RESEARCH ARTICLE

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Land Suitability for None-Rice Cultivation Areas in Ekiti State Using a GIS-Based Analytic Hierarchy Process Approach

Adeyinka Jimoh Lamidi and Victor Ayodele Ijaware

ABSTRACT

This research aimed at carrying out a land suitability analysis for non-rice cultivation areas in part of Ekiti state using a Geographic Information System based Analytic Hierarchy Process (AHP) approach with a view to ascertaining whether rice can grow in commercial quantities in other Local Government Areas that will lead to improving rice production in the State. To achieve the aim of the research, specific objectives were set, which were to (i) determine the land use/land cover within the study area, (ii) assess the climatic, soil, and topographic factors that pertain to rice cultivation, and (iii) carry out a land suitability analysis on rice cultivation. In this study, the Analytical Hierarchy Process method was used to combine land use/land cover, rainfall, temperature, slope, soil texture, and pH to produce a land suitability map for rice cultivation in non-rice growing areas of the study area. The research result shows that the spatial expanse of land unsuitable for rice cultivation in the non-rice cultivation area of Ekiti state was 1121.6 km^2 which translated to 44% of the entire study area. Similarly, areas moderately suitable and suitable for the cultivation of rice were 529.1 km^2 (21%) and 899 km^2 (35%) of the study area respectively. Furthermore, the outcome of AHP validation showed that the consistency ratio was 0.07, which was less than the specified standard maximum value of 0.1, which signifies that there was a realistic degree of uniformity in the pairwise comparison. Based on the obtained results, it was discovered that: the built-up area in the study was only 5.2%, which signified that the remaining 94.8% of the study area was undeveloped and can serve agricultural purposes in the state. The land suitability map for non-rice cultivation produced for this study was detected to be a true representation of areas suitable for rice cultivation subject to overlay analysis and AHP validation. It was therefore recommended that this study can be used as vital background information for the improvement of rice production in Ekiti State Nigeria.

Keywords: Analytic Hierarchy Process (AHP), GIS, Landuse Landcover, Land Surface Temperature, Multi-Criteria Evaluation.

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I. Introduction

Assessment of arable lands and agricultural potential to support present and future agricultural uses is one among the best agricultural policies for food security in developing countries [1]. Rice (Oryza sativa) is a food crop chiefly grown and extensively used all over the world and at least about 3 billion population of the world uses it as common food [2]. It is presently the third most important cereal crop after maize and wheat. It's gaining popularity among rural folk as well and rice consumption has risen considerably over the last three years to stand at 300,000 metric tons per year [3]. Rice is the ultimate rapidly growing source of food in Africa and is of serious importance to food security and self-sufficiency in a rising number of low-income food shortage countries [4].

Maximizing production of rice can be achieved through sustainable agriculture or farming [3] and by employing crop-land suitability analysis, which is essential to accomplishing most suitable utilization of the available land resources for sustainable agricultural production [5]. The aim of this study is to carry out land suitability analysis for non-rice cultivation areas in part of Ekiti state Nigeria with a view to improve rice production and create a sustainable land management. Ekiti State government went into partnership with Lagos state in the area of rice production with over ten thousand rice farmers deriving gain from the agreement but there is still a shortage of rice in the state The major challenges linked to this is not far from (i) the inability of the world's natural resources to cater the needs of its increasing population is a crucial issue for the international community [6]. (ii) even though rice is one of the most fore chosen food crops in Nigeria, locally produced rice declined with the oil boom of the 1970s causing demand to overtake supply [7], and (iii) Destruction of foodstuff and properties by fire during the 2020 ENDSARS protest at Shasha market in Ibadan, Oyo State, Nigeria. In addition to this, the stoppage of food supply from the

Northern Nigeria to the Southern States ordered by the Amalgamated Union of Foodstuffs and Cattle Dealers of Nigeria on the 1st of March, 2021and the subsequent demand of 4.5billion Naira as compensation are some of the problems confronting the production of local rice in the study area.

In orderr to solve the herculean problems and to also achieve the aim of the research, the following research questions were given critical considerations: (i) where is the undeveloped land that can be used for rice cultivation? (ii) What are the factors to be considered before rice cultivation? And (iii) Where are the most suitable locations for the cultivation of rice within the study area? The rise in global population, particularly in developing countries has notably resulted in an increase in demand for arable crops such as rice [8]. Improving the productivity of rice systems would hence bring about hunger eradication, poverty alleviation, national food security and economic development [4].

However, previous researchers such as Ayehu et al and Yangouliba *et al.* researched Land Suitability Analysis for Rice crop Production using Geographic Information System (GIS), Remote Sensing, and Multi-Criteria Analysis in Burkina Faso and Amhara Region, Ethiopia respectively [4, 9]. Similarly, Alake researched on suitability assessment and mapping of Oyo State, Nigeria, for rice cultivation using GIS [7] while Aondoakaa *et al.* studied an Assessment of Land Suitability for Rice Cultivation in Dobi, Gwagwalada Area Council, Federal Capital Territory (FCT), Abuja, Nigeria using analog soil sample collection approach [10]. None of the researchers earlier mentioned considered land use/land cover, as well as climatic factors namely rainfall, land surface temperature, soil (pH and texture) and topography (slope) in in their studies and this, is the gap this research wishes to fill. However, GIS technique and Analytic Hierarchy Process (AHP) approach, which is an approach of multi-criteria evaluation used to assess land suitability of the selected five LGAs for rice cultivation yielded a significant result that played important role for suitable soil resources and sustainable land managements.

