REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS (GIS) APPLICATION TO LAND SUITABILITY CLASSIFICATION FOR IRRIGATION FARMING IN ARGUNGU FADAMA, KEBBI STATE OF NIGERIA

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KEY WORDS: Land Suitability Classification, Remote Sensing and GIS.

ABSTRACT

This study assessed the land suitability classification for irrigation farming in Argungu Fadama using GIS technique. The factors used to evaluate land suitability in the study area are soil, slope and land cover. Based on these factors considered, it was found out that Argungu Fadama is highly suitable for irrigation farming as the slope is less than 2% in accordance with FAO guidelines 1976 throughout. This serve as indication that surface irrigation can thrive in the study area. The soil properties evaluated in the study area indicates that no major threat to crop production as such the entire 1,000 ha of the study area was found to be suitable for irrigation and can support the cultivation of crops other than rice such as wheat, tomato, pepper, onions cowpea and tobacco. One of the recommendations is that policy decision making for development of irrigation activities in the study area. that future researches should include water quality, economic and social factors.

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INTRODUCTION

Local irrigation farmers in Argungu *Fadama* for quite a very long time have traditionally been cultivating rice as a mono crop which is entirely dependent on annual flooding. However, the unreliable nature of rainfall and flooding conditions owing to the semi- arid nature of the environment which is a marginal dry land in the north west Nigeria; have lead to heavy losses being incurred by farmers as a result of crop failure arising from occasionally erratic droughts and sometimes over flooding. As part of the adaptation and mitigation strategies, the adoption of dry season cultivation has being and is gaining momentum as a means of food security amongst farmers of Argungu *Fadama*.. However, the farmers are yet ignorant about conducting the conventional land suitability classification based on the principle of indirect method of land evaluation. Rather, the farmers rely on their experience which is the direct method of land evaluation that has the disadvantage of time resource wastage before understanding the land quality which offers guide to decide on the land management for specific cropping expected of land suitability classification.

The ability to conduct the land suitability studies by indirect method involving field data collection together with the use of remote sensing products involving imageries interpretation with Computer Aided Technology that fast track the conduct of the classification through quick imagery processing is presently recognized and therefore herby applied to this study.

The use of Remote sensing and GIS technology along with the analysis of the physical data do assist to avoid delays in decision making towards judicious land suitability classification to aid boosting food production in the light of the current Millennium Development Goal on Food Security which most developing nation is yearning to achieve by 2015 of which Nigeria and specifically the study area as this case.

It is also important to reiterate that besides 1998 soil survey of Kebbi state *Fadamas* at the instance of Kebbi Agriculture and Rural Development Authority (KARDA), which was only to carry out detailed soil survey and to construct soil maps no previous study has been undertaken to find suitable lands for irrigation farming in the study area using GIS technique, more especially to match suitability classes with appropriate crops. It is in the light of this, that, this study attempt to fill in the gap from the previous study.

In the light of the foregoing conduct of the land suitability classification by highly sensitive and accurate method is imminent because of the possibility of unveiling other crops suitable on the irrigable land. The use of the GIS technology perhaps might be due to heterogeneity of the soils and physical conditions observed that rice may not be the only crop that can be cultivated in Argungu *Fadama*. Other crops might as well do even better by their placement under most suitable classes. This surely will benefit the farmers more so there will be variety of crops on their farms for sale, they will also be able to have varieties of food on their table as subsistence farmers. In addition, the farmers have security of their crops against failure due to infection by pest and diseases because hardly two crops get infected by same type of disease.

Therefore, this study aim to conduct land suitability classification for irrigation farming in Argungu *Fadama* using GIS technique. The objectives include; To construct land suitability classification map for irrigation, to match land suitability classes with specific crops and to produce soil and slope maps with a view to expose spatial coverage of the values of each attribute in the study area.

2.00 CONCEPTUAL BASIS OF LAND SUITABILITY CLASSIFICATION AND THE APPLICATION OF REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEMS

2.1 Conceptual Framework

The concept of this study is based on Food and Agriculture Organization framework for land evaluation (FAO, 1976), which described the process of land suitability classification as the appraisal and grouping of specific areas of land in terms of their suitability for define uses. In order to achieve this goal, data about the land in terms of it soils, topography, climate is required for a realistic alternatives for improving the use of that land.

FAO (2001) also stressed that for irrigation land suitability classification particular attention is given to the physical properties of the soil, to the distance from available water sources and to the terrain conditions in relation to the irrigation method considered. Surface irrigation method is the introduction of and distribution of water in the field by gravity flow of water over the soil surface. The surface irrigation method involves the introduction at one edge of the field and covers the field gradually. The soil acts as the medium in which water is stored and conveyance medium over which water flows as it spreads and infiltrate.

Furthermore, Baja *etal* (2007) reported two approaches to land suitability evaluation on the basis of FAO framework for land evaluation 1976, qualitative and quantitative. By qualitative approach, suitability is expressed in qualitative terms only without precise calculation of costs and returns. Qualitative classifications are in fact based mainly on the physical productive potential of the land. They are commonly employed for general appraisal of large areas. On the other hand, in quantitative approach, inputs and benefits are expressed in measurable terms normally economic. The quantitative approach may easily become out of date more rapidly than qualitative as a result of changes in relative costs and prices.

FAO (1987) conducted a study to assess land and water potential for irrigation in Africa on the basis of river basins of countries. It was one of the first GIS based studies of its kind at continental level. It proposed qualitative based approach based on physical characteristics of the land (soil, land use, topography) to assess irrigation potential. Its main limitations were in the sensitivity of criteria for defining land suitability for irrigation and in water allocation scenarios needed for computation of irrigation potential.

Another study conducted by FAO (1995) and a follow up to the earlier studies carried out, in 1997 by FAO, for country wide collection of secondary information on water resources and irrigation. A survey was carried out in all African countries, where information on water resources and irrigation potential was systematically collected from master plans and sectoral studies. Such an approach integrates many more considerations other than physical approach to assessing irrigation potential.

Similarly, Melaku (2003), carried out a study on assessment of irrigation potential at Raxo dam area in Portugal for the strategic planning by using Geographic Information System (GIS) and Remote Sensing technique. The study only considered the amount of water available in the dam and topographic factor (slope) in identifying potential irrigable sites in the downstream side of the dam. The main focus of his work was on crop water requirement, he did not consider other important factors for assessing irrigation potential such as soil as specified in the FAO framework for land evaluation for irrigation. Therefore could not come up with any suitability classes.

Negash (2004), conducted a study on irrigation suitability analysis in Abayo-Chamo lake basin of Ethopia. It was GIS based and had taken into consideration soil, slope, land use and water resources availability in perennial rivers in the basin to identify potential irrigable land. His study only tried to find the most appropriate irrigation method that can be applied based on water resources, soil and topography of the area. He therefore, fail short also in analyzing land suitability classes for irrigation crop production from the soil classification map and digital elevation model of the study area. This is also a great deficit as land suitability evaluations cannot be complete without classifying the land into suitability classes based on the physical properties of the land evaluated.

Hailegebriel (2007), however carried out another study on irrigation potential evaluation and crop suitability analysis using GIS and Remote sensing technologies in the Beneshangul Gumuz region of Ethiopia. The study considered slope, soil, land cover/land use, water resources and climatic factors in evaluating surface irrigation suitability. Still in Ethiopia, Kebede (2010), has carried out another study at Dale Woreda zone of Ethiopia to assess the suitability of river catchments for surface irrigation development. The study considered soil, slope, land use and water resources. Much emphasis was given to watershed delineation and thus less attention was given to other suitability factors and on the overall crop suitability analysis was not carried out in the study. Hence the study has left a wide gap to be filled.

On the overall, the results and conclusion drawn from previous studies conducted and reviewed in this work have indicated the significance and ability of GIS technology to land suitability evaluation for irrigation in the various study areas which are related to the present study. However, the results of the previous studies conducted have in one way or the other fall short of providing the necessary suggestions on most appropriate crops that can be most efficiently cultivated on the basis of each evaluated class. It is therefore in furtherance to that, the present study intends to bridge the gap by providing suggestions as to most appropriate and efficient irrigation crops that can be cultivated on each of the suitability classes identified in the study area on the basis of land suitability evaluation factors outline in the FAO framework for land suitability evaluation for irrigation farming..

