants of lower elevations. In addition, these plants receive a special type of sunlight, which has short-wave radiation. Whereas this poses an advantage for higher elevation plants because they receive more sunlight that they need to grow, it can also damage the plants if the short-wave radiation exceeds a certain amount. Area ranging from 108.33m to 64.66m at medium elevation will received normal sunlight that will make the crops grow in addition with the temperature and the rainfall amount of the area. Area ranging from 64.66m to 21m is the lower elevation. Lower elevation plants typically require less sunlight, and they are safer from many short-wave radiation waves, which do not reach farther down into lower elevation regions of earth's surface. At the top of the hill, most rain and irrigation will run off downhill, and not be available to the tree. This can put the tree under some amount of drought stress, which may affect fruit quality and yield. At the bottom of the hill, there are risk problems with saturated soils, which can lead to root- and crown-root.

4.2 Slope Analysis of the Study area

Slope is the measure of steepness or the degree of inclination of a feature relative to the horizontal plane. Gradient, grade, incline and pitch are used interchangeably with slope. Slope is typically expressed as a percentage, an angle, or a ratio. The profile curvature is the shape of the surface in the direction of the slope provides insight on the acceleration and deceleration of water flow, which influences flooding, erosion and deposition of organic and inorganic materials. From the figure 3 below, the areas ranging from 0 to 2.38% has a steep-slope; it will be flood prone areas, and less erosion area, because of slow movement of the run-off during precipitation. The water tends to flow faster from areas of higher elevation to the areas of lower elevation because of variation in height which affects the slope of the terrain. The areas ranging from 2.38% to 5.62% will be more vulnerable to erosion and flood free areas. The High Slope area is not suitable for Cultivation, the heavy rain, the rainwater wash away good soil off hillside right down to the bottom of the hill. This washes the topsoil. And the topsoil contains most of soil’s nutrients and organic matter. The areas ranging from

5.62% to 27.58% will be brightly vulnerable to erosion and flood free zone area, because of its higher slopping elevation.

4.3 Soil Characteristic of the Study

Soils vary greatly in their chemical and physical properties which depend on their age and on the conditions (climate, topography and vegetation) under which they were formed. Inorganic material is the major component of most soils. It consists largely of mineral particles with specific physical and chemical properties which vary depending on the parent material and conditions under which the soil was formed. It is the inorganic fraction of soils which determines soil physical properties such as texture and has a large effect on structure, density and water retention. The type of soil determines how well it is suitable to plants. The figure 3 above shows that the soil textures in our study area are mainly sandy clay and sandy loam. Soils support plant roots and provide plants with oxygen, nutrients and water. How well they do this depends on the soil particle type and size. Sand is the largest particle, silt is smaller and clay particles are tiny. Loamy soils have a combination of all three particle sizes, and sandy loam contains about 60 percent sand, 10 percent clay and 30 percent silt. It has good drainage and can grow many types of plants well, especially if it's amended so it contains more organic matter.