II. Study Area

The study area (Fig. 1) covered five Local Government Areas (LGA's) in Ekiti State, which was Ikole (7.8°N, 5.5°E), Irepodun/Ifelodun (7.7°N, 5.2°E), Gbonyin (7.6°N, 5.5°E), Ise/Orun (7.4°N, 5.4°E), and Emure (7.4°N, 5.5°E). The five LGA's were purposely selected because of their spatial locations as well as having similar visual soil types. Specifically, the LGA's was located within the Eastern part of Ekiti State, Southwestern Nigeria. In 1996, Ekiti State was carved out of the territory of old Ondo State and covered the previous 12 local government areas (LGAs) that made up the Ekiti Zone of old Ondo State. It had 16 Local Government Areas (LGAs) on creation.

The study area to a large extent is an upland zone, rising over 250 meters above water level. It lies in a neighbourhood underlain by metamorphic rock. It's by and large an undulating part of the country with a characteristic landscape that comprises old plains broken by step-sided out-crops that may occur singularly or in groups or ridges [11]. The State enjoys a tropical climate with two recognizable seasons. These are the rainy season (April – October) and the dry season (November – March). The temperature in the area ranges between 21 and 28 °C with high humidity. The southwesterly wind and the northeast trade winds blow in the rainy and dry (Harmattan) seasons respectively.

The tropical forest is present in the south, while the savannah occupies the northern peripheries [12]. The population of Ikole, Irepodun/Ifelodun, and Gbonyin were 168,436, 129,149, and 148,193 while the population of Ise/Orun and Emure was 113,754 and 93,884 respectively [7]. The population of Ekiti state in 2022 is projected as 3,939,597 [13]. Economically, some important minor industries are logging and tourism (Global Data Lab. 2021).

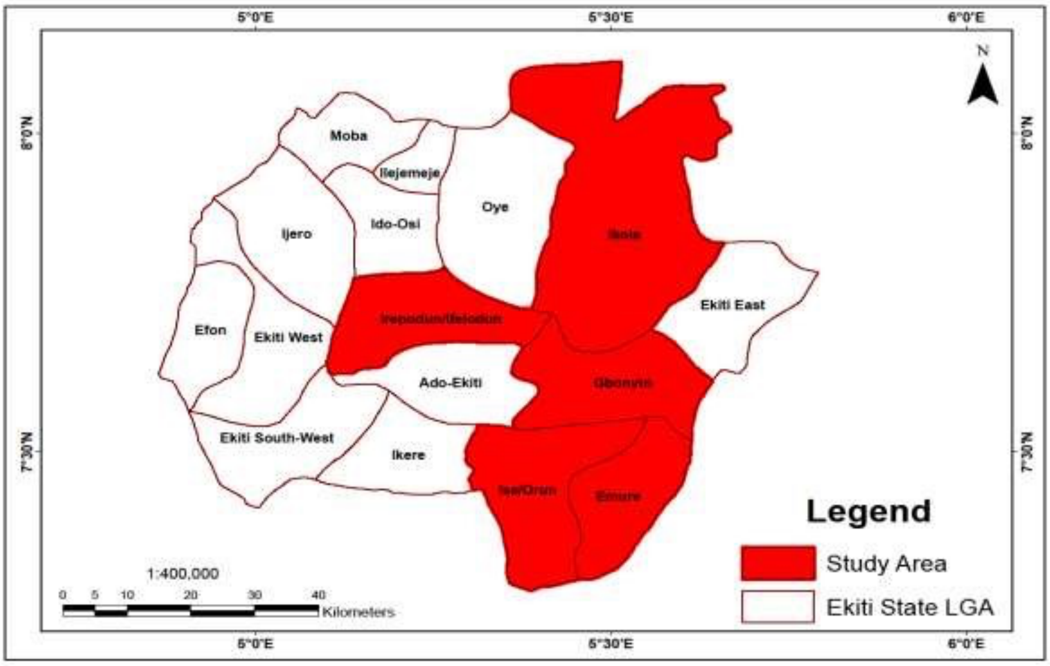

Fig. 1. Map of Ekiti State showing the study area.

The land in the area is buoyant in agricultural resources with cocoa as its principal cash crop. It was largely known that Ekiti land constituted well over 40% of the cocoa products of the old western region. The land is additionally known for its forest resources and because of the favourable climatic conditions, the land enjoys luxuriant vegetation, thus it has ample resources of different species of timber. Food crops like yam, cassava, and also grains like rice and maize are grown in immense quantities. Other notable crops like kola nut and varieties of fruits are also planted in commercial quantities.

III. Materials And Methods

The data utilized in this research were generated from primary and secondary sources. Soil samples and GPS coordinates of every location where the soil sample was taken were the primary data used in this research. Also, the secondary data used were Landsat imagery, Tropical Rainfall Measuring Mission (TRMM), Shuttle Topography Mission (SRTM) Digital Elevation Model (DEM), administrative map of Ekiti State and soil type map covering the study area (Table I).

Using Landsat Imagery covering the study area, the land use and land cover (LULC) of the study area were mapped. Image pre-processing was carried out by extracting Landsat image bands 5, 4, 3 from the zipped file to create a composite Landsat band according to USGS (2014).

Image enhancement was carried out to increase the resolution of the composite band from 30 m resolution to 15 m resolution using a pan-sharpened raster dataset in an ArcGIS 10.3 environment. Employing clipping tools, image sub-setting was carried out by utilizing the boundary shape file (.shp) of the study area to clip all images for easy image processing. Image mosaicking was later carried out by merging two composite images together to form a single image. This was accomplished because the study area fell within two Landsat scenes with a path of 190 and rows of 054 and 055, respectively.

