THE APPLICATION OF REMOTE SENSING AND LOGISTIC REGRESSION MODEL TO THE ANALYSIS OF THE GROWTH OF SULEJA AND ITS ENVIRONS, NIGERIA.

BY

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A DISSERTATION SUBMITTED TO THE POST-GRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D) IN REMOTE SENSING APPLICATIONS, DEPARTMENT OF GEOPGRAPHY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

FEBRUARY 2009

DECLARATION

I hereby declare that this thesis titled: Application of remote sensing and logistic regression model in the analysis of the growth of Suleja and its environs, Nigeria: is an authentic study carried out by me and has not been presented elsewhere for any form of academic award.

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ABSTRACT

Understanding the growth of settlements and factors responsible for the growth is very essential in urban planning and management. The long held belief that growth of Suleja is as a results of its proximity to Abuja was without any empirical evidence to ascertain the major determinants of this growth and their level of influence. This study was aimed at determining the factors responsible for the growth of Suleja by using Landsat TM and Landsat ETM of 1987 and 2001 to analyse the spatio temporal changes in the built up area of Suleja and environs. Logistic Regression model was used to establish the level of impact of the five independent variables of distance to Abuja, distance to road, topography, population and locality influence on the dependent variable, change, between 1987 to 2001. The classified image from the two dates was used to obtain the change in the built up area by subtracting the 1987 image from 2001 image. The resultant image 'change' was the dependent variable. Population data, topographic data, time to Abuja and locality were used in modelling the growth of Suleja and environs. The result of the regression showed that the five variables had strong influence on the growth of Suleja and environs with a Relative Operating Characteristic (ROC) of 0.9452. The study also showed that the independent variables had varying influences on the dependent variable, change, ranging from 0.8809 for ROC of distance to road variable which is the highest for the regression of the individual independent variables to 0.5799 the lowest for the independent variable, topography. Using conditional probability equation, the study established that the closer a place is to Abuja the higher the probability of getting developed. The probability of change ranges from 0.057 for areas around Madalla to 0.002 for areas further away towards Minna. The study demonstrated the limitation of using remote sensing in estimating population of a highly developed area. Between 1987 to 2001, all the localities, except Suleja old city, showed a growth in population through remote sensing estimation. Madalla grew from 5,065 in 1987 to 48,669 in 2001 and Rafinsanyi grew from 589 in 1987 to 6,974 in 2001, while Suleja old town grew from 48,522 in 1987 to 110,001 in 2001. Comparing the population estimate obtained through remote sensing with the census based estimate using the annual growth rate of 2.8 showed that Suleja old town grew from 84,169 in 1987 to 147,481 in 2001. On the other hand, Madalla grew from 6,698 in 1987 to 11,734 in 2001 and Rafinsanyi grew from 1,655 in 1987 to 2,900 in 2001.There is a clear similarity between the rate of growth in built up area and population over the same period using remote sensing estimation. Despite the rate of growth of localities outside the Suleja main town, the policy and impact of Niger State Government is minimal and concentrated in the city centre. The fringes that experienced the highest growth were left without control and planning. Without a proactive policy and involvement of the people in planning and development control, Suleja and environs would continue to grow without plan thereby making sustainable growth and development of this area unrealisable.

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ABBREVIATIONS.

CA	Cellular Automata
CBD	Central Business District
CCT	Cell Crossing Time
DEM	Digital Elevation Model
EAD	Enumeration Area Demarcation
ETM	Enhanced Thematic Mapper
FCDA	Federal Capital Development Authority
FCT	Federal Capital Territory
GIS	Geographic Information System
GLP	Global Land Projects
IHDP	International Human Dimension programme
ITLUP	Integrated Transportation and Land Use Package
LUCC	Land Use and Cover Change
MEA	Millennium Ecosystem Assessment
ROC	Relative Operating Characteristics
SAR	Synthetic Aperture Radar
SLEUTH	Slope, Land-use, Exclusion, Urban extent, Transportation, and Hill shade.
TM	Thematic Mapper
UGM	Urban Growth Model
UNCHS	United Nations Centre for Human Settlement

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ABBREVIATIONS.

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CBD	Central Business District
CCT	Cell Crossing Time
DEM	Digital Elevation Model
EAD	Enumeration Area Demarcation
ETM	Enhanced Thematic Mapper
FCDA	Federal Capital Development Authority
FCT	Federal Capital Territory
GIS	Geographic Information System
GLP	Global Land Projects
IHDP	International Human Dimension programme
ITLUP	Integrated Transportation and Land Use Package
LUCC	Land Use and Cover Change
MEA	Millennium Ecosystem Assessment
ROC	Relative Operating Characteristics
SAR	Synthetic Aperture Radar
SLEUTH	Slope, land use, Exclusion, Urban extent, Transportation, and Hill shade.
TM	Thematic Mapper
UGM	Urban Growth Model
UNCHS	United Nations Centre for Human Settlement

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

The rate of growth of our cities is proceeding at a very rapid rate. It is becoming more alarming due to its unplanned nature. According to Global Land Project (GLP) Science Plan (2005), Human transformation of ecosystems and landscape are the largest source of change on earth affecting the ability of the biosphere to sustain life. We humans have become ever more adept at appropriating and altering the earth resources for human needs. Intensification and diversification of land use and advances in technology , the report added , have led to rapid changes in biogeochemical cycles , hydrologic processes and landscape dynamics. Changes in land use and management affect status , properties and functions of ecosystems ,which in turn affect the provision of ecosystem services and human well being. The biophysical alterations and social forces generate different responses in the northern hemisphere than in the southern hemisphere, in urban environments than rural environment and in developed countries than in developing countries (GLP science plan, 2005). This difference in response due to lack of clear understanding or level of economic growth is the main cause in magnitude of impact. This study seeks to analyze to the growth of Suleja and understand the process and facts behind it.

This work focused on improving the understanding and application of modelling methods and techniques to analyze urban growth in a complex system. The broad concept of urban development according to Cheng (2005) implies changes, growth or decline. The term includes the physical, socio economic and environmental dimensions. Physically and functionally, urban development includes both new development and redevelopment. In contrast to decline, growth involves the transition into urban or non urban activities and spaces. The physical aspects of urban growth are related to land cover which is reflected by the land use. Temporal and spatial urban growth indicates the spatial and temporal dimensions of land cover /land use change at the level of the urban landscape.

The aim of modelling is to abstract and represent the entity being studied. Modelling can be conceptual, symbolic or mathematical, depending on the purpose of the specific application. In the area of urban plan , modelling can be utilized for analyzing, evaluation , forecasting ,and simulating urban systems to support decision making . From the perspective of spatial science, modelling must take the spatial and temporal dimension of urban systems into account.

1.2 STUDY AREA

Suleja, the former headquarters of Abuja province lies between latitude $9^0 14'51''$ and $9^0 16'52''$ North and longitude $7^0 06'32''$ and $7^0 15'35''$ East. Suleja town is about 110km away from Minna. The town is an important junction town linking the highways, F-126 and A-124 from Minna and Bida to the West and south respectively, to the highway A.234 passing through Abuja to Keffi and Akwanga in plateau State. The town is also located on the highway, A-2, which is probably the most important Federal trunk road in the country today linking Kaduna which is about 155km to the North with Abuja 40km, Lokoja 145km, and Benin 450km to the South.

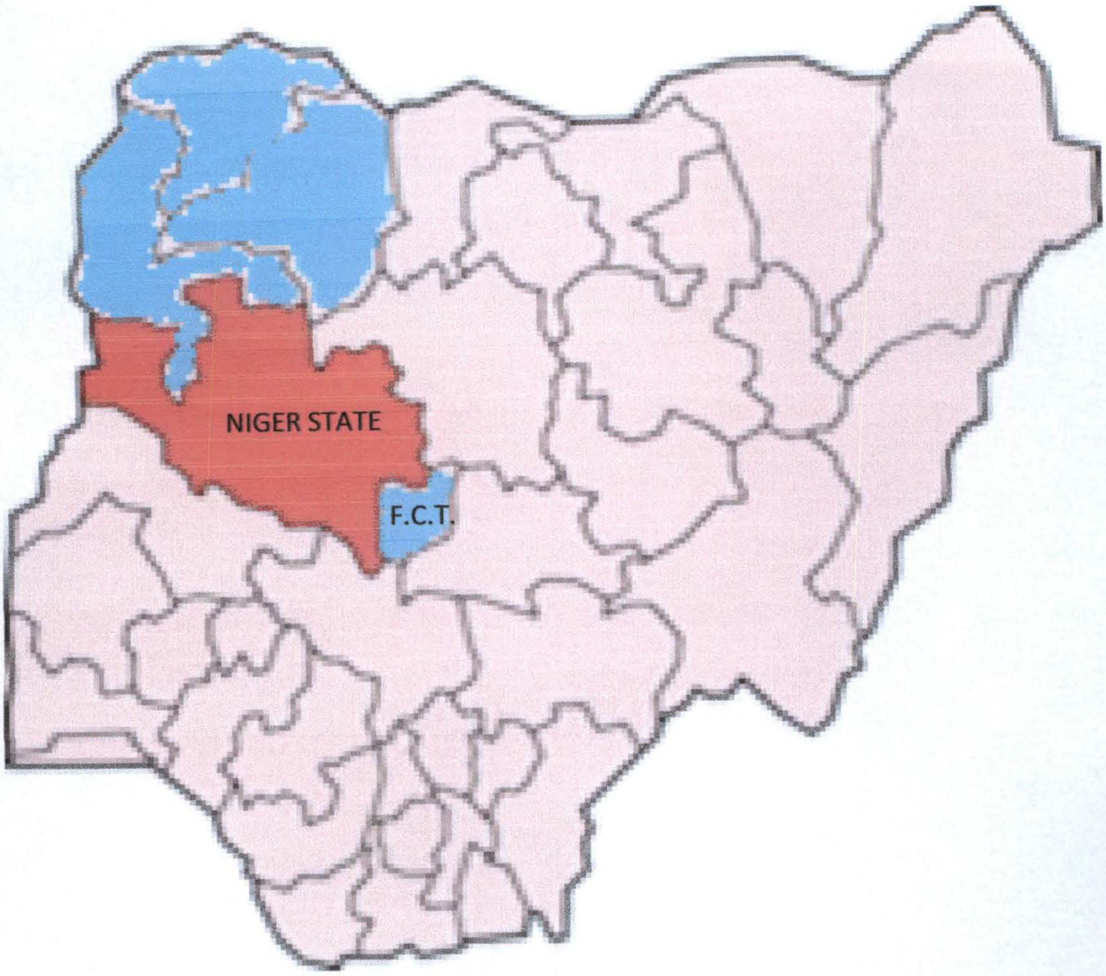


FIGURE 1.1: MAP OF NIGERIA SHOWING THE LOCATION OF NIGER STATE.

Source: National Population Commission, 2006.

Suleja is one of the oldest local government areas in Niger State and has been the headquarters of the local government since the creation of the State in 1976 .Niger state is bounded on the North by Kaduna and Kebbi, on the East by the Federal Capital Territory (F.C.T.), on the South by Kwara state and on the west by Republic of Benin.

