

SITE SUITABILITY FOR YAM, RICE AND COTTON PRODUCTION IN ADAMAWA STATE OF NIGERIA: A GEOGRAPHIC INFORMATION SYSTEM (GIS) APPROACH.

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ABSTRACT

This paper demonstrated the potentials of GIS technique for mapping and delineating the suitable sites for Yam, Rice and Cotton production in Adamawa State. Site suitability mapping is necessary to create data bank and to guide the farmers in decision making on sites for crop production in the state. The use of GIS for this decision making introduces reliability and saves time with a consequent increase in agricultural productivity. The six criteria that were used for the study include soil, topography, vegetation, temperature, annual rainfall and lengths of rainy season. A combination of Ilwis 3.0 Academics, Arcview GIS 3.0 and Idrisi 32 were used for data capture and analysis. Using Boolean operations on the six criteria, and based on the requirements for each crop, all the areas that met the six conditions were considered "most suitable". The areas with five conditions were assigned "suitable", while the areas with four and/or three criteria were considered "just suitable". The areas that were considered unsuitable are those areas that met no condition or the areas that met only one or two conditions. The study revealed that yam production in the state is "most suitable" in only Ganye Jada and Toungo Local Government Areas (LGA) in the Southern part of the state, covering only 5.05% of the state land mass. Rice is "most suitable" at the central parts of the state, that is, Lamurde, Numan, Demsa, Yola North and South, Girei, Song and Fufore LGAs. "Most suitable" areas for rice cover 34.26% of the state's area, and 44.06% as "suitable areas". The 'most suitable' areas (5.38%) for Cotton are found at the north western part of the state, covering, Guyuk, Shelleng, Demsa, and Lamurde LGAs as well as the central part comprising; Mayo Belwa, Fufore, and Yola South LGAs. "Suitable areas" are found in Yola North and South, Song, Michika, Hong, Gombi Madagali and Fufore LGAs. This work is therefore recommended to be a guide for farmers in selecting their sites for the production of the three crops.

INTRODUCTION

Farmers all over the world, no doubt, need a comprehensive information and data bank of site suitability of the crops which they grow, since the world comprises varied climate, soil, vegetation, and other determinant factors. For the fact that these requirements for crops also vary in space, there is the need for the study of site suitability for various crops, so as to optimise production. In order to achieve sustainable agriculture, national planners and decision makers require timely, accurate and detailed information on land resources. (Kahubire, 2002), in order to address global problems related to food security, regional and national planners using multidisciplinary decision support systems require among others adequate information on where crops are grown in order to monitor agricultural production over vast areas (McGuire, 1997). Detailed landuse maps on location of major croplands are not readily available for many sub-Sahara countries (McGuire, 1997). Agricultural land is too often classified into broad classes like tree cropping, irrigated

cropping and mixed cropping (Agypong and Duadze, 1999). Having knowledge on meaningful production area allows decision makers to locate populations that are most vulnerable to food insecurity and poverty. Remote sensing is regarded as a source of accurate and timely data needed to create site suitability, while Geographical Information Systems (GIS) has the capabilities to integrate these data for accurate and comprehensive analysis.

Statement of the Problem

Agricultural plants provide food, fibres and other raw materials needed to sustain human life and culture. An expanding human population requires that these living resources be effectively inventoried and monitored on a global scale to facilitate management tasks. Remote sensing and GIS are regarded as potential sources of the accurate and timely data needed to meet these requirements, since existing conventional ground survey methods are proving inadequate for the present magnitude of the tasks. This research work therefore, examines the use of GIS technology for crop production suitability survey with respect to agricultural information requirements,

McGuire, (1997), reviewed that land suitability assessment is inherently an evaluation/decision problem involving several factors, and that the principal problem of suitability analysis is to measure both the individual and cumulative effects of these different factors. Aloja and Ekeh, (1997), identified these factors to include soil fertility data, soil types, insect infestations, weed locations, rainfall distribution and terrain elevation. Boateng et al, (1999) used three different management technologies for crop suitability assessments of pearl millet, sorghum, cowpea and brown rice. The crop variety data were averaged to produce one map for each management level, that is, the high, medium and low management levels.

In Adamawa State, very few works have been carried out on site suitability of crops. Among the previous work was that of Adebayo and Musa (2004). They used rainfall conditions to map areas suitable for upland rice production in Adamawa State. Sajo and Kadams (1999) generated Adamawa State maps showing food and cash crop production areas.