3.0 STUDY AREA AND METHOD

3.1 Study Area

Argungu is the headquarters of Argungu Local Government Area of Kebbi state. The Local Government Area was created in 1976, Argungu is also the headquarters of Argungu Emirate council which existed since the year 1515 founded by Muhammadu Kanta. It is the oldest emirate in the state and also home of the famous and widely attended Argungu international fishing and cultural festival which is the oldest known festival of its kind in Nigeria. Argungu town has a population of 50,064 (NPC, 2006) and projected population of 57,824 (2011) on the basis of 3.1percent annual growth rate. Argungu Local government has total land area of 428 Km^2 about 9.6 percent of the total landmass of Kebbi state. Most of the inhabitants of the area leaves along the marshy *Fadama* land and are mostly farmers, fisher men and hunters. Major crops produce in area include rice, vegetables and fruits in the *fadama* area while sorghum, millet, beans are the upland or rainfed crops,. The Argungu *Fadama* under study covers an area of 10 Km^2 (1,000 Ha).

3.1.1 *Location*

Argungu is located between latitude 12^{0}30'33''N to 12^{0}44'54''N and longitude 4^{0}20'54''E to 4^{0}30'54''E covering an area of 491.128 Km^2 and elevation of 241 meters above sea level. It is bounded by Yabo Local Government of Sokoto state to the North-East, in the South by Gwandu and Birnin Kebbi Local Governments, while to the North and West by Augie and Arewa Local Governments respectively.

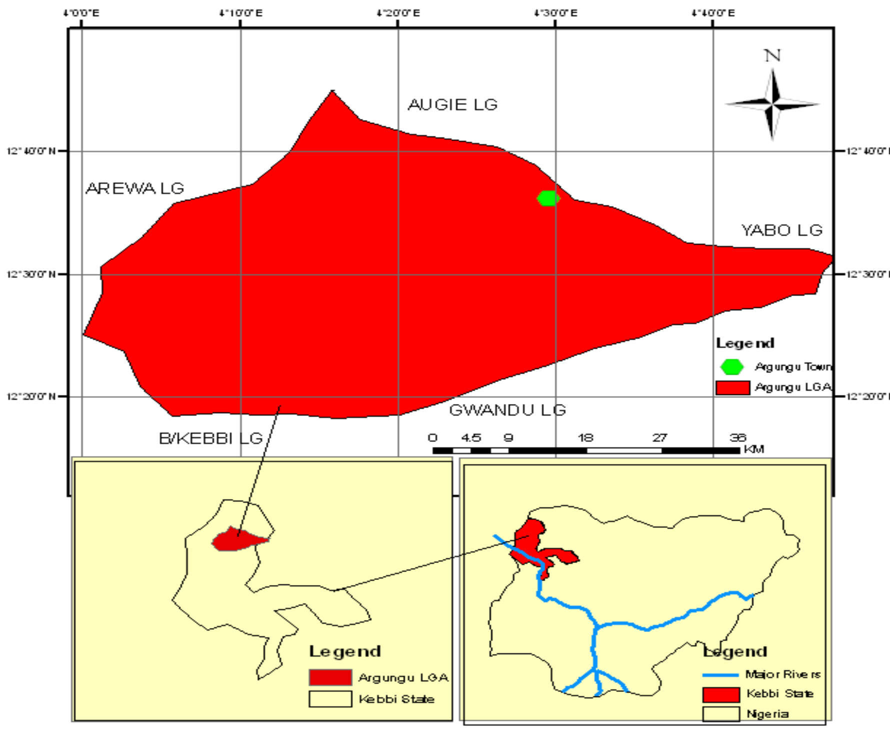


Figure 3.1: Location Map of Argungu LGA

Figure 3.2: Location Map of the Study Area

3.1.2 *Climate*

The study area enjoys tropical continental type of climate, which is largely controlled by two air masses namely; tropical maritime and tropical continental blowing from Atlantic and Sahara desert respectively. The air masses determined the two dominant seasons, wet and dry. Humidity is 27% while wind blow at 15Km/h in ESE direction.(Abdulrahim, 2004)

Argungu receive a mean annual rainfall of 800mm between May to September with a peak period in August, the remaining period of the year is dry. The average temperature is 26^0C and can rise up to 40^0C in the peak of hot season (March-July). However, during harmattan, (December – February) temperature falls to 21^0C.

3.1.3 *Soils and Vegetation*

Two groups of soils can be identified in the study area, the upland and *Fadama* soils. The *Fadama* consist of two distinct phases: wet and dry season operations. While the upland soils are generally sandy and well drained, the *Fadama* soils are generally clayey and hydromorphic which range from deep well drained soils, loamy sand, sandy loam, clay and clay loam. The study area is characterized by Sudan savannah which consists of open wood land with scattered trees such as Acacia Albida (*Gawo*), parkia clappertoniana, porassus and dum palms. The natural vegetation has however, been altered by intensive cultivation, grazing, fuel wood harvesting and bush burning.

3.1.4 *Ecology*

The study area is mostly affected by desertification, which manifest itself by incidence of wind erosion and exposure to lateritic iron stone on the landscape. Desertification is the product of a number of factors both natural and man-made which include limited rainfall, indigenous method of cultivation, excessive sourcing for fuel wood and indigenous grazing techniques all these have combined to deprive the environment of its natural vegetation thus accelerating the incidence of soil erosion. Other ecological problems include flooding commonly caused by uncontrolled released of water from Goronyo and Bakalori reservoirs upstream in Sokoto and Zamfara states respectively. Flooding has caused devastation of croplands within the flood plains and settlements bordering them and sometimes even lives are lost. Pests are also known to have adverse effects especially during long cessation of rains.

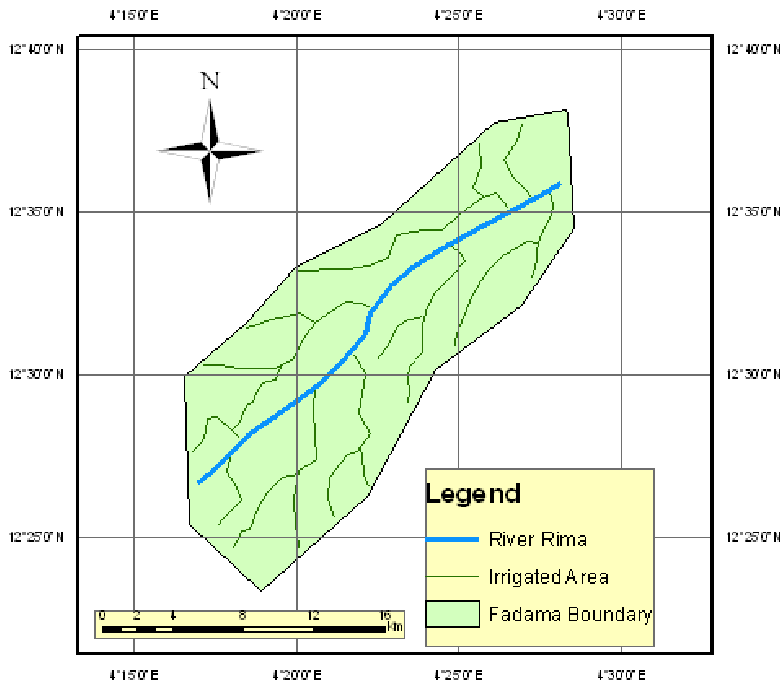


Figure 3.3: Drainage Map of the Study Area

3.2 METHODS

The research work is divided into three stages: pre-fieldwork, fieldwork and post-fieldwork respectively. The pre-fieldwork stage included activities such as identification of research problem, objectives, selection of appropriate research method, data requirement (basically secondary sources of data will be used in this work) and data processing. The second stage is fieldwork which involves geo-referencing, on-screen digitization, soil classifications as well as image classification (supervised). However, unsupervised classification was carried out in order to have a picture of the land cover and land use of the study area. The last stage is post-fieldwork which consists of data entry, analysis results and discussions as well as recommendations.

