DEVELOPMENT OF ROBUST PROCEDURE FOR MAPPING ARABLE AND IRRIGABLE LAND OF EDO STATE FOR CROP PRODUCTION AND NATURAL RESOURCES PRESERVATION

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Abstract: The quest for food has resulted to several methods of farming to increase food production that would meet the demand for food by the growing population of man and livestock. The farming processes have led to the destruction of forest which is host to wildlife and biodiversity. Forest and species extinction are as a result of agricultural practices, bush burning, and Urban sprawl. To balance the energy circle among the ecosystem, crop production should be planned in such a way that forest reserve, water body, and farming activities are preserved to maintain natural resources and biodiversity. Arable land, water bodies, and farming activities can be preserved by properly delineating land use/cover of natural earth to ensuring that crop production does not interfere with wildlife to satisfy the growing population of mankind and Livestock. Remotely sensed images were used to acquire data across a range of 25 years to monitor the impacts of agricultural activities on Natural resources, arable land degradation, and Wildlife of Edo State and Nigeria. A desktop application was developed called “UNEC Geospatial Calculator” to automate most of the spatial analysis algorithms adopted in this research work. The calculator, among other functionalities, was used to calculate vegetation indices to automate the mapping process. This UNEC calculator was used to extract vegetation indices before using ENVI 4.7 software for accurate classification of Land use and Land cover classes in the study area. Survey data were used to accurately delineate the boundaries for the various land use and land cover, and to generate results to categorize the arable land types, the different indices outputs, accuracy assessment, database, and arable and irrigable land. The statistical zonal analysis was carried out on the different classes to analyze the changes that have occurred over time in the study area in terms of farming activities, deforestation, urban sprawl, species extinction, and destruction of biodiversity. The influence of Land Surface Temperature and Evapotranspiration on agricultural activities were also monitored and analyzed in the study area The study developed information about the arable and irrigable land to suggest ways for sustainable agricultural practices in Edo State and Nigeria that will end wildlife-human conflicts, herdsmen, and Farmer's bickers in the country. The Land use and Land cover (LULC) classification was used to evaluate the land use and arable land use intensity in the study area and it was observed that built-up is 4.09%, 8.21%, 16.5%, farm land 21.67%, 3.09%, 19.76%, thick forest 45.84%, 28.11%, 16.45%, light forest 20.07%, 58.92%, 26.56%, bare land 0.5%, 0.23%, 11.61%, and water body 7.83%, 1.44%, 9.82% for 1986, 2000, and 2018 respectively. The various vegetation indices such as Normalized difference vegetation indices, Soil adjusted vegetation indices, transformed difference vegetation indices were used to enhanced the classification of LULC and arable and irrigable land. While land surface temperature and evapotranspiration results were used to analyzed the impact of climate change and farming activities on arable land degradation, ecosystem, and natural resource. The soil properties and the digital soil maps were used to suggest soil suitability for crop production in the study area. From the LULC analysis, farming activities has degraded arable land in the study area. The calculated lineament, slope and aspect, and digital elevation model were used to determine site for irrigation and for water reservoir site selection. A database and a farm manual were developed to provides information about arable and irrigable land location, forest land, drainages and water catchment area, soil properties, soil suitability for crop production in the study area.

Index Terms— Mapping, Arable, Irrigable, Land, Crop, Resources, Preservation.

1 INTRODUCTION

Arable land is an essential part of land resources, directly affects the food security of any region [24]. Arable land is land capable of being ploughed and used to grow crops [26].

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Arable and irrigable land are important factors for crop production [1]. Mapping the spatial distribution of these arable and irrigable land are important for farm management and natural resource preservation [3, 4, 5, 36]. Knowing the location of this arable and irrigable land require measuring their spatial distribution on the surface of the earth [5, 26, 36]. The Geospatial Scientist's interest is to measure land Surface features and produce maps for real-time investigation and monitoring of earth’s surface features to solve many of man’s problems.

Food, water, and natural resources are essentials products for sustainable development. These vast resources are on the surface of the earth and are needful for crop production, industrial development, and habitat to man and wildlife. Food supply depends on quality crop production. To have food in surplus quantities, the fertile arable land is necessary to grow crops. Crop's growth depends on nourish soil with appropriate freshwater [3, 25, 28, 30]. In many cases of crop production, water supply for crop growth and health depends mostly on rainfall, which most often it's not enough to grow crops that will satisfy food demand by man and livestock [25 32, 44]. Crop production depends on good arable land, and water supply for plant's health and productivities. And this has led to arable land degradation because of unorganized farming system which has led to crop stresses [28,31]. Crops stresses are as a result of water deficiencies, lack of quality soil, nutrient supply, and excessive evapotranspiration [8, 32]. Many Crop types depend on water, especially seasonal crops which require enough water to grow [8, 25]. Therefore, a better method to maintain crop growth is by an artificial method of supplying water to crops through irrigation as was adopted in developed agricultural practices [3, 23, 25]. The spatial distribution of all these arable and irrigable land is required for crop production and preservation of natural resources, hence, it is necessary to have these arable and irrigable land identified and mapped for planning and decision-making processing [4,5, 15, 24, 27, 30].

The growing demand for food and fresh water is due to the increase in population [14]. This has resulted to food scarcity [7, 49] and human-wildlife conflicts [33, 34, 37,] which led to the spread of many viruses that affect the health of mankind including Corona Virus that is killing innocent people in the world [19]. Hunger is the major reason for Human-Wildlife conflicts [34].

The environment where human leaves need to be friendly and free of hunger for mankind (human and animals), environmental pollutions, and wildlife's attack [6, 37, 38, 39]. The ecosystem has to be preserved from further degradation caused by farming activities, hostility, ignorance, industrialization, and carelessness [6, 35]. Forest must be restored, species, biodiversity, wildlife especially those ones that has almost gone into extinction must be restored [6, 35, 37]. Because the fall of man and his consequential punishment to till and developed the land for lives' sustenance has led to degradation and imbalance, that beset the built environment ever since and up to our time [42], hence, the natural resource should be preserved against further degradation and imbalance that has beset the built environment. The only remedy is to have an organized farming system put in place.

This study discussed the procedure for mapping arable and irrigable land of Edo state which will separate the various type of arable land for proper agricultural planning, and organized farming systems for Edo state and Nigeria.

The spatial pattern of arable and irrigable land was determined to locate fertile land for crop production and to manage land resources for sustainable agriculture and preservation of the ecosystem. About 800 million people in the world are hungry [6, 17, 43]. In Nigeria alone, about 60 million people go to bed daily without food [43]. Hunger does not have a tribe [2]. And the best security for Nigeria is food security [16, 17, 22, 49]. To tackle this food scarcity problem, unorganized farming system were carried out resulting to arable land degradation and destruction of the ecosystem including habitants and wildlife destruction and displacement [11, 13, 21, 22]. This has resulted to food insecurity [17, 49] and spread of several virus including COVID_19 pandemics [20]. On this basis, the FAO in 2020 has proposed to end hunger before 2030 and Nigeria Conservation Foundation has suggested in their campaign for nature and natural resource preservation that nature and the ecosystem must be preserved to have a friendly environment. Also, the International Union for the Conservation of Nature (2003) proposed to end wildlife and human conflicts, including species restoration and preservation. The aim of this research is the development of a robust procedure for mapping arable and irrigable land of Edo State for crop production and natural resource preservation using geospatial techniques.

The specific objectives of the research are to: (i) develop a desktop software (Geospatial Calculator) to automate mapping of arable and irrigable land, (ii) to process and calculate the vegetation indices for arable and irrigable land mapping, (iii) to determine land surface temperature, evapotranspiration, and to determine soil properties in the study area, (iv) to evaluate arable and irrigable land use intensity, degradation, and possible impact on natural resources and wildlife, (vi) to determine factor that enhance irrigation site selection, and (vii) to develop a farm manual with a comprehensive database for the study. These objectives were achieved through a nethodological approach of data acquisition, data processing, and data analysis. Several literatures on vegetation indices [41, 42], classification [46, 47, 48], arable land mapping methods [4, 5, 22, 24, 26, 30], irrigation [3, 25, 32, 36, 44, 45], soil salinity [7, 8], soil classification [7], and method of preserving nature [6, 33, 35] were review to buttress the research findings and objectives.