In this research, effort was made to use relief, vegetation, soil and climatic parameters for assessment and mapping of site suitability of rice, yam and cotton production in Adamawa state. The study therefore, is relevant in the solution to the protracted food crisis in Adamawa state in particular and Nigeria in general.

Objective of the Study

The specific objectives of the study include:

- ◆ mapping site suitability for yam, cotton and rice production areas in Adamawa state.
- ◆ identification of the LGAs as well as the villages in the state where the crops are suitable or unsuitable.
- ◆ calculation of the areas of the suitable/unsuitable sites in kilometres square
- ◆ generation of data bank maps for reference and for agricultural planning, so as to eliminate factors that may limit yield or waste in the crops production.

The Study Area

Adamawa State is located in the North- Eastern part of Nigeria. It lies between Latitudes 7° and 11°N and Longitude 11°and14°E. It shares boundary with Taraba State in the South- Western part, Gombe State in the North-western, and Borno in the North. The State has international boundary with the Republic of Cameroon along the Eastern side. Adamawa is divided into twenty-one Local Government Areas.

The Climate of the Study Area.

The climate of the state is generally of the hot humid Tropical type, with two distinct seasons: the dry seasons last for a minimum of five months (Nov. – March), and the wet seasons spans from April to October. (Adebayo, 1999).