The research work involved the adaption of qualitative approach based on FAO (1976) framework for land suitability classification for irrigation. Qualitative approach is based mainly on the physical productive potential of the land and is commonly employed for appraisal of large areas. The adaption of qualitative approach is advantageous as it is permanent when compared with quantitative approach which may become out of date rapidly as a result of changes in relative costs and prices.

3.2.1 Materials Used

The materials and data to be used for land suitability classification study for irrigation farming in Argungu Fadama include: Topographic map, Satellite image, Soil map/Data, Digital elevation model (DEM) and GIS Software (ArcGIS 9.2, Erdas Imagine).

3.2.2 *Topographic Map*

Topographic map of the study area on a scale of 1:100,000 obtained from Department of Lands and Town Planning of the state Ministry of Lands will be used as a base map for land use classification. The map was geo-referenced projected to UTM (WGS84) and then digitized using on-screen digitization method. This is in order to have a geo-referenced map of the study area which will also be used as base for land use classification.

3.2.3 *Satellite Imagery*

Enhance Thematic Mapper (ETM), a nine bands imagery acquired in September, 2005 with spatial resolution of 30 meters was obtained from Global Land Cover Facility (GLCF) which was used to classify the land cover of the study area.

3.2.4 *Soil Map/Data*

Soil map of Kebbi state (1998) on a scale of 1:1,000,000 and detailed soil survey (Final Report) as well as status of irrigation waters in *Fadama* areas as well as fertility and salinity status of *Fadama* soils of Kebbi state were used. The data was obtained from the Irrigation department of Kebbi Agricultural and Rural Development Authority (KARDA) and used for soil suitability analysis for irrigation and delineation of *Fadama* area.

3.2.5 *Digital Elevation Model (DEM)*

Digital Elevation Model (DEM) is a point elevation data stored in digital computer files. These data consists of X, Y grid locations and point elevation of Z variables. They are usually generated in variety of ways for a different map resolutions or scales. These data were used to yield important derivative products such as slope, aspect, flow accumulation and flow direction. DEM of the study area was obtained through Shuttle Radar Topographic Mission (SRTM) at 90m resolution from National Aeronautic Space Administration (NASA). The DEM of the study area will be imported into ArcGIS environment for the generation of slope for irrigation suitability analysis.

3.2.6 *Software*

The software to be used to prepare and analyzed data include ArcGIS 9.2, Erdas Imagine 8.4 GIS softwares.

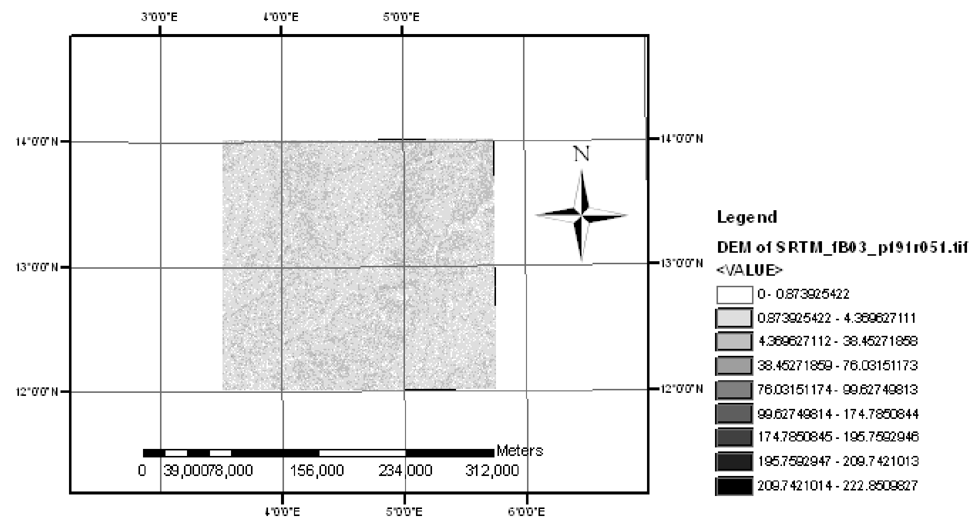
3.3 Data Pre-processing and Checking

The data collected may contain errors due to failures of measuring devices or recorders. Therefore, before using the data for specific purpose, the data has been checked and errors have been removed as much as possible. The maps was scanned, geo-referenced, updated, projected and digitized in order to have a unified map projection for all the data set to been used in the study.

3.4 Method Of Data Analysis

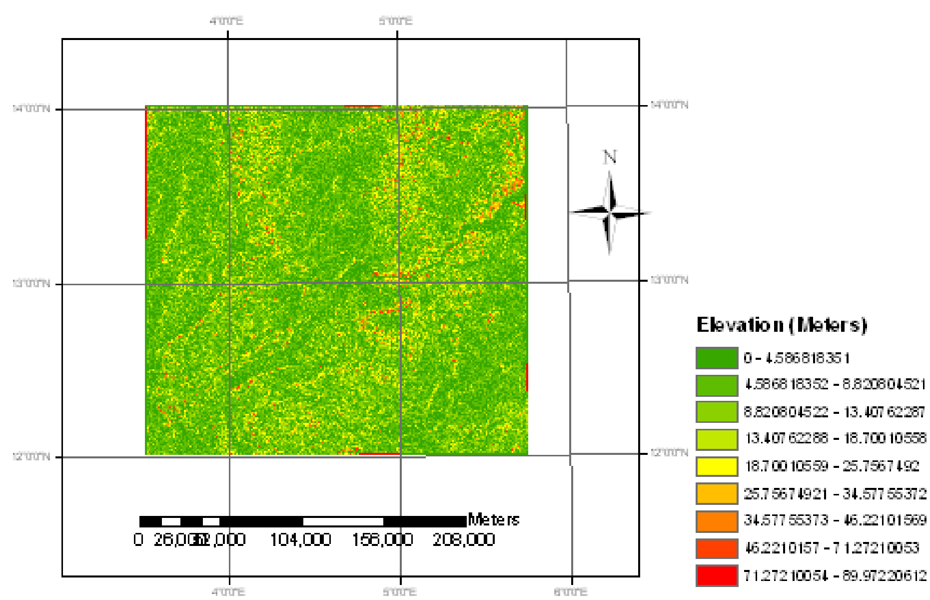
3.4.1 Importing Digital Elevation Model (DEM) Data

The Digital Elevation Model (DEM) single band raster image of the study area was downloaded as a Tagged Image File (TIF) and imported into ArcGIS 9.2 Spatial Analyst Extension environment in order to generate slope map of the study area. Subsequently, the sub image of the area of interest (AOI) was carried out.