2 Material and Methods

2.1 Study Area

The case study area is Edo state, Nigeria. Edo is located in the southern Nigeria with eighteen local government areas as shown in Fig. 1 and fig. 2. Its capital is Benin City. It is so located that it forms the nucleus of the Niger Delta region. It is bordered by Kogi State to the North and Delta State to the East and South, and the Ondo States to the West. It lies between 05°44′ N and 07°34′ N latitudes, 05°04′ E and 06°45′ E longitudes. The State has a landmass of about 19,794 km square. Edo State is politically divided into three Senatorial districts which are; Edo South (the Bini speaking area), Edo Central (the Esan speaking area), and Edo North (the Afemai speaking area) senatorial districts. The state is low lying except towards the northern axis where the Northern and Esan plateaus range from 183 meters of the Kukuruku Hills and 672 meters of the Somorika and Ososo Hills. The climate is typically tropical with two major seasons- the wet (rainy) and the dry seasons with a cold harmattan between December and January. The wet season lasts from April to October with a break in August and average rainfall ranging from 150cm in the extreme north of the state to 250cm in the south. The dry season lasts from November to March. The temperature averages about 250C in the rainy season and 280C in the dry season. The climate is humid tropical in Edo South senatorial zone which covers the Benin City area. It is mainly characterized by heavy rains almost all year round and thick rainforest. Edo North senatorial zone covers the Auchi area and the Okpameri axis of Ikiran-Ile and Afeyeh which borders the Ondo area of the State and Umoga, Lamkpese, Ososo, Okpella that borders the Kogi State.

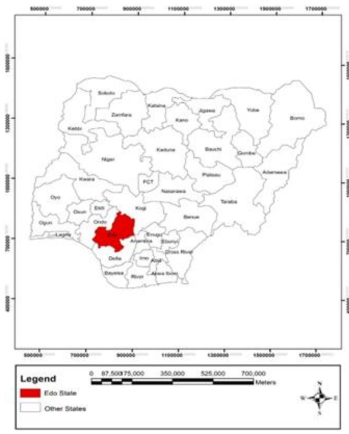

Fig.1. Administrative Map of Nigeria

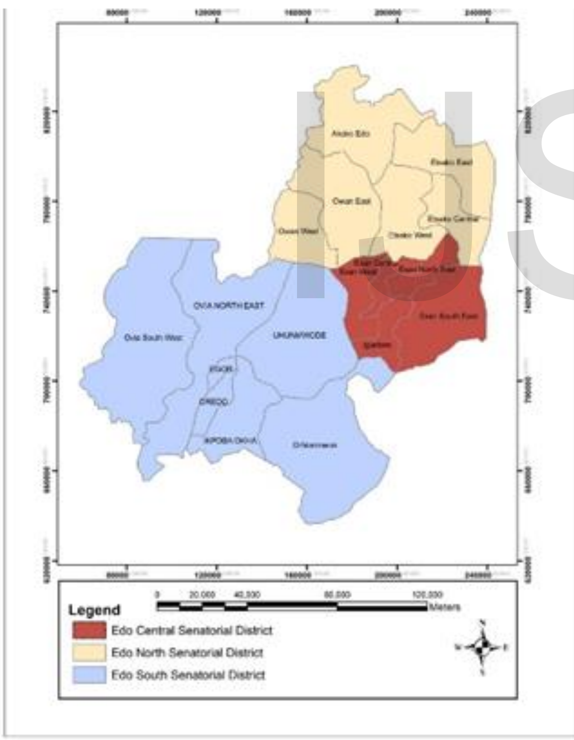

Fig.2. Map of Edo State Senatorial Districts

2.2 Materials

The secondary data are the administrative map of Edo State and Edo State Senatorial districts maps and were collected from the office of the Surveyor General of the Federation, the digital soil maps and agricultural statistical data were collected from the Federal Ministry of Agriculture and Rural Development. The primary data were the Landsat data set, SRTM, and MODIS data downloaded from USGS websites and Sentinel 2 downloaded from Copernicus website. The ground truth data were acquired using Global mobile mappers software installed on Samsung android phone. The hardware used are hp. Laptop and hp. Printer, 1 terabyte hard dick for storage. The software used for the research are Geospatial Calculator, ARCGIS 10.2, QGIS 3.8.1, and ENVI 4.7 for image downloading, data processing, and analysis.

2.3 Methods

The study adopted investigatory and empirical design. Time series remotely sensed data from satellite images of Sentinel 2, Landsat, MODIS, and SRTM dataset were collected for the investigation. The developed standalone software name UNEC Geospatial Calculator was use to download Landsat and Sentinel 2 dataset from USGS and Copernicus websites and for calculating Normalized difference vegetation indices, soil adjusted vegetation indices, enhanced vegetation indices, transformed normalized difference vegetation indices, and normalized difference water indices to automate the arable and irrigable land classification. Mathematical model and algorithm were used to determine indices for mapping arable land. Arable and irrigable land use intensity were determined using zonal analysis in ARCGIS software to analyzed the landuse and landcover LULC) classes from 1986 to 2018. The factors for selecting possible irrigation site such as slope and underground mineral deposit were calculated using Landsat and SRTM data set and ARCGIS 10.7 software. These calculated factors: lineaments, slope, and aspect, drainage and water catchment area, Land Surface Temperature, and Evapotranspiration were used to analyzed and validate crops suitability for arable and irrigable land. A comprehensive database was developed for the study to store required information for farm manual.

2.3.1 NDVI

This geospatial calculator was used to aeparate vegetation indices. NDVI = NIR-RED/NIR+RED (1). The values range from -1 to 1. Zero values indicate no vegetation, negative values indicate non-vegetation areas, while green vegetation ranges between 0.2 to 0.8.

2.3.2 EVI

The enhance vegetation index was formulated to reduce atmospheric influence and soil background signals on vegetation particularly in area with dense canopy cover (Liu & Hauete 2014). The value of EVI ranges from -1 to 1. Heathy vegetation ranges from 0.2 to 0.8. the formula for calculating EVI is EVI = 2.5 x ((NIR – Red) / ((NIR) + (C1 x Red) – (C2 x Blue) + L)) (2) [19].

C1 and C2 are variables to correct for aerosol scattering present in the atmosphere, and L to adjust for soil and canopy background. This was developed for MODIS, but can also be apply for Landsat and Sentinel 2 images. C1=6, C2=7.5, and L=1. In case of Sentinel 2 or Landsat 8 data, use the same values or simply use Crop Monitoring, which also allows to download the results.

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2.3.3 SAVI

The soil adjusted vegetation index was used to minimized soil influence on vegetation quantification by introducing soil adjustment factors L as described in SAVI = NIR-RED/NIR+RED+L x (1+L) (3) [18]. The variable L was introduced to NDVI order to correct for soil noise effects (soil color, soil moisture, soil variability across region. In high vegetation, the value of L is 0.0 or 0.25, low vegetation covers -1.0, intermediate 0.5, these values are widely used. In this Model, if L is 0, is the same as NDVI. If SAVI is zero, it is considered as an indicator for bare soils. This means that L is 0.5 which generated a constant of 0.5 and 1.5 in equation 2. This is known as gain and offset coefficients.

2.3.4 NDWI

The normalized difference water index was developed by Gao (1996) to enhanced vegetation analysis and categorization as in equation 3 and 4. The values for 100% vegetation is 0.06, soil -0.022, grass 0.0084, and cropland 0.215. These models were used to accurately separate arable land type in the study area. NDWI= (NIR-SWIR)/(NIR+SWIR) (4)

2.3.5 TDVI

The transformed difference vegetation idex was developed to enhanced the normalized difference vegetation index [10]. TDVI = 1.5X[(NIR-RED)/√NIR2+RED+0.5 (4)

2.3.6 Drainage and Catchment Extraction

The DEM data was used to separate catchment area and drainage pattern in the study area using spatial analysis tools in ARCGIS. The ASTHER DEM data was used in ARCGIS to determine the flow direction of water using raster calculator. The direction of water flow was determined using flow direction tool in spatial analysis toolbox to determine the raster of the hydrological flow direction. The catchment basin was determined using basin tool to delineate all the basin within the study area using the flow direction as input surface. The basin was transformed to raster using raster to polygon tools in the conversion sub toolbox. The stream network was created using flow accumulation to calculate the number of up slopes into a location using the flow direction as input surface. The threshold was defined to determine the watershed using the raster calculator of the map algebra tool.

2.3.7 Definition of Terrain and underground configuration for site suitability for Irrigation.

The SRTM 30m resolution was used to generated DTM, slope, and aspect map. The Landsat thermal bands were used to extract the lineament map of the study area using ARCMAP The thermal band of Landsat data was used to calculate the lineament, SRTM data was used to calculate slope, aspect, and DTM for the study area.

2.3.8 Soil Type Classification

The soil composite, structure, geology, and texture were classified across the study area using ARCGIS 10.7. The various soil types are separated using GIS to defined and delineated soil composition in the various local government area. The crops suitability for the various soil were defined and properly stored in a GIS database management system

2.3.9 LULC Classification

The landuse and landcover classes were classified using the calculated NDVI results. ENVI 4.7 spectral mixture algorithm was used for the classification. The results of the LULC classes for 1996, 2000, and 2018 were used to analyzed landuse and landcover changes from 1986 to 2018.