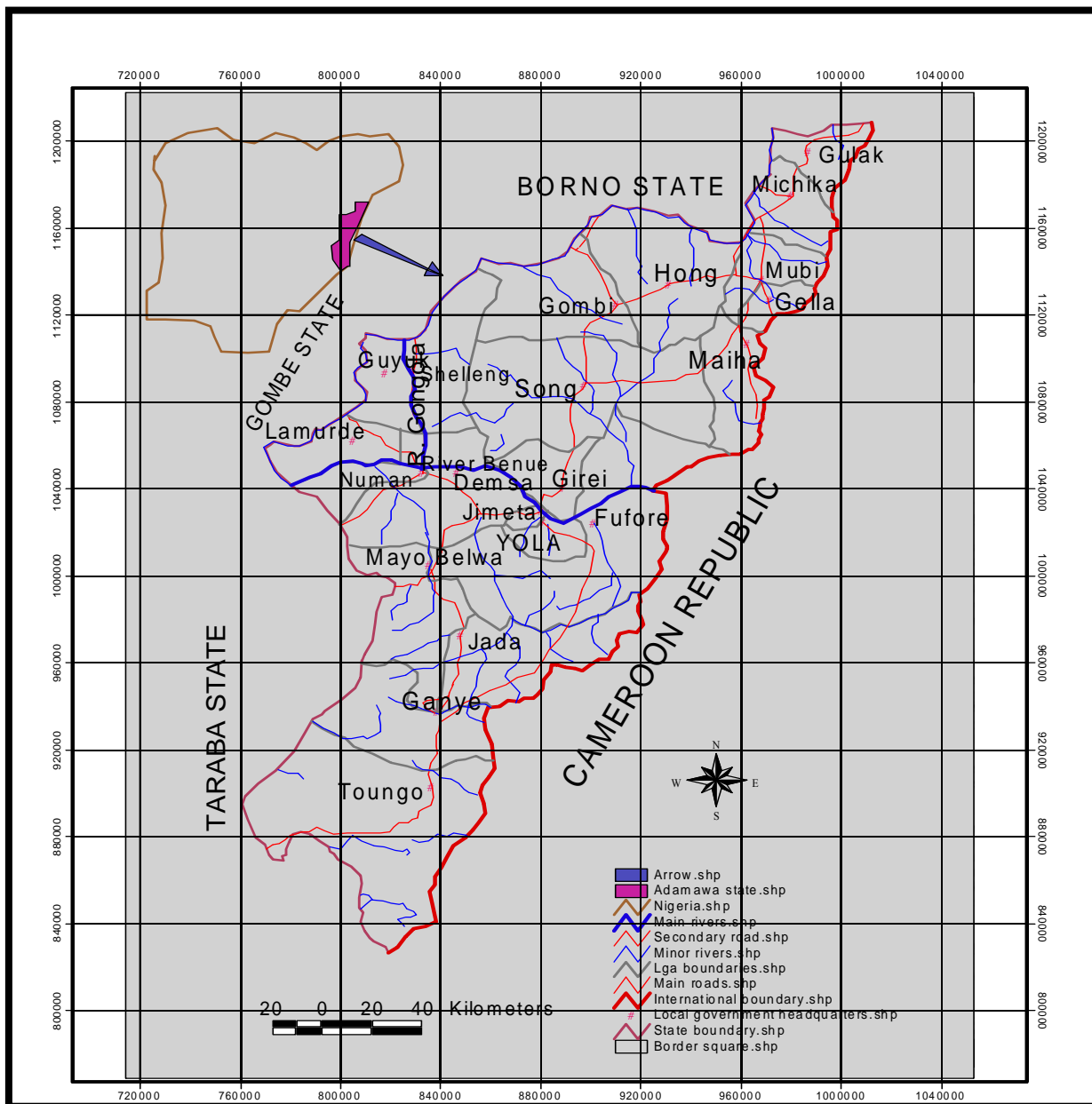


Fig. 1.1 ADAMAWA STATE: THE STUDY AREA

The Soils and Vegetation of the Study Area

The Soils in Adamawa state are classified as ferruginous Tropical Soils with marked differences of horizons with an abundance of free oxides usually deposited as yellow or red concretion. The vegetation comprised of the Southern Guinea savannah, the Northern Guinea savannah and the Sudan savannah types. (see Fig 3.1)

Data and Sources:

Description of Materials

HP Laptop with high RAM, HP Scanner, and a Colour HP Printer as well as three GIS packages: ILWIS Academic 3.0; which was used for georeferencing, ARCVIEW GIS 3.0 for digitizing maps, and IDRISI 32 Release 2 for map overlay and analysis as well as other complimentary non- GIS packages like COREL DRAW 12 were used.

Description of Data

Relief, vegetation, annual rainfall, length of rainy season, temperatures and soil were the six thematic information used, as data, for this study. These data were acquired from the Adamawa State in maps (Adebayo and Tukur, 1999). Hence, the thematic maps of the Relief, Vegetation, Temperature, Annual rainfall map, Length of rainy season, and Soil maps of Adamawa state were acquired to generate the site suitability map. Settlement and Political maps of the state were additional maps that were used for analysis. The maps for each of the six environmental conditions are presented in

Fig. 3.1 Annual Rainfall Map of Adamawa State Figs. 3.1- Fig 3.2 Length of Rainfall Season Map of Adamawa State