Source: Shuttle Radar Topographic Mission (SRTM of NASA)

Figure 3.4: DEM of the Study Area (P191 R051)

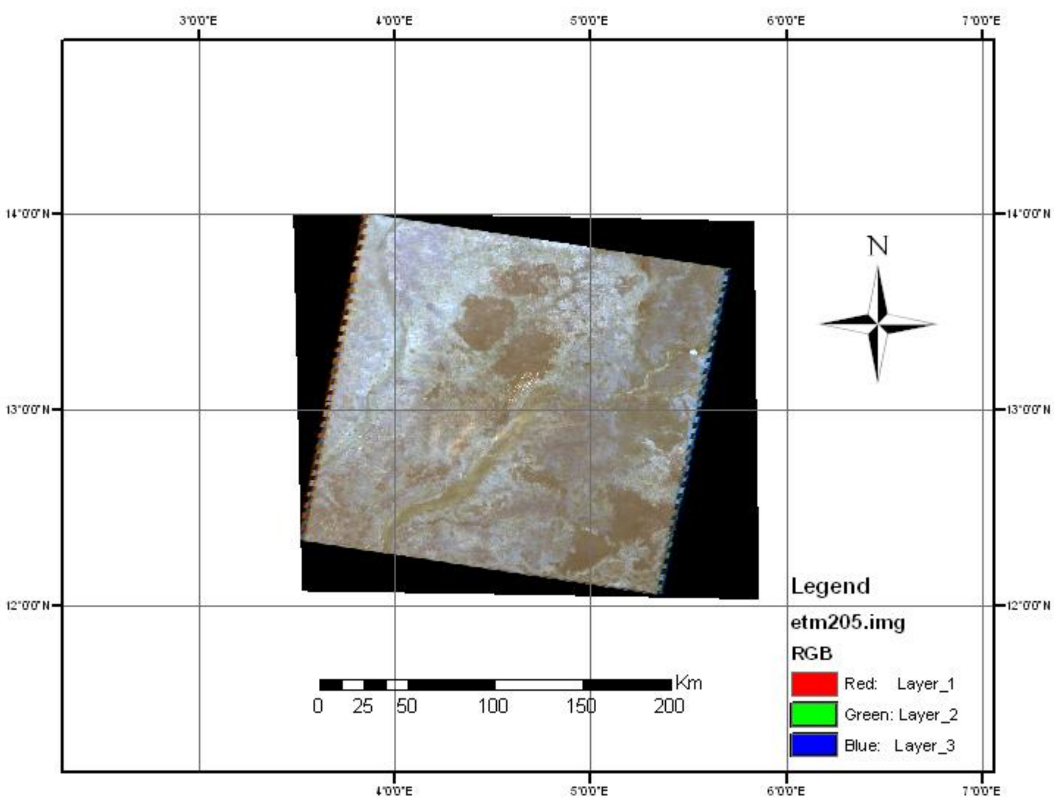


Source: Shuttle Radar Topographic Mission (SRTM of NASA)

Figure 3.5: Slope map of the Study Area (P191 R051)

3.4.2 *Importing and Layer Stacking Bands*

The ETM (9 bands) image of the study area was imported into ERDAS Imagine 8.4 environment where the bands were layer stacked using utilities in the image interpreter tool. The true color composite image were created by combining the spectral bands that mostly resemble the range of vision of the human eye which in the ETM image is used for land cover analysis. A true color composite uses the visible red (band 3), visible green (band 2) and visible blue (band 1) channels to create an image that is very close to what a person would expect to see in a photograph of the scene.



Source: Global Land Cover Facility Earth Science Data Interface

Figure 3.6: ETM 2005 Composite Image of the Study Area (P191 R051)

3.4.3 *Image Classifications*

Image classification is the process of creating thematic maps from satellite imagery. A thematic map is an information representation of an image that shows the spatial distribution of particular theme (Lillesand and Kiefer, 2000). There are two approaches to extract spectral information: the unsupervised and supervised classifications (Richards, 1986). Unsupervised classification is the method in which image pixels are assigned to spectral classes without the user having previous knowledge about the study area, whereas supervised classification is a method that involves selection of areas in the image which statistically characterized the areas of interest (AOI).

Prior to the field work, unsupervised classification from the ETM image was conducted using ERDAS Imagine 8.4 to understand the general land cover classes of the study area. Based on the results from unsupervised classification and information from topographic map of the study area, land cover and land use characteristics of the study area were better understood and this forms the basis for supervised classification. The signature values of the classified ETM 2005 image will be validated to ensure accuracy, this is to ensure that the pixels of the area of interest (AOI) were classified correctly. The individual classes have to be converted to shape files vector layers in ArcGIS 9.2 environment

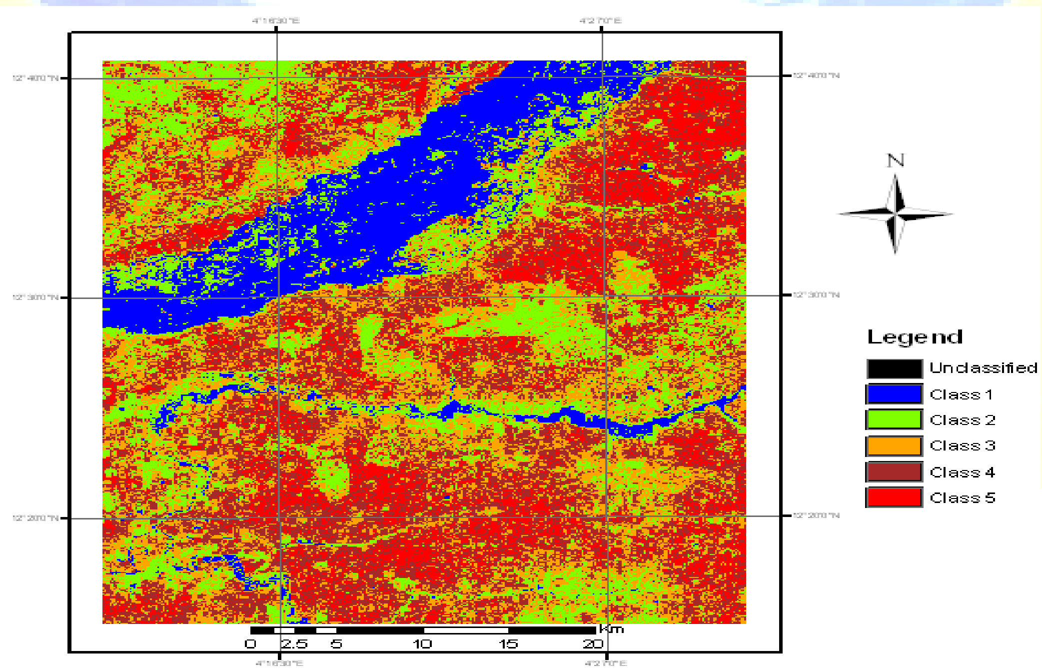


Figure 3.7: Unsupervised Classification Map of the Study Area

3.5 Identification Of Suitable Irrigation Sites

The identification of suitable sites in the study area was achieved through factors as soil, slope and land use. The individual factors were analyzed in order to arrive at suitability class for each factor.

3.5.1 Slope Suitability Analysis

The most important factor for irrigation suitability is the topography of the land. Spatial Analyst Extension was used in ArcGIS 9.2 environment to generate slope from the DEM based on FAO (1976) guidelines for land suitability classification. The slope was then reclassified into classes S1, S2, S3 and N for surface irrigation. Slopes ranges between 0-2 percent are highly suitable (S1), 2-5 are moderately suitable (S2), 5-8 are marginally suitable (S3) and slopes greater than 8 percent are not suitable (N) respectively for irrigation.