2.3.10 Land Surface Temperature (LST) and Evapotranspiration (ET)

The land surface temperature and Evapotranspiration was calculated using ARCGIS 10.7 raster calculator to compute ET and LST in the study area to monitor the rate of evapotranspiration by plants and soil across the study area. Landsat data was used to calculate the LST while MODIS was used to calculate ET. The LST was estimated using the surface radiant temperature. The calculated radiant surface temperatures were subsequently corrected for emissivity using the following equation developed by Artis and Carnahan (1982):

LST = TB/ (1 + (λ TB/ ρ) lnε equation (6)

Where LST is land surface temperature (in Kelvin);
TB is radiant surface temperature (in Kelvin);
λ is the wavelength of emitted radiance (11.5 μm);
ρ is h×c/σ (1.438×10−2 m K);
h is Planck's constant (6.26×10-34J s);
c is the velocity of light (2.998×108 m/sec);
σ is Stefan Boltzmann's constant (1.38×10-23J K-1);
and ε is emissivity.
Finally, the LSTs were converted to Celsius by subtracting 273.15 from the value calculated in Equation (6).

3 Results

3.1 The Geospatial Calculator

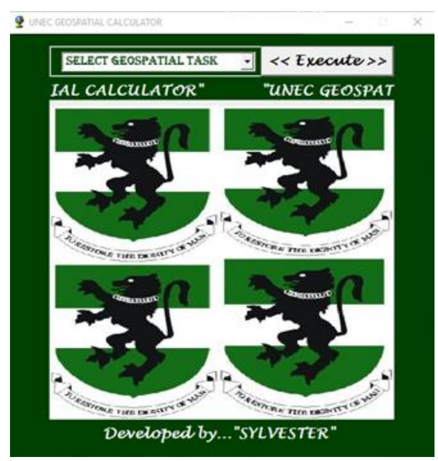

Fig. 3. Geospatial Calculator

The Geospatial Calculator have an interface for downloading Landsat data and Sentinel 2 images. It also has interface for calculating vegetation indices such as SAVI, ARVI, EVI, GEMI, IC, IPVI, IR, LST, MSAVI, MSAVI2, NDBI, NDPI, NDSI, NDTI, NDVI, NDWI, PVI, SRWI, TNDVI, TSAVI,

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WDVI, and RVI.
This software is flexible and easy to use. The selected bands for calculating VI is first corrected for atmospheric errors and conversion of DN number to reflectance values before loading it for VI calculation.

3.1 NDVI, NDWI, SAVI, TNDVI, and EVI for 2016

The NDVI, NDWI, SAVI, TNDVI, and EVI calculated results were represented in table 1, 2, and 3 for analysis and discussing.

Table 1: Vegetation Indeces (VI) for Arable Land Types 1986 (Akpata & Okeke 2019) for 1986

NAME	NDVI	NDWI	SAVI	TNDVI	EVI
Fallow Land	0.436671	0.763327	0.163511	0.967398	0.562011
Farm Land	0.447549	0.735699	0.157704	0.972464	0.493933
Forest Land	0.402283	0.762075	0.1494	0.948236	0.796637
Plantation	0.450606	0.764041	0.16407	0.973799	0.554518
Grass Land	0.432289	0.745794	0.16514	0.965327	0.559758
Non arable	0.411875	0.772085	0.155819	0.954548	0.570594

Table 1 represents the NDVIspectral values with response to the arable land type.

Table 2: Vegetation Indeces (VI) for Arable Land Types 2000 (Akpata & Okeke 2019)

NAME	NDVI	NDWI	SAVI	TNDVI	EVI
Fallow Land	0.313143	0.76191	0.143247	0.895455	0.234353
Farm Land	0.197188	0.742814	0.089886	0.828323	0.168005
Forest Land	0.126138	0.753618	0.05944	0.786722	0.121943
Plantation	0.20348	0.751678	0.093156	0.832388	0.175918
Grass Land	0.329298	0.749663	0.14934	0.908088	0.23609
Non arable	0.376029	0.794944	0.167579	0.933487	0.277757

Table 3 VI Values Vegetation Indeces (VI) for Arable Land Types 2018 (Akpata & Okeke 2019)

NAME	NDVI	NDWI	SAVI	TNDVI	EVI
Fallow Land	0.305117	0.34408	0.25204	0.896622	0.21514
Farm Land	0.344708	0.34282	0.27466	0.917936	0.24975
Forest Land	0.39406	0.24937	0.319866	0.944285	0.33717
Plantation	0.355514	0.30789	0.29045	0.923586	0.26767
Grass Land	0.301506	0.35813	0.253978	0.894822	0.21975
Non-arable	0.315452	0.28888	0.264058	0.902542	0.22781

3.2 LULC Classification

Table 4. LULC Change Statistic from 1986

1986	Value	Count	Area (Ha)	Pct (%)
1	Built Up	891033	80192.97	4.09
2	Farm Land	4724170	425175.3	21.67
3	Thick Forest	9995711	899613.99	45.84
4	Light Forest	4376770	393909.3	20.07
5	Bare Land	111140	10002.6	0.51
6	River	1706476	153582.84	7.83
Total		21805300	1962477	100.00

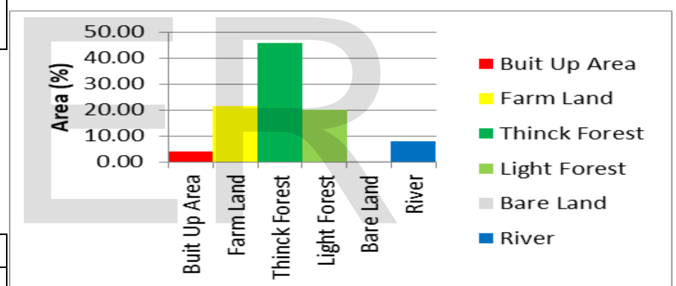

Fig. 4. Bar Chart of LULC intensity for 1986

Table 5 LULC Change Statistitic for 2000 (Akpata & Okeke 2019)

2000	Value	Count	Area (Ha)	Pct (%)
1	Built Up	1790989	161189.01	8.21
2	Farm Land	674101	60669.09	3.09
3	Thick Forest	6130121	551710.89	28.11
4	Light Forest	12845604	1156104.36	58.91
5	Bare Land	49511	4455.99	0.23
6	River	314974	28347.66	1.44
Total		21805300	1962477	100.00

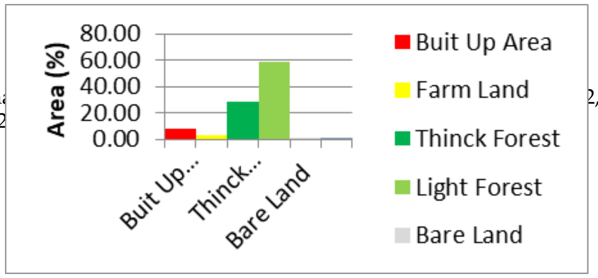

Fig. 6. Bar Chart of LULC intensity for 2000 (Akpata & Okeke 2019)

Table 6 LULC Change Statistitic for 2018 (Akpata & Okeke 2019)

2018	Value	Count	Area (Ha)	Pct (%)
1	Built Up	2382742	214446.78	16.50
2	Farm Land	3436096	309248.64	19.06
3	Thick Forest	9255088	832957.92	16.45
4	Light Forest	5115956	460436.04	26.56
5	Bare Land	1509189	135827.01	11.61
6	River	106229	9560.61	9.82
Total		21805300	1962477	100.00

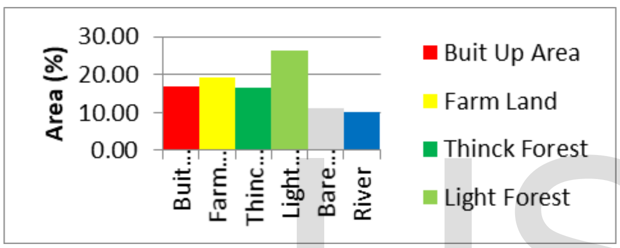

Fig. 5. Bar Chart of LULC intensity for 2018 (Akpata & Okeke 2019)

Table 7 Accuracy Assessment results

Land cover	Overall accuracy (%)	Kappa Coefficient (%)
Bare land	73.53	56.99
Built-Up	85.69	82.02
Thick vegetation	89.91	85.82
Light forest	87.86	83.67
Farm land	55.21	50.12
R body	89.94	84.62

3.3 Irrigation Data

The data for site selection for irrigation are shown in fig. 7 to 12. These maps are used to determine flow direction, slope, topography, and any rock deposits for making decision on irrigation site selection.