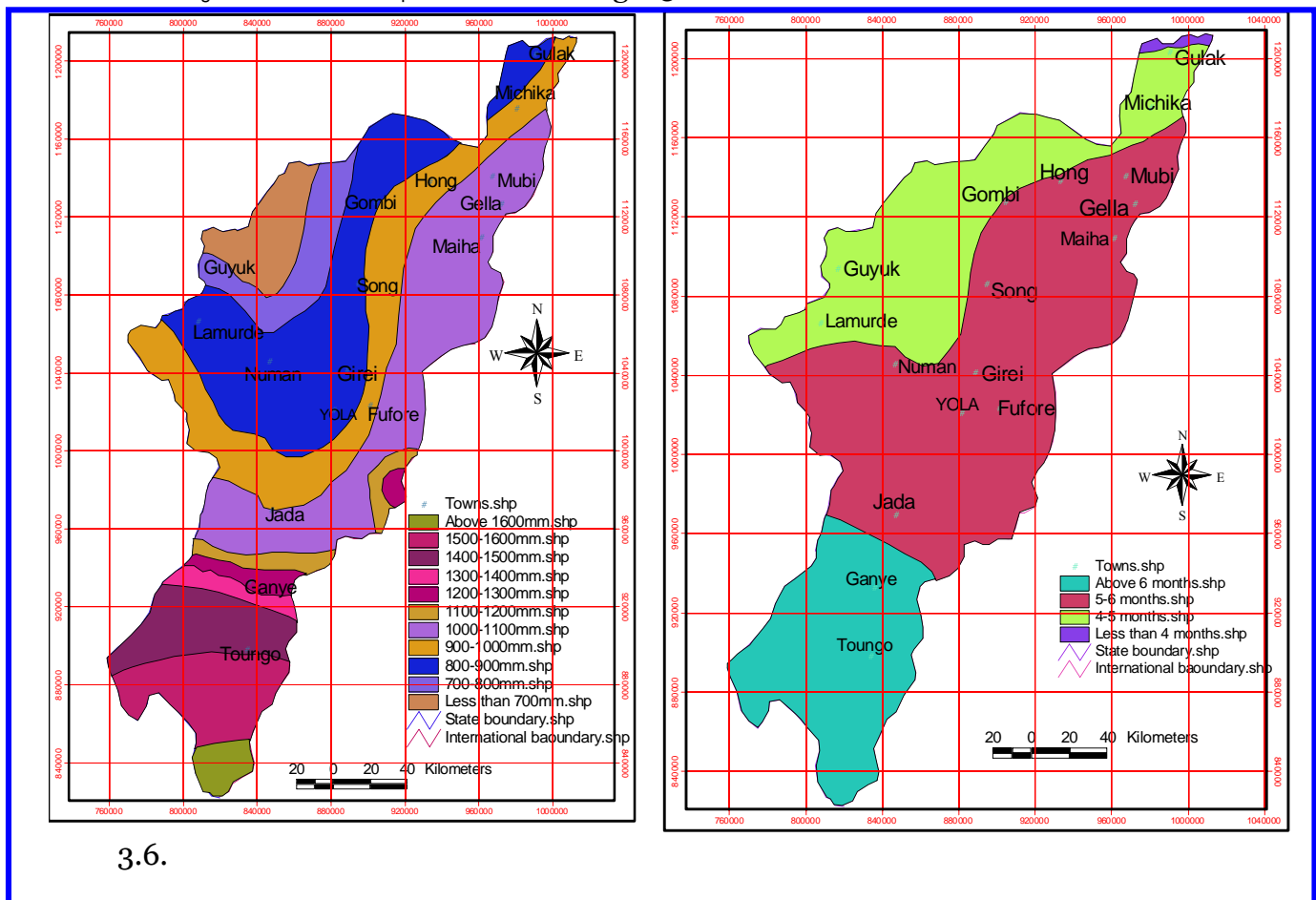


Fig. 3.3 Relief Map of Adamawa State

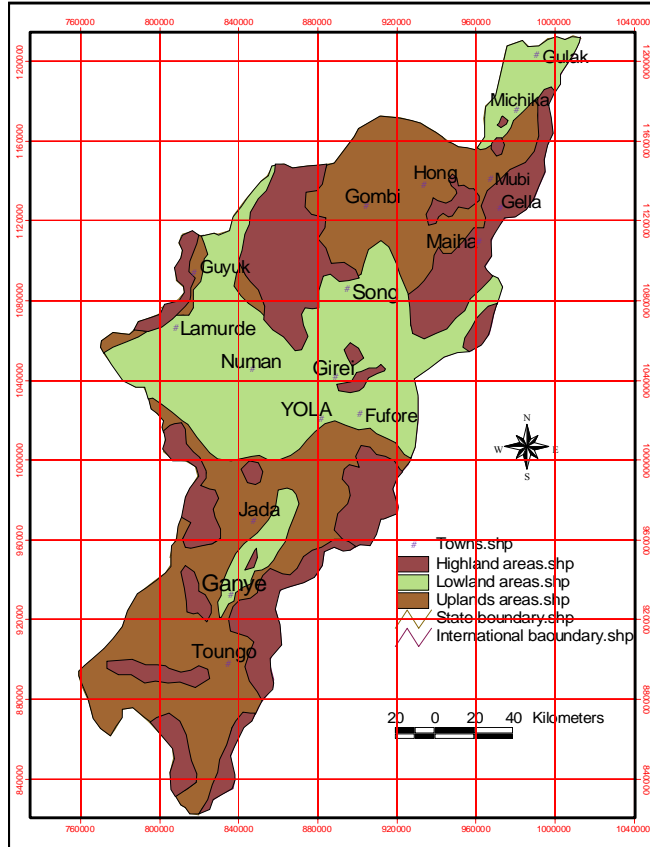