MAP OF NIGER STATE SHOWING SOME LOCAL GOVERNEMENT HEADQUATERS AND SULEJA

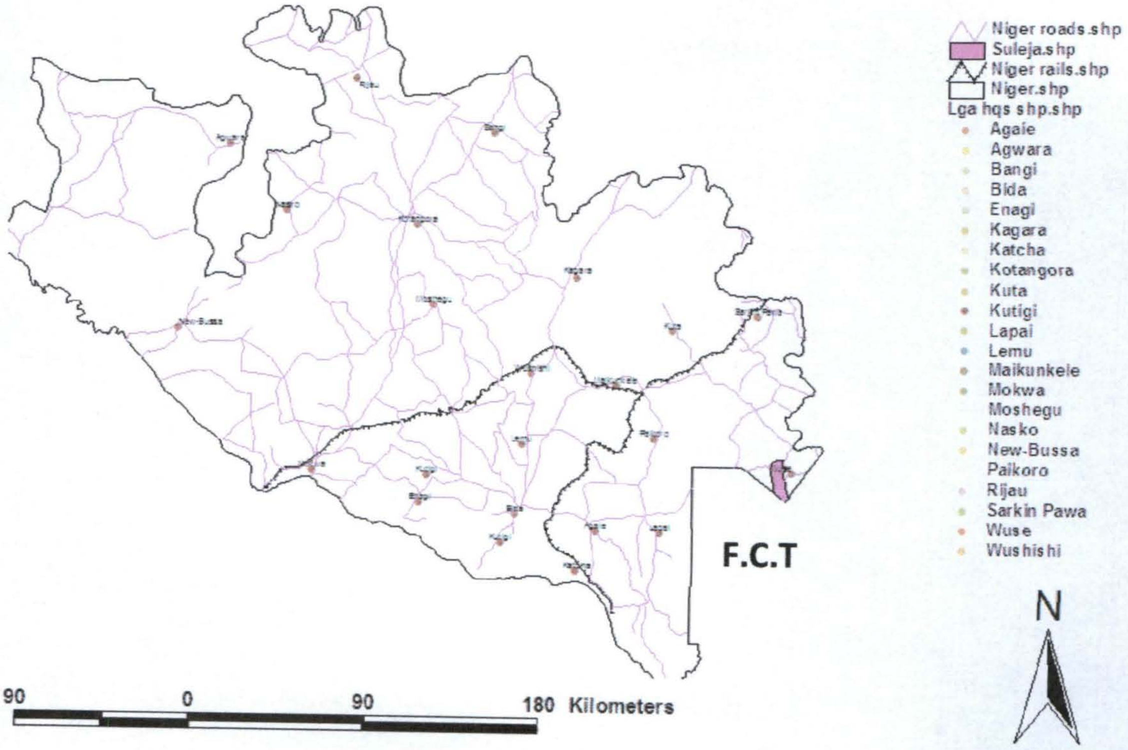


FIGURE 1.2: MAP OF NIGER STATE SHOWING THE LOCATION OF SULEJA

SOURCE: National Population Commission, 2006

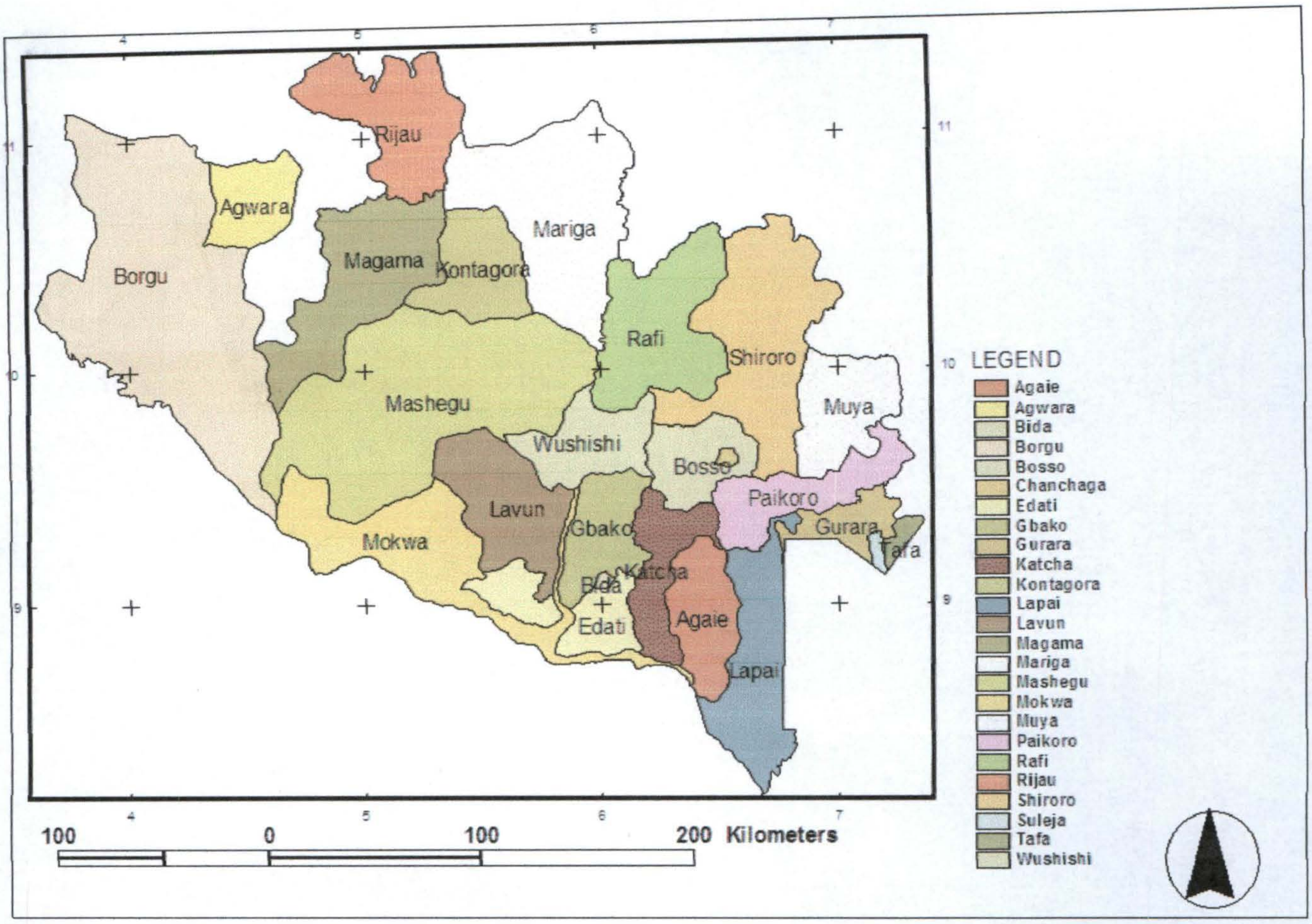


FIGURE 1.3: MAP OF NIGER STATE SHOWING THE LOCAL GOVERNMENTS

SOURCE: National Population Commission, 2006.

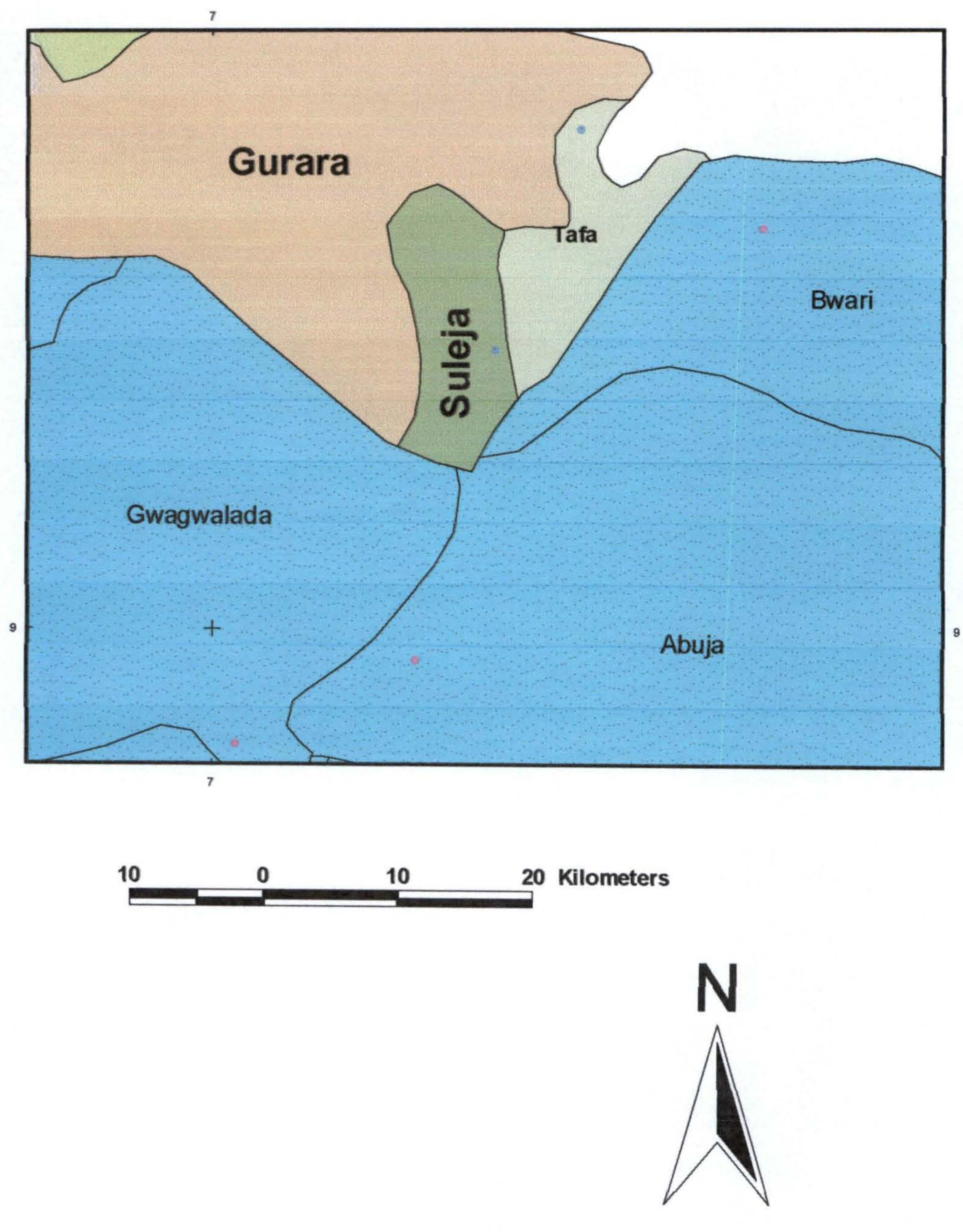


FIGURE.1.4: MAP OF SULEJA

SOURCE: National Population Commission, 2006

Due to its location and proximity to Abuja, Suleja is among the most densely populated local government in the state. Based on the official projection of the 1991 census, Suleja local government has a population density of 1343 behind Minna 2621 and Bida with the highiest 2644 as at 2001.Figure 1.1 shows the location of Niger State within the country. Figure 1.2 shows how Suleja is proximate to the Federal capital and figure 1.3 shows the location of Suleja within Niger state.

1.3 HISTORICAL BACKGROUND

1.3.1 Prior to the decision to move the Federal Capital from Lagos to a more central location, Suleja was known as Abuja. The ancient Abuja town was named after the founder Abubakar Jatau popularly known as Abu-ja (meaning Abu the red).

Based on Historical account, the people of Abuja migrated from Zaria which was known as Zazzau. Mallam Musa, one of the flag bearers of Shehu Usman Danfodio waged a war on Zaria in 1804 and forced the ruler Muhammadu Makau to Flee.

Makau and about 3000 followers moved South West to the present location of Suleja to settle among the tribes of Gwaris, Koro, Gade, Gana-gana, Gwandara and the Bassa. The Foundation of ancient Abuja was laid in the year 1828 after a period of over 20 years in transit from Zazzau by Abuja, Makau's brother who took over after his death.

Territorial expansion intensified through conquest of the tribes around. This increases the population of Abuja significantly. The town continued to experience growth until the coming of the British in 1902 (Max Lock, 1988).

The advent of the colonial rule in 1902 and creation of new local governments in 1975 attracted growth and development. The combined effect of this is increase in population.

One of the initial catalysts for the growth in the housing sector and population influx in recent times was in 1974 when the first battalion of the infantry brigade of the Nigerian Army was moved to the town. There was a very high demand for housing to accommodate the military personnel newly posted to the area. The few available tenement houses were immediately taken over while incomplete structures were hurriedly completed.

The Single most important decision that greatly affected the growth of Suleja came in 1976 when decrees No. 6 establishing the Federal Capital Development Authority (FCDA) was promulgated upon the recommendation of the special panel to move the capital of Nigeria from Lagos to Abuja. By 1977 the FCDA liaison office was established in the town and the FCDA Secretariat built and started operating in its field base in Suleja between 1978 and 1979.

Despite the fact that almost 80% of the total land area of the Federal Capital Territory (FCT) was carved out of the former Abuja province, the Abuja town itself did not fall within the territory for some obvious reasons. It became obvious that, if the new FCT is to bear the name Abuja, then the name of the then existing Abuja town has to be changed to avoid confusion. It was based on this that in 1979 the name Suleja was introduced as the name of that geographical entity which constituted the former Abuja town and which represent the remaining area of Abuja Local Government not included in the FCT (Shuaibu, 1998).

In poetry by Vatsa (1982) he said Abuja was my town but the nation asked for her. I kept her and then gave the name to our nation. Suleja is now my town and Abuja our town. I once owned Abuja, but now Abuja owns me". This shows the metamorphosis of the two settlements and has precipitated the necessity for the study.

Shuaibu (1998) argued that, a cursory observation of the map of the FCT in relation to Suleja town would reveal how Suleja is almost made an enclave sandwiched by the FCT.

The exclusion of the town out of the FCT raises a lot of questions, most especially when one considers the fact that more than three quarters of the total land area of the FCT initially belonged to Suleja Local Government Area. This would not be unconnected to the fact that the minority ethnic groups populate the whole of the vast land included in the FCT, while Suleja town is purely a traditional Hausa settlement with a typical Hausa Fulani traditional set-up. Thus Hausa being one of the three major opposing ethnic groups in Nigeria, the only reason why the original demarcators of the FCT would avoid Suleja was that, its inclusion would contradict the intended ethnic neutrality of the FCT.

Whatever may be the case, the ongoing relationship between Suleja and Abuja points to the fact that, politically, Suleja may not be located in the FCT, but their common physical characteristics, proximity, accessibility and historical connection show that, culturally and socio economically the two centres are inseparable.

It is a situation like this that made Bailey (1973) to opine that, the most underrated external linkages of a new town is that between the new community and the stream of history. Each new increment of today's built environment is an expression of this stream.

1.3.2 CLIMATE:

The climate of the area is conditioned by the movement of the Intercontinental Convergence Zones (ICZ), which determines the season. The dry season begins from November to March/April and the wet season from April/May to October. The average annual rainfall is about 1640mm and a rainy season of about 7 months. The dry season has high temperature and low relative humidity, while the wet season has lower temperature, small diurnal variation and high relative humidity. The dry season winds are predominantly from N.E. to S.W. and the wet seasons winds are predominantly from S.W. to NE.

1.3.3 SOILS AND VEGETATION

The seasonal variation and accompanying seasonal fluctuations in the absorption of moisture by the soil is believed to encourage the formation of extensive largely unproductive ferruginous crusts in Suleja. Apart from river valleys the main soils of the town is the heavy fertile blackish soil, which makes the soil, very fertile for agriculture. Generally the soil condition of any place is influenced by the geology of the area. The geology of Niger State (Fig. 1.5) consists of three geological forms. Suleja is located on the basement complex geological formation.

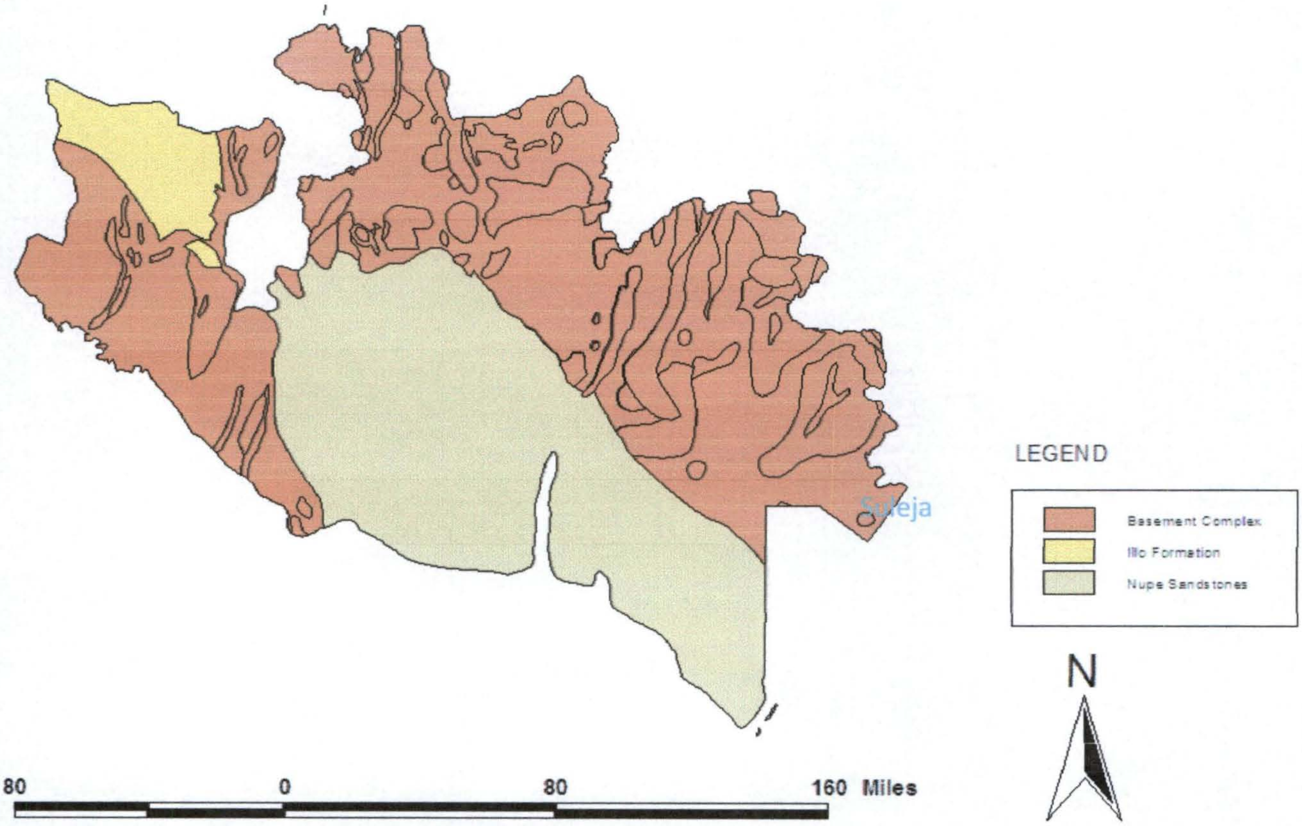


FIGURE 1.5: GEOLOCAL MAP OF NIGER STATE

SOURCE: National Population Commission, 2006

The true climax vegetation of Suleja is the semi deciduous forest. The rapid population growth of the town and demand for fuel wood has greatly affected the natural vegetations. Forest clearing followed by recurrent cultivation, has now given rise to shrub/tree savannah vegetation undistinguishable from the southern Guinea Savannah.