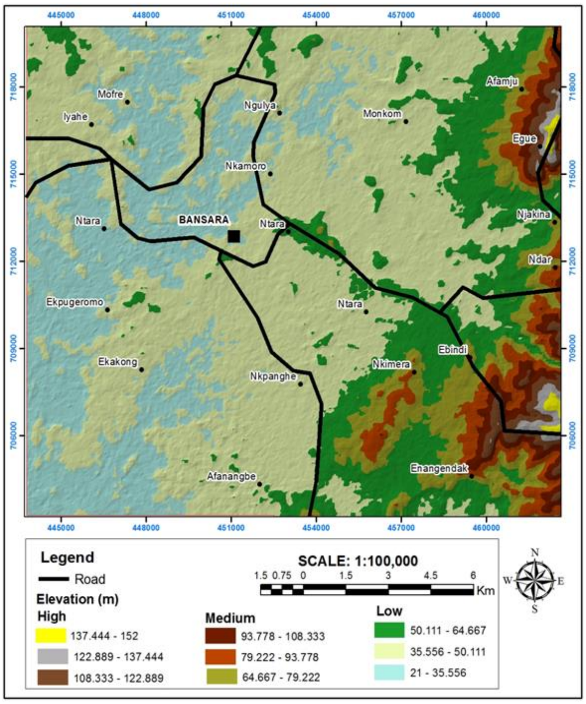

Figure 2: Digital Elevation model of the Study Area

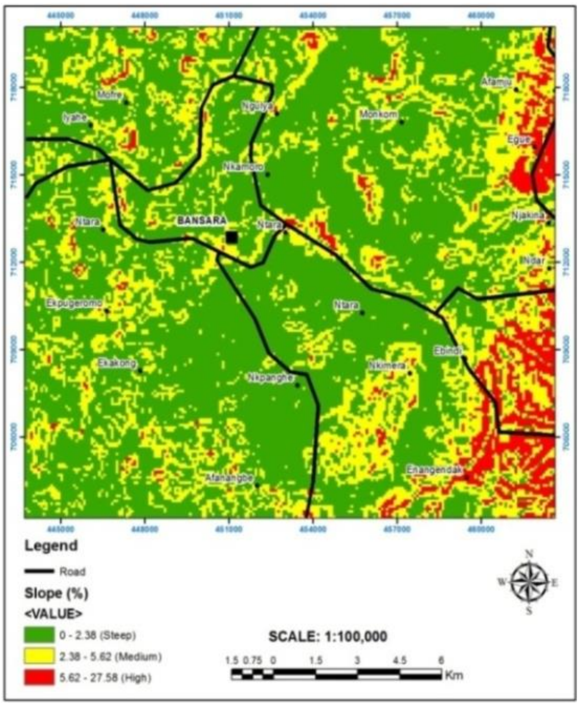

Figure 3: Slope Map of the Study Area

4.4 Determine the Land Cover/ Land use using supervised image classification

The Figure 4 below shows that the LCLU of the study area is composite of five (5) classes such as built up area, farm land, light forest, heavy forest and River. The total of 367,778 pixels were used to extract an area of 33.100km^2 (33,100.00 hectares). The table 1 revealed that built up area accounted for 5.35% about 17.692km^2 of the study area while Farm land accounted for 71.494km^2 almost 21.60%. The light forest accounted for 88.935km^2 almost 26.87% and heavy forest was 147.487km^2 at almost 44.56%. The water body including all river tributary of the area accounted for 5.393km^2 almost 1.63%.

Table 1: Forest evaluation of the study area in 2018

Value	Class name	Pixels	Area (ha)	Area (km^2)	Percentage %
1	Built Up Area	19,658	1769.20	17.692	5.35
2	Farm Land	79,438	7149.40	71.494	21.60
3	Light Forest	98,817	8893.50	88.935	26.87
4	Heavy Forest	163,874	14748.64	147.487	44.56
5	River	5,992	539.26	5.393	1.63
Total		**367,778**	**33,100.00**	**33.100**	**100.00**