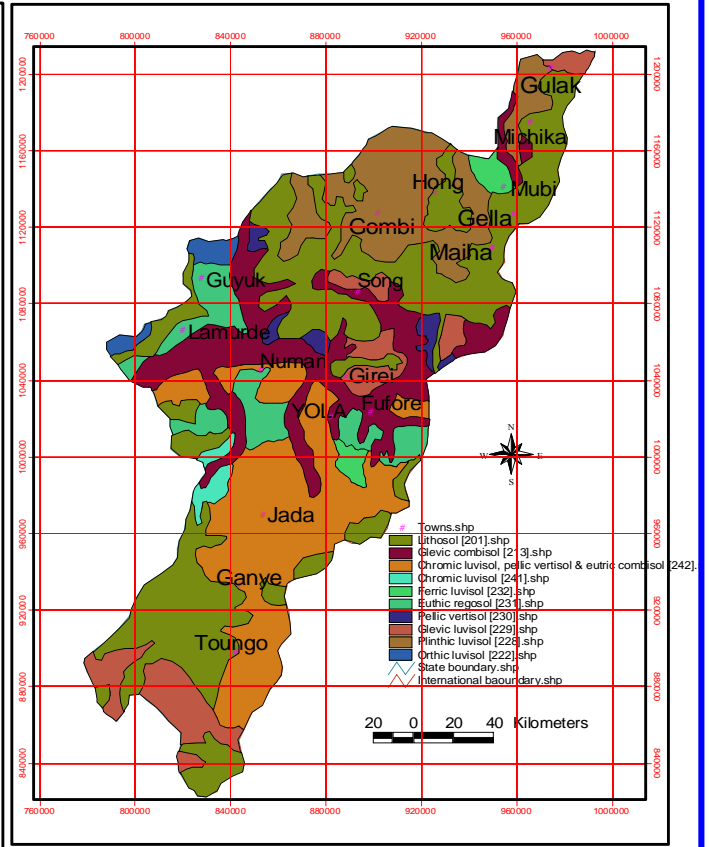
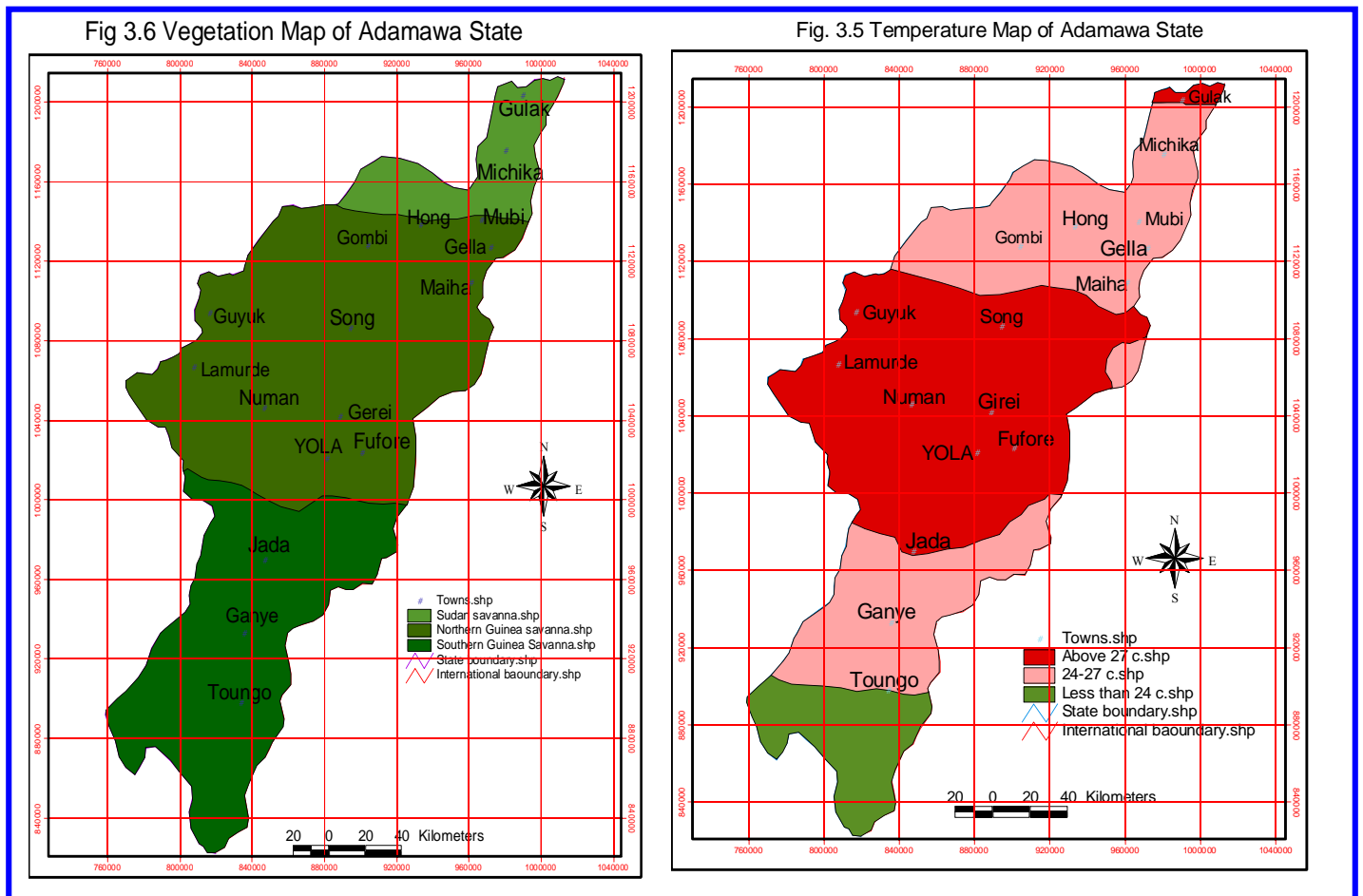