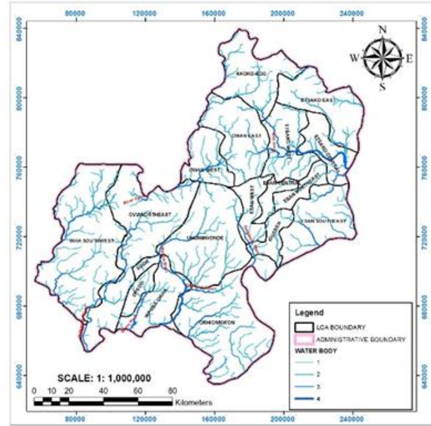

Fig. 7. Drainage Map (Akpata & Okeke 2019)

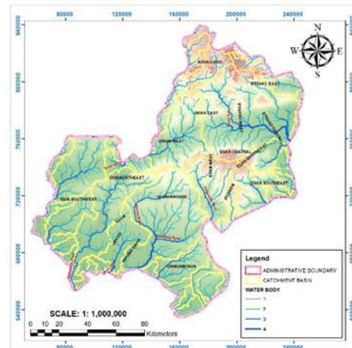

Fig. 8. Catchments map of Edo State (Akpata & Okeke 2019)

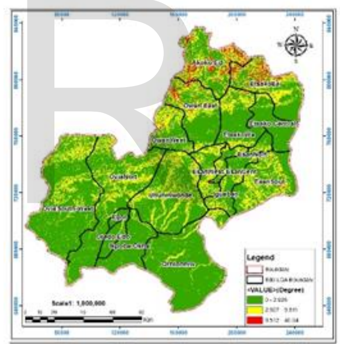

Fig. 9. Slope map of Edo State (Akpata & Okeke 2019)

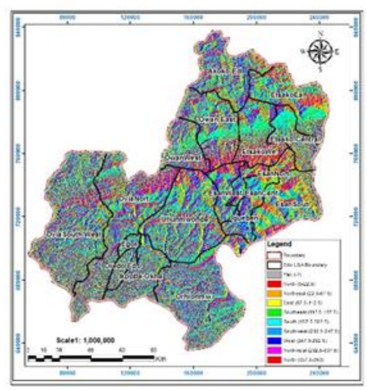

Fig. 10. Aspect Map (Akpata & Okeke 2019)

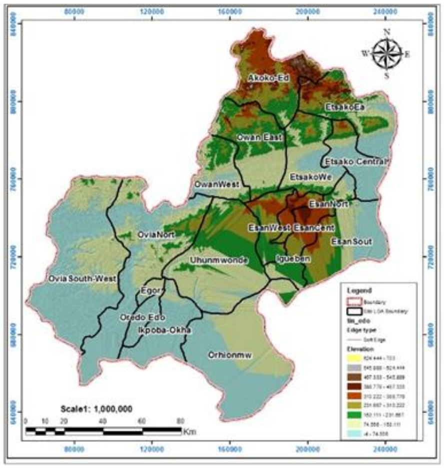

Fig. 11. DEM Model of Edo State (Akpata, & Okeke 2019).

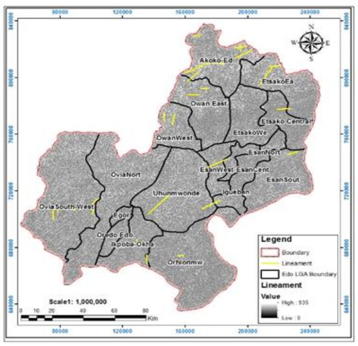

Fig. 12, Lineament Map (Akpata & 2019)

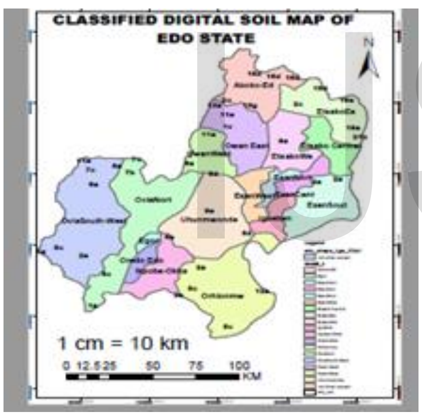

Fig. 13. Digital Soil Map (Akpata & Okeke 2019)

4 Analysis of Results

The geospatial calculator can download Landsat and Sentinel 2 images. It can also calculate all the following indices SAVI, ARVI, EVI, GEMI, IC, IPVI, IR, LST, MSAVI, MSAVI2, NDBI, NDPI, NDSI, NDTI, NDVI, NDWI, PVI, SRWI, TDVI, TSAVI, WDVI, and RVI. The NDVI, SAVI, TDVI, and EVI. The VI responses to vegetation were used to analyzed vegetation phenology in the study area from 1986 to 2018 and to analyzed LULC changes and Arable land use intensity in the study area. It was observed from the LULC and VI result that forest land degraded from 46% in 1986 to 29% in 2000 and 16% in 2018 due to massive agricultural activities and deforestation in the study area. Light forest was 20% in 1986, 59% in 2000, and 23% in 2018. This explained the massive agricultural campaign from 1987 to 1994 in the study area and farm land abandonment from 1994 to 2000. Built-up increased from 4% in 1986 to 8% in 2000, and 11% in 2018. Built-up, farming activities, and deforestation considerable degraded forest cover and indirectly degraded arable land and biodiversity in the study area. The LULC accuracy assessment certified the classified results. The slope, aspect, DEM, and Lineaments results suggest the terrain and underground configuration in the study area. And the digital soil map provides useful soil information for crop production, afforestation, species habitat restoration, and grassland production.

4 Farm Manual

The developed robust procedure for mapping arable and irrigable land produced interesting results which was analyzed to assist farmers or any land user to manage land resource in the study area. This manual is necessary because of the national and global challenge on food insecurity, Nigeria herdsmen and farmers quarrel over land for food production, and the call for preservation and restoration of wildlife, nature, and the ecosystem. The degradation of the ecosystem due to farming activities, Urban sprawl, and industrialization has exposes the perfect formation of the earth crust to erosion, deforestation, and destruction of landform resulting to climate change and arable land degradation. These challenges have resulted to severe consequences of Urban Heat Island (UHI), food scarcity, and, global pandemic such as COVID_19.

The arable and irrigable map can be used to manage land resource to balance the need for food, folders for herds, and forest land to cool the environment.

The arable map shows the location of different vegetation. The vegetation area such as grass land, fallow land, crop (farm) land, forest land, reserved land, and non-arable land. The irrigable map indicate location on the study area that could be used for irrigation. These potential locations for arable and irrigable land in the study area are discussed in this section to serves as path way to sustainable agricultural practices in the study area.

In Akoko Edo LGA, the LGA has two major rivers, River Oyami and Ovia (Ose) River and several other rivers. Akok Edo LGA is the LGA with the highest Elevation, highest LST, and lowest ET. The LGA's arable land type is predominantly farm land, grass land, fallow land, non-arable land, and small percentage of forest land located around the Ikiran-Ile axis towards the Ovia River and the South Easter part of the LGA. This LGA recorded low ET and high LST for the years of investigation. This means that the temperature in this region of the state is high and daily ET low because of lack of water in the soil and plants. This region need enough water to improve crop production. Irrigation method of farming in this region would require the establishment of wells in selected location using lineament maps as a guide to selects location. The well would be located outside the area without rock outcrop to service irrigation farm for cereals, vegetables, and legumes crops. The results from the mapping unit of Akoko Edo as contained in the digital soil map of Nigeria clearly defined the following: map unit 18d with geological composition of migmatite, 0-2% slope, Savanah soil that is moderately drained. Its soil ph. is between 5.5-6.3 strongly acidic to slightly acidic. The soil texture is clay loamy of ustipsamment and its vegetation type is savannah shrub land that is moderately suitable for crops production such as sugar cane, cassava, yam, Irish potatoes, cocoa, Rubber, Groundnut, Millet, sorghum, cowpea, rice, and oil palm. The second mapping unit is 15g. This mapping unit is characterized with undifferentiated basement complex with a slope of 0-2% and savannah soil that is imperfectly drained. Its soil ph. is 6.3, this is slightly acidic sandy clay of topic tropaquept with open savannah woodland's vegetation that is fairly highly suitable with few physical limitations for cultivating Sorghum, cotton, groundnut, millet, cowpea, maize, cocoa yam, and cassava. The third mapping unit in Akoko Edo LGA is 2c with geological composition of lagoonal marshes and back fresh water, 0-2% slope with wet land soil that is poorly drained. The soil ph. is 5.5-5.9 that is moderately acidic with silty loam soil texture of typic tropaquent of raphia palms and ferns vegetation of eutric gleysol soil class that is moderately suitable for the cultivation of yam, cassava, plantain, banana, cocoa, oil palm, and vegetables. The fourth mapping unit is 6a. This mapping unit contained coastal plain sand geology with 0-2% slope of rain forest soil that is well drained. The soil ph. is 5.1-5.9 that is strongly acidic to slightly acidic sandy loam soil of typic paleudult and dystric nitosoil of secondary bush vegetation that is fairly highly suitable with few physical limitations for cultivating yam, rice, plantain, banana, maize, cocoa, oil palm, rubber, and vegetables. And the fifth mapping unit is 13a with undifferentiated basement complex and 6-25% slope of rain forest soils that is well drained. The soil ph. of this mapping unit is 5.1-7.3 with a very strong acidic to neutral sandy clay of lithic troporthent and lithosol soil of rain forest vegetation suitable for cultivating maize, rice, cassava, yam, cocoa, and oil palm.