1.4 STATEMENT OF RESEARCH PROBLEM

The impacts of Abuja on its neighbours are many and interrelated. The development of the capital city is one of the most ambitious projects ever embarked upon by the Federal Government of Nigeria. The concept of the development was designed with consideration to land uses in the surrounding states. It also considered the importance of cooperation of the adjoining states in its development plan.

Unfortunately this concept of joint co-operation with neighbouring states is not given the desired attention. The development of the Federal capital is associated with many problems among which are;

I. The implementation of the Abuja Master Plan proceeds at a pace much slower than its population increase due to rapid immigration.

II. Tenement houses which are the abode of the Nigerian low incomes earners in cities are virtually absent among the houses completed or on-going while the few rentable accommodation are outside the affordability of both the low and medium income groups.

III. The beaurocratic procedures in land administration and high demand for developable land has skyrocketed the market value of land.

IV. Building plan approval procedure and development control measures are very stringent which makes it almost impossible for ordinary developer to fulfil.

These have affected low-income developers especially non-government workers. In the alternative these groups seek alternatives outside the Federal Capital City (FCC). Suleja provides an ideal alternative due to;

I. Its proximity to Abuja

II. Availability of basic Infrastructure

III. Availability of tenement house

IV. Less stringent development control and land administration process.

These conditions have aggravated the physical planning problems of Suleja. Development of various magnitude and use are daily being carried out without regard to standard. The planning agency of the State is incapacitated by financial and logistic problems.

Housing which is one of the most important human needs is in short supply everywhere in Nigeria. Supply is far behind demand and the rising cost of construction is making it difficult for the low-income earners to build their own house. Unlike other satellite towns within the Federal Capital Territory (FCT), Federal Government does not include Suleja in its housing programme despite its pioneer role as the base of the Federal Capital Development Authority (FCDA).

The present housing problem in Suleja could be attributed to its location relative to Abuja. The region, as a result of Abuja, would continue to attract population and it would spread to Satellite towns. Without adequate knowledge of the factors responsible for the increase in population and the interaction between the various components of the urban system, urbanization problems would persist unabated.

The urban area represents man's greatest impact on nature because it concentrates and intensifies all of these factors (Miller, 1975). The study area, Suleja, is experiencing all of those factors, which give rise to present situation.

The complex interaction that is taking place between the FCT and the surrounding settlements is dynamic and has resulted in the massive growth of Suleja. To understand the forces behind the growth we need to identify the factors responsible and determine, through empirical means the level of contribution of the various variables in the overall growth of Suleja.

In the field of urban planning, one of the important subjects of concern is to predict the trend of land transition. Cheng, et al (2002), argued that systems' thinking has been widely accepted by urban planners and other decision makers engaged in urban management and construction. When we consider urban growth as a system, in particular a complex system, we need to uncover the universal and unique characteristics that it shares and distinguishes it from other complex systems.

By adopting the empirical techniques in the analysis of the growth of Suleja we would be able to isolate the causes and understand the magnitude of the problem and possible ways of effective intervention. The previous measures taken by Niger State government were unsuccessful in addressing the various problems of Suleja. The failure of previous effort by the state government could be as a result of the approach to the problem. Most of the works gave only a description of the 'known' problems without analysing the contributions of each of the factors and how the proximity of Suleja to Abuja influences some of these factors.

One of the best ways to undertake empirical analysis like this is through modelling. According to Cheng (2003) the aim of modelling is to abstract and represent the entity being studied. Modelling, he said, can be mathematical or symbolic depending on the purposes of the specific application. In the domain of urban planning, modelling can be utilised for analysing, evaluating, forecasting and simulating urban systems to support decision making. From the perspectives of spatial science, modelling must take both the spatial and temporal dimensions of urban systems into account. That is what we have explored in this study.

1.5 MODELLING AND ITS BENEFITS TO THE STUDIES OF URBAN GROWTH.

Changes in settlement pattern and size could be temporal or spatial. Urban development indicates changes or growth. This growth could be organized or unorganized like in Suleja. The expansion includes the physical, socio economic and environmental dimensions. To be able to put all these factors into one place we need a suitable model that would be able to synthesis all the various factors and give a reasonable result that would aid in better understanding of the problems associated with growth.

The main trust of this work is to try and model the growth of Suleja and to see the factors that are responsible for the rapid changes. The aim of modelling, as we earlier said, is to abstract and represent the entity being studied. This could be conceptual, symbolic or mathematical depending on the purpose of the specific application.

The relevance of any research work, according to Cheng (2003) should be assessed based on any of the following: the social, scientific and practical relevance. In line with this, the aim of this research is three fold, based on which perspective one wish to take.

1. **Societal relevance of modelling:** Urban growth in any part of the world, developed or developing, has both negative and positive impacts on the people and environment. There is therefore the need to have a better understanding through modelling. The impact of urban growth on environmental sustainability is becoming more prominent globally through the cumulative effects. Faced with

these impacts, urban planners need to rethink the most important development policies and manage urban sprawl and urban growth more scientifically. More importantly in developing countries like Nigeria, patterns of urban growth have been studied in the context of their special social and economic circumstances. There is no universal solution. However, it is recognized that the scientific management and planning should be based on a proper understanding of the spatial and temporal processes of urban growth. This is the objective of modelling spatial and temporal urban growth.

2. **scientific relevance of modelling**: theoretically , urban growth modelling should be considered as an interdisciplinary field as it involves numerous scientific and technical areas e.g. Geographic Information Systems (GIS), remote sensing, urban geography, complexity theory, land use /land cover Modelling etc. Understanding urban growth and applying this knowledge for planning are both closely linked with these areas. Hence a systematic and 'holistic' perspective should be adopted in the processes of modelling.

3. **Practical relevance of modelling** : the rapid urban growth nationally and the impact of Abuja on its surrounding satellite towns , coupled with the recent government policies on housing and demolition have forced people to areas like Suleja. This has resulted in massive conversion of agricultural land into built up land. Land sat TM and ETM of 1987 and 2001 clearly showed the extent and rate of urban expansion under the period. It can be predicted that an urgent follow up task will be to model urban expansion for the purpose of decision making in planning and management at various levels of governments , based on the outcome of the monitoring exercises. Urban sprawl has become a serious topic in the urban planning and management practices of many countries in both the developed and developing

world. Individual case studies and further comparative research can be helpful in the sharing of experiences and lessons.

1.6 THE GROWTH OF ABUJA AND ITS IMPACTS ON SURROUNDING SETTLEMENTS.

The final movement of the seat of government on 12^{th} December 1991 to Abuja from Lagos completed the long journey that started some 25 years earlier. This movement has brought about major transformation in the social and physical make up of settlements around the new Federal Capital. This change in the development of Abuja from a rural sparsely populated area to one of the fastest growing cities in Africa requires that the urban planning system be modified to take into account other areas that are in one way or the other linked to it. Most of the previous works concentrated on urban growth of the city of Abuja without looking at the impact of Abuja on its neighbouring settlements. There is no systematic research on the interactions between Abuja and other towns and understanding of the driving forces of growth. The empirical investigation of Suleja in this study has attempted to find answers to the following questions:

1. How can we understand the growth of Suleja over the past years?
2. What are the spatial and temporal patterns and processes of Suleja's growth?
3. Is the growth of Suleja linked to the rapid expansion of Abuja?
4. How effective are government policies and development control in ensuring orderly development of Suleja?

1.7.1 AIM

Based on the above, the aim of this research is to identify the factors that are responsible for the growth of Suleja and to use these factors (variables) in modelling the growth pattern of Suleja and environs.

1.7.2 OBJECTIVES

The objectives of the study are;

I. To assess land development and formal land supply within Suleja urban.

II. To examine space integration within Suleja and environs through traffic flow.

III. To determine land use changes and space convergence within Suleja and environs between 1987 to 2001 and to apply quantitative method for a comparative measurement of long term temporal urban growth of Suleja.

IV. To establish relationship between land use changes and population.

V. To recommend a strategy for effective monitoring of the growth of Suleja and environs in a sustainable and scientific method.

1.7.3 RESEARCH HYPOTHESIS

1- There is no statistical relationship between distance from Abuja and growth of Suleja.

2- There is no statistical relationship between population and rate of expansion of Suleja.

Apart from the above hypothesis, we equally answered some research questions;

I. Are the residents of Suleja building within planned areas?

II. Are residents of Suleja seeking approval before commencing developments?

III. Are the residents of Suleja aware of the impact of Abuja on the growth and development of Suleja and environs?

3. They are characterized by extreme fluidity and mobility of the population. Availability of relatively cheap transport such as two stroke motor bikes , buses, and trucks has facilitated relatively quick movement over longer distances. Thus , these zones are characterized by both commuting to the larger urban centres and also intense movement of people and goods within the zones.
4. These zones are characterized by an intense mixture of land use , with agriculture , cottage industries , industrial estates , sub-urban development's and other uses existing side by side. This has both negative and positive effects. Agricultural produce, particularly if it is industrial crops, has a ready market. On the negative side, the waste from industrial activity can pollute and destroy agricultural land. On the whole, these zones are much more intensely utilized that the megalopolis.
5. Another feature of these zones is the increased participation of women in the non-agricultural labour. In part , this is associated with demand for female labour in industry , to domestic service, and other activities .But it is also closely related to changing patterns of agricultural production in the *desakota* region.
6. Lastly, these zones are to some extent "invisible "or "grey" zones from the point of view of the state authorities. Urban regulations may not apply in these areas and it is difficult for the state to enforce them despite the rapidly changing economic structure of the regions . This feature is particularly encouraging to informal sector and small scale operators, who find it difficult to conform to labour or industrial regulation in the capital city.

These features of a desakota by McGee , even though specifically for the south east Asian cities are applicable to our situation and can help in our management strategy . By looking at mega cities beyond their boundary into surrounding areas and provide a better opportunity for managing both the problems and prospects. For instance the 6^{th} feature clearly resembles the Suleja-Abuja relation. Due to high control standard in Abuja and inability of Niger state government to effectively monitor the area has encouraged the expansion of slums and planlessness.

The problem of city management in Nigeria can be attributed to the attitude and disposition of government. Lack of good government policy on city planning and management could lead to disorganization of the cityscape. This symptom of disorganization ,according to Hamer (1994) include limited access to public services and urban infrastructure ; existence of squatter settlements and unregulated subdivisions; prevalence of pollution and congestion; poor maintenance of urban assets; poor cost recovery and tax administration , price controls and untargeted subsidies; physical plan and regulations /standards that ignore affordability ; a local government work force that has few tools and fewer incentives to use them. All these factors are interconnected and are widely visibly in our case study, Suleja. If the government's role is to improve living conditions of the people , then we are failing based on the outlook of our cities , like Suleja. One cannot improve living conditions without addressing the issue of what government should do and not do, and how it can finance its initiative.(Hamer and Linn, 1987).

One important factor in the growth of urban areas not only in Nigeria but is most developing countries is land. The consensus in the developing world housing literature, according Gilbert (1994), is that the cost of land is rising, thereby slowing the growth of owner –occupation and the prospects for self – help housing consolidation.

Access to land for self housing in the last 30 years was much easier. Baros (1983) observed that the majority of people who came to the large cities in developing country in the last two to three decades found or developed housing in popular settlements. It was an historical epoch of non-commercialized or cheap commercial land supply. In his word, people did not have to pay or paid very little. This era in many developing countries is drawing to an end.

In the same vein, the United Nations Centre for Human Settlements (UNCHS) also pointed out that land, particularly in the cities, is being quickly transformed from a resource with a use value to a commodity with a market value. Gilbert tried to explain why access to free land has become rare now in most cities of developing countries thereby making government policy difficult to implement:

1. the combined forces of demographic growth and suburbanization have simply used up most of the accessible land
2. a fully commercialized land market has been established in most cities low-density sub-urban development and has led to increasing numbers of middle class owners occupying peripheral land . This has meant that most owners including public sector, have become well aware of the market value of their land
3. Commercialization has been further encouraged by the action of the state.
4. Official intervention has sometimes brought additional problems for the poor, in particular , efforts to control urban sprawl have reduced the supply of land and particularly that available to low income groups.
5. Finally , access to land has been hindered by the sheer physical growth of the city and worsened , in places by the inadequate development of transport services.

These problems affect access to land thereby encouraging spread out of informal developments in areas that are sometimes unfit to be developed. This scenario should not be allowed to continue unchecked. Gilbert stressed that there is a clear need both to slow and to direct the pattern of urban growth. Informal suburban development can get out of hand. It can spread too quickly as is taking place around the federal capital of Nigeria, creating very low density suburbs that are very difficult to service. In addition, it often occupies land that should not be urbanized because it is too high to be drained , or too rugged to be provided with drainages and road as in Suleja. To safeguard orderly development in our cities especially among the low income group, Gilbert gave some suggestions:

1. sites and services scheme
2. Lowering of building and servicing standards. He argued that the higher the standard, the less accessible the plots,
3. authorities should publish guidelines to informal settlers pointing out what is expected of them by the government,
4. land holders should be discouraged from selling their land without planning permission
5. Finally land banking.