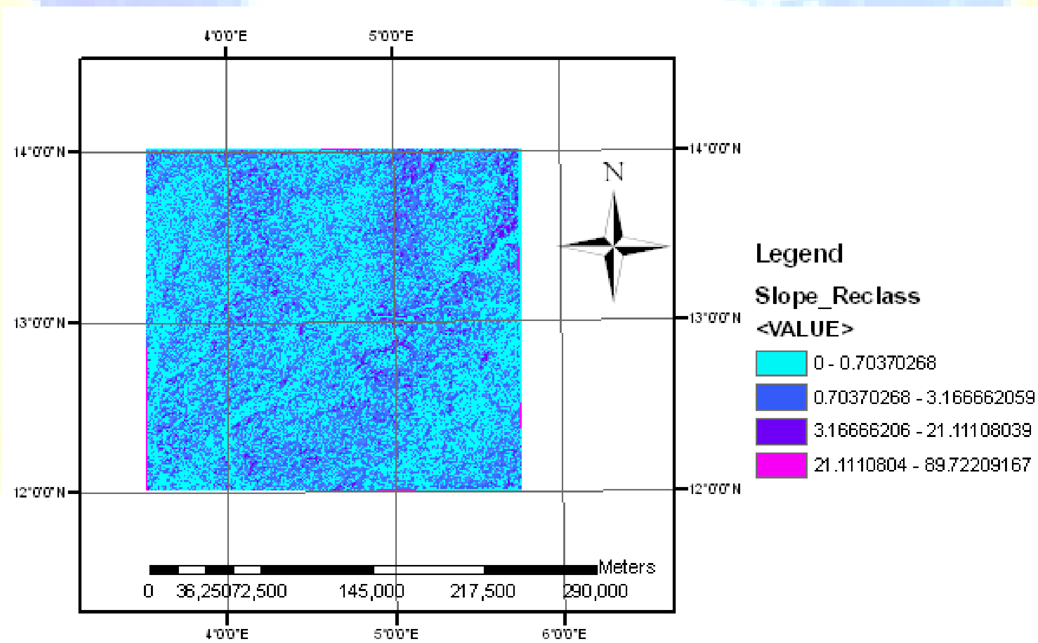
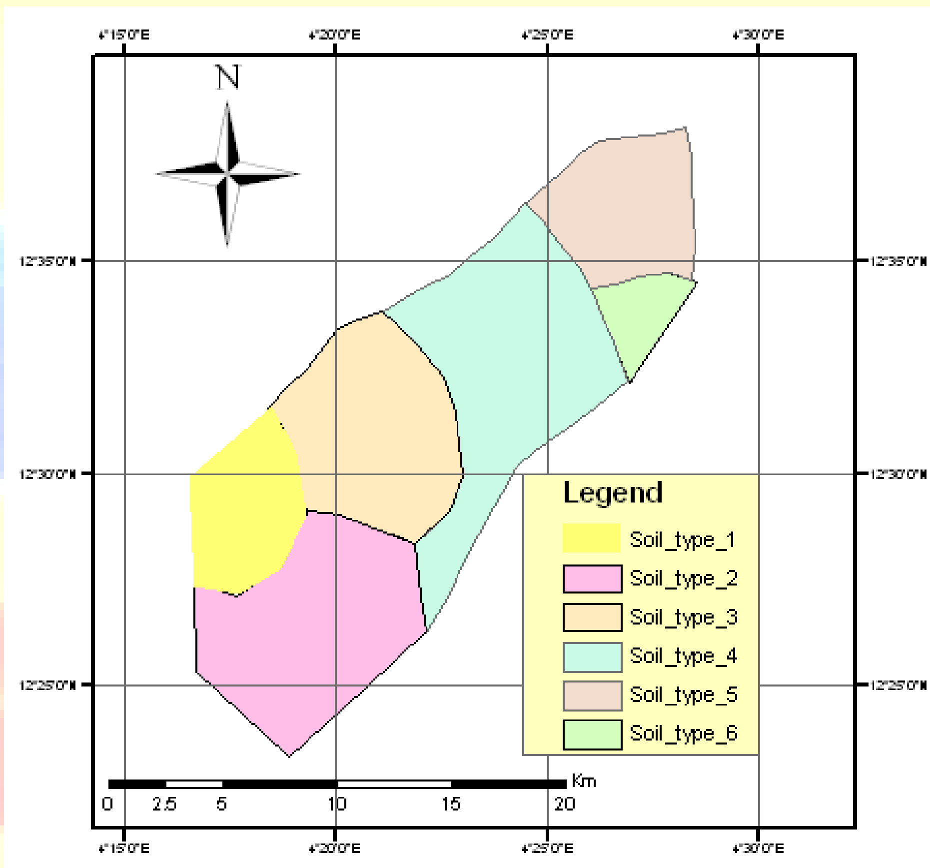


Figure 3.8: Reclassified Slope Map of the Study Area

3.5.2 *Soil Suitability Evaluation*

To evaluate soil suitability for irrigation farming in the study area, soil map of Kebbi state based on soil map of Nigeria on a scale of 1:1,000,000 was used. The major soil types in the study area classified under mapping unit 2a include: deep well drained and deep poorly drained soils, sandy loam and loamy sand, sandy clay and sandy clay loam, clay and sometimes gravelly sub soils.

Furthermore, since weighted overlay accept only raster, the soil vector has to be converted to raster layer using feature to raster conversion tool in arc tool box.

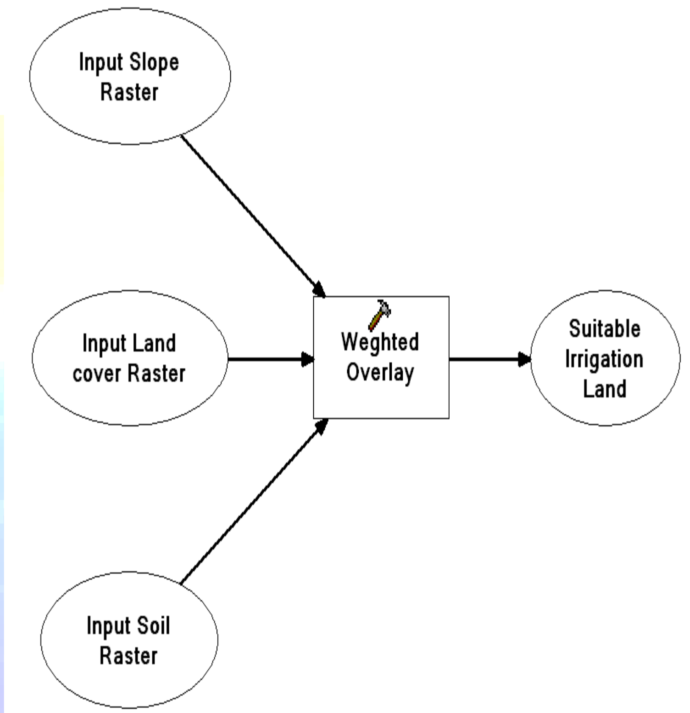


Source: Soil Map of Kebbi State (1998) based on Soil Map of Nigeria

Figure 3.9: Soil Types Map of the Study Area

3.5.3 *Weighing of Irrigation Factors to Find Suitable lands*

The irrigation suitability factors considered in this study are soil, slope and land use. A suitability model was created using model builder in ArcGIS 9.2 arc tool box spatial analyst extension tool. Soil, land cover and slope factors were used as input for irrigation suitability model in order to find the most suitable site for irrigation.



Source: Weighted Overlay tool in Arc Tool Box

Figure 3.10: Irrigation Land suitability Model

4.0 RESULTS AND DISCUSSIONS

4.1 Suitable Slope

Slope is the most important factor considered for evaluation in irrigation suitability analysis. The slope suitability analysis of the study area reveals that the entire fadama area of Argungu (study area) covering 1,000 ha is below 2 percent with respect to slope which indicated that it falls under class S1 (highly suitable) class for surface irrigation based on FAO framework for land evaluation (1976).

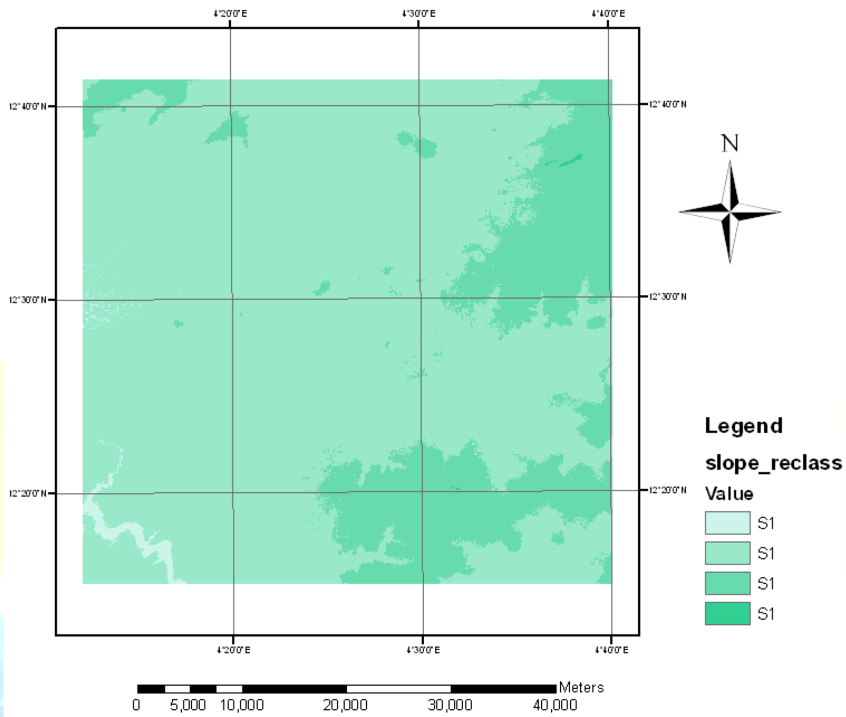


Figure 4.1: Suitable Slope Map of the Study Area

Surface irrigation method follows the slope gradient which does not require energy for the distribution of water within the irrigation field. Gentle lands are generally known to be the most suitable for crop production (Hailegebriel, 1997).