Etsako East is the second LGA with high elevation, high ET, and second LGA to record low ET. The LGA has river network that could be utilized for irrigation especially the side having boundary with river Niger. The LGA is divided into five mapping units, the first is 18d with geological composition of migmatite, 0-2% slope with Savanah soil that is moderately drained. Its soil ph. ranges from 5.5-6.3 strongly acidic to slightly acidic. The soil texture is clay loamy of ustipsamment and its vegetation type is savannah shrub land that is moderately suitable for crops production such as sugar cane, cassava, yam, Irish potatoes, cocoa, Rubber, Groundnut, Millet, sorghum, cowpea, rice, and oil palm. The second mapping unit is 15g. this mapping unit is characterized with undifferentiated basement complex with a slope of 0-2% and savannah soil that is imperfectly drained. Its soil ph. is 6.3, this is slightly acidic sandy clay of topic tropaquept with vegetation type of open savannah woodland that is fairly highly suitable with few physical limitations for cultivating Sorghum, cotton, groundnut, millet, cowpea, maize, cocoa yam, and cassava. The third mapping unit is 2a of recent alluvium geological composition with 0-2% slope poorly drained wetland soils. The soil ph. is between 5.9-5.9 very acidic sandy loam vertic tropaquept eutric fluvisol sol class of savanna vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. The fourth mapping unit is 19a with sandstone and shakes geological composition of 0-6% slope with a well-drained savannah soils. The soil ph. is between 8.5-9.1 very strongly to strongly alkaline sandy clay typic haplustalf orthic luvisol soil class of savannah woodland vegetation moderately suitable for the cultivation of cassava, yam, rice, cocoa, oil palm, millet, sorghum, cowpea, cotton, and groundnuts. The fifth mapping unit is 21b consisting of sandstone and shakes geology with 0-6% slope of well drained savannah soils. The soil ph. ranges from 4.9-6.5, very strongly acidic to neutral sandy loam typic paleustuit and orthic acrisol soil class of guinea savannah vegetation that is marginally suitable for cultivating sorghum, cowpea, millet, cotton, and maize. And the sixth mapping unit in Etsako East LGA is 21c. This mapping unit is composed of undifferentiated basement complex of 0-6% with well drained Savannah soils. The soil ph. is 5.6-5.9 moderately acidic sandy clay oxic haplustults orthic luvisol soil of fallow vegetation that is moderately suitable for cultivating yam, rice, sugar cane, millets, groundnut, sorghum, bean, cowpea, cotton, and cassava.

Etsako Central LGA has high LST and low ET but the highest ET in Edo North Senatorial districts. The LGA has 2a, 9a, and 2c mapping unit. The mapping unit 2a of recent alluvium geological composition with 0-2% slope and poorly drained wetland soils. The soil ph. is between 5.9-5.9 very acidic sandy loam typic ustifluvent and eutric fluvisol soil class of savanna grassland vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. The second mapping unit is 9a consisting of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges from 5.1-6 and moderately acidic sandy clay typic tropaquept and gleyic cambisol soil of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. The third mapping unit is 2c with geological composition of lagoonal marshes and back fresh water, 0-2% slope with wet land soil that is poorly drained. The soil ph. is 5.5-5.9 that is moderately acidic with silty loam soil texture of typic tropaquent of raphia palms and ferns vegetation of eutric gleysol soil class that is moderately suitable for the cultivation of yam, cassava, plantain, banana, cocoa, oil palm, and vegetables.

Etsako West LGA is one of the LGA in Edo North with average LST of 25.8 degree Celsius and average ET of 450mm/t. The soil mapping unit of this LGA is 9a consisting of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges from 5.1-6, moderately acidic sandy clay typic tropaquept and gleyic cambisol soil of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. The second mapping unit in Etsako West LGA is 2a of recent alluvium geological composition with 0-2% slope poorly drained wetland soils. The soil ph. range from 5.9-5.9 very acidic sandy loam typic ustifluvent and eutric fluvisol soil class of savannah grassland vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. The second mapping unit is 9a consisting of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges from 5.1-6. moderately acidic sandy clay typic tropaquept and gleyic cambisol soil of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. The third is 2c with geological composition of lagoonal marshes and back fresh water, 0-2% slope with wet land soil that is poorly drained. The soil ph. is 5.5-5.9 that is moderately acidic with silty loam soil texture of typic tropaquent of raphia palms and ferns vegetation of eutric gleysol soil class that is moderately suitable for the cultivation of yam, cassava, plantain, banana, cocoa, oil palm, and vegetables. The fourth mapping unit in Etsako West LGA is 15g. This mapping unit is characterized with undifferentiated basement complex with a slope of 0-2% and savannah soil that is imperfectly drained. Its soil ph. is 6.3, this is slightly acidic sandy clay of topic tropaquept with vegetation type of open savannah woodland that is fairly highly suitable with few physical limitations for cultivating Sorghum, cotton, groundnut, millet, cowpea, maize, cocoa yam, and cassava. And the fifth is 5d with geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope and well drained rain forest soils. The soil ph. ranges from 4.2-4.7 very acidic sandy loam oxic dystropept and syatric cambisol soil of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

The owan East LGA has LST of average of 26.8 degree Celsius and average ET of 200mm/t. This mean that the temperature in this LGA is high and the amount of water loss to the atmosphere from soil and plant is very low. The soil mapping units in this LGA are 9a, 11a, 13a, 1c, 2c, 5d, and 15g. The mapping unit 9a consisting of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges from 5.1-6 and is moderately acidic sandy clay typic tropaquept and gleyic cambisol soil of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. The second mapping unit is 13a with undifferentiated basement complex and 6-25% slope of rain forest soils that is well drained. The soil ph. of this mapping unit is 5.1-7.3 with a very strong acidic to neutral sandy clay of lithic troporthent and lithosol soil of rain forest vegetation suitable for cultivating maize, rice, cassava, yam, cocoa, and oil palm. The third is 11a with undifferentiated basement complete of 0-6% and 5-30% slope of well drained rain forest. The soil ph. ranges from 5.1-6.5 strongly acidic to slightly acidic sandy clay tropudalf orthic and luvisol soil class of rain forest vegetation that is moderately suitable for maize, rice, cassava, yam, cocoa, and oil palm. The fourth mapping unit is 1c of beach ridge sands and mounds geology with 0-2% slope of poorly drained wet land soils. The soil ph. ranges from 5.0-5.5 very strongly acidic sandy typic tropopsamment and dystric regosol soil of bush coconut and cassava vegetation for cultivating yam, rice, cassava, plantain, banana, cocoa, oil palm, fruits, and vegetables. The fifth mapping unit is 2c with geological composition of lagoonal marshes and back fresh water, 0-2% slope with wet land soil that is poorly drained. The soil ph. is 5.5-5.9 that is moderately acidic with silty loam soil texture of typic tropaquent of raphia palms and ferns vegetation of eutric gleysol soil class that is moderately suitable for the cultivation of yam, cassava, plantain, banana, cocoa, oil palm, and vegetables. The sixth mapping unit in Owan East LGA is 15g. This mapping unit is characterized with undifferentiated basement complex with a slope of 0-2% and savannah soil that is imperfectly drained. Its soil ph. is 6.3, this is slightly acidic sandy clay of topic tropaquept with vegetation type of open savannah woodland that is fairly highly suitable with few physical limitations for cultivating Sorghum, cotton, groundnut, millet, cowpea, maize, cocoa yam, and cassava. And the seventh is 5d with geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope and well drained rain forest soils. The soil ph. ranges between 4.2-4.7, very acidic sandy loam oxic dystropept and syatric cambisol soil class of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