These are some suggestions on how to discourage excessive suburban development which if properly studied and applied could bring about orderly development.

City growth and by extension urbanization is viewed as also having its impact on sustainable development. City growth that does not consider the wider Implication of population growth on available resources is bound to create unsustainable situation. The ability to measure vulnerability is increasingly being seen as a key step towards effective risk reduction and the promotion of a culture of disaster resilience (Birkmann, 2006). In the light of increasing frequency of disaster and continued environmental degradation in both rural and urban areas, measuring vulnerability is a crucial task if science is to help support transition to a more sustainable world (Kasperson et al ,2005)

2.5 REASONS FOR THE STUDY OF URBAN GROWTH.

Human transformation of ecosystems and landscapes are the largest sources of change on earth, affecting the ability of the biosphere to sustain life. Humans have become ever more adapt at appropriating and altering the earth's resources for human needs. Intensification and diversification of land use and advances in technology have led to rapid changes in biogeochemical cycles, hydrologic processes and landscape dynamics. Changes in land use and management affect the status , properties and functions of ecosystems, which in turn affect the provision of ecosystems services and hence humans well being..

Local communities surrounding biosphere reserves may hold very different views about what constitute a "healthy" or "best case" forest from those held by biologists or forestry officials. .Understanding these perceptions is an essential prerequisite for understanding the magnitude of potential reactions. Undoubtedly ,the perception of global change can only be analyzed in the context of the knowledge and value systems of local societies.

According to Global Land Projects (GLP) science plan (2005), urban expansion into peri urban area is a common feature throughout many regions of the world. Peri urbanization refers to a highly dynamic process where rural areas, both close to, but also distant from, city centres becomes enveloped by, or transformed into, extended metropolitan regions. These changes are usually rather piecemeal and non uniform processes, but involve complex adjustments to social and ecological systems as they become absorbed into the sphere of the urban economy.

The interest in the study of the peri urban areas by researchers and organization like International Human Dimension Programme (IHDP) on Global Environmental change is because they are key interface between urban and rural areas due to the provisions of essential services in both directions. They suffer the negative consequences of urban areas, and have also been neglected in most urban and environmental studies.

2.6 ROLE OF PLANNING IN SETTLEMENT GROWTH:

Planning as defined by Davidoff and Reiner (1973) is a process for determining appropriate future action through sequence of choices. They use the word determining in two senses: Finding out and assuring, which are achieved through goal formulation and action to effectuate this goal.

To understand the relevance of planning to human endeavor we should highlight the characteristics of planning as prescribed by Davidoff and Reiner (1973).

a. The achievement of ends
b. Exercise of choice
c. Orientation to the future
d. Action and
e. Comprehensiveness.

In fact by Comprehensiveness, planning serves to relate the components of a system for better understanding and efficient Management.

The present State of affairs in our towns in Nigeria can be attributed to lack of strong commitment by the government in the area of planning. For instance, the British Government has accepted in principle the function of safeguarding the public interest by providing a civic approach to land planning (Davidoff and Reiner, 1973). This, they said flows from the general recognition that present conditions of overcrowded, physically mean, and spatially sprawling conurbations constitute a distinct threat to healthy and civilized life. We can draw from this to see the lapse in our city management where they continue to spread without control, which result in many problems.

In fact one of the three elements of town planning ideology as spelt out by the authors is, Town Planning, as part of a broader social programme is responsible for providing the physical basis for better urban community life; the main ideals toward which town planning is to strive are (a) the provision of low-density residential areas (b) the fostering of local community life and (c) the control of urban growth. This ideological view accepts town planning as responsible for allocating land and improving the physical environment and controlling the current urban growth and expansion in the interest of preserving or recreating town life.

From this general philosophy, these propositions derive: the further growth of conurbations and larger towns shall be carefully controlled so as to provide reasonably short trips to work, to relieve the congestion arising from too many long commuting trips within a conurbation, and to provide a sense of balance to the community so that it is not a mere 'dormitory' like is the case in Suleja/ Abuja relationship.

The city is an extremely complex social system, only some aspects of which are expressed as physical buildings or as location arrangements. According to Weber (1964), we are coming to understand that each aspect lies in a reciprocal causal relation to all others, such that each is defined by, and has meaning only with result to, its relations to all others.

Based on better understanding of the city as a system, we can no longer speak of the physical city versus the social or the economic city or the political city. We can no longer dissociate a physical building, for instance, from the social meanings that it carries for its users and viewers or from the social and economical functions of the activities that are conducted within it (Weber, 1964). This goes further to explain the rise in new form of city management through systems approach for better understanding and predications.

The role of a planner is to provide a plan that would guide the growth of the city. According to Innes (1998), the plan must be comprehensive in the sense that it covers the whole city, deals with all essential physical elements of the urban environment and recognizes its relationships with all significant factors, physical and non-physical, local and regional, that affect the physical growth and development of the community. It should take into account demographic and economic forecasts and anticipated technological change.

In his work, Burgess, (1925) found that urban fringe areas are highly mobile. Mobility is a measure of the rate of cultural and technical change in urban areas. The implication of high mobility is break down in primary control. Burgess (1925) found that areas of high mobility are areas of delinquency. He argued that land values reflect movement and are the best measure of mobility. Burgess work can be used to explain the situation in Suleja were land value is high.

One of the fundamental features of any settlement is transportation route. Considerable time, money and effort are usually expended in the planning and design of such route .For the most part, the planning work is carried on within the framework of an urban transportation study (U.S. Dept of Transportation, 1983).

Urban traffic pattern of any given area now, and in the future, are a function of,

1-the type and extent of the transportation facilities available in the area

2-the pattern of land use in an area including the location and intensity of use;

3-the various social and economic characteristic of the population of an urban area. The transportation planning process utilizes these interrelationships to provide quantitative information on the travel demands generated by alternate land use patterns and transportation systems.

2.7 URBAN GROWTH THEORY

The strategic role that theory plays in man's quest for understanding and knowledge is so basic, so well documented and so widely accepted that it seems unnecessary to stress its essential importance for the planning field. Theory according to Chapin (1970) refers to a system of thought which through logical verbal or mathematical constructs supplies an explanation of urban areas – why they exist, how their growth and change occur, and what the basic structure and form components are in the urban scene. In addition to supplying an explanatory rationale, theory frequently provides a rationale for prediction.

Some outstanding applications of urban growth theory to spatial growth are the Von thunen theory in agricultural land development, Weber (1964) and Isard (1956) on land value. The view taken in these approaches, according to Chapin (1970), sees urban development processes as economic phenomena. The organizing concept is the market mechanism and the sorting process it provides in allocation of space to activities.

The economic explanation of the urban land use pattern begin with forces extending far beyond the immediate environs of any particular urban centre of interest, and involve considerations of the structure and functioning of the urban economy as it fits into the larger economy of the region and the nation. Knos (1962) tested the relationship between land values and several commonly assumed characteristics of land use in his study of Topeka. His work provides empirical evidence that land values influence the intensity of land use. Others are the concentric theory by Burgess (1925) and Multiple Nuclei Model of the city by McKenzie (1933). From these entire theories one can see that growth and internal arrangements of the city are a function of various interacting elements.

The urban ecologist also introduces some concepts of ecological processes in explaining the urbanization process. This concept clearly explains our own peculiar situation around settlements surrounding Abuja. In the Natural Science concept of ecology, there is a strong emphasis upon processes by which living things adapt to their environment, and so it is not surprising to find urban ecologist centering their attention on processes by which man adapts to his urban environment. As might be expected, opined Chapin (1970), economic forces figure prominently in explanations of these ecological processes.

The major classification of the processes by Chapin (1970) are seven but the ones relevant to this work are (1) Dominance, gradient and segregation (2) Invasion and succession of one population group by another. In the first, the city usually dominates the entire scene due to concentration of activities and business opportunities that attract people to the center while the sphere of influence of the city decreases as one move away from the city. This brings about the separation within the urban area based on functions and services.

On the other, invasion and succession are usually linked in sequence. Invasion is the interpenetration of one population group or use by another, the difference between the old and new being economic, social or cultural (Chapin, 1970). Invasion of one population group by another is usually a spatial manifestation of the change processes at work in the social structure of the city. Invasion is also used to describe shift in land use as, for example, when business penetrates into residential areas or non-agricultural use penetrate into agricultural use areas like is the case along the road to Abuja. The principal consequence of invasion is a break-up of the existing population and land use make-up of the area. Succession is the culmination of the break-up, with the new achieving complete displacement of the old. This clearly fits into the situation around Suleja where the traditional occupation is displaced by more lucrative higher order commercial use e.g. petrol stations.

The adoption of ecological concept in explaining urban interactions was born from the expansive curiosity of the biologist of the late 19th century, who wished to understand the distribution and abundance of earth's organisms. Collins et al (2000) summed up by saying, cities are some of the most profoundly altered ecosystems on the planet; within their boundaries are also found some of the most diverse ecological conditions. If there is a laboratory where ecological change can be viewed at close hand, they opined, it is the city.

It has proved very difficult to provide a model of the ecosystems that effectively incorporates human activity and behaviour. The processes and dynamics within cities largely elude an understanding based on traditional ecological theories. Collins et al (2000) argued that ecologists conceive of ecosystems as consisting of habitat 'patches'. A city –with its concretes- and – glass down town, industrial parks and tree lined residential streets- is quite a patchy ecosystem, and together with all its patches it is part of a large landscape full of other patches. It is such kind of interaction that the systems theory tries to explain.

In the study of the fringe areas or peri-urban areas, more conceptual questions were raised by Collins et al (2000).The questions were on the dynamic nature of such areas where must of the orthodox techniques seems to fail, thus the need for a better all encompassing theory or model like systems model where the existing problems within the fringe is analyzed not in isolation but as a consequence of its proximity to an urban centre. Some of the questions raised were, how do we study the change in the position or shape of 'urban fringe'- the dynamics of the edge of the city and its expansion? The expansion of the urban fringe, they explained, could be understood in terms of the density of surrounding neighbourhoods, residences "produced" from nearby "occupied" cells and dispersed to nearby empty cells. This "empty cell" can be explained in terms of the accessibility to developable land outside the main central area where the planning control and administration of land is strong. These force developers to move to nearby "empty" cells like Suleja.

In the field of urban planning, one of the important subjects of concern is to predict the trend of land use transition. However, prediction without scientific understanding of the system under study implies a certain degree of uncertainty due to the numerous factors involved.

The complexity of urban growth and its impacts on urban development planning and sustainable growth management have not been systematically researched (Cheng et al, 2003). They raised two questions on the complexity of urban growth: what is the urban growth system? And why and how should the complexity be understood?

The fact that the urban system is highly complex is well recognized. Systems thinking has been widely accepted by urban planners and other decision makers engaged in urban management and construction. Cheng et al (2003) argued that, when we consider urban growth as a system, in particular a complex system, we need to uncover the universal and unique characteristics that it shares with and distinguishes it from other complex systems.

As far the type of urban development is concerned, it consists of physical expansion and functional changes. The former, according to Cheng et al (2003) refers to the change in space (transition from non-built up to urban), the latter to the change in major activities (land uses). As a result, space and activity should be the basic elements of the systems defined for understanding urban growth.

Their work tried to show the basic elements that compose the urban system. They tried to explain the evolution of urban area over time. They opined that urban growth occurred in a specific period from time t1 to t2 and they assumed that this growth is closely related to three system-P,U and N. U is a highly complex social and economic system, as the concentration of considerable urban activities present at time t1shows. It offers current activities rather than space for urban growth to come. N is a typical physical ecological system, including various ecological units (water body, forest etc) and agricultural land. It primarily provides possible spatial and conceptual system that result from a spatial planning scheme. It prepares organized space and activities for urban growth in the future. They treated each new urban growth as an independent system within the specific period under modelling. Under such an assumption urban growth can be defined as a system resulting from the complex dynamic interactions (only from t1 to t2) between the three systems P, U and N). To explain how these three interact, Cheng et al (2002) state that system P contributes planning control and requirement to G; system N contributes developable land , and system U contributes activities and stimulant to the growth of G. A key to understanding urban growth is to understand the complex dynamic interactions. It can be said that interaction is open, non linear, dynamic and emergent. Urban growth is a self-organized system.

Urban growth, at any given place, creates a new dynamic system, which comprises a quantity of projects constructed that are increasing with time from t1 to t2. In the spatial dimension, new development density (population density or land conversion) decreases non-linearly with the distance from the city centre and sub-centre. The structure and function of each local project depend not only on its neighbouring projects but also its built up environments. These new projects interact not only with each other but also with developed areas spatially and temporally. These non-linear interactions result in globally ordered land use patterns. The order is typically indicated by large-scale spatial agglomeration or by clustered patterns. From this we can infer that urban growth is a typical self-organized system where the systems are treated as a whole.

Cheng et al (2003) concluded their work by stressing that planning is a future oriented activity strongly conditioned by the past and present. Planners have always sought tools to enhance their analytical, problem- solving and decision-making capabilities. Consequently, urban modelling should be able to assist planners in looking to the future. It should facilitate scenario building and provide an important aid to future directed decision-making. Therefore, a new challenge requires that a focus of modern urban modelling be shifted from macro to micro, from static to dynamic, from top down to bottom up, from space to space time , due to the unpredictability, instability , incompatibility , irreducibility and emergence that exist in the process of urban evolution. The time and space dimensions need to be incorporated into the urban modelling process by further integrating with GIS and complexity and non-linearity theory.

Planning seeks to regulate or control the activity of individuals and groups in such a way as to minimize the bad effects which may arise, and to promote better performance of the physical environment in accordance with a set of broad aims and more specific objectives set out in a plan (McLaughlin ,1970).To a greater or lesser degree much of the vast canvas of an individual's life is "plan related" – that is, certain activities and communications occur at certain locations and along certain routes in a regular patterned way. The more regular and patterned (in both space and time) human activities are, the more they are susceptible to certain kinds of analysis and the more they are the concern of the planner.

Systems according to McLaughlin (1970) are a complex whole, group of objects related or interacting so as to form a unity. All systems have the same common characteristics. These common characteristics are summarized below (Pidwiny, 2003):

i. all systems have some structure

ii. all systems are generalization of reality

iii. they all function in the same way

iv. there are functional as well as structural relationships between the units of a system

v. Function implies the flow and transfer of some material. Systems exchange energy and matter internally and with their surrounding environment through various processes of input and output.

vi. Function requires the presence of some driving force, or some source of energy

vii. All systems show some degree of integration

Within its defined boundary the system has three kinds of properties.

a. Elements: are the kinds of things or substances comprising the system.
b. Attributes: are characteristics of the elements that may be perceived, for example, quantity, size, colour etc.
c. Relationships: are the associations that exist between elements and attributes based on cause and effect.