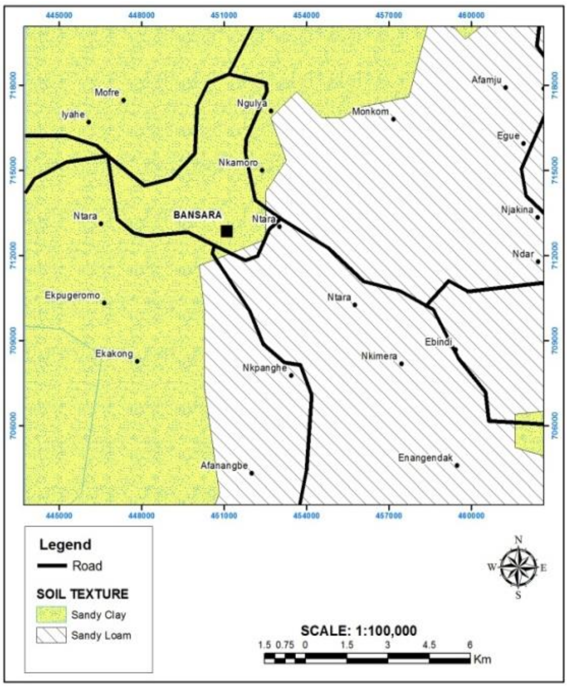

Figure 4: Soil Characteristics Map of the Study Area

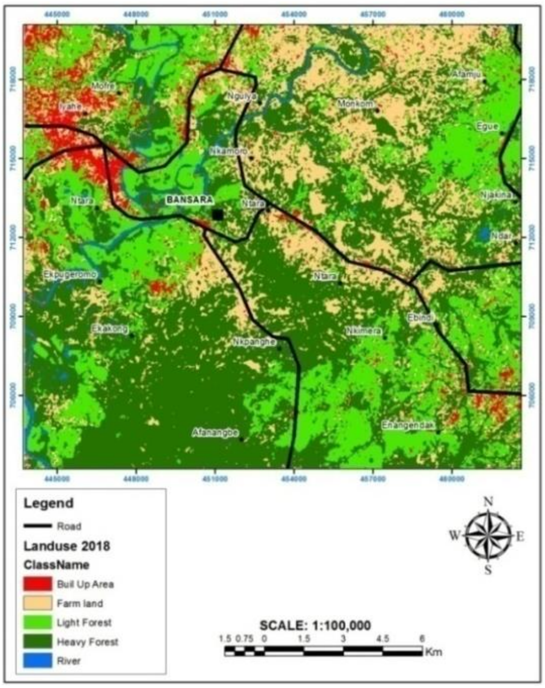

Figure 5: LCLU Map of the Study Area 2018

4.5 Evaluation of Top of Atmosphere (TOA) spectral radiance

The figure 5 shows the spectral radiance of vegetation in the study area, with the highest radiance was evaluated at 12.80 while the lowest was 8.95. The radiations that have a positive effect on plant growth are at lower radiation levels and harmful effects are at higher levels. Plants need some types of non-ionizing radiation like sun-light for photosynthesis. Though these solar radiations are vital for the survival of plants but some other forms of non-ionizing and ionizing radiations are dangerous to plants. Ultraviolet radiation affects plant growth and sprouting and the amount of damage is proportional to the radiation received. Due to radiation exposure soil can become compact and lose the nutrients needed for plants to grow.

4.6 Extraction of Normalized Difference Vegetation Index

NDVI shows vegetal heath condition over Bansara and surrounding area and figure 7 below has shown that from the spectral reflectance of vegetation the NDVI range 0.33 to - 0.03. The high reflectance was noticed around the vegetation area while the lower was at non vegetation area. Vegetation indices, which are determined by the spectral reflectance measurements, are believed to be the most reliable and nondestructive method for effective assessment of total dry matter (TDM), leaf area index (LAI) in wheat and barley and vegetation health and productivity. The estimation of Greenness of Crops in the spectral regions of red and near-infrared can be effectively measured by vegetative indices such as NDVI and simple ratio (SR). NDVI measures the amount of green vegetation in an area. NDVI is based on the principle that actively growing green plants strongly absorb radiation in the visible (VIS) region of the spectrum or photo-synthetically active radiation (PAR), while strongly reflecting radiation in the near-infrared (NIR) region.

4.7 Extraction of Land Surface Temperature

Land Surface Temperature (LST) of the study area represented in figure 5 shows maximum air temperature is 35.72^{o}C and minimum is 18.79°C in the study area. These derived temperatures from the LST calculation was justified in comparison with change in Land use pattern from the year. Rate of plant growth and development is dependent upon the temperature surrounding the plant and each species has a specific temperature range represented by a minimum and maximum. Responses to temperature differ among crop species throughout their life cycle and are primarily the phonological responses, i.e., stages of plant development. For each species, a defined range of maximum and minimum temperatures form the boundaries of observable growth. Vegetative development (node and leaf appearance rate) increases as temperatures rise to the species optimum level. For most plant species, vegetative development usually has a higher optimum temperature than for reproductive development.