4.2SuitableSoils The results of soil analysis of the study area revealed that six types of Fadama soils were identified and classified accordingly. The soils are generally clayey and hydromorphic which range from deep well drained soils, loamy sand, sandy loam, sandy clay, clay and clay loam were identified and classified based on irrigation suitability with soil as a factor. In terms of salinity and sodicity status, according to Singh (1998), no major threat was reported as analyzed in the soil sample of the study area. The analysis also revealed that majority (92%) of the soils appeared to be free from salinity problems. However, they have potential threat of salinity development in view of the fact that they contain substantial quantities of calcium and are continuously irrigated with waters having appreciably high concentrations of calcium and magnesium (Singh, 1998). Furthermore, the results have established that there is no land in the study area with soil type that can be categorized as S2 or S3 (relatively suitable or marginally suitable) for surface irrigation. Hence all soils in the area are suitable and can perform very well for one irrigated crop or another.

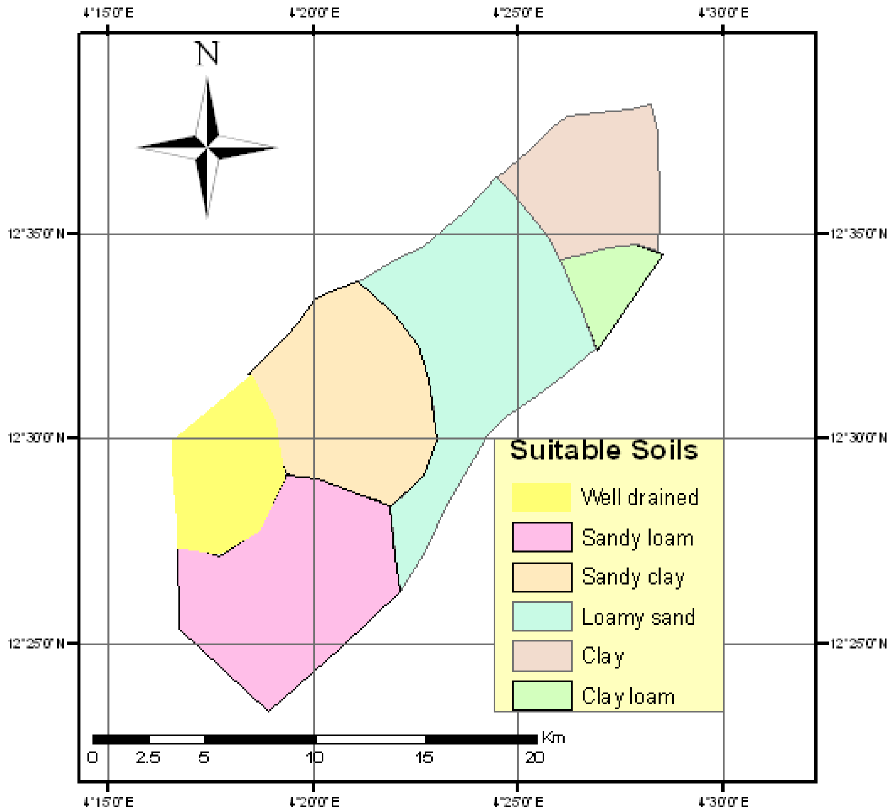


Figure 4.2: Suitable Soil Map of the Study Area

On the basis of soil and land suitability analysis carried out in the study area, beside the traditional rice cultivation, other crops such as wheat, onion, tomato, tobacco, potatoes and pepper can as well be produced. Virtually, all the crops stated above can perform well in the suitability classes outlined in the study area.

4.3 Crops Suitability Classification

Soil qualities are related to agricultural use of the soil and more specifically to specific crop requirements and tolerances. Therefore, based on the range of soil types analyzed and classified in the study area, suitable crops are matched with various suitability classes as follows:

4.3.1 *Wheat*

Though grown under wide range of soils, loamy soil is the best for wheat cultivation, however, sandy loam is moderately suitable while loamy sand and clay loam are marginally suitable provided there is a proper system of drainage and these soils should not be either acidic or sodic.

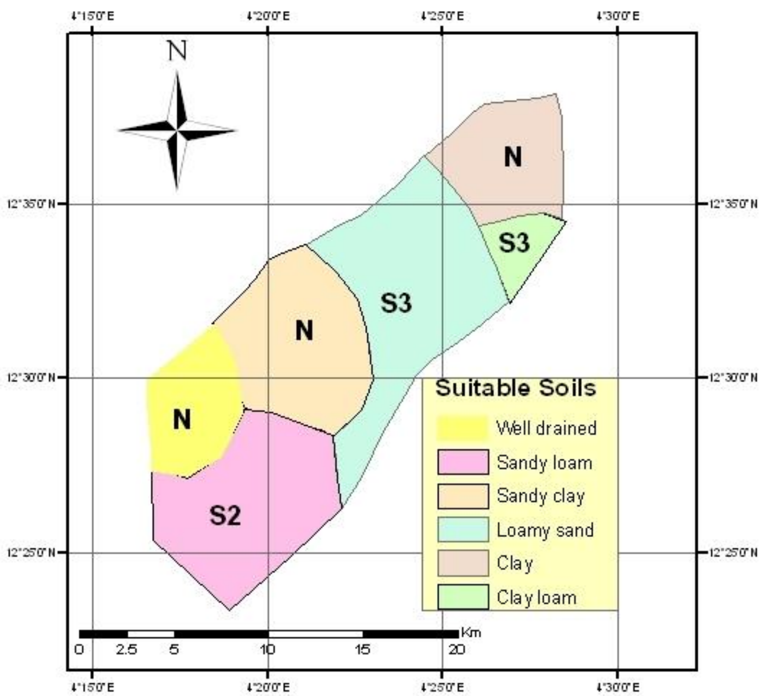


Figure 4.3.1: Suitable soil class map for Wheat production

4.3.2 ***Potatoes***

Sandy loam slightly acidic soil with pH range 5.0 to 6.0 that can retains and drains water well is the best for the cultivation of potatoes. Loamy sand soils are however moderately suitable.

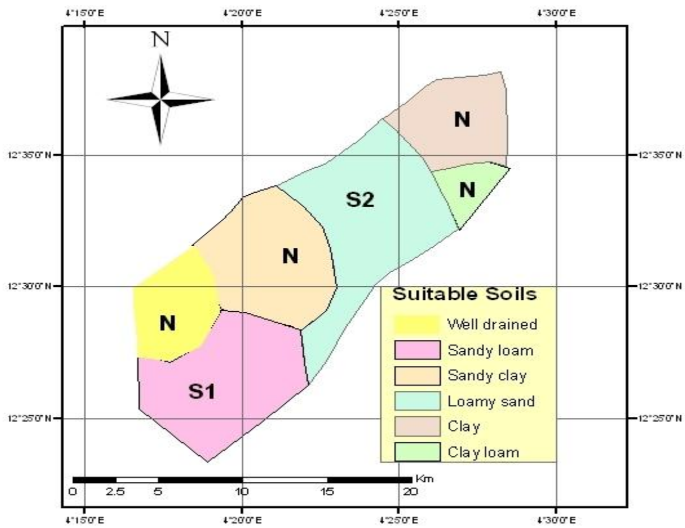


Figure 4.3.2: Suitable soil class map for Potatoes production

4.3.3 *Tomatoes*

Tomatoes can be grown on many different soil types, but a deep well drained loamy soil is most suitable. The soil should be slightly acidic with pH of 6.2 to 6.8. Furthermore, sandy loam and loamy sand can also be used.