In accordance with Food and Agriculture Organization, soil, topography, and climate were the three major factors assessed for rice cultivation [4] in the study area. Essentially, climate influences the growth, development and yields of agricultural crops, as well as rice either favourably or otherwise. Hence, rainfall and temperature are the two most significant climatic factors considered before the cultivation of rice, because it is both a tropical and sub-tropical crop, which is normally planted at a fairly high temperature ranging between 20 °C to 40 °C and a high rainfall ranging from 1250 mm to 2000 mm annually [4]. Specifically, temperature being one of the climatic factors for rice cultivation was determined using Land Surface Temperature (LST) as a ground temperature indicator, which has a direct impact on soil. This was calculated using the Landsat imagery in a three steps mode:

A. Digital Number (DN) Conversion to Radiance

For Landsat Operational Land Imager (OLI)/Thermal Infrared Sensor (TIRS) or Landsat 8, (1) was used by invoking raster calculator in Arcgis 10/3 environment [14].

$$P\_\lambda = M\_L\ R\_cal + D\_(L) \quad (1)$$

where

$P\lambda$ = Top of the Atmosphere spectral radiance (Watts/(m^2·srad·μm));

ML = Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number);

DL = Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_x, where x is the band number);

RCAL = Quantized calibrated standard product pixel values (DN).

Similarly, for Landsat Thematic Mapper (TM) or Landsat 5, (2) by [19] subsists

$$P\_\lambda = ((P\_MAX - P\_MIN)/ 〚RCAL〛\_MAX - 〚RCAL〛\_MIN)) * (RCAL - 〚RCAL〛\_MIN) + P\_MIN \quad (2)$$

where

P_λ = Spectral Radiance at the sensor's aperture in Watts / (Metre Squared·Ster·μm);

RCAL = the quantized calibrated pixel value in DN;

PMIN = the spectral radiance that is scaled to QCALMIN in Watts / (Metre Squared·Ster·μm);

PMAX = the spectral radiance that is scaled to QCALMAX in Watts/(Metre Squared·Ster·μm);

RCALMIN = the minimum quantized calibrated pixel value (corresponding to LMIN) in DN;

RCALMAX = the minimum quantized calibrated pixel value (corresponding to LMAX) in DN.

The formula was inputted into the ArcGIS environment.

TABLE I: Data Used And Their Attributes

S/N	Data	Source	Year	Resolution/Scale
1	Shuttle Radar Measuring Mission (SRTM) Digital Elevation Model (DEM)	United State Geological Survey (USGS)	2014	30 m
2	LANDSAT Operational Land Imager	United State Geological Survey (USGS)	2021	3 0m
3	Tropical Rainfall Measuring Mission (TRMM)	National Aeronautics and Space Agency	2021	30 km
4	Soil Map	Nigerian Meteorological Agency (NIMET)	1964	1:5000, 000
5	Administrative map	Office of the Surveyor General of the Federation	-	1:1,300.000
6	GPS Coordinates	Field Survey	2021	-

B. Conversion to Top of the Atmosphere (TOA) or At-Satellite Brightness Temperature

Thermal band data was converted from spectral radiance to top of the atmosphere brightness temperature utilizing the thermal constants in the Metadata (MTL) file in accordance with (3) by [16]:

$$T = X\_2/(l\_n\,(X\_1/(P\_\lambda + 1))) - 273.15 \qquad (3)$$

where
T = Top of the atmosphere (At-Satellite) brightness temperature (K);
Pλ = Top of the Atmosphere (TOA) spectral radiance (Watts/(m^2·srad·µm));
X1=Band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_x, where x is the thermal band number);
X2 = Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x, where x is the thermal band number).

C. Land Surface Temperature Calculation

Land Surface Temperature (LST) which denotes the ground temperature and its effect on soil within the study area was calculated based on (4) in line with [16]

$$LST = BT/1 + W \times (BT/p) \times ln\,(e)) \qquad (4)$$

where
BT = At-Satellite temperature;
W= Wavelength of emitted radiance (Thermal band);
p = h·c/s (1.438×10^{-2} m K);
h = Planck's constant (6.626×10^{-34} Js);
s = Boltzmann constant (1.38×10^{-23} J/k);
c = velocity of light (2.988×10^{8} m/s);
p = 14380;
e = 0.004Pv + 0.986.

Proportion of vegetation (Pv) =
(NDVI – NDVImin/NDVImax - NDVImin)2

Pv = Proportion of vegetation.

Similarly, the rainfall regime of the study area was extracted out from the Tropical Rainfall Measuring Mission (TRMM), in the ArcMap environment, using the "Extract value to point" tool. The extracted rainfall data were then interpolated utilizing Inverse Distance Weighting (IDW) method and presented in a raster format, which showed areas with high and low rainfall.

Significantly, the slope within the area in percentage was generated from Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM). The higher slope value means steeper terrain while lower slope value implied a flatter terrain. However, Soil is a basic raw material for the cultivation of rice while soil pH is an indication of the acidity or alkalinity of a soil type and it generally ranges from 1 to 14 but the optimum specification for rice production is 8.2 (FAO, 2022). Also, soil texture can affect soil Available Water Capacity (AWC). Hence, the knowledge of soil chemical and physical properties is important for crop land suitability analysis and mapping [4]; Soil map produced by the Nigerian Meteorological Agency (NIMET) was assessed to have an idea of the type of soil present in the study area. The location of these soil types was assessed, and soil samples was collected.