Fig. 3.4 Soil Map of Adamawa State





Methodology

Three important crops were selected among the few crops that are grown in the state. They are: yam, rice and cotton

Each of the three crops under study requires different conditions for growth and maturation. These conditions as listed in table 3.1 were considered for generating a site suitability map for the crops. These crop growth conditions were widely reported in the literature, especially, Raemaeker, (2001), and Webster and Wilson, (1980)

Table 3.1 Environmental Conditions Suitable for Crop Growth Map Georeference

	RICE: (Oriza Sativa)	YAM: (Dioscoria Spp)	COTTON: (Gossypium Hi)
Annual Rainfall	Upland rice (800-1000mm), irrigation canals (1000-1500mm), Therefore, rice requires an average of 800-1500mm of rainfall.	An annual rainfall between 1200mm – 1500mm	Between 600-900mm
Length of Rainfall Season	Early short rice, 90-120 days, medium cycle rice, 120-150 days, late or long cycle, more than 150 days. Hence, rice needs 4-6 months	Yam requires at least six (6) months rainfall	Well defined dry season of less than six (6) months
Temperature	Temperatures of 25 and 30°C.	Temperature requirements for yam ranges from 23 - 30°C	The best ambient Temperature for cotton is 25 and 30°C
Soil	Friable loams to clayey loams. PH from 6.0-7.0 The suitable soil units are 213, 231, 242.	Deep friable and permeable sandy soils, rich in potash and organic matter. PH from 5.0-6.0. Soil units are 201, 213, 231, 232, 241 and 242	Clayey sands or sandy loam. 222, 230, 231 and 241 are the units. PH between 6.0 and 7.0.
Vegetation	All the savannah belts	Wooded savannah belts, that is, Southern Guinea savannah.	Northern Guinea Savannah) and Sudan Savannah
Relief	Lowlands and upland areas.	Lowlands/Uplands Areas	Lowlands and uplands areas.

Each of the six thematic maps (Fig 3.1) required for the study was scanned, using Corel Draw 12 and imported to Ilwis environment via Tagged Image File Format (TIFF) at where the maps were Georeferenced. The essence of Georeferencing is to make all the maps to have the same rows, columns, pixel numbers and other reference parameters without which the maps will not overlay. The Latitude and Longitude coordinates of the location of the state (7° to 11°N and 11° to 14°E) were transformed to Universal Transverse Mercado (UTM) through the transform module of Ilwis 3.1, to crate the georeference corner. The Transformation gave the minimum “X” and “Y” values as 718533.39 and 774148.20 respectively, and also 1052951.36 and 1216597.63 as the maximum “X” and “Y” respectively. Nine (9) points were selected on one of the maps which were used as tiepoints for all the other maps. The tiepoints were then used to georeference all the maps individually. The referenced maps were then resampled one after the other into an earlier created Georeference Corner map.

Data Capture

All the resampled maps in Ilwis environment were exported to Arcview environment, to create vector data as themes. Features on the map were represented as polygon, line and points, depicting areas, roads and small settlements respectively. Fully digitized maps (e.g. Fig 3.1) were then saved as project maps and imported to Idrisi for analysis.

Map Algebra

Addition subroutine of the Overlay module of Idrisi was used throughout this work. The Climate of the study area was considered first with annual rainfall map and the length of rainfall as the first two overlaid maps. All areas that met the annual rainfall requirements for each crop were assigned “3” while those areas without the conditions were assigned “0”. The same was done to the length of rainfall for each crop. The two maps were overlaid to become “Crop rainfall Map”. Any area that met the suitable conditions in both maps carried value “6”, areas where only one of the maps met the condition and the same area in the other map do not meet the conditions carried “3”, while areas that did not satisfy the conditions in both map carried “0”. The same values (3 and 0) were assigned to suitable and unsuitable areas respectively on the temperature map. Crop Rainfall map (annual rainfall + length of rainfall maps) was overlaid on the Temperature map to become “Crop climate Map”. On Crop climate map, all areas that met the conditions in the two maps carried value “9” (addition of 3 scores in three maps). Annual rainfall, length of rainfall and temperature maps). Any area with value “6” means that the area met the suitability conditions in two out of the three maps. And those areas that met the requirements in only one out of the three maps had value “3”. Any area with value “0” means that the area did not satisfy any of the conditions in the three maps.