Pidwiny (2003) classify systems into eight different types: Isolated system; closed system, open system, Morphological system, cascading system, process-Response system, control system and Ecosystem. The urban environment is an open system because there is interaction across the boundary of the system.

The City is a system whose components parts were small zones of land uses or activity and whose connections are all forms of communication and especially road traffic. As opined by McLaughlin (1970), if a future land use traffic could be defined then the resultant traffic would be derived and a suitable transport system designed to fit it.

The basic characteristics of urban system are that; it has spatial (land uses) and non-spatial (population) components; characterised by numerous variables and subsystems which are connected by feedback relationship; the feedback relationship operate over time.

The interaction that takes place within an urban system is between the various systems. The main object of the urban system being people, places and processes. Any treatment of a particular problem has to be done within the framework of the relationship as they exist between the subsystems.

Basically, spatial arrangement of land uses is a function of various interacting factors like population, economy, accessibility etc. These combine to determine the use. From the previous works we have seen like the ecological concept of invasion and succession can be explained from systems point of view.

The work of Christallar (1966) showed the relationship between the 'rarity' of a service and the population needed to support it, the size of the 'Field' or 'hinterland' within which such a population was contained and the size of central place itself: Colby (1933) identified 'centripetal' and 'centrifugal' forces at work within cities, having the effect of concentrating certain activities and dispersing others. In contrast with Christaller whose work suggests a static equilibrium condition, Colby opined that although such assumptions of equilibrium may be necessary for the study of the phenomena. These were infact highly dynamic if not inherently unstable.

Most of these scholars explain their work by models. These models usually explain the present situation and predict the future for the purpose of planning. For theoretical and practical reasons, the most promising form of models to satisfy the dynamic urban setting, according to McLaughlin (1970) is that in which the systems evolution is handled recursively. A recursive model, according to him, simulates the evolution of a system in a series of steps; the output of each stage is the input to the next.

In urban studies, quantitative models are more appropriate. Quantitative models need large amounts of data as they are going to reflect in any way the realities and complexities of a large urban agglomeration. Brail (1989) in describing the Integrated Transportation and

Land Use Package (ITLUP) that is currently in use in a number of regions in the United States classified the data needed as predicators in three groups;

I- spatial interaction i.e. travel time,

II- land suitability i.e. vacant land

III- Household composition variables, social factors, i.e. income.

Each group requires various datasets that have to be obtained from available data sources. He grouped the data sources into three types; small area statistics, administrative data, and physical data (maps, aerial photos, satellite images).

In practice, all sources of data may present problems, especially in developing countries like ours. However, development of a class of models based on observable physical changes that can be interpreted from aerial photos and /or satellite images might lead to a viable alternative for data-poor situations.

The relevance of model in urban planning especially in developing countries where planning control is weak cannot be overemphasized. According to Bruijn(1991)where planning control is not very effective, there is a need for models that can be used to predict the possible outcomes of the combination of partial planning and individual behaviour, and to guide public investment more realistically. He further argued that models quantify assumptions about how an urban area develops and grows, not in isolation but as an integrated whole which systems thought is all about.

Our emphasis on urban form in discussing the housing problem of Suleja is due to the fact that housing which is a basic human need is a function of population. The size and pattern of any urban set-up follow the housing development within the area. Suleja, due to its strategic location close to Abuja has become an important attractor of population thereby affecting the housing sector. Lowry (1964) demonstrated, using his model, how to assign urban activities to sub-urban areas of a bounded region in accordance with those principles of locational interdependence that could be reduced to quantitative form; regional totals of population, employment etc.

Three broad groups of human activities are dealt with from Lowry's model point of view.

i. A basic sector of industrial, business and administrative activities whose locations are assumed to be unconstrained by local circumstances of population distribution, market areas e.t.c. and whose locations and employment levels may therefore be taken as 'given'.

ii. A retail sector including all those activities dependent directly on local resident population and whose locations are powerfully influenced by population distribution. Their employment levels and locations are therefore determined inside the model.

iii. A household sector on which the retail sector depends and which itself depends on the total number of jobs (both basic and retail). It is assumed that the location of households is powerfully influenced by the distribution of jobs. Therefore both population size and distribution is determined within the model.

Effective management of urban area is achieved through sound physical planning. The physical planning situation in Suleja is in disharmony. The master plan of Suleja prepared by Max Lock in 1988 was never implemented. As a result of neglect of basic planning procedures our urban centres continue to grow in chaos due to lack of effective control.

The fundamental questions that any new development in an urban area should satisfy according to McLaughlin are:

I. Activity: is the type and size of activity consistent with the intention of the plan.

II. Space: is the amount and intensity of space use proposed consistent with the plan.

III. Communication: is the amount and mode of communication proposed consistent with the plan

IV. Channels: is the type of channel and the location consistent

These questions need to be asked whenever a plan is on ground and a proposal is brought to bear into an area. In Abuja – Suleja situation, the planning work are never followed. The obvious relationships that exist are never taken into consideration. The consequence is what is being felt in Suleja.

Tees-side Survey and Plan (1968) stressed the need to keep developments under constant observation, and the report states that monitoring services should consist of (a) regular collection of statistics, (b) improved forecasting methods and (c) local planning experience. The kinds of statistics to be collected are demographic indices, economic indices, housing indices, statistics of income etc.

The need for information about various subsystems of the urban systems (e.g recreation, housing, public road transport) makes the application of Geo-information very relevant. The overriding need for an information service within the planning office, according to McLaughlin (1970), arises from the continuous monitoring and control function needed in urban management. Obtaining the best possible descriptions of the current state of the system, modeling the effects of recent planning permissions and developments and their interpretation in policy context provide the justification for a better spatial information gathering techniques.

To achieve an efficient urban area, there must be control on the activities within a given area. Planning standards are usually some of the instruments for achieving effective control. The physical expansion of Suleja is on a daily basis. This is as a result of the impact of Abuja. Without effective control, the situation of Suleja would be compounded and would affect both the government and the residents.

In the U.S various sub division regulations and other zoning standards were provided to guide the growth of both urban area and peri-urban areas. Ambrose and Gonas (2003) reviewed the sub division control regulation by the Fayette County. By creating 'urban service area and rural service area the county has defined where future development would be prohibited as well as encouraged. They opined that urban containment studies usually take one of two basic forms (1) measuring the effectiveness of policy's ability to provide and sustain contiguous and efficient urban land use with desired densities and accessibility to public services and (2) measuring a policy's ability to preserve open space, farm land, and environmentally sensitive areas that are not suitable for development.

They made a number of propositions in their attempt to model the effects of growth controls on land values and conversion;

(i) First, urban areas are usually modelled as systematically monocentric with an urban core – the Central Business District (CBD)

(ii) second , most models assumed that all urban residents commute to the CBD,

(iii) third , lot sizes and parcel characteristics are fixed parameters; few models actually have lot sizes, increasing population densities decreasing in their distance to the CBD ,

(iv) Fourth, land rents, or value as is the case in Nigeria, are linearly decreasing in their proximity to the CBD.

(v) Fifth , commuting costs are linearly increasing in their proximity to the CBD

(vi) Sixth, urban areas are usually represented as either 'open' or 'closed' cities – based on whether new residents can freely move into a city (open) or are banned from entering while existing residents are banned from exiting(closed) . Also, (closed) city usually denotes that existing residents are allowed to internally move across communities or cities within an urban system. Such an assumption sometimes incorporates another condition-the existence of a "passive" city or community within an urban system that is uncontrolled. This condition, they stressed enables residents in a controlled area of a closed city to move to an adjoining area that has no density or boundary restriction.

These are some of the propositions by Ambrose and Gonas which can be used to understand our peculiar situation. The federal capital territory is composed of districts and satellite towns. There are also other major towns like Suleja that are outside the FCT but play significant role. We can explain the relationship using some of these propositions especially those of commuting to CBD, land rate decreasing with distance from the CBD and commuting costs that are linearly increasing in their proximity to the CBD. It is the economic interaction between Suleja and Abuja that affects the housing and other planning situation of

Suleja. For instance, due to the strict control and high land value in the F.C.T, developers rush out to fringe areas for cheaper land.

Salingaros (1998) employed the concept of urban web to explain the interaction that exists within an urban area .He explained that the urban web consists of all exterior and connective elements such as pedestrian and green areas, footpaths , and row of increasing capacity from a bicycle path up to an express way . It has been established that the stronger the connections and the more substructure the web has, the more life city has.

The relevance of this principle of the urban web to our study is to highlight the inadequacy of the existing connections between Abuja and Suleja. This greatly affects the ease of movement and efficiency in the urban area. It is already a known fact that Suleja, due its role as "dormitory" for workers of the FCT, faces serious traffic problem especially during the working days or rush hours.

Many researchers have tried to model urban growth for better understanding and management. For instance, Makse et al, (1998) used correlated percolation principle to explain the growth of cities. They opined that traditional approaches to urban science as exemplified in the work of Christaller and others are based on the assumption that cities grow homogeneously in a manner that suggests their morphology can be described using conventional Euclidean geometry. However, recent studies have proposed that the complex spatial phenomenon associated with actual urban systems is rather better described using fractal geometry consistent with growth dynamics in disordered media.

Makse et al (1998) develop a mathematical model that relates the physical form of city and the system within which it exists, to the locational decisions of its population, thus illustrating how paradigms from physical and chemical science can help explain a uniquely different set of natural phenomena-the physical arrangement, configuration and size of distribution of towns and cities. Specifically, they argued that the basic idea of percolation theory, which they adopted, when modified to include the fact that the elements forming clusters are not statistically independent of one another but are correlated, can give rise to morphologies that bear both quantitative and qualitative resemblance to the form of individual cities and systems of cities.

They consider the application of statistical physics to urban growth phenomena to be extremely promising, yielding a variety of valuable information concerning the way cities grow and change, and more importantly, the way they might be planned and managed. Such information includes (but not limited to) the following ;(i) the size distribution of towns in terms of their population and areas (ii) the fractal dimensions associated with individual cities and entire systems of cities ;(III) interactions or correlation between cities which provide insight into their interdependence and (iv) the relevance and effectiveness of local planning policies, particularly those which aim to manage and contain growth.

The main premise of Makse et al work is that cities grow in a way that might be expected to resemble the growth of two dimensional aggregate of particles and this has led to recent attempts to model urban growth using ideas from statistical physics and clusters.

2.8 RELEVANCE OF REMOTE SENSING IN URBAN STUDIES

Remote sensing, which is an aspect of Geo-information is defined by Davis and Simonett (1991) as measurement of the electromagnetic properties of a surface or object without being in contact with it. It has been applied to various fields like population estimating, land use/land cover mapping, socio- economic characteristic, Agriculture e.t.c. (Lo, 1990).

Urban areas in developing world are under constant pressure of growing population, which has both spatial and temporal implication. This has made the application of remote sensing very useful. Tiwari (2003) and Herold et al (2002) explained that the utility of remote sensing in urban growth modelling and analysis is that it provides data that are liable, timely, accurate and periodic and GIS provide various methods of integration tools to create different planning scenarios for decision making. Remote sensing methods have been widely applied in the mapping land surface features in urban areas. In general, remote sensing techniques can provide spatially consistent dataset that cover large areas with both high detail and high temporal frequency, including historical time series.

Herold et al (2002) agreed that most of the earlier works focus on research rather than on application. However, during the last years, models of land use change and urban growth have been expanded and have become important and innovative tools for city planners, economists, ecologists and resource managers to support intelligent decisions So they can take timely and effective action for sustainable development of urban regions. They applied the SLEUTH model for modelling the growth of Santa Barbara CA region. The simulation was based on the Clarke Urban Growth Model (UGM) that simulates the combined influence of topography, adjacency and transportation networks on the pattern of urbanization through time. The model uses cellular automata to model the urban expanse based on growth rules in the gridded representation of geographic space on a cell-by-cell bases. SLEUTH is a reference to the model input data requirements; Slope, Land cover, Exclusion, Urban, Transportation, Hill shade.

The growth of the Santa Barbara CA region was studied from 1929, the first year for which an air photo of the area is available to 1997. The observed land use pattern (distribution of urbanized and non urbanized land) formed the basis for model calibration as it represents the spatial and temporal growth pattern in the Santa Barbara region. Once the model is calibrated it can be used for prediction of future developments based on different user defined scenarios.

The approach used in this case study just predicts the change in the extant of the urban area. It does not differentiate between different urban land use classes.

Duong, (2002) combined multi spectral and SAR remote sensing data In the study of Hanoi city. Using post classification approach. Lotfi (2001) employed aerial photography and satellite stereo images to test remote sensing data in providing urban growth map. Lee, et al (2000) undertook a land cover change in China using time series analysis, 1982 – 1999. The study reveals some temporal-spatial dynamics of land cover change over the period through principal component analysis of pathfinder AVHRR land (PAL) Normalized Difference Vegetation Index (NDVI) data.

The results of Lee et al (2000) work proved that PCA/TSA is a very effective method in which to identify both macro and micro factors driving the change of NDVI. In particular the work paves the way to detect the impacts of extreme physical changes and human – induced activities upon the NDVI change. The analytical results are quite exciting and satisfactory.

Hung et al (1997) employed classical linear regression and spatial statistical models in their analysis of urban-rural linkages in Thailand. Their study showed that the significant 'pull' factors were index of lacking opportunity, index of industrial economy, population density, and significant 'push' factors are rural –urban dichotomy, spatial lag of response variable itself.

Uttarwar, (1997) argued that traditional approaches and techniques designed for town and cities may turn to be inadequate tools to deal with metropolises. New approaches need to be invented; other actions/ methods need to be incorporated in the existing method. He therefore suggested the application of GIS / remote sensing techniques at the various stages of planning, implementation and monitoring of urban projects.

He observed that the fringe areas where most of urban development is taking place is very dynamic in terms of land development, so a device /method is required to detect changes on continues bases , so that planning proposals can be re-adjusted and reshaped as per the ground realities . He highlighted the application of remote sensing by Delhi Development Authority in their large-scale urban projects. He concluded that remote sensing and GIS technology have capability to provide necessary physical input and intelligence for preparation of base maps, formulation of planning proposals and act as monitoring tool during implementation phase. Satellite images help to maintain truthful record of terrain over projects area over a long period. Thus GIS and remote sensing have capability to provide fourth dimension to the city –TIME.