D. Soil Test Laboratory Procedure

1) Specific gravity test

Specific gravity is the ratio of the mass of unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at the same temperature. The specific gravity of soil samples oven-dry at 105°C was determined by using pycnometer in accordance with part 2 of British standard specification (BS 1377, 1990). The test was performed by determining the mass of empty density container (m1), mass of container and dry soil occupying one third volume of density bottle (m2), mass of container, soil and water as m3 and the mass of container filled with water (m4). It is express mathematically as shown in (5).

$$G\_S = ((m\_2 - m\_1))/([(m\_4 - m\_1\,) - (m\_3 - m\_2\,)]) \qquad (5)$$

where m1 is the weight of empty density container, m2 is the weight of container and dry soil, m3 is the weight of container, soil and water and m4 is the weight of container and water.

2) Particle size distribution test

The test was carried out in accordance with part 2 of British Standard (BS 1377, 1990) so as to analyse the grains that make up the soil. 500g of air-dried sample of soil was soaked in a bowl for 24 hours after which it was washed and sieved with 75 µm sieve to remove silt/clay portions of the soil until the water was clean. Soil particles retained on the sieve was oven dried for mechanical sieve by pouring the soil into the assemblage of sieves of varied sizes. The portions of sample passing through 75 µm sieve in sort of liquid during the process of washing were subjected to a hydrometer test by using a hydrometer 152H in order to determine the silt and clay content in percent that is present in the soil sample. Graph of soil passing each sieve in percentage were plotted against the sieve sizes.

Basically, land suitability analysis for the cultivation of rice was determined utilizing Analytic Hierarchy Process (AHP) algorithm of GIS technique, which is a procedure of multi-criteria evaluation. AHP pairwise comparison and ranking of the criterion was calculated using (6) according to [17].

$$F\_((1,1))\ 〚F〛\_((1,2))\ 〚F〛\_((1,3))\ \ldots F\_((1,n))$$
$$F\_((2,1))\ 〚F〛\_((2,2))\ F\_((2,3)\,) \ldots F\_((2,n))$$
$$〚F〛\_((n,2))\ (F\_((n,3))\ \ldots F\_((n,n)) \qquad (6)$$

Weights of the criteria for land suitability for rice cultivation were calculated according to their importance in rice cultivation and were multiplied by the raster surface of these criteria, which was then added together in order to give a single raster surface showing a land suitability map for rice cultivation within the study area.

IV. Results And Discussions

The results covered five categorical parts viz: Land Use/Land Cover (LULC), soil (texture and pH), climate (rainfall and temperature), slope and Analytic Hierarchy Process (AHP). The results of landuse/land cover classification of the study area showed that the major land use/land cover in the study area were built up area, forest, grassland, shrub, bare land, water body and wetland. The spatial extent of each LULC categories indicated in Table II revealed that forest occupied the vast area whilst water body covered smallest portion within the study area.

The criterion for determining LULC suitability class for ri ce cultivation according to Tesfamariam as shown in table 3 r evealed that suitable areas for cultivation of rice in terms of LULC spread across the study area (Fig. 2) but mostly conce ntrated within Emure LGA [18].

TABLE II: Spatial Extent Of Land Use/Land Cover In The Study Area

S/N	Land Cover	Area (sq.km)	% Coverage
1	Bare land	323.5	12.7
2	Built Up Area	132.6	5.2
3	Forest	957.5	37.6
4	Grass land	212.3	8.3
5	Shrub	561.7	22.0
6	Water Body	28.9	1.1
7	Wetland	333.1	13.1

TABLE III: Land Use And Land Cover Suitability For Rice Cultivation

S/N	Land use and land cover	Suitability Class
1	Built up area, water body and forest	Not Suitable
2	Grass land and bare land	Moderately Suitable
3	Wetland and shrub	Suitable

Similarly, moderately suitable areas were also concentrate d in the Northern region of Ikole LGA and towards the centr al part of Ise/Orun LGAs, whereas areas not suitable for rice cultivation were scattered across nooks and crannies of the st udy area and this justifies the percentage of the LULC class o ccupied. The soil factor was subdivided into soil texture and soil pH so as to determine the optimum land for the cultivati on of rice. The major soil textures discovered in the study ar ea through field observation were loam, sandy loam, loamy s and, and sandy clay loam. The suitability of the soil texture w as determined through the judgments of previous related stud ies such as [19] which stated that the soil used for growing ri ce should have a good water-holding capacity. The soil textu re for land suitable for rice cultivation were reclassified into sandy clay loam (suitable) and sandy loamy (moderately suit able) respectively (Fig. 3). The figure revealed that sandy cla y loam and sandy loamy soil were concentrated towards the North-Eastern part and southern part of Ikole LGA while, Sa ndy Loamy was found in large quantities as it occupies the s outhern part of Ikole LGA and also covered the remaining fo ur LGAs such as Irepodun/Ifelodun, Gbonyin, Ise/Orun and Emure LGAs.

Also, the soil pH of the area of study ranged between 6.7 (low) and 8.1 (high) respectively but, after reclassification based on their relevance to rice cultivation, the soil pH ranges between 5.6 and 7.4 (Fig. 4) and this is within the limit set by [4]. It was therefore discovered from the soil pH analysis that the highest pH values were concentrated at the central part of the study area (Gboyin LGA) as well as Irepodun/Ifelodun and the Southern part of Ikole LGA while the least range of soil pH were found to exist in the extreme Northern and Southern parts of area of study, which covered part of Ikole, Ise/Orun and Emure LGAs. The PH results also revealed that substantial part of Ise/Orun and Emure including northern part of Ikole LGAs are suitable for rice cultivation while majority of remaining land in the study area are moderately suitable apart from some sizeable, dotted location which are not suitable for cultivation of rice (Fig. 5).Essentially, the results of rainfall analysis for land suitability for the cultivation of rice showed that the rainfall of the study area ranged between 1704.72 mm and 2173.54 mm. This indicated that the study area according to [4], [20], and [21] had sufficient amount of rainfall for rice cultivation. in addition, it was discovered that the temperature of area of study ranged from 20.9 °C and 33.6 °C which were considered as an optimum temperature that is adequate for rice cultivation (Fig. 6) according to [22]-[25].