The same process was done to Crop Vegetation map and Crop Soil maps for each crop to become “Crop Physical Factors Map”. Crop physical factors which contained only two maps carried maximum of “6” values. Values “3” and “0” were other possible values on the map.

Finally, Crop Climate map was overlaid on Crop physical factors to produce “Crop Suitability Map”. All the areas that met the conditions in all the five maps carried value “15”, areas that have suitable conditions in four maps and an unsuitable condition in only one map carried value “12”. Three suitable conditions and two unsuitable conditions carried value “9”, while two suitable areas and three unsuitable areas carried value “6”. Value “3” was assigned to areas that met suitable conditions in only one map. Any area where no condition was met maintained “0”.

Mapping Suitability Areas:

On the Crop Map, All areas with value 15 were assigned “4” and were considered “Most suitable”, areas with value 12 were assigned “3” and were considered “suitable”, those with values 9 and 6 were assigned “2” and were considered “just suitable” and the areas with values 3 were assigned “1” and were classified along with “0” as “unsuitable”.

Result and Discussion.

Yam production is most suitable only at Toungo, Jada and Ganye Local Government Areas. (Fig 4.1) Notable villages site are Kaika and Toungo in Toungo LGA as well as

Ganye, Gamu and Gidan Kowa in Ganye LGA. The whole Jada LGA is considered "suitable" for the crop as well as most part of Mayo Belwa and the southern part of Fufore LGAs, Yam suitable areas had 1933.6453km² and 8215.0363 km² as most suitable and suitable areas, representing 5.05% and 21.44% respectively, of Adamawa land area. The unsuitable areas were found at the Northern part of the state especially Hong and Gombi LGAs. The unsuitable areas cover 15658.0874 km², that is, 40.86% (See Fig 4.1)

A total area of 34.26% is most suitable for rice production in Adamawa state, while 44.08% of the land area is suitable. The producing areas are found in the central part of the state comprising Numan, Demsa, Song, Yola North and South, Girei, Fufore, Jada and Mayo Bani, as well as the extreme North Eastern part of the state comprising Michika, Mubi North and Maiha LGAs. Unsuitable areas are only found at the southern extreme of the state, that is, Toungo LGA. (Fig 4.2)

Cotton production is least suited in the state, only small patches of land which are scattered in few LGAs like, Demsa, Guyuk, Lamurde Shelleng Yola South, and Fufore LGAs are most suitable. (Fig 4.3). Only 5.38%, that is, 2061.2603km² are most suitable for the crop, however, the "suitable" areas for cotton production covers Mayo Belwa, Yola South, Fufore, Hong, Song, Gombi, Madagali and Mickika LGAs with 54.53% .(20894.0107km²) The only area that is completely unsuitable is Toungo and Ganye LGAs, which covers about 5673.3509km² (14.81%)

Conclusion

With increasing population pressure throughout the world and the need for increased agricultural production, there is the need for improved management of the world's agricultural resources. In order to accomplish this, it is first necessary to obtain reliable data on not only the types, but also the quality, quantity, and the location of these resources. It is believed that GIS technique has demonstrated here, will, in the future, have an increasingly important role to play in the execution of agricultural surveys because limitations, such as the lack of a uniform sampling frame, the subjective basis for many surveys, the costliness of on-the-ground surveys, the relative inaccessibility of many undeveloped agricultural areas, and the timeliness, are particularly amenable to improvement using GIS technique. Since the acquisition of these data is the objective of agricultural surveys, not only do such surveys provide valuable data on which management decisions can be based, but they also provide a benchmark against which future agricultural development can be measured.

The research revealed that GIS/Remote sensing techniques are vital tools in agricultural planning. The result of this work indicated the site suitability for production of yams, rice, and cotton in Adamawa state. Yams for instance, are only produced extensively in Toungo and Ganye and Jada LGAs with minor productions at parts of Mayo Bani LGA as revealed in the study. The population of the state is drastically increasing, the demand for food is also rising, the government should intensify efforts towards increasing yam production especially at the southern part of the state to meet the demand of the people. Since about 85.1% of the state's land mass is most suitable and/or suitable for Rice productions, as revealed in the study, the state can be a major producer of rice, if the land areas are optimised for the crop.

More rice producing establishments such as the Upper Benue River Basin and Rural Development which established Lake Geriyo Irrigation scheme for Rice Production should be intensified. The work might be specifically very useful for the Afcot Cotton Complex at Ngorore and the Cotton Ginnery at Lamurde. This work could assist them in knowing the specific places where their raw materials can be optimally cultivated.