Owan West recorded average LST of 25 degree Celsius and average ET of 450mm/t. The soil mapping units for Owan west are 6a, 9a, 11a, 13a, 2c, and 5d. The mapping unit 6a have geological composition of coastal plain sands with 0-2% of well drained rain forest soils. The soil ph. ranges from 5.1-5.9 strongly acidic to slightly acidic sandy loam typic paleudult and dystric nitosol soils of cassava maize vegetation that is fairly highly suitable with few physical limitations for cultivating yam, rice, cassava, plantain, banana, cocoa, oil palm, fruits, and vegetables. The second mapping unit in Owan West LGA is 9a consisting of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges from 5.1-6, moderately acidic sandy clay typic tropaquept and gleyic cambisol soil class of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. The third mapping unit is 13a with undifferentiated basement complex and 6-25% slope of rain forest soils that is well drained. The soil ph. of this mapping unit is 5.1-7.3 with a very strong acidic to neutral sandy clay of lithic troporthent and lithosol soil of rain forest vegetation suitable for cultivating maize, rice, cassava, yam, cocoa, and oil palm. The fourth is 11a with undifferentiated basement complex of 0-6% and 5-30% slope of well drained rain forest. The soil ph. ranges from 5.1-6.5 strongly acidic to slightly acidic sandy clay tropudalf orthic luvisol soil class of rain forest vegetation that is moderately suitable for maize, rice, cassava, yam, cocoa, and oil palm. The fifth mapping unit is 2c with geological composition of lagoonal marshes and back fresh water, 0-2% slope with wet land soil that is poorly drained. The soil ph. is 5.5-5.9 that is moderately acidic with silty loam soil texture of typic tropaquent of raphia palms and ferns vegetation of eutric gleysol soil class that is moderately suitable for the cultivation of yam, cassava, plantain, banana, cocoa, oil palm, and vegetables. The sixth mapping unit in Owan East LGA is 15g. This mapping unit is characterized with undifferentiated basement complex with a slope of 0-2% and savannah soil that is imperfectly drained. Its soil ph. is 6.3, this is slightly acidic sandy clay of topic tropaquept with vegetation type of open savannah woodland that is fairly highly suitable with few physical limitations for cultivating Sorghum, cotton, groundnut, millet, cowpea, maize, cocoa yam, and cassava.

And the sixth is 5d with geological composition of transitional materials of sub recent alluvium and coastal plain sands of 0-2% slope and well drained rain forest soils. The soil ph. ranges from 4.2-4.7, very acidic sandy loam oxic dystropept and syatric cambisol soil class of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

Esan Central LGA have average LST of 25.6 degree Celsius and average ET of 266mm/t. The soil mapping units are 9a and 5d. The mapping unit 9a consisting of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges from 5.1-6, moderately acidic sandy clay typic tropaquept and gleyic cambisol soil of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. And the mapping unit 5d have geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope and well drained rain forest soils. The soil ph. ranges from 4.2-4.7 very acidic sandy loam oxic dystropept syatric cambisol soil of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

Esan North have LST of 24. 8 degrees Celsius with an average ET of 327mm/t with soil mapping units of 2a, 9a, and 5d. The mapping units 2a of recent alluvium geological composition with 0-2% slope poorly drained wetland soils. The soil ph. is between 5.9-5.9 very acidic sandy loam typic ustifluvent and eutric fluvisol soil class of savannah grassland vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. The second mapping unit in Esan North is 9a, consisting of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges from 5.1-6, moderately acidic sandy clay typic tropaquept and gleyic cambisol soil of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. And the third mapping unit 5d have geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope and well drained rain forest soils. The soil ph. ranges from 4.2-4.7 very acidic sandy loam oxic dystropept and syatric cambisol soil of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

Esan South have mapping unit 2a, 9a, 2c, and 5d. The mapping units 2a is composed of recent alluvium geological composition with 0-2% slope and poorly drained wetland soils. The soil ph. is between 5.9-5.9 and is very acidic sandy loam typic ustifluvent and eutric fluvisol soil class of savannah grassland vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. The second mapping unit in Esan South LGA is 9a, consisting of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges between 5.1-6 with moderately acidic sandy clay typic tropaquept and gleyic cambisol soil class of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. The third mapping unit is 2c with geological composition of lagoonal marshes and back fresh water, 0-2% slope with wet land soil that is poorly drained. The soil ph. is 5.5-5.9 that is moderately acidic with silty loam soil texture of typic tropaquent of raphia palms and ferns vegetation of eutric gleysol soil class that is moderately suitable for the cultivation of yam, cassava, plantain, banana, cocoa, oil palm, and vegetables. And the fourth mapping unit is 5d having geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope and well drained rain forest soils. The soil ph. ranges between 4.2-4.7 very acidic sandy loam oxic dystropept and syatric cambisol soil class of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

Esan West has LST of 24.8 Celsius and average ET of 470 mm/t with soil mapping units of 2a and 5d. The mapping units 2a is composed of recent alluvium geological composition with 0-2% slope and poorly drained wetland soils. The soil ph. is between 5.9-5.9 and is very acidic sandy loam typic ustifluvent and eutric fluvisol soil class of savannah grassland vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. And the mapping unit 5d having geological composition of transitional materials of sub recent alluvium and coastal plain sands of 0-2% slope and well drained rain forest soils. The soil ph. ranges between 4.2-4.7 very acidic sandy loam oxic dystropept and syatric cambisol soil of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

The Iggueben LGA have average LST of 25.6 Celsius and average ET of 460mm/t. The soil mapping units are 9a and 5d. The mapping unit 9a consist of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges from 5.1-6 with moderately acidic sandy clay typic tropaquept and gleyic cambisol soil class of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. And the mapping unit 5d have geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope and well drained rain forest soils. The soil ph. ranges between 4.2-4.7 very acidic sandy loam oxic dystropept and syatric cambisol soil class of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

The Uhunmwode LGA have average LST of 23.9 degree Celsius and average ET of 790mm/t. the soil mapping units are 6a, 9a, 11a, 13a, 1c, 2c, 5d, and 15g. The mapping unit 6a have geological composition of coastal plain sands with 0-2% of well drained rain forest soils. The soil ph. ranges from 5.1-5.9 strongly acidic to slightly acidic sandy loam typic paleudult and dystric nitosol soils of cassava maize vegetation that is fairly highly suitable with few physical limitations for cultivating yam, rice, cassava, plantain, banana, cocoa, oil palm, fruits, and vegetables. The second mapping unit in this LGA is 9a consisting of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges from 5.1-6 moderately acidic sandy clay of typic tropaquept and gleyic cambisol soil class of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. The third mapping unit is 13a with undifferentiated basement complex and 6-25% slope of rain forest soils that is well drained. The soil ph. of this mapping unit is 5.1-7.3 with a very strong acidic to neutral sandy clay of lithic troporthent and lithosol soil of rain forest vegetation suitable for cultivating maize, rice, cassava, yam, cocoa, and oil palm. The fourth is 11a with undifferentiated basement complete of 0-6% and 5-30% slope of well drained rain forest. The soil ph. ranges from 5.1-6.5 strongly acidic to slightly acidic sandy clay of tropudalf orthic luvisol soil class of rain forest vegetation that is moderately suitable for maize, rice, cassava, yam, cocoa, and oil palm. The fifth mapping unit is 2c with geological composition of lagoonal marshes and back fresh water, 0-2% slope with wet land soil that is poorly drained. The soil ph. is 5.5-5.9 that is moderately acidic with silty loam soil texture of typic tropaquent of raphia palms and ferns vegetation of eutric gleysol soil class that is moderately suitable for the cultivation of yam, cassava, plantain, banana, cocoa, oil palm, and vegetables. The sixth mapping unit in this LGA is 15g. This mapping unit is characterized with undifferentiated basement complex with a slope of 0-2% and savannah soil that is imperfectly drained. Its soil ph. is 6.3, this is slightly acidic sandy clay of topic tropaquept with vegetation type of open savannah woodland that is fairly highly suitable with few physical limitations for cultivating Sorghum, cotton, groundnut, millet, cowpea, maize, cocoa yam, and cassava. And the seventh is 5d with geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope and well drained rain forest soils. The soil ph. ranges between 4.2-4.7 very acidic sandy loam oxic dystropept syatric and cambisol soil of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables. The eighth mapping unit is 1c of beach ridge sands and mounds geology 0-2% slope of poorly drained wet land soils. The soil ph. ranges from 5.0-5.5 very strongly acidic sandy typic tropopsamment and dystric regosol soil of bush coconut and cassava vegetation for cultivating yam, rice, cassava, plantain, banana, cocoa, oil palm, fruits, and vegetables.