Land use/land cover and population are important in systems application. Remote sensing can be used to estimate the various land uses, transportation network, and population. Howarth and Boasson (1983) applied Landsat Digital enhancement technique to detect changes in urban environment. They opined that land cover ranges from high density residential and industrial to bush. In their analysis, they tried to correct the usual difficulty reported by many workers attempting change detection with land sat digital data, that is, accurate registration of imagery from two dates. They overcome this problem in their work using land-sat data produced on the Digital Image Correction System (DICS). These data are referenced to the Universal Transverse Mercator (UTM) system and are resampled to provide 50*50m2 pixels.

On methodology, they argued that, most methods for change detection could be subdivided on the basis of classification and classification plus enhancement. They adopted three methods to detect change by digital enhancement of imagery from two dates. These are the overly, ratio and vegetation index methods.

For change in the environment to be detected on landsat images, they stressed that, it is necessary that there be a change in the spectral reflectance characteristic of the surface between the two dates of imagery. In an urban area, most changes are identified as the surface goes from a vegetated to a non-vegetated state (occasionally vice versa). This explains why band 5, which displays vegetated surface in dark tone and bare or manmade surfaces in a lighter tone, is most useful for change detection.

They cautioned that, although enhancements are suited to the detection of change in urban and forested environments, they are clearly not an appropriate medium in agricultural areas. In such areas, change is the norm as farmers practice crop rotation. For agricultural regions, information on acreages of specific crops is more important, and classification methods are required.

They suggested that image enhancement is much more sensitive for change detection than classification, especially in small areas. There are instructive analogies with geological interpretations (where enhancements are also emphasized) that help to explain this suggestion. In geological interpretation, rock surfaces are often very similar, so that a classification is unable to display subtle differences in surface radiance. These can only be detected using enhancement algorithms.

They gave two other major advantages to use digital enhancements rather than classification. First, it is easy because you do not need to know the land cover in the areas being studied nor is there need to devise and /or apply a classification scheme. Second, it consumes less time.

Compared with classification, digital enhancements using multi-temporally registered data have the advantages of increased sensitivity to change, easy manipulation of data, easy detection on the composite image and speed of analysis. They suggested that the method could readily be adopted by government agencies that have the responsibility to monitor land use developments over large administrative areas.

Green et al (1994) applied remote sensing to detect and monitor land-cover and land use change. They opined that planners and resource managers need a reliable mechanism to assess changes due to rapid population growth and declining land base. The primary thrust of their project is the Land Use and Cover Change Analysis System (LUCCAS), which in turn was associated with demographic and economic change. They concluded that a mere knowledge that a change has occurred is relatively uninformative unless the change can be linked to an impact on resources or on benefits and costs of those resources. Therefore, an assessment of change needs to include an analysis of impact of the change.

Singh (1989) tried to explain the digital change detection techniques using remotely sensed data. He argued that, the basic premise in using remote sensing data for change detection is that changes in land cover must result in changes in radiance values and changes in radiance due to land cover change must be large with respect to radiance changes caused by other factors. These 'other' Factors he stressed include (1) differences in atmospheric conditions (2) difference in sun angel and (3) difference in soil moisture. He enumerated ten different ways of digital change detection techniques, which can be applied, with their various levels of accuracy.

Allan and Alemayehu (1975) employed Air photographs to estimate population of a rural settlement in Ethiopia. They argued that the need for population estimate based on photo interpretation might arise in urban areas because complete census survey takes place irregularly and more up-to-date population estimate are often required by planners in areas of urban renewal, re-housing or slum replacement. They pointed out that, air photos can aid in providing information about social and family organization, types of dwelling, pattern of settlement, farming practice e.t.c. These are all relevant in planning and remote sensing can provide insight into these requirements.

Planning at any level is dependent on accurate and up-to-date data. According to Ottichilo (2002) about 80% of the data and information used in planning and decision making relate to geographic space, typically involving locations or positional data. He argued that Geo-information is vital for sustainable development. Thus when information about the geography, social and economic conditions and policies and institution is readily accessible, creative problem solving can lead to sound decisions with lasting positive impacts on people's lives.

Mohan et al (1994) opined that conventional ground survey methods of data collection on physical features, natural resources, geographical landscape and land use could not provide the quantum of necessary information due to its time over-run, cost ineffectiveness and involvement of large manpower. Moreover, inaccessibility to certain areas for surveying may limit the effectiveness of conventional means. They outline areas where remote sensing can be applied in urban and regional planning. These include urban land use mapping, urban sprawl studies, urban land use zoning, urban demographic studies and forest/Natural vegetation mapping.

Effective urban planning requires access to accurate and continually updated information concerning the changing conditions of urban areas. According to Berttaud (1989), originally, remote sensing using satellite was not very suitable for urban applications because of the relative poor resolution provided by 80m by 80m resolution images. The new generation of remote sensing systems with resolution equal to 10m by 10m in panchromatic mode and 20m by 20m in multi spectral mode has now made urban application possible.

Bertaud observed that in most third world cities, accurate up-to-date data on current land use are nonexistent. This makes planning urban infrastructure and shelter programmes difficult, if not impossible since there is no knowledge of existing urban area. He stressed that costs and time required for traditional data collection efforts have made systematic updating of urban data base beyond the reach of many planning authorities.

Land use changes induced by rapid urban growth amplify the need for up to date land use inventories. Many cities in the developing world have urban population growth rates in excess of 6 percent, doubling their population about every ten years. This rate of growth showed the need for close and constant monitoring.

In his study of Karachi, Pakistan, Bertaud ,(1989) analyses the urban problem of a typical city in a developing country. The growth of Karachi is attached to its history. By 1843, Karachi was still a walled township of 14,000 people on a site of 35 acres that had been developed as a port by the British for exporting the products of the Punjab. As recently as 1941, the population of Karachi district was less than half a million. A metropolis that burst into being with the birth of the new nation. Between 1947 and 1951, approximately 600,000 displaced persons who migrated into Karachi from India as a result of the creation of Pakistan in 1947, found shelter in the city, swelling the population to 1,130,000.

Bertaud's work found that a large part of Karachi's housing is now situated on the periphery of the city, in sprawling informal settlements that exhibits little planning and nominal infrastructure. He also found that Karachi has by far the largest squatter settlement in the province.

To be able to achieve an improved condition of human settlements in Karachi, the UNCHS recommended the use of satellite images to evaluate the actual extension of Karachi urban area and its land use. This case study illustrates how data derived from remote sensing and other sources were utilized to develop computerized urban information system.

In his work on spatial factors in urban growth, Bruijin (1991) tried to analyze the role of cities and relevance of model in assessing the growth pattern of cities in developing countries. He argued that cities develop as a result of many decisions made by many different actors on the basis of existing situation and their expectations of what the future will bring. In a perfect market, land prices reflect these expectations. In reality, however, various factors can disturb land prices as indicator of expected urban development. He noted that models quantify assumptions about how an urban area develops and grows, not in isolation but as an integrated whole. The assumptions mutually influence each other, which may reinforce or reduce certain expected effects. The performance and spatial resolution of the model depend, of course, on the quality and accuracy of the basic data.

Housing demand and spatial expansion of settlement is to a greater extent a function of the population of the given area. Therefore to be able to estimate any growth rate a reliable population figure is needed. A remote sensing technique has been employed to provide a fast means for planning purposes. Clayton and Estes (1980), Adeniyi (1987), Nkambwe(1983) all worked on the various methods of applying remote sensing to population studies.

Clayton and Estes work was on image analysis as a check on census enumeration accuracy. They argued that remotely sensed data from aircraft and satellite platforms, both in digital and non-digital format, have successfully been used to provide information concerning socioeconomic and demographic characteristics of populations. These data sources, which complement alternative sources such as those collected by the Federal Bureau of the census, they stressed, have a number of characteristics that have proved useful in public and private decisions making.

The major findings of their work were:

(i)Manual image analysis of high altitude aerial photography can provide a more accurate estimate of the number of single family dwelling structure than can alternative source of information.

(ii) Counts derived from imagery will most likely be on the conservative side i.e undercounting will prevail,

(iii) The errors associated with imagery-derived data can be less in both magnitude and in variability.

(iv)Independently derived estimates may provide similar degrees of accuracy at one spatial scale and highly dissimilar estimate at another scale,

(v) Although suggestion can be made concerning how the errors were made in this particular case, no systematic spatial bias in the error was discernible.

They concluded that, it must not be inferred from their work that they advocate the superiority of image-based data over census data for all uses. However, it certainly appears that with regard to some type of information, mainly the number of residential structures per given spatially defined unit, image interpretation procedures are superior in providing a count of higher absolute accuracy than the Federal census. The importance of this from remote sensing stand point, however, should not be underestimated because it is virtually impossible and practically infeasible to count individuals on remotely sensed data and the role of surrogates for population estimates per given area becomes most important.

Adeniyi (1987) employed Land sat MSS and TM and aerial photography to estimate the population of a model town and to establish enumeration areas (E.A.'s) for census. He argued that census survey and population estimation are carried out primarily to obtain:-

i-the absolute number of people within an administrative unit (e.g. nation, state or local government area) at a given time.

ii- information about the characteristics of the people e.g. age ,sex, education, occupation, income e.t.c.

In many developing countries especially Africa, properly conducted and nationally acceptable census surveys have not been conducted during the last few decades. The reasons for this state of affairs, according to Adeniyi are complex and they include;

(i) political instability,

(ii) poor economic situation

(iii) inadequate base data for census surveys

(iv) Poor assimilation and utilization of contemporary technology.

He emphasized that remotely sensed data provided information about physical and cultural elements with unique and valuable characteristics. The information can be generated in unbiased form, acquired at a known point in time displayed accurately, geographically referenced , prepared in real time (or nearly so) and assembled in useful , stable format.

He based his methodology on the fact that most people live in buildings with specific physical structure and dwelling characteristics. It is assumed that the population of a settlement can be estimated by;

(i) Identifying and classifying the residential buildings in appropriate groups,

(ii) Counting the number of buildings or dwelling units in each residential class,

(iii) Determining the average number of people per building or dwelling units.

On the bases of these assumptions, the population of a settlement can then be estimated thus:

EP=(BP)R1+(BP)R2+..............+(BP)Rn.....(1)

Or EP=(dp)R1+(dp)R2+..............(dp)Rn...(2)

Where:

EP=estimated population

B=Number of building

P=average population per building

D= number of dwelling units

p=average population per dwelling units

R1........R2=different residential types.

To ease the counting process, each residential class was divided into block zones. The counting was done directly on the photographs with acetate overly. He employed the use of sample survey to determine the average number of people per dwelling in each residential class.

In the final result of his Enumeration Areas Demarcation (EAD) he observed that;

(i) The population for each EA are within the stipulated range and they allow for future growth,

(ii) The data on the number of buildings, dwelling units and average population per dwelling unit for each EA permits the monitoring of growth, adherence of planning control and cross validation of census surveys,

(iii) The delineation of the EAs in a map form provides a permanent spatial base for census surveys and other social surveys,

(iv) The EAs and any data aggregated into them can be geo-coded and stored in computer for easy manipulation and retrieval.

Nkambwe(1983) applied floor space rate to estimate urban population and its distribution using aerial photographs. He argued that where data on urban population and its distribution is either outdated or non-existent, it has been difficult to apply sophisticated or sensitive models for urban planning or administration. He pointed out that, even where decennial censuses, which may supply these data are statistically accurate, their usefulness, beyond the period immediately following the physical collection of data, is reduced by two main factors;

(i)There is a time lag between actual collection and delivery inherent in using traditional Methods of a population census. The length of this period depends on the efficiency of the census machinery, usually worst in Less Developed Countries (L.D.C.'s) where urban population changes are fastest,

(ii) The ten year inter-census period is too long even in cities where population growth may be considered relatively moderate.

Adeniyi and Nkambwe demonstrated how remote sensing can be used to estimate population especially in an area where basic population data are lacking. We can borrow from their work to estimate the population of our study area.

2.9 THE IMPORTANCE OF STATISTICAL METHODS IN ANALYSING URBAN GROWTH.

To understand the importance of statistical methods in the analysis of spatial land use change or urban growth we would use an extended review of the work of Lesschen et al (2005).They provided a clear insight into land use/land cover and importance of statistical method. According to them Land Use and Land Cover Change (LUCC) has important impacts on the functioning of socioeconomic and environmental systems with important trade offs for sustainability , food security , biodiversity and vulnerability of people and ecosystems to global change impacts. Land cover change refers to the complete replacement of one cover type by another, e.g. deforestation. Land use change includes the modification of land cover type e.g. intensification of agricultural management or other changes in the farming system. Land use/ land cover changes are the result of the interplay between socio economic, institutional and environmental factors. Key to understanding LUCC is to recognize the role of individual decisions makers bringing about change , through their choices, on land resources and technologies. They argue that ,a unifying hypothesis that links the ecological an social realms , and an important reason for pursuing integrated modelling of LUCC , is that humans respond to cues both from the physical environment and from their socio-cultural and economic contexts. Therefore, much LUCC research is devoted to the analysis of relations between land use and the socio economic and biophysical variables that act as the 'driving factors' of land use change. They explained that 'Driving forces' are generally subdivided into two groups: proximate causes and underlying causes. Proximate causes are the activities and actions that directly affect land use e.g. wood extraction or road construction while underlying causes are the fundamental forces that underpin the proximate cause including demographic , economic , technological , institutional and cultural factors. In most cases, a wide range of factors are used to represent the underlying causes; examples include population density, rainfall and accessibility. They can also be differentiated into driving forces that are expected to change over time, such as population density and market condition and 'conditioning factors that are relatively stable over time but may be spatially differentiated such as agro climatic and cultural context. This allows differentiation into spatial and temporal expectations of change. At different scales of analysis , different driving forces have a dominant influence on the land use systems; at local level this can be the local policy or the presence of small ecologically valuable areas; at a the regional level distance to the market, port, airport or major urban centres might be the main determinant of land use change (Verburg, et al 2003).

When driving and conditioning factors exhibit a high degree of spatial variations, such as in the cases of soil conditions and market access or still proximity to city centre like Abuja, this spatial variation give rise to spatially distinct land use patterns related to the variations in social , economic and environmental context. Given the importance of spatial variation, LUCC research frequently uses techniques that analyze the relationship between land uses and its supposed driving and conditioning factors based on partially differentiated data. Empirical techniques are used to verify hypothesis of driving factors and quantify relations between driving factors, the decision maker and land use. The actual use of empirical techniques differs. Often the prime interest of the social scientist is explanation of observed land use changes, while the ecologist focuses on prediction. Nelson (2002) maintained that ,where as the use of spatial analysis for explanation enhances our understanding of the processes underlying LUCC, Briassoulis (2000) was of the opinion that temporal prediction helps to explore the past and future importance of driving factors and model future land use dynamics by predicting the spatial and temporal distribution of changes we can target areas for intervention ,and develop appropriate , location–specific intervention strategies. Based on the forgoing, Pontius et al(2004) opined that spatially explicit analysis is increasingly used to predict landscape change and is often evaluated both in terms of conventional inference on variables coefficients and goodness of fit ,and with respect to ability to predict actual landscape change.