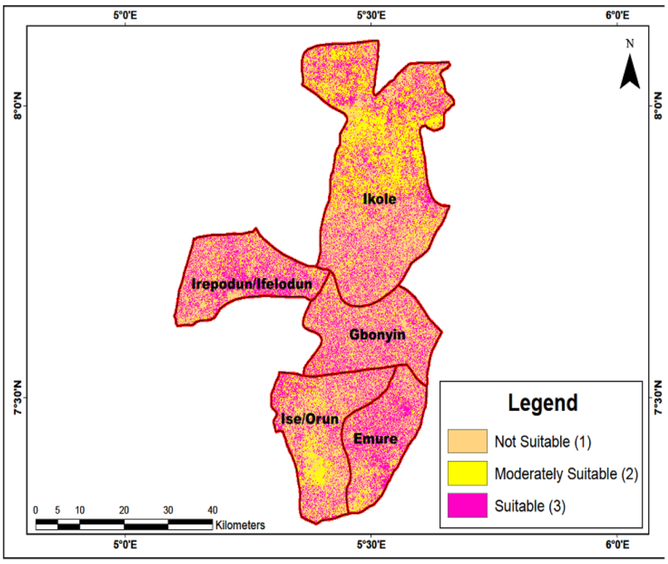

Fig. 2. Areas suitable for rice cultivation.

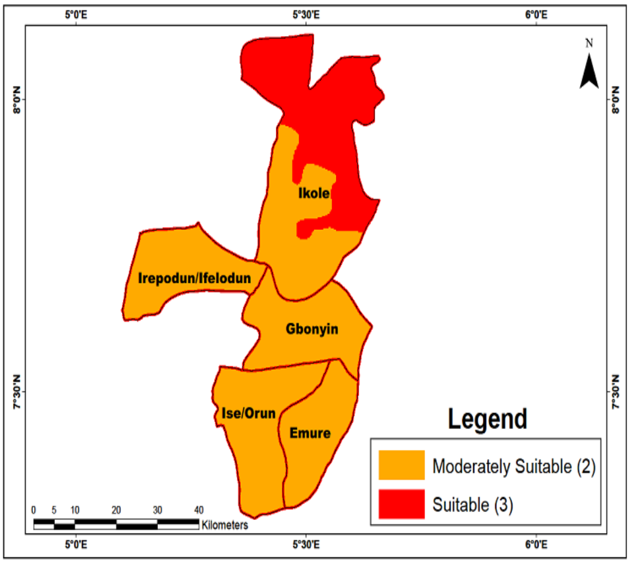

Fig. 3. Reclassified soil texture map.

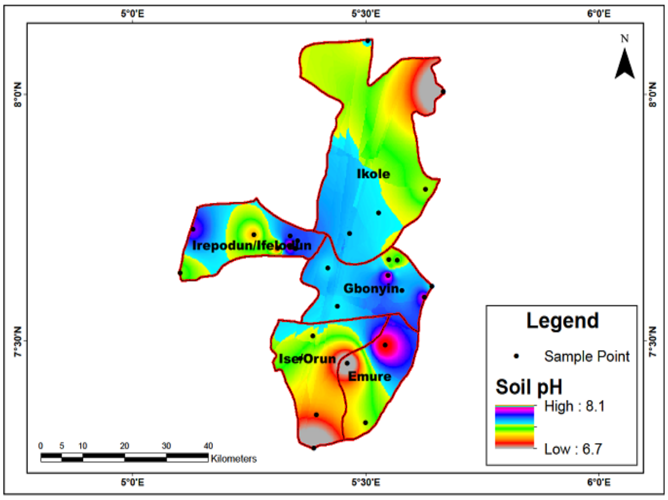

Fig. 4. Soil pH of the study area.

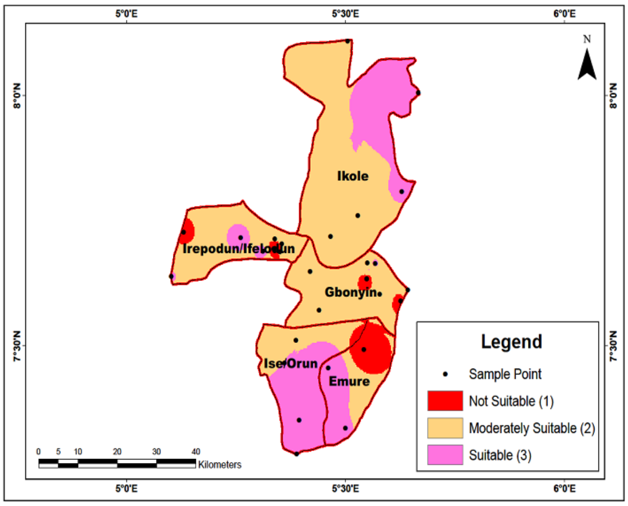

Fig. 5. pH of area suitable for rice cultivation.

Significantly too, Fig. 6 revealed that the areas suitable for cultivation of rice in terms of Land surface temperature were concentrated in the central part of Emure, the Eastern part of Gbonyin, the Southern part of Irepodun/Ifelodun and the Northern part of Ikole LGAs respectively. However, areas moderately suitable dominated the entire study area especially Ise/Orun, Gbonyin, Southern part of Ikole. The western part of Irepodun/Ifelodun, and the Southern part of Emure LGAs whereas, areas not suitable for rice cultivation were located in the Southeastern part of Ikole LGA. Furthermore, Shrestha et al [26] as well as Ayehu et al [4] categorized areas with 0-4% slope as suitable for rice cultivation, while areas with 4-20% and areas above 20% slope are moderately suitable and not suitable for rice cultivations respectively. Essentially, the slope of the study area ranged between 9% and 30.9% which signified that Ikole, Gbonyin, Ise/Orun, Emure and some parts of Irepodun/Ifelodun LGAs are suitable for rice cultivation in terms of slope (Fig. 7).