Orhionwon LGA have average LST of 28 degree Celsius and average ET of 870mm/t. The mapping unit are 2a, 6a, 9a, 12a, 5c, and 5d. The mapping units 2a is composed of recent alluvium geological composition with 0-2% slope and poorly drained wetland soils. The soil ph. ranges from 5.9-5.9 and is very acidic sandy loam typic ustifluvent and eutric fluvisol soil class of savanna grassland vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. The second mapping unit 6a have geological composition of coastal plain sands with 0-2% of well drained rain forest soils. The soil ph. ranges from 5.1-5.9 strongly acidic to slightly acidic sandy loam typic paleudult and dystric nitosol soils of cassava maize vegetation that is fairly highly suitable with few physical limitations for cultivating yam, rice, cassava, plantain, banana, cocoa, oil palm, fruits, and vegetables. The third mapping unit in this LGA is 9a consisting of sandstone and shakes geology with 0-6% slope of moderately drained rain forest soils. The soil ph. ranges between 5.1-6 moderately acidic sandy clay typic tropaquept and gleyic cambisol soil of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oil palm, rubber, and vegetables. The mapping unit 12a consist of coastal plain sands and sandstone geology of 0-6% slope of well drained rain forest soils. The soil ph. is 4.5-5.5 slightly acidic sandy loam typic tropaquept and gleyic gambisol soil class of bush cassava/maize farm vegetation for cultivating cassava, yam, rice, maize, oil palm, plantain, and vegetable. The mapping unit 5c is consist of coastal plain sands and 0-2% well drained rainforest soil. The soil ph. is 4.5-5.5 very strongly acidic sandy loam rhodic paledult and orthic acrisol of rain forest for cultivating yam, rice, maize, cassava, cocoa, oil palm, and fruits. And the mapping unit 5d with geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope with well drained rain forest soils. The soil ph. ranges from 4.2-4.7 very acidic sandy loam oxic dystropept syatric cambisol soil of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

Ikpoba Okha LGA recorded average LST of 25.5 degree Celsius and average ET of 900mm/t. The soil mapping units are 2a, 6a, and 5c. The mapping units 2a is composed of recent alluvium geological composition with 0-2% slope with poorly drained wetland soils. The soil ph. is 5.9-5.9 and very acidic sandy loam typic ustifluvent and eutric fluvisol soil class of savannah grassland vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. The second mapping unit 6a, have geological composition of coastal plain sands with 0-2% of well drained rain forest soils. The soil ph. ranges from 5.1-5.9 strongly acidic to slightly acidic sandy loam typic paleudult and dystric nitosol soils of cassava maize vegetation that is fairly highly suitable with few physical limitations for cultivating yam, rice, cassava, plantain, banana, cocoa, oil palm, fruits, and vegetables. And the mapping unit 5c is consist of coastal plain sands and 0-2% well drained rainforest soil. The soil ph. is 4.5-5.5 very strongly acidic sandy loam of rhodic paledult and orthic acrisol of rain forest for cultivating yam, rice, maize, cassava, cocoa, oil palm, and fruits. And the mapping unit 5d with geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope with well drained rain forest soils. The soil ph. ranges from 4.2-4.7 very acidic sandy loam of oxic dystropept syatric cambisol soil of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

Ore Edo LGA recorded average LST of 24 degree Celsius and average ET of 1600mm/t. The soil mapping units of Oredo are 2a, 6a, and 5c. The mapping units 2a is composed of recent alluvium geological composition with 0-2% slope and poorly drained wetland soils. The soil ph. is between 5.9-6.9 and is very acidic sandy loam of typic ustifluvent and eutric fluvisol soil class of savannah grassland vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. The second mapping unit 6a have geological composition of coastal plain sands with 0-2% of well drained rain forest soils. The soil ph ranges from 5.1-5.9

strongly acidic to slightly acidic sandy loam of typic paleudult and dystric nitosol soils of cassava maize vegetation that is fairly highly suitable with few physical limitations for cultivating yam, rice, cassava, plantain, banana, cocoa, oil palm, fruits, and vegetables. And the mapping unit 5c is consist of coastal plain sands and 0-2% well drained rainforest soil. The soil ph. is 4.5-5.5 very strongly acidic sandy loam rhodic paledult and orthic acrisol of rain forest for cultivating yam, rice, maize, cassava, cocoa, oilpalm, and fruits.

Egor LGA recorded average LST of 28 degree Celsius and average ET of above 1700mm. The soil mapping units in this LGA is 6a. The mapping unit 6a have geological composition of coastal plain sands with 0-2% of well drained rain forest soils. The soil ph. ranges from 5.1-5.9 strongly acidic to slightly acidic sandy loam of typic paleudult and dystric nitosol soils of cassava maize vegetation that is fairly highly suitable with few physical limitations for cultivating yam, rice, cassava, plantain, banana, cocoa, oil palm, fruits, and vegetables. This LGA is composed of non-arable land.

Ovia North recorded average temperature of 21.25 degree Celsius and average ET of 900mm/t, 1200mm/t, and 600mm/t for 1987, 2000, and 2018 respectively. the mapping units in this LGA are 1a, 2a, 6a, 9a, 7b, 5c, 7c, and 5d. The mapping unit 1a is composed of delliac basin and tidal flats with 0-2% slope of poorly drained wet land soils. The soil ph. ranges from 4.6-5.0 very strongly scidic sandy loam of typic tropaquent and eutric gleysol soil classes of ferns vegetation that is moderately suitable for cultivating yam, maize, rice, cassava, oil palm, cocoa, coconuts, and vegetable. The mapping units 2a is composed of recent alluvium geological composition with 0-2% slope and poorly drained wetland soils. The soil ph. is between 5.9-5.9 very acidic sandy loam of typic ustifluvent and eutric fluvisol soil class of savannah grassland vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. The mapping unit 6a contained sandstone and shales geology with 0-6% and 5-30% slope of rain forest soil that is moderately drained. The soil ph. is 5.1-6.0 that is moderately acidic sandy clay soil of oxic dystropepts that is fairly highly suitable with few limitations for cultivating yam, rice, plantain, banana, maize, cocoa, oil palm, rubber, fruits, and vegetables. The third mapping unit in this LGA is 9a consisting of sandstone and shakes geology with 0-6% and 5-30% slope of moderately drained rain forest soils. The soil ph. ranges from 5.1-6 moderately acidic sandy clay of typic tropaquept and gleyic cambisol soil of oil palm bush vegetation that is fairly highly suitable with few physical limitations for the cultivation of rice, cassava, plantain, maize, cocoa, oilpalm, rubber, and vegetables. The fourth mapping unit is 7b with sandstone geology of 0-6% slope and well drained rainforest soils. The soil ph. ranges from 4.6-4.8, very strongly acidic sandy loam of typic paleustalf and orthic arcrisol soil class of secondary forest fallow vegetation that is fairly highly suitable with few physical limitations for cultivating yam, rice, cassava, maize, cocoa, and oil palm. The fifth mapping unit 5c is consist of coastal plain sands and 0-2% well drained rainforest soil. The soil ph. is 4.5-5.5 very strongly acidic sandy loam rhodic paledult orthic acrisol of rain forest for cultivating yam, rice, maize, cassava, cocoa, oil palm, and fruits. The sixth mapping unit is 7c consisting of undifferentiated basement complex of 0-2% and well drained rainforest soil. The soil ph. ranges from 5.6-6.5 moderately acidic sandy loam of orthic tropudalf and orthic luvisol class of soil rain forest vegetation that is fairly highly suitable with few limitations for cultivating yam, rice, cassava, maize, cocoa, and oil palm. And the mapping unit 5d with geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope with well drained rain forest soils. The soil ph. ranges from 4.2-4.7 very acidic sandy loam of oxic dystropept and syatric cambisol soil of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

Ovia South West LGA recorded average LST of 20.25, and 26 degrees Celsius, and average ET of 1000mm/t, 1350mm/t, and 500mm/t for the year 1987, 2000, and 2018 respectively. The mapping units of Ovia SouthWest LGA are 2a, 6a, 8a, 11a, 13a, 2c, and 5d. The mapping units 2a is composed of recent alluvium geological composition with 0-2% slope and poorly drained wetland soils. The soil ph. is between 5.9-5.9, very acidic sandy loam of typic ustifluvent and eutric fluvisol soil class of savanna grassland vegetation that is moderately suitable for cultivating yam, rice, maize, millet, and Irish potatoes. The mapping unit 6a contained sandstone and shales geology with 0-6% slope of rain forest soil that is moderately drained. The soil ph. is 5.1-6.0, moderately acidic sandy clay soil of oxic dystropepts that is fairly highly suitable with few limitations for cultivating yam, rice, plantain, banana, maize, cocoa, oil palm, rubber, fruits, and vegetables. The second mapping unit is 8a and its consist of undifferentiated basement complex of 0-2% and 5-30% slope of well drained rainforest soils. The soil ph. ranges from 5.1-6.5 strongly acidic to slightly acidic sandy loam of oxic tropudalf and chromic luvisol rain forest that is moderately suitable for cultivating yam, rice, cassava, maize, cocoa, and oil palm. The third mapping unit is 11a with undifferentiated basement complete of 0-6% and 5-30% slope of well drained rain forest. The soil ph. ranges from 5.1-6.5 strongly acidic to slightly acidic sandy clay of tropudalf orthic and luvisol soil class of rain forest vegetation that is moderately suitable for maize, rice, cassava, yam, cocoa, and oil palm. The fourth mapping unit is 7b with sandstone geology of 0-6% slope and well drained rainforest soils. The soil ph. ranges between 4.6-4.8, very strongly acidic sandy loam of typic paleustalf and orthic arcrisol soil class of secondary forest fallow vegetation that is fairly highly suitable with few physical limitations for cultivating yam, rice, cassava, maize, cocoa, and oil palm. The fifth mapping unit 5c is consist of coastal plain sands and 0-2% well drained rainforest soil. The soil ph. is 4.5-5.5 very strongly acidic sandy loam of rhodic paledult and orthic acrisol of rain forest for cultivating yam, rice, maize, cassava, cocoa, oil palm, and fruits. The sixth mapping unit is 7c consisting of undifferentiated basement complex of 0-2% and well drained rainforest soil. The soil ph. ranges from 5.6-6.5 moderately acidic sandy loam of orthic tropudalf and orthic luvisol class of soil rain forest vegetation that is fairly highly suitable with few limitations for cultivating yam, rice, cassava, maize, cocoa, and oil palm. And the mapping unit 5d with geological composition of transitional materials of subrecent alluvium and coastal plain sands of 0-2% slope and well drained rain forest soils. The soil ph. ranges between 4.2-4.7 very acidic sandy loam of oxic dystropept and syatric cambisol soil of secondary bush oil palm vegetation for cultivating yam, rice, cassava, maize, cocoa, oil palm, and vegetables.