2.9.1 INSIGHT INTO THE HISTORY OF SPATIAL ANALYSIS OF LAND USE AND LAND COVER.

Since the 19^{th} century many scholars tried to explain the variations in land use using agricultural land and distance to market .Von Thunen (1966) analysed this relationship. To him, intensity of use decreases with increasing distance from market. His work forms the foundation for subsequent works on theories and explanation of land use. The major shortcoming of this early work was its overlook of other biophysical, socio economic and institutional factors influencing land use (Rasul et al,2004) . The basic model of von thunen , according to Lesschen et al (2005) represents a featureless plain. However scholars like Nelson (2002) subsequently introduced other variables like land productivity, prices, transport cost and multiple markets. This addition according to Leschen et al makes the analysis more complex.

The critiques of von thunem mono-variable theory of spatial land use based their argument on the fact that his theory was a simplified representation of the location decision which , according to Alonso, Walker etc cannot give a real world situation with multiple factors. The works of Alonso (1964), Walker (2004) ,Walker and Soleki (2004) , tried to expand on von thunem work by including more variables or factors which to some extent capture the real world situation unlike the von thunem world.

Despite the contribution of the work of Von thunem and subsequent ones by other people in explaining LUCC Leschen et al (2005) opined that there is no single all embracing theory to explain the variation in land use patterns. Due to this scenarios and the need by planners and policy makers to understand the course and effect of land use change and its location, Tuner et al (1990) stressed the need for the use of empirical methods to explore land use change data to find evidence for the proximate causes of land use change and its spatial extent . This information would help in understanding which of the factors explain the causes of land use change.

2.10 URBANIZATION AND ITS IMPLICATION.

Urbanization process varies between the developed and developing countries. These differences are as a result of what is called the time –space telescoping of transition. Marcotullio (2006) questioned whether: urban environmental transition hold similarly for both cities that developed earlier as well as those undergoing rapid development now. He argued that there are important differences between the two experiences. One, being the telescoping of the timing between transitions. As cities are now developing under strong pressures of globalization , as in Nigeria , they are influenced by a variety of different demographic and technological shifts and lack the institutions and capacity to deal with challenges related to these new pressures. They are experiencing sets of environmental problems in different fashions than were experienced by the now developed world. This submission of Marcotullio is very relevant to situation in Nigeria and Suleja. The rate at which the town is growing is far beyond its capacity to cope. It is pertinent to mention that the developed world of North America passed through stages of development spanning 150 years before getting to their present city form . This has allowed them to develop a better strategy to cope with most of the urban problems.

Generally speaking urban expansion is conversion of non urban land into built up land. These impacts make an understanding of the factors driving urban expansion essential to global environmental research.

Millennium Ecosystem Assessment (2005) identifies drivers of ecosystems change to be direct and indirect drivers. According to Nelson et al (2006) a driver is any natural or human induced factors that directly or indirectly cause a change in an ecosystem. . Direct driver unequivocally influences ecosystems process. An indirect driver operates more diffusely by altering one or more direct drivers. Global driving forces are categorized as demographic, economic, socio-political, cultural and religious, scientific and technological and physical and biological. Nelson et al (2006) insist that driver in all categories other than physical and biological are considered indirect and they are the most common and influential.

The problem of urbanization as we said is conversion of non urban land to built up land. In Nigeria and Suleja, in particular, this conversion is taking place unabated and undocumented. At a global level, Nelson et al (2006) in their study document regions around the world in which rapid and recent changes in land cover occurred since 1970's. The result focused on four types of land conversion which are relevant to our local environment in Suleja; deforestation, dry land degradation, agricultural expansion and abandonment and urban expansion. The important outcome of the Millennium Assessment is that with better study of our ecosystem, we are more likely to govern sustainably, where;

1. resources and the use of the resources by humans can be monitored and the information can be verified and understood at relatively low cost
2. rate of change of resources , resources use, population, technology and economic and social conditions are moderate
3. communities maintain frequent face to face communication and dense social networks
4. outsiders can be excluded at relatively low cost from using the resources and users support effective monitoring and enforcements.

The last point is really important especially in our situation where the rules are always broken and enforcement non effective.

Population increase is one important factor in urbanization. As population increases so would our needs for shelter, energy, population etc. Hardin (1968) opined that the population problem has no technical solution ; it requires a fundamental understanding in morality . He based his assumption on so many propositions which , even though made many years ago, are relevant. In his submission, he highlighted the problem of providing for the worlds growing population the food needed. He submitted that reaching an acceptable and stable solution will surely require more than one generation of hard analytical work – and much persuasion.

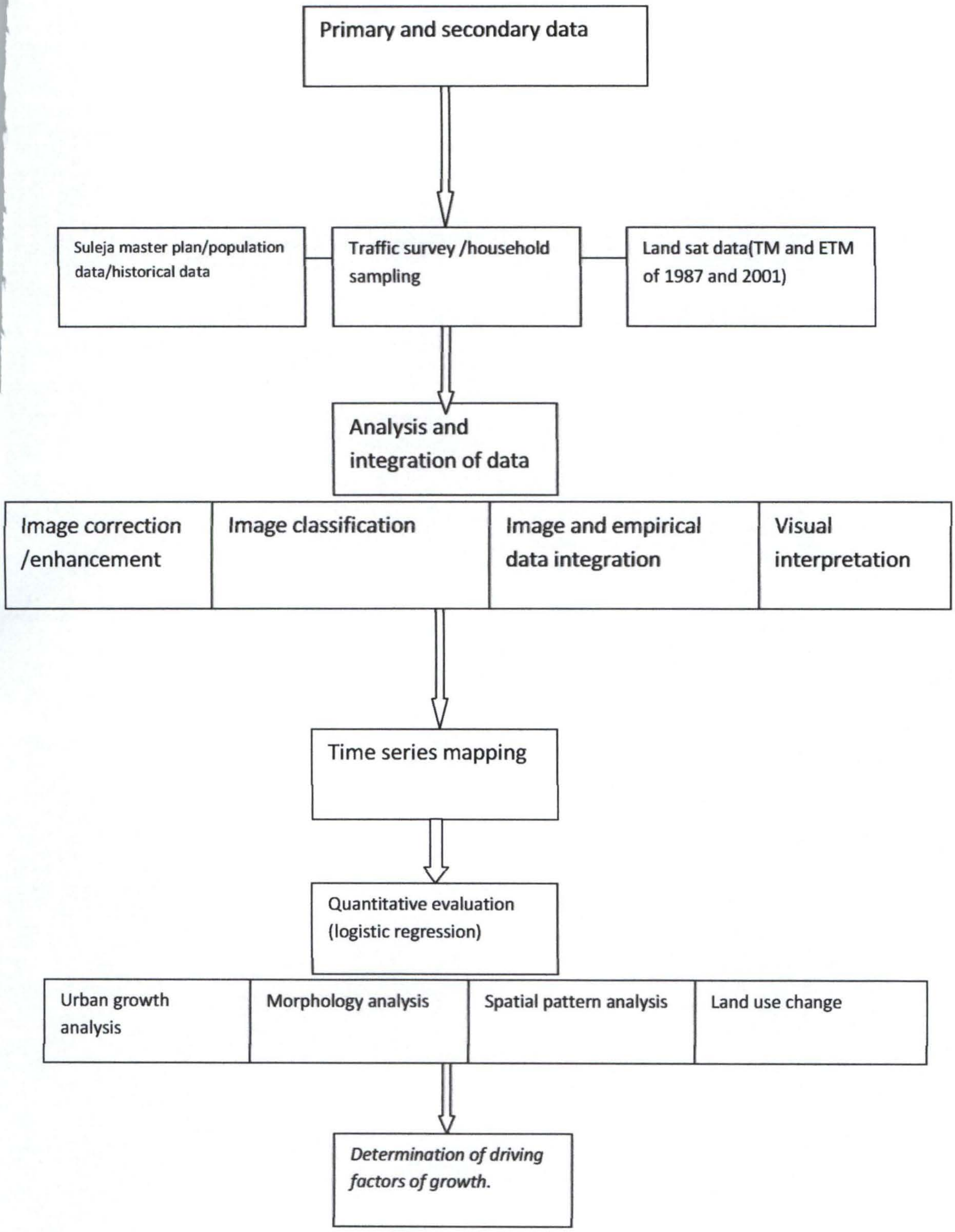


FIGURE 3.2: METHODOLOGICAL STAGES OF THE RESEARCH

Source: Adopted from Cheng (2003)

In this section we concentrated on methodology used in the analysis of traffic pattern, changes that took place especially between 1987 and 2001 using the land sat images, and using logistic regression to analyze how the independent variables that were identified influence the urban land use changes and determine the probability of the change. All these steps were captured in fig. 3.2.

The first step was the gathering of both primary and secondary data. The information was obtained from Suleja master plan, Zonal office of both the Ministry of Lands and Housing and Niger state Urban Development Board Suleja, traffic survey and the Land sat image. The next step in the chart is the analysis of the data. This involve the image correction and enhancement, image classification and empirical data integration. The result of this analysis provided the input for the next step which is time series mapping. This was done through the use of the classified images of 1987 and 2001. A logistic regression method was used to analysis the growth of the study area to determine the driving factors of the growth. Idrissi Andes was used for the logistic regression and the probability of change calculation.

3.3 SPATIAL EXPANSION OF SULEJA.

As mentioned variously, the growth of Suleja is as a result of many factors. However the proximity to Abuja may be a dominant factor. The rapid change in the built up area over the period is as a result of conversion of agricultural land which has a very serious implication on the ability of Suleja to meet up its own demand in the future . It is therefore important to analyze these changes so as to fashion out ways to address the problem.

3.3.1. SULEJA URBAN GROWTH 1976 TO 2001

I- PRE- 1976 PERIOD: Prior to the Decree No. 6 of 1976 that gave legal backing to the movement of Nigerian capital from Lagos to Abuja, Suleja was one of the Local government headquarters in Niger state. It is located along the trunk A road that links Kaduna and Lokoja. It was an agrarian local government. This has now changed due to population pressure from the federal capital.

II INITIAL TAKE UP PERIOD: the changes in the structure and function of Suleja from a local government headquarters to the closest town to Abuja commenced with establishment of the field base in Suleja. This singular action attracted people from all over the country because suleja became the official seat of the federal capital administration. This was the beginning of the spatial expansion of suleja which has continued till date.

III THE FINAL STAGE OF THE MOVEMENT OF THE CAPITAL IN 1991: With the final movement of Nigeria's capital from Lagos to Abuja in 1991 by the official relocation of the president saw the movement of all government activities to Abuja . This was followed with high influx of people to Abuja who ultimately moved to surrounding settlements for accommodation.

3.4 METHODOLOGY.

Urban growth involves complex physical social, economic and ecological processes. As a consequence, the interpretation and evaluation of urban growth based on qualitative knowledge is difficult if not impossible. Cheng (2003) argue that physical or ecological processes lead to changes in landscape, and the socio economic processes to changes in land uses. Therefore ,analyzing urban growth should take both (physical and functional) into account an should also be based on quantitative modelling .

Individual indicators are only able to explain specific aspects of the processes. The spatial indicators used in this work quantify the structural and functional complexity inherent in urban growth systems. According to Zipperer et al (2000) structure is the physical arrangement of ecological, physical and social component and function refers to the way the components interact. In this work, we propose the methodology below which is based on monitoring temporal urban growth from remotely sensed imagery. The main quantitative analysis included the spatial pattern analysis based on changes over the years (temporal). Regression analysis was selected as analytical method.

This study specifically explored:

I. The traffic characteristics between Abuja and Suleja

II. Government effort in urban land planning and development,

III. The temporal spatial changes overtime.

IV. Modelling the growth of Suleja using logistic regression.

3.5 JUSTIFICATION FOR THE METHODOLOGICAL APPROACH IN SULEJA URBAN GROWTH STUDY.

Urban growth has become a severe problem not only in the developing world but also in the industrialized countries. Urban expansion or sprawl has been criticized for its inefficient use of land resources and energy and large scale encroachment on agricultural land. With modern remote sensing techniques, extensive data sources of satellite imagery with various resolutions are becoming available and less expensive. This has greatly enhanced the possibilities for monitoring urban growth at various spatial and temporal scales. However, sustainable urban growth management and development planning need to take account of the dynamic process of temporal urban changes (Cheng, 2003). This results in a requirement for the comparative measurement of temporal urban growth. He therefore opined that dedicated measurement of urban form can provide a more systematic analysis of the relationship between urban form and process.

3.5.1 LAND DEVELOPMENT AND FORMAL LAND SUPPLY.

Secondary information and field interview was conducted to assess the land development and formal land supply within Suleja and environs. Information on the following were obtained from the state ministry of Lands, Suleja office.

I. Number of application for land between 1978 – 2003

II. Number of allocation of plots between 1978 and 2003.

III. Number of layouts designed between 1978 – 2003

IV. Total number of plots in all the layouts.

V. Information on compensation over the acquired land.

VI. Number of building plans approved between 1978 – 2003.

Questionnaires were administered in the selected areas to ascertain the socio economic characteristics of the people. The major aim of the questionnaires was to have the view of the people on some major issues that bother on orderly development.

3.5.2 TRAFFIC SURVEY:

The number of vehicles leaving or entering suleja from four major points was obtained. The points at which the survey was conducted were:

I. Maje high point (Zuma FM)

II. Kaduna road junction (Bakin-iku)

III. Madalla town

IV. Abuja – Kaduna road at Madalla.

The count was for both working and weekend days. This was done so as to see the variation with time of the day .The count was from 6 am to 6pm.The traffic count conducted was to provide insight into the direction of movement of people and time of the day when such movement is done. As we know people travel to their place of economic activity. By our count we should be able to see how the impact of Abuja is on Suleja.

3.5.3 TEMPORAL CHANGES IN THE BUILT UP AREA WITHIN SULEJA AREA FROM 1987 TO 2001

Remote sensing data were used to determine the pattern of growth of Suleja. The following were used for the purpose of this work:

a. Land Sat Thematic Mapper (TM) of 1987
b. Land Sat Enhanced Thematic Mapper (ETM) of 2001

The aim of this analysis was to assess the continued spatial expansion of Suleja as a result of the impact of Abuja. The different dates images were classified and the change calculated and compared. The whole suleja and environs was initially classified and then the five selected localities of Madalla, Dakwa, Dikko, Maje, Rafinsanyi and Suleja town were separately analyzed to assess the rate of individual growth.