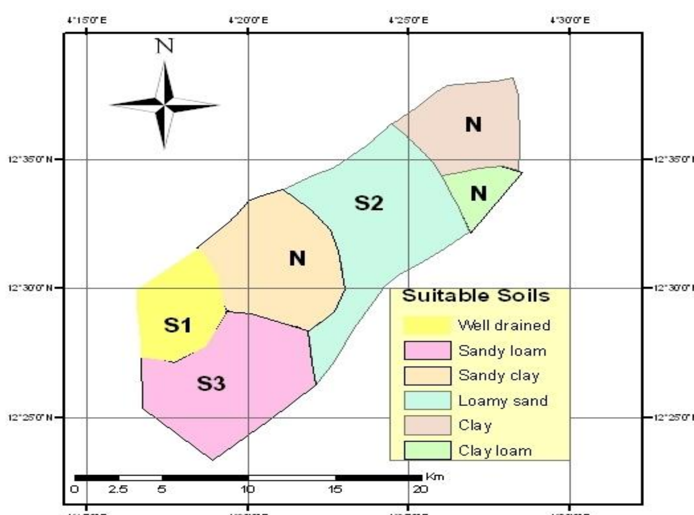


Figure 4.3.3: Suitable soil class map for Tomatoes production

4.3.4 *Pepper*

Peppers grow best in well drained soils, though not very sensitive to soil acidity but best results are obtained in 6.0 to 6.8 pH range. However, sandy loam and loamy sand soils are moderately and marginally suitable respectively.

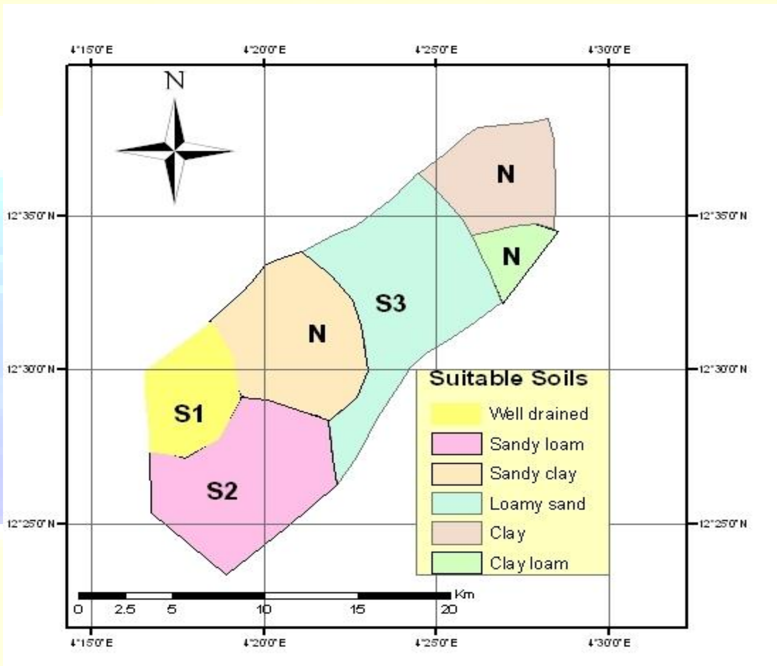


Figure 4.3.4: Suitable soil class map for Pepper production

4.3.5 *Cowpea*

Cowpea performs well on a wide variety of soils and soil conditions, but performs best on well drained sandy soils where soil pH is in the range of 5.5 to 6.5. Sandy loam and loamy sand are moderately and marginally suitable respectively for production of cowpea.

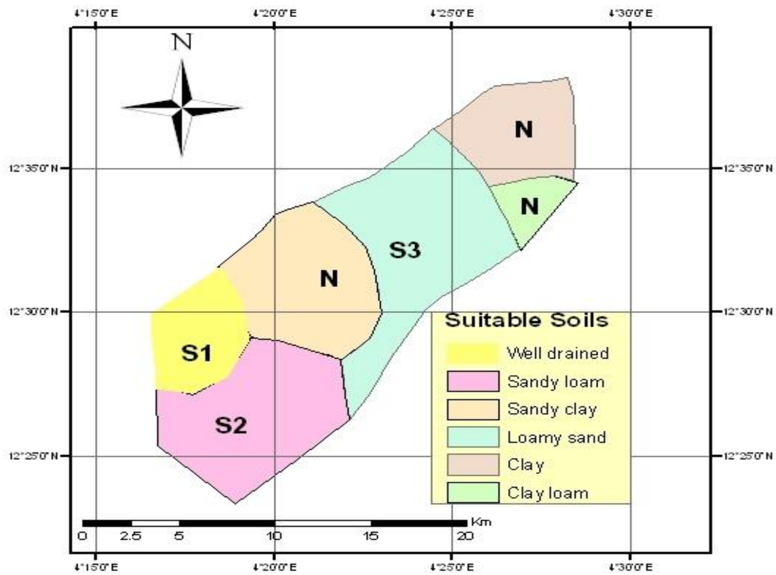


Figure 4.3.5: Suitable soil class map for Cowpea production

4.3.6 *Onions*

Onions grow on variety of soil types but best in a loose well drained soil of pH 6.2 to 6.8, it is highly sensitive to acidic soils. However, sandy loam is moderately suitable while sandy clay and loamy sand are marginally suitable respectively.

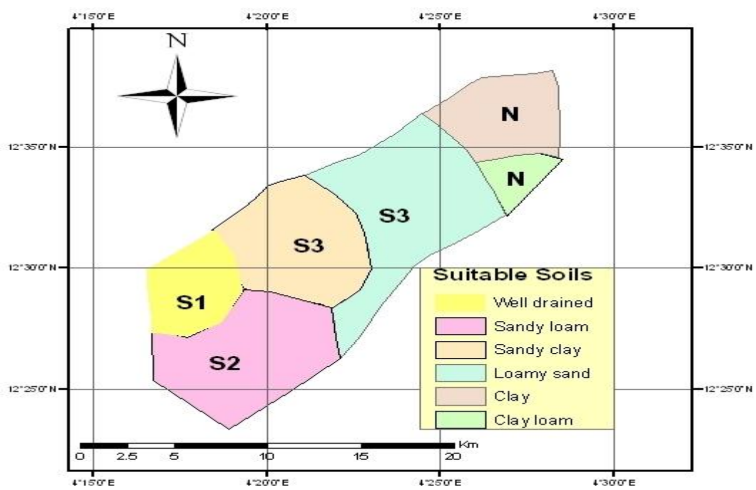


Figure 4.3.6: Suitable soil class map for Onions production

4.3.7 *Tobacco*

Clay loam soils are most suitable for tobacco production. It is sensitive to water logging and therefore demands drained soils. In this vein, well drained, sandy loam soils are moderately suitable while sandy loam and sandy clay are marginally suitable respectably.