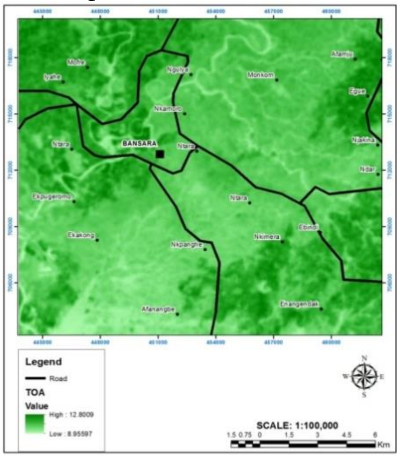

Figure 6: Top of Atmosphere (TOA) Spectral Radiance Map

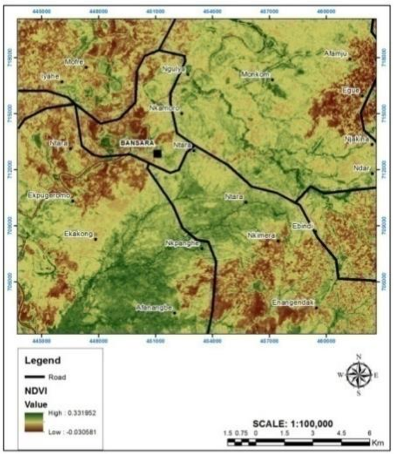

Figure 7: Normalized Difference Vegetation Index Map

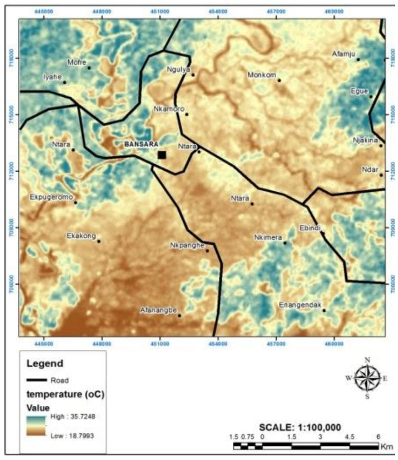

Figure 8: Surface Temperature Map

4.5 Evaluation of Suitability area for agriculture in the study area

From the table 2 below, it was determined that 51.54% (170.246km^{2}) of the study area be highly suitable for agricultural production, 32.30% (106.693km^{2}) is moderately suitable, 16.15% (53.355m^{2}) is low suitable land for agricultural production. The land evaluation method is the systematic assessment of land potential to find out the most suitable area for cultivating some specific crop. Theoretically, the potential of land suitability for agricultural use is determined by an evaluation process of the climate, soil, and water resources and topographical, as well as the environmental components under a given criteria and the understanding of the local biophysical restraints. The table 2 shows the suitability percentages while figure 9 shows regions of high, medium and low suitability.

Table 1: Evaluation of Land Suitability For agriculture in the study area

Suitability	**Count**	**Area (km^{2})**	**Percentage %**
Low Suitability	6,587	53.355	16.15
Medium Suitability	13,172	106.693	32.30
High Suitability	21,018	170.246	51.54
Total	40,777	330.294	100.00