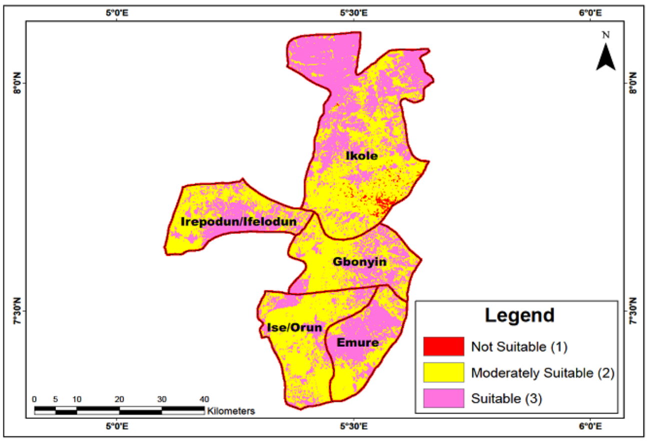

Fig. 6. Land surface temperature suitable for rice cultivation.

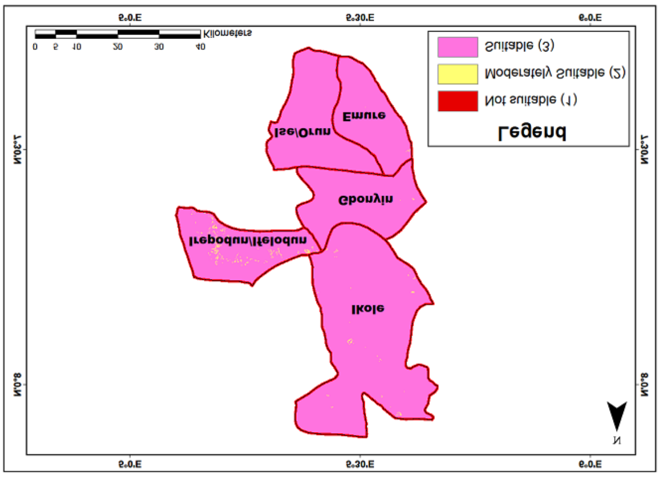

Fig. 7. Slope suitability for rice cultivation.

Utilizing the Analytic Hierarchy Process (AHP) algorithm of GIS, ranking and prioritization process was carried out using a matrix of pair-wise comparisons (Table IV). Weight for each factor for rice cultivation was assigned and all the map layers (Factors/Criteria for the Selection of Suitable locations for rice cultivation) were multiplied by their respective weights (Table V and overlaid in the ArcGIS environment to produce a land suitability map for cultivation of rice in the area of study (Fig. 8). The results of the pairwise comparison and ranking of the criterion are presented in Table VI where T1= Land Use/Land Cover, T2= Temperature, T3= Rainfall, T4 = Soil Texture, T5 = Slope, and T6 = Soil pH. The calculated relative criterion weights (Table VI) were then multiplied by the raster layers of the factors (Land Use/Land Cover, Temperature, Rainfall, Soil Texture, Slope and Soil pH) and overlaid in the ArcGIS environment to generate the potential areas suitable for rice cultivation (Fig. 8). Specifically, it was observed as showed in Fig. 8, that suitable areas were largely concentrated at Emure, Ifelodun/Irepodun and the Northeastern areas of Ikole. Similarly, moderately suitable areas were concentrated majorly in the central parts of Ikole and also part of Ise/Orun, while fragment of moderately suitable areas were scattered within Irepodun, Gboyin and Emure. Notably too, non-suitability area was also found majorly at Ise/Orun, Gbonyin, Southern part of Ikole and the Western areas of Irepodun/Ifelodun area.

TABLE IV: A MATRIX OF PAIR-WISE COMPARISONS OF SIX CRITERIA FOR THE ANALYTIC HIERARCHY PROCESS

	T1	T2	T3	T4	T5	T6
T1	1.00	2.00	3.00	4.00	5.00	6.00
T2	0.58	1.14	1.60	2.30	2.85	3.50
T3	0.36	0.73	1.00	1.50	1.80	2.00
T4	0.29	0.57	0.88	1.00	1.43	1.74
T5	0.20	0.41	0.64	0.88	1.00	1.20
T6	0.17	0.35	0.58	0.82	0.92	1.00
SUM	2.60	5.2	7.70	10.5	13.0	15.8

TABLEV: DETERMINED RELATIVE CRITERION WEIGHTS

	T1	T2	T3	T4	T5	T6	Weights	Percent %
T1	0.38	0.38	0.39	0.38	0.38	0.38	0.38	38%
T2	0.22	0.22	0.21	0.22	0.22	0.22	0.22	22%
T3	0.14	0.14	0.13	0.14	0.14	0.14	0.14	14%
T4	0.11	0.11	0.11	0.10	0.11	0.11	0.11	11%
T5	0.08	0.08	0.08	0.08	0.08	0.08	0.08	8%
T6	0.07	0.07	0.08	0.08	0.07	0.07	0.07	7%
SUM	1.00	1.00	1.00	1.00	1.00	1.00	1.00	100%