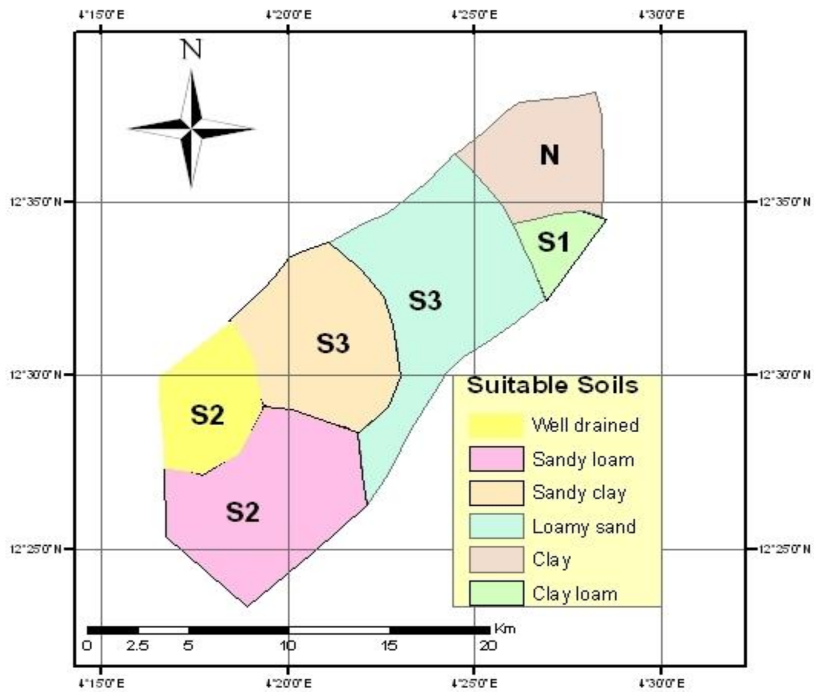


Figure 4.3.7: Suitable soil class map for Tobacco production

4.4 LAND COVER/LAND USE

Enhanced Thematic Mapper (ETM) image 2005, of the study area was subset to area of interest (AOI) and then classified into five land cover classes using supervised classification after the ground truth. These classes include: Water body (river), Wetland (fadama), bare soil, scattered vegetation and cultivated land.

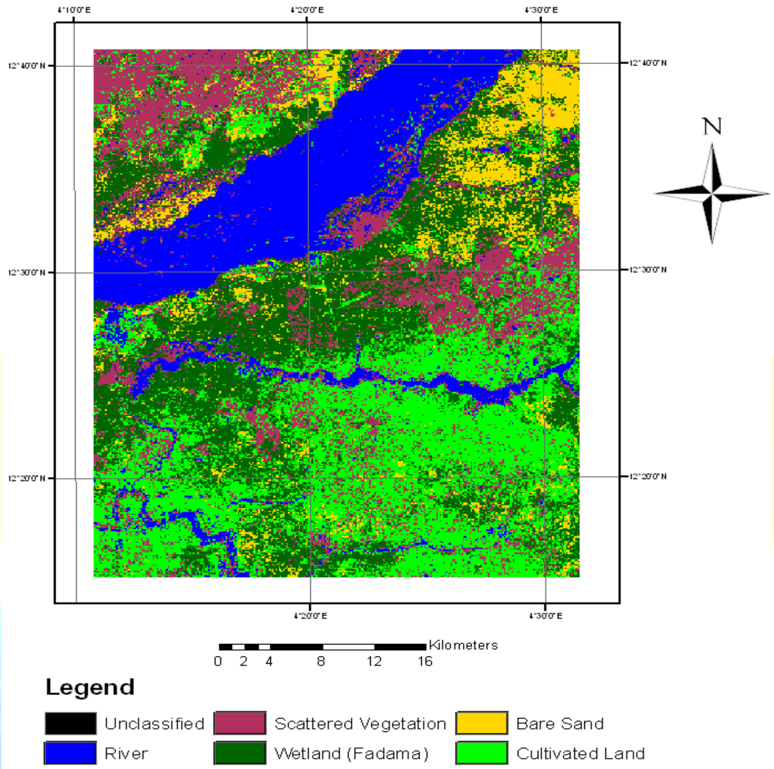


Figure 4.4: Supervised Classification Map of the Study Area

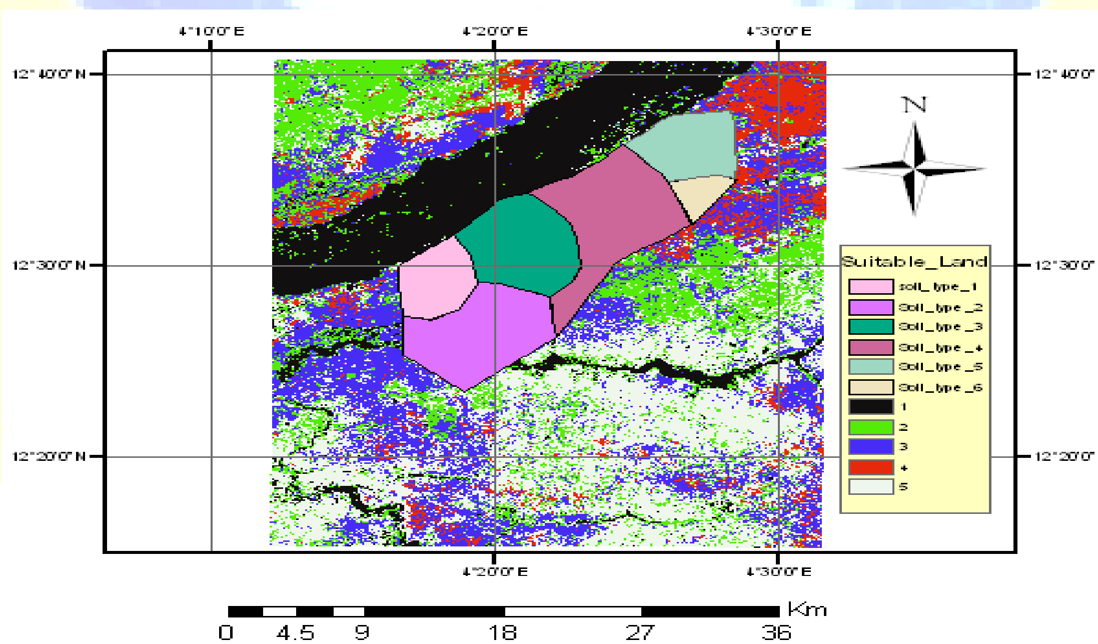


Figure 4.5: Land Suitability map for Irrigation

4.4.1 Cultivated Land

This land cover type is dominant in the study area. The crops commonly grown include millet, sorghum, maize, beans, sugar cane, and orchard.

4.4.2 *Wetland (Fadama)*

This land unit is found near River Rima valley and is the second dominant land cover in the study area. In this area irrigation farming is carried out, rice is the major crop cultivated. However, suitability assessment conducted with soil and slope as factors reveal that other crops such as wheat, onions, tomato, pepper, cowpea and tobacco can efficiently do well in the Fadama.

4.4.3 *Scattered Vegetation*

This land cover is characterized by area covered with dense grasslands, shrubs and weeds used mostly for grazing purposes. It is commonly found mixed with cultivated land and is the third dominant land cover in the study area.

4.4.4 *Water Body*

This covers some part of River Rima popularly called *Matan Fada* by the natives of the area because the river which passes through *Argungu*. It is the fourth dominant land cover in the study area. This land cover class is the most important source of water for irrigation in the *Fadama*. Besides the provision of water for irrigation, the river also serves as drinking source for domestic animals.

4.4.5 *Bare Sand*

This land cover which is the least dominant is commonly found at the river banks and around the Fadama area. It is characterized by coarse sandy soil which does not support vegetation cover.

However, the land cover classes such as scattered vegetation and cultivated land were classified as highly suitable for irrigation with the assumption that their land cover classes can be irrigated without limitation.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Concluding Remarks

Thi s study have shown that the need for employment of GIS as a veritable tool for land suitability classification that will serve as a guide for the cultivation of appropriate crops in Argungu *Fadama* cannot be over emphasized. GIS therefore, as a decision support system is likely to provide answers to the need for an increased food production through land suitability classification for irrigation farming in the light of Food security that will make provision of efficient decision for all year round cultivation and harvesting in the study area.

5.2 Recommendations

- Irrigation farming is considered as an important investment especially for the rural poor for improving income and food security through increase in productivity. Therefore, the suitability classifications made can assist in policy decision making for development of irrigation activities in the study area.

- The present study assessed the physical suitability of land for irrigation crops. It is therefore recommended that future researches should include water quality, environmental, economic and social factors.

- Application of GIS and remote sensing was found to be helpful in evaluation of land suitability for irrigation farming in this study. In view of this therefore, it is recommended that future studies should exploit the use of these technologies for better assessment of land in the study area and beyond.

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