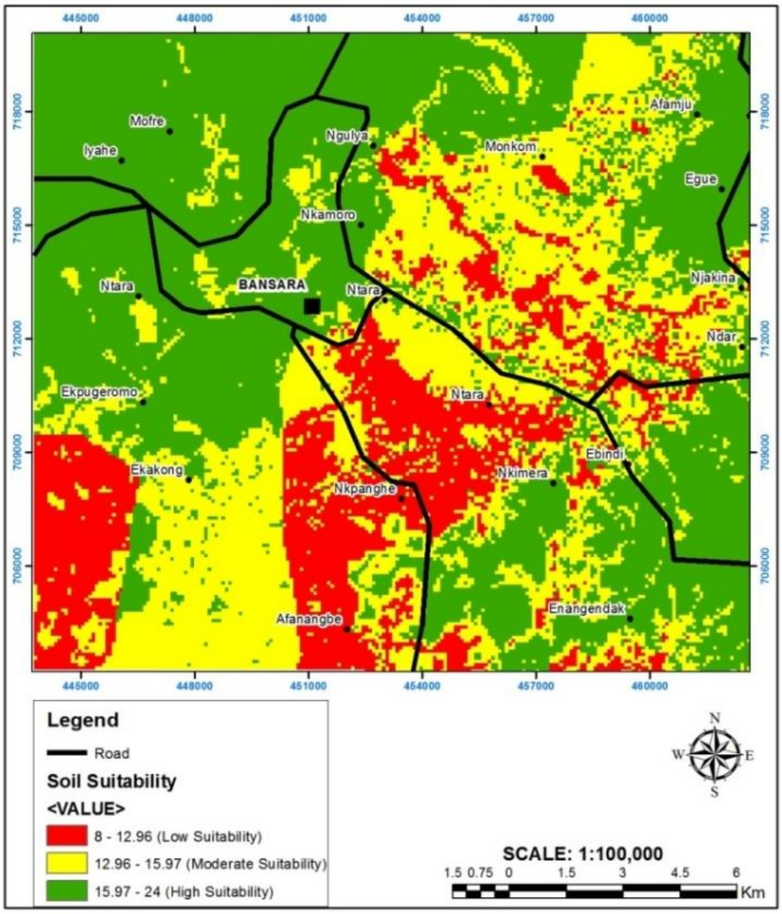

Figure 9: Suitability Map for Agriculture in the Study Area.

The high suitable land having no significant limitation for agricultural productivity i.e. maize crop is useful for developing in the highly suitable zone. The moderate suitable area is land having some limitations that are severe for sustained productivity. The oilseed is the better decision to develop in the moderately suitable zone of the study area. The low suitable area is land with major limitations for sustained agricultural productivity. In the low suitable area of the study area, it is preferable to grow wheat.

5.1 Discussion of Results Summary

From the above resulted parameter of LCLU, NDVI, LST the decision could be followed that Bansara and its surrounding area might have started expansion due to the rate of urban growth. The increased of population also cause the problem of food. A closer look at the percentage coverage of the suitable lands with the land use indicates about 51.54 % of Bansara and its environs have a very high suitability land, this mean that 50% of the study area is highly productivity of agriculture. The soil characteristics of the study area are mainly sandy loam and sandy clay. Loams are generally regarded as the best all-round soils because they are naturally fertile and can be used for growing any crop provided the depth of soil is sufficient. These soils can be used for most types of arable or grassland farming but, in general, mixed farming is carried on. Cereals, oilseed rape, potatoes and sugar beet are the main arable crops grown, and leys and forage maize provide grazing and fodder for dairy cows, beef cattle or sheep. The most influential factors in the climate are temperature and moisture. Plants can grow only within certain limit of temperature. For each species and variety there are not only optimal temperature limits, but also optimal temperatures for different growth stages and functions, as well as lower and upper lethal limits. Temperature determines which species can survive in a particular region. Crop growth is influenced by temperature as every plant has its specific degree-day. A degree-day or heat unit is the departure from the mean daily temperature above the minimum threshold temperature. The minimum threshold is the temperature below which no growth has taken place. The threshold varies with different species of plants and for majority ranges from 4.5^0 to 12.5^0C.

5.2 Recommendation

Base on the knowledge and experience acquired in the course of this project, one the idea that Remote Sensing and Geographical Information System is more easy and sustainable solution in identify suitability of land for particular crop in other to have a good yield and surveyor should look into this aspect of GIS in agriculture and produce more map of land suitability in order for agricultural film to know important of surveyor.

5.3 Conclusion

The project was on identifying land suitability for FADAMA farming in Bansara. Background of the study was examined statement of the problem and aim of project was stated. Literature review on the topic was carried out. The execution of this project involves proper planning and following. The study area relied on LANDSAT satellite imagery of the area from secondary data, soil characteristic, and climate data and was used to produce a map of the study area. Accessing the needed high resolution data for this research work has been very difficult. The cost implication of high resolution satellite imagery is very high. Therefore, the researcher used LANDSAT imageries. It is not also on recorded that the topic related to our study has been done in the study area, thus getting the required literature for review was hampered. It has been noted also that the free software used in the topic related to object based classification was a trial version and has a limitation in data processing.

Unavailability of network internet caused a lot frustration for the study. The ground truthing which was carried out in the course of this work suffered a lot of financial challenges which posed major setback for the study. This study has revealed the potential agricultural land in the study area and also that is very suitable for agriculture. The terrain is mainly flat and it a good advantage for irrigation farming and also free for erosion menace. The land use analysis has showed that some of these agricultural lands are being taken up by non-agricultural uses and this has a potential of negatively affecting in the study area. For crops to be matched the biophysical conditions, the biophysical variables (climatic, geo-morphological, soil texture, average temperature, and NDVI of the study area were collected to enable the interpretation of the climatic variables with reference to their suitability for specific crop production.

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