In conclusion, this technique provides a cheap, rapid and efficient method for mapping crop suitable areas over large areas in the country where in situ information is limited or incompatible with satellite data. It is hoped that the detailed state crops suitable area maps will benefit planners within and outside the state where over most of the total population depend on rain fed agriculture for their livelihoods. It is therefore, also hoped that this technology would be exploited to help the farmers to know and select what crop is good for which area or which area is good for what crop.

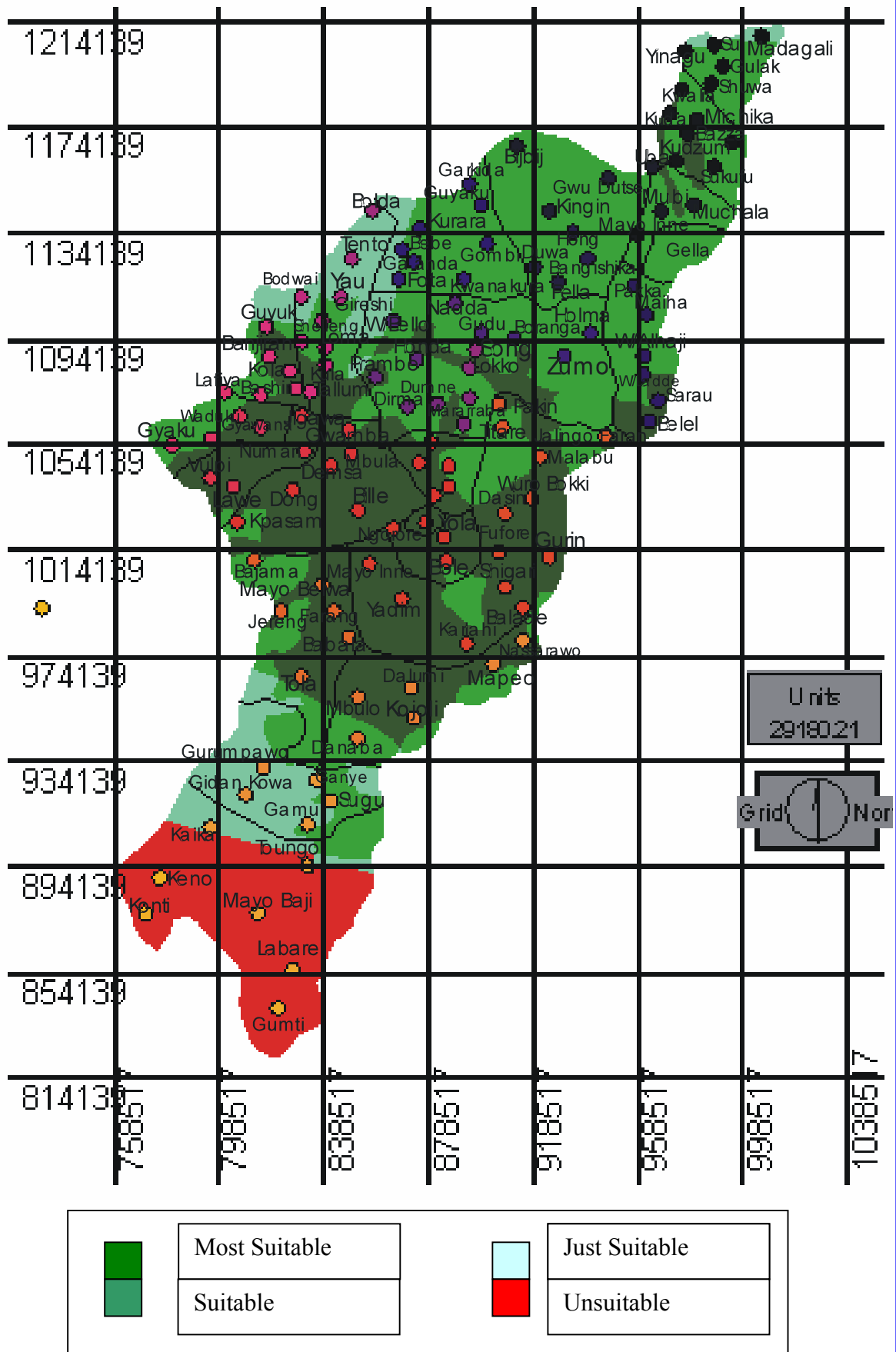


Fig. 4.2 Rice Suitability Map of Adamawa State

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