TABLE VI: RANKING OF THE CRITERION WEIGHT

Criteria No.	Criteria	Weight
T1	Land Use and Land Cover	0.38
T2	Temperature	0.22
T3	Rainfall	0.14
T4	Soil Texture	0.11
T5	Slope	0.08
T6	Soil pH	0.07

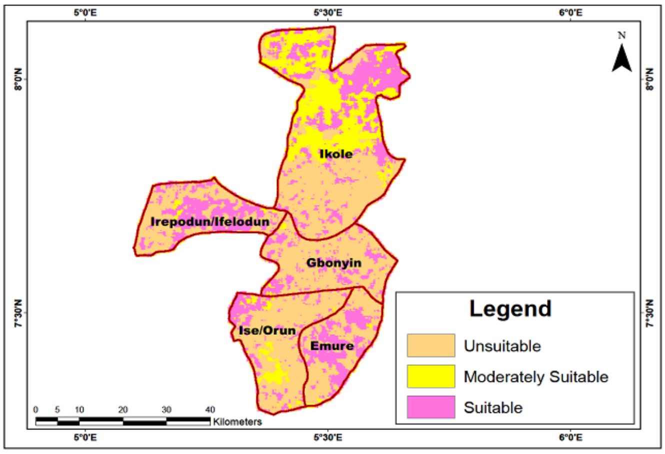

Fig. 8. Land suitability analysis for cultivation of rice.

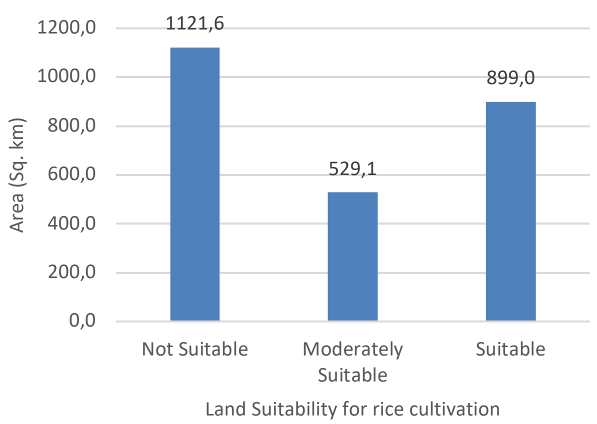

Fig. 9. Chart showing the spatial extent of land suitable for cultivation of rice.

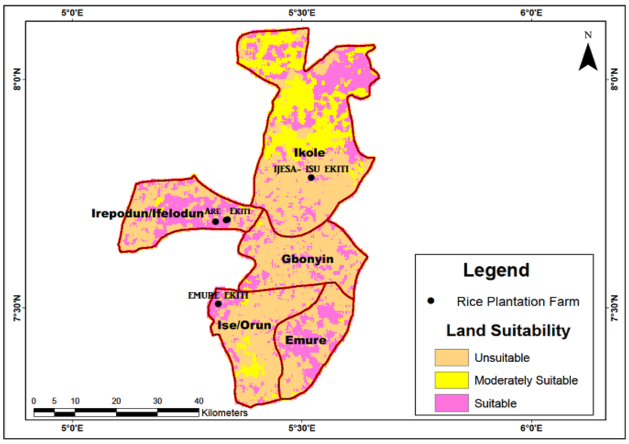

Fig. 10. Overlay of existing rice farms on the suitability map.

The spatial extent of the suitability classes was calculated in order to determine the spatial extent of land not suitable, moderately suitable, and suitable for the cultivation of rice in the area of study. It was observed that the spatial extent of land not suitable for rice cultivation was 1121.6 sq.km which is 44% of the entire study area while area moderately suitable for rice cultivation was 529.1 sq.km, which is 21% of the area of study and the area suitable for cultivation of rice was 899 sq.km, which is about 35% of the study area (Fig. 9). This implies that areas that can be considered for rice cultivation (Suitable and moderately suitable) constitute about 56% (1428.1 sq.km) of the study area while the remaining 43.99% represents area not suitable for rice cultivation.

Furthermore, validation of the land suitability analysis for the cultivation of rice in the area of study was carried out by first overlaying the sample points where rice is being cultivated within the study area and also validating the AHP pairwise used for assigning weight for factors of land suitability for the cultivation of rice. The result (Fig. 10) shows that existing rice farms at Ise Ekiti, Ijesa-Isu Ekiti and Emure Ekiti were situated on the suitable areas of the land suitability map, which confirmed that the land suitability map represent existing ground situation of cultivation of rice in the area of study.

Additionally, the Consistency Ratio (CR) (7) which is an estimate of departure from consistency was used to validate the AHP pairwise matrix for relative criterion weight determination while The Consistency Index (CI) was calculated using (8):

$$CR = CI/RI \tag{7}$$

$$CI = (\lambda/n - n)/(n-1) \tag{8}$$

where

CR= Consistency Ratio; CI= Consistency Index; and RI = Random Index;

n = number of factors (i.e., 6) and λ = average value of the consistency vector determined from Table VII and Table VIII respectively.

From (8): λ=38.68; n=6; λ/n = 6.45; λ/n – n = 6.45-6 = 0.45; and n-1 = 5.

Therefore, CI = 0.45/5= 0.089.

The Random index (RI) used to calculate the consistency ratios (CR) is shown in table 9 according to [17] where RI is

1.24 (the number of criteria).

From (7), $CR = \frac{0.089}{1.24} = 0.07$. Thus, since $0.07 < 0.1$, it indicates that there is a reasonable degree of consistency in the pair wise comparison and as a result of the weights 0.38, 0.22, 0.14, 0.11, 0.08 and 0.07 for Land Use and Land Cover, Temperature, Rainfall, Soil Texture, Slope and Soil pH respectively.