4 DISCUSSION OF RESULTS

The arable and irrigable land of Edo state were mapped out using geospatial techniques for sustainable agricultural practices and preservation of natural resources in the three senatorial zones. The land use and land cover (LULC) classification delineated the land used pattern across the study area from 1986 to 2018. The LULC classes clearly shows the various changes that has occurred in the LULC classes across the study area. The changes show the impact of Urban sprawl and agricultural activities on arable and non-arable land including earth's surface degradation due to soil erosion. Especially farmland that is close to settlement and industrial location. Forest cover has actually disappear taking notice of this changes from 1986 till date. To avert for further degradation of the ecosystem, the research developed an approach for organized farming system that will ensure unnecessary deforestation through farming and Lumbering activities. Crop plating and speciation including afforestation and conservation was proposed as solution to restore nature in this research.

Several approaches including NDVI were used to generate results for the classification of the various arable land types and irrigable land in the study area. These arable land classes in the study area were classified into arable land classes for sustainable agricultural practices in the study area. The arable land in the study area has degraded drastically from 1986 to date to either grass land, fallow land, crop land, and abandoned land. Note that, arable land includes uncultivated land (virgin land) that is now occupied with built-up and agricultural activities leaving behind less than four percent just like in the case of Nigeria forest cover as recorded in past review [35]. The usual method of moving from one forest to the other searching for rich soil for crops production is occupying the remaining non-arable land (virgin). Farmland should be enriched using manure and shifting cultivation. Species should be preserved including earthworms in order to ensured that nature is restored. The reduction in the forest land cover was as a result of agricultural activities and uncontrolled lumbering without afforestation.

The various arable land type was identified and mapped out using ground truth data and corresponding VI. The VI values vary according to vegetation phenology. So, with ground truth data and VI values, the arable land types were classified. The cropland (farmland) is the cultivated land used for crops production. The crops land is located across the study area and need to be identified. To effectively identify the crops land, non-arable land, reserved land, grassland, non-agricultural land, agricultural land, fallowed land, and abandoned land, ground truth data, VI values and satellite images were used. The developed Geospatial calculator software was used to calculate VI values for analysis and presentation. The developed Geospatial Calculator can download Landsat and Sentinel 2 satellite images faster and with less data because of the processes involved in the design. Thereby minimizing and maximizing time usage and save cost for data.

The fallowed land is arable land that has loss it powers of productivity and as such it is allowed to fallowed to regained its strength for producing crops. If it is allowed to stays fallow for more than 5 years, it is regarded as grassland, if grown with shrubs, woodland, with trees, forest land. But if it is allowed to fallow for a long time like in the case of Dangbala, Ikiran-Oke axis where the tobacco farm was abandoned, it is called abandoned land. These various categories are located across the 18 local government area and can be used for grass land production for livestock. The predominant grassland location is in the Akoko-Edo Local Government Area and some part of Etsako and Owan East, and West LGA. The non-arable land belongs to the categories of built-up, forest, reserved, uncultivated land, and welt lands. The uncultivated lands are identified, biodiversity, and endemic species hot spot are also identified for conservation and speciation. The delineated conserved area is also suggested to be used for captive breeding of endanger species if you are sure the new location have the same habitat with the proposed species to be relocated to avoid the spread of viruses. The biodiversity hot spot is investigated and area with same categories of soil, environmental condition is selected for speciation (extra and intra speciation) to increase species and biodiversity.

The arable land for crops production is selected across the 18 Local Government Area and soil suitability for crops production were suggested to enhanced precise and sustainable agricultural practices in Edo and Nigeria.

The digital soil map generated for the study shows the soil suitability for crops production as recorded in the farm manual. This will enhance sustainable agricultural practices that would make food available for man and livestock in Edo state and Nigeria.

The uncultivated arable land especially the virgin land which is host to species and biodiversity including forest reserves can be well manage by ensuring that too much pressure is not put on the uncultivated arable land. The only remedy to stop excessive deforestation is to manage the cultivated land by using manure to increase crop yield on fallowed and abandoned land. More also, irrigation system of farming is another way of increasing crops production, biodiversity and speciation.

Irrigation farming, honestly is a global solution to hunger and food crisis in Nigeria, Africa, and Asia. It could be sited along the river bank or sited in upland by creating water tanks in choice location for water supply to farmland. This is the best way for speciation and crops production including development of parks and beautification and modelling of the ecosystem. Irrigation farming was said to have contributed to 40% of crops production in America, Russia, and Europe. But, in Nigeria, this method of farming has not been utilized probably because of access to facilities. Although, peasant farmers practiced small scale irrigation farming along the river bank, especially in the Northern part of Nigeria. If the river network system in Nigeria is used for irrigation farming, no doubt, it would contribute lots to crops production.

More also, the Human-Wildlife conflicted caused by man quest for food and industrialization could be checked and monitor using tips from this research. Lumbering and farming activities could be manage using the developed organized farming system for the study. Species preservation through captive breeding of endanger species and speciation would be ensured using the organized developed database for the study. Endemic species location was identified and speciation (intra and extra speciation) encourage to preserve wildlife habits to ensure friendly ecosystem that is free from viruses.
The map for water drainage and water catchment contains information about water potential in the study area. These maps would be used to locate possible site for irrigation and proposed well location to supply water for irrigation farming.

Also, slope map is another valuable information for the farmers. It would help to know elevation in their farm site and to avoid siting farm location and irrigation farm along a steep slope. The farmer can understand better and faster if he uses aspect map which indicate flow direction. This would help the farmer to know water flow direction and to plan farming activities in such a way that erosion would not interfere with crop production. More also, the slope and aspect map would help the farmer to make choice on the location suitable for irrigation farming.

The farm manual contains useful information that would assist farmer on selecting appropriate soil, crop types, and the amount water requires for farm production. The manual detail the soil, geology, ph, crop suitability, and vegetation type in all the 18 LGA in the study area. This information would tell the farmer all he wants to know about farming activities in the study area.

5 CONCLUSSION

The study investigated arable and irrigable land use intensity and possible threat to arable land, nature and biodiversity. The LULC change from 1986 to 2018 shows that there is degradation in arable land dues to farming activities. Forest cover has reduced to a very low percentage when you compare the changes from 1986 to 2018. The study also provided organized procedures for arable and irrigable land to enhance crop production and natural resource preservation. These was achieved by considering soil composition, textures, and nutrient. Also, land surface temperature and evapotranspiration in the study area was calculated to estimate the amount of water loss to the atmosphere as compared to the daily temperature and ET. The drainage pattern and water catchment area was extracted to indicate potential site for irrigation. The slope, aspect, and lineament information were calculated to further authenticate irrigation site selection. VI was used to accurately estimate vegetation changes in the study area. The arable map was designed using information from the NDVI and survey data to implement the mapping process. Selected GIS software were used to automate the research process. The Geospatial calculator was used to download Landsat and Sentinel images and to calculate VI and it was very effective for this process in this research. MODIS and SRTM data were downloaded from USGS website using google chrome. ARCGIS 10.7, ENVI 4.7, and GQIS 3.8.1 was used for some of the processes, map production and classification for arable land, LULC maps, Lineament, drainage map, water catchment area, slope, and aspect map, ET and LST maps were all produced to serves as farming useful information. Microsoft excel was used to automate some of the analysis using zonal statistics. The results from the LULC analysis show that arable land has degraded from 1986 to 2018 and LST is high in the northern part of the state. While Egor, Ore Edo, and Ikpoba Okha record the highes ET due to Urban Heat Island effect and the Ikpoba hill's rivers located in these LGAs. The loss in forest cover in the study area has affect the climate and Wild life habitat. The digital soil map of the study area was developed to prepare alongside other results from the study to developed a farm manual for the study to increase crop production and preservation of natural resources. The farm manual contains all the farm information requires for crop production and define how farming activities can be carried out in the study area to preserve nature and natural resources. A database was created to store the results of the study.

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