TABLE VII: DETERMINED CONSISTENCY INDEX (CI)

	T1	T2	T3	T4	T5	T6
T1	1.00	2.00	3.00	4.00	5.00	6.00
T2	0.58	1.14	1.60	2.30	2.85	3.50
T3	0.36	0.73	1.00	1.50	1.80	2.00
T4	0.29	0.57	0.88	1.00	1.43	1.74
T5	0.20	0.41	0.64	0.88	1.00	1.20
T6	0.17	0.35	0.58	0.82	0.92	1.00
*	0.38	0.22	0.14	0.11	0.08	0.07

TABLE VIII: SUM 1/WEIGHT

							SUM1				
T1	0.38	0.44	0.42	0.44	0.40	0.42	2.50	/	0.38		6.58
T2	0.22	0.25	0.22	0.25	0.23	0.25	1.42		0.22	=	6.45
T3	0.14	0.16	0.14	0.17	0.14	0.14	0.89		0.14		6.36
T4	0.11	0.13	0.12	0.11	0.11	0.12	0.70		0.11		6.36
T5	0.08	0.09	0.09	0.10	0.08	0.08	0.52		0.08		6.5
T6	0.06	0.08	0.08	0.09	0.07	0.07	0.45		0.07		6.43
							SUM 2		Λ		38.68

TABLE IX: RANDOM INDEX (RI) USED TO COMPUTE CONSISTENCY RATIOS (CR)

N	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

(Source: Saaty 2008–Decision making with Analytic Hierarchy Process).

V. DISCUSSION

The major land use/land cover in the study area were bare land, built-up area, forest, grassland, shrub, water body and wetland. Forest occupied the largest extent of land, which was 957.5 sq.km (37.6%) followed by shrub and wetland, which were 561.7 sq.km (22%) and 333.1 sq.km (13.1%) respectively. In addition to this, bare land and grassland also covered 323.5 sq.km (12.7%) and 212.3 sq.km (8.3%) sequentially, while built-up area occupied 132.6 sq.km (5.2%) and water body covered the least land in the study area which was 28.9 sq.km (1.1%). The extent of the forest category was because of government legislation against illegal logging in the State while the size of the built-up area and bare land were due to slow developing status of Ekiti state.

The factors required for rice cultivation when classified based on the level of importance to rice cultivation it was discovered that rice can be cultivated in a non-rice growing area of the study area in line with [18] who opined that wetlands and shrub are suitable areas for cultivating rice, while grass lands and bare land are moderately suitable for rice cultivation, and LULC types namely built up areas, water body and forest are not suitable for rice cultivation. Similarly, the soil types discovered in the study area support optimum rice cultivation according to the recommendation of previous researchers such as [19] while the pH value obtained according to [4] ranges between the favorable limit that will enhance rice cultivation in the non-rice growing area of the area of study. Additionally, the rainfall results of the area of study ranged between 1704.72 mm and 2173.54 mm which were adjudged to be an ideal rainfall for the cultivation of rice in the area of study with respect to [4], [20], and [21]. Also, the temperature recorded in the study area ranged between 20.9 °C and 33.6 °C and after classification based on related research such as [22]-[25] was accepted to be the right temperature required for rice cultivation. Notably, too, the result of the topographic factor (slope) revealed that the slope of the study area ranged between 9% and 30.9% which [4] as well as [26] stressed that it is safe for rice cultivation and are therefore moderately suitable for cultivation of rice. Utilizing the classified factors in Analytical Hierarchy Process (AHP), the result showed that land use/land cover had the highest weight at 0.38, then followed by temperature with 0.22, rainfall at 0.14, soil texture with 0.11, slope with 0.08 and soil pH with 0.07. The result revealed that the spatial area of land not suitable for the cultivation of rice was 1121.6Sq.km which was 44% of the entire study area while area moderately suitable for rice cultivation was 529.1 sq.km (21%) and area suitable for rice cultivation was 899 sq.km (35%). The results of the land suitability map level of accuracy overlay and AHP validation revealed that sample points where rice are being cultivated fall on the location of the existing rice farms which confirmed that the land suitability map represent ground condition of rice cultivation. Furthermore, the result of AHP validation showed that the consistency ratio was 0.07 which was less than the maximum value of consistency ratio (0.1), which indicated that there was a reasonable degree of consistency in the pair wise comparison.

VI. CONCLUSION

The research showed that an area of 132.6 sq.km, which is 5.2% of the total area of the area of study (2549.7 sq.km) is covered by built-up area, which implied that these areas were already occupied by inhabitants' buildings, hence, cannot be used for cultivation of rice.

The study revealed that 35% of the area of study is suitable for cultivation of rice while 21% is moderately suitable and 44% is not suitable for cultivation of rice respectively in line with [18]. This implies that about 56% of the area tag 'non-rice growing' area is found to favorably support rice cultivation.

It was also discovered that the major soil texture in the area of study were loam, loamy sand, sandy clay loamy and sandy loamy but sandy loamy was found in large quantities as it spread across the five LGAs when compared to the spread of other soil textures.

The PH results also revealed that the majority of land in the study area are moderately suitable apart from some small portions which are not suitable for rice cultivation.

The research showed that the AHP validation shows that there is a reasonable degree of consistency in the pair-wise comparison which confirms the correctness of the outcome of the factors considered for rice cultivation in the non-rice growing area of the study area.

VII. Recommendations

This study recommends that:

i. this study should be used as vital background information for the improvement of rice production in Ekiti State.
ii. Ekiti State government should utilize the 94.8% undeveloped portion of the study area for various agricultural purpose.
iii. This study should be extended to the remaining LGAs of Ekiti State, in order to determine the spatial extent of land that can be used for the cultivation of rice in the entire State.

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