3.6 STEPS ADOPTED IN THE ANALYSIS OF THE DATA.

The main methodological procedure for this work is the traffic analysis, urban growth pattern and application of logistic regression to assess the urban change behaviour of Suleja. However to arrive at that, we had to obtain the basic information that would serve as both dependent and independent variables. To this end we had to:

1. Classify the image for the two period -1987 and 2001
2. Digitize the image to obtain road networks and other human features,
3. Extrapolate the population data for the area between the period,
4. Download and reorder the Shuttle Radar Topography Mission (SRTM) elevation data for the study area so as to extract height information

5. Model the variables to obtain the probability of change. This was done through the use of Idrissi Andess.

In this work, multi spectral Land Sat Thematic Mapper (TM) of 1987 and Enhanced Thematic Mapper (ETM) of 2001 with a 30m resolution were used for the classification and comparison to assess the growth rate. The image was downloaded from Global land cover facility website (www.glcf.umiacs.umd.edu/data/landsat/).

The images were radio-metrically corrected by normalizing the radiance of 1987 image to those of 2001. A tasselled cap orthogonal transformation was performed on some bands to condition the image prior to classification. The classification was performed based on 4 classes using unsupervised classification. Unsupervised classification is a method in which the computer searches for natural groupings of similar pixels called clusters. The fewer clusters there are , the more the pixels within each cluster will vary in terms of spectral signature , and vice versa. The unsupervised classification was done using ***Ilwis*** academic. Samples from each class were selected after which the sample was used to classify the image of the study area.

Accuracy assessment was carried out on the classification to ascertain the accuracy of the various classes. Accuracy assessment is an important final step of the classification process . The goal is to quantitatively determine how effectively pixels were grouped into the correct land cover classes. The procedure is relatively simple. Pixels are randomly selected through the image using a specified random distribution method. Then the original image was used along with ancillary information such as field observation to determine the true land cover represented by each random pixel. The ground truth was compared with the classification map. If the ground truth and classification match, then the classification of that pixel was accurate. Given that enough random pixels were checked, the percentage of accurate pixels gave a fairly good estimate of the accuracy of the whole map.

The overall accuracy of the classification using the surface matrix is 89%. The difference between these two images gave us the dependent variable of change (urban growth). We generated change from non urban to urban by subtracting the earlier image from the later image. Figure 4.4 shows the classified image of 1987 while figure 4.5 is the classified image of 2001.

Since the study is on Suleja, we subset the two-date classified images (fig. 4.4 and 4.5) to have the study area alone figures 4.8. and 4.9.

In this study change from non-built up to built up was our concern and knowing the factors responsible for this growth was the main focus of this study. Therefore we needed to identify the variables that influence the growth of suleja. It is these variables that served as our independent variables used in the logistic regression. Below are the independent variables we used in the regression.

3.6.1 TOPOGRAPIHIC DETAILS:

A Digital Elevation Model (DEM) of the area up to Abuja was acquired by the Shuttle Radar Topography Mission (SRTM) from (www.glcf.muiacs.umd.edu/data/srtm) and used in the study. DEM provides information on height, slope and aspect. DEM was included as an independent variable as proxy for drainage that increase the cost of land development. A combination of the DEM and other data was used to derive cost distances within the study area.

3.6.2 COST DISTANCE SURFACE;

Measure of accessibility – defined as the ability for contact with sites of economic or social opportunity -were included in the model because accessibility represents a cost in land use decisions. This is very true in our case study. Accessibility can be expressed in terms of money, time, preferences, effort or any concept of cost. In this study, accessibility was measured in terms of travel time to get to major roads within the study area and also to get to Abuja which we surmised influences urban land use decisions.

The estimation of travel time took place in 3 steps. In the first place, frictional elements (slope gradients, land use and types) were reclassified based on the relative difficulty in moving over a cell of a given element or gradient. The higher the gradient so would be the effort. The second step in the process was to add the raster map of all the frictional elements to derive the costs raster map in meters. The last steps computed the travels time by multiplying the cost raster map with the estimated average motor vehicle travel speed of 60km/h. The formula for calculating Cell Crossing Time (CCT) is:

$$CCT = \frac{f*60}{TS*1000}$$

Where: CCT=cell crossing time (minutes)

P=pixel size

T=travelling speed (km/h)

3.6.3 ROAD EXTRACTION.

In modelling distance factor, accessibility is very important. In this regard, all available roads that are visible both on the raw composite image or classified one were picked and digitized on-screen. This digitized image (figure 3.3) was coded according to the type of road e.g. Double lane, single lane, footpath etc. and saved as grid before exporting to arc view.

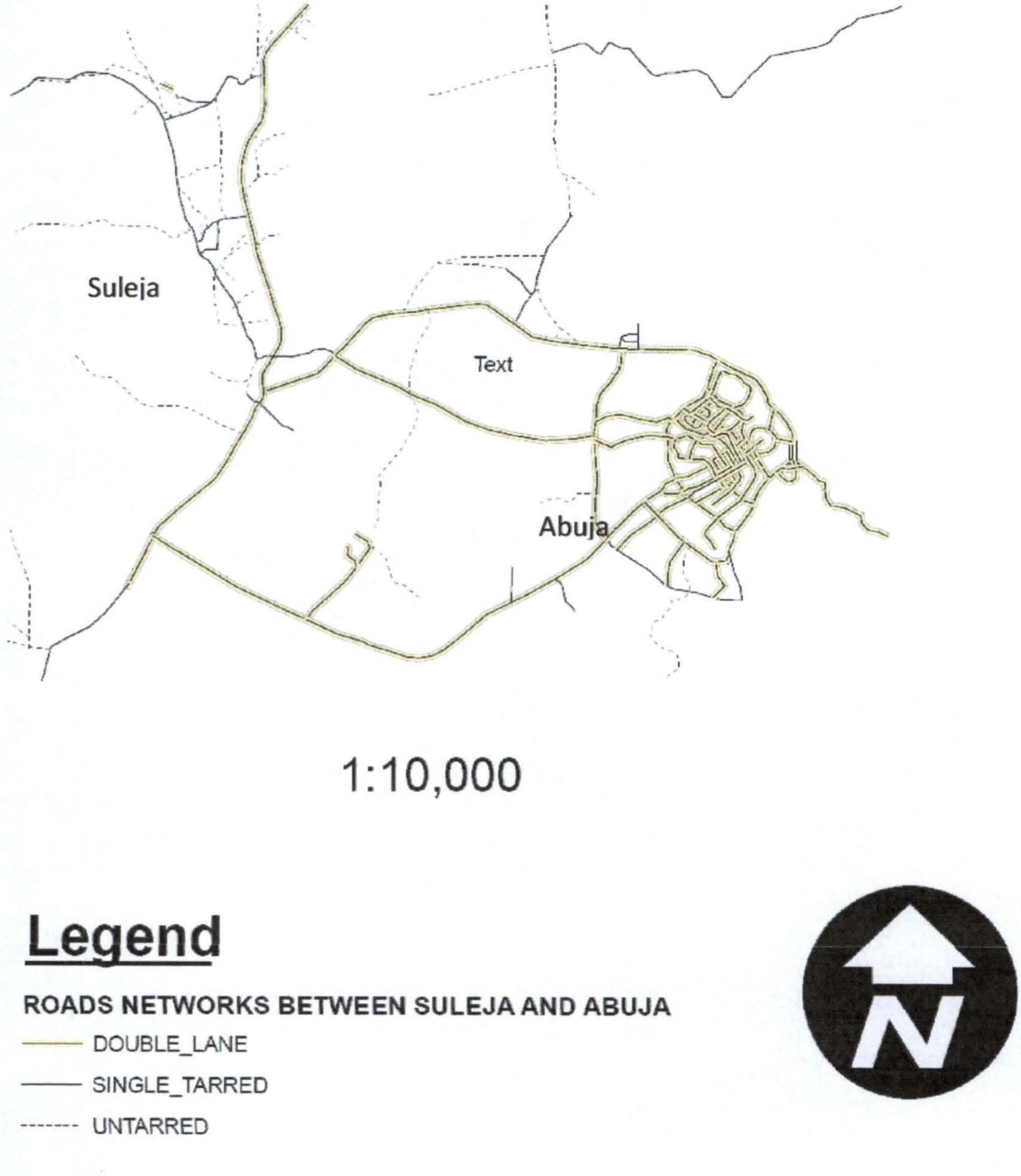


FIG: 3.3 **DIGITISED ROADS NETWORK WITHIN THE REGION**

SOURCE: *AUTHORS WORK 2006*

Distance to Road : This variable is considered very important in this study because the ease of movement to and from Abuja could affect the influx of people to Suleja. It is this distance that we used to map the cost-distance surface for the study area. Accessibility can be expressed in terms of cost or time to a specific place (Braimoh and Onishi, 2006).In this work we used time to measure our accessibility and our reference point is the Aso radio junction in Maitama. The assumption here is that whoever is going to Abuja from suleja, getting to this place is getting to Abuja. The ease or time or cost of getting to this place would determine the choice of location by individuals. It is also on the basis of this distance to road that we obtained our time to Abuja so to establish the effect of proximity on growth.

3.6.4 POPULATION VARIABLES:

Population is another independent variable used in the modelling. The reference period for this study was from 1987 to 2001. The 1991 population estimate for the study area was obtained from the National Population Commission. This figure was projected using the national growth rate of 2.8% to have the figure for 2001 for the study area. The 1991 census result was used because it was one of the most acceptable when compared with other censuses conducted.

Population data at discrete locations (centroids of settlements) were distributed to reflect the flow of people as they move across the landscape. As we have shown, we demarcated the study area into six wards namely Suleja town, Rafinsanyi ward, Madalla ward, Dakwa ward, Maje ward and Dikko ward. It is important to state that these wards are for the purpose of this research to segregate the areas and do not follow the political or administrative wards. The centre of each of these five wards was used to map the population potential surfaces for 1987 and the difference between 1987 and 2001 using the distance inverse weighting formula:

$$P^*(s) = \frac{1}{\sum_{x=1}^{n} \frac{1}{|s-s_x|^2}} \sum_{x=1}^{n} \frac{1}{|s-s_x|^2}(s)P(s_x).$$

. . . . (Eq. 3.1)

Where*(s) is the population potential at a given location *S*, x =1, 2, 3, ...settlements within the study area and $P(s_x)$ is the population of the settlement located at S_x. The above equation shows that population at a given location is a linear combination of several surrounding observations, with the weights being proportional to the square of distance between observations and locations. Thus, the population potential is a measure of population pressures with distance from the centroids of settlements. We used the difference in population between1987and 2001 to get the difference in population.

The equation shows that population at a given locality is a combination of many factors which is proportional to the distance between observations and locations (Braimoh and Onishi, 2006). Therefore population potential which is a measure of pressure reduces with distance from the centre of the wards. We subtracted the population surface map of 1987 from 2001 to account for the possibility that urban development may not vary linearly with population.

To be able to have a representative population of the area with the rate of growth in built up area using remote sensing estimate, the equation of Adeniyi (Eq. 3.7) was used to estimate the population of the six wards based on the rate of growth in the built-up area. The rate of expansion in settlement size in these areas is not corresponding with the population as provided by the official estimate using 2.8 % annual growth. The population of each locality was estimated from the size of the built up area of each of the wards and compared with the official rate. However we limited our use of population estimate in the logistic regression to the estimate using the national growth rate of 2.8 %.

3.7 MODELLING URBAN LAND USE CHANGE.

In this study binary logistic regression was used to model the probability that a given area is converted to built-up or urban and or not converted between 1987 to 2001 as a function of independent variables identified. One of the main concerns of this work was the probability of a non urban land use to change to a built up or urban. The dependent variable for the logistic regression was a presence or absence of event, where ***y=1*** means a given pixel was converted to built up and ***y=0*** is that there is no change. The analysis was carried out at a spatial resolution of 90m which is dictated by the grain size of the digital elevation model. The logistic regression model was of the form:

$$\ln\left[\frac{p(y=1|X)}{1-p(y=1|X)}\right] = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + e, \quad \text{. . . (Eq 3.2)}$$

Where P(y=1/x) is the probability that y takes the value 1 , given the vector of independent variables X, βs are model parameters to be estimated, and e is the residual error. The quantity $\frac{p(y=1|X)}{1-p(y=1|X)}$ referred to as the odds, where as $\ln\left[\frac{p(y=1|X)}{1-p(y=1|X)}\right]$ is called the logit. After back transformation, the result of the regression may be expressed in terms of conditional probability as:

$$\hat{p}(y=1|X) = \frac{\exp^{(\hat{\beta}_0 + \sum_{i=1}^{n} \hat{\beta}_i x_i)}}{1+\exp^{(\hat{\beta}_0 + \sum_{i=1}^{n} \hat{\beta}_i x_i)}}, \quad \text{. . . . . (Eq 3.3)}$$

The hat notation was used to indicate estimated values. Equation 3.3 shows logistic regression results in continues predicted values in the interval {0, 1}. Another major interest of this study is to assess the relative importance of the variables in determining conversion to urban land uses. The un-standardized logit coefficients, that is, the βs in equation 3.3 measures the absolute contribution of variables in determining the probability that a particular land use change occurred. However, this information may be misleading when a unit change in a variable is not equivalent from variable to variable as a result of disparities in units and scales of measurement. Thus prior to performing the logistic regression, we standardized the independent variables to zero mean and unit standard deviation, using the formula:

$$x'_i = \frac{x_i - \bar{x}_i}{\sigma_x} \qquad \text{......... (Eq. 3.4)}$$

Where x'_i is the standardized variable, X_i the value of the original variables, $\bar{x}_i$ the mean, and σ_x the standard deviation.

The relative contributions of independent variables to land change are indicted by odds ratio $\exp(\beta_i)$. An odds ratio that is greater than 1 indicates a positive effect, that is, the odds of urban land change increases with a unit increase in the independent variable by 1 standard unit. An odds ratio that is smaller than 1 indicates that an increase in the independent variable decreases the odds of urban land change, whereas an odds ratio of 1 indicates that the odds of urban land change is neutral to an increase in the level of the independent variable.

The goodness of fit of the models was evaluated using the Relative Operating Characteristics (ROC). The ROC compares observed values, that is, the binary data over the whole range of predicted probabilities. Its value ranges from 0.5 for a model that assigns the probability at random, to 1 for a model that perfectly assigns the probability of urban land use change on the landscape.

3.8 PROCEDURE FOR THE ATTAINMENT OF THE RESEARCH OBJECTIVES

Systems grow and change by the alteration of their component parts (activities in spaces) and their connections (communications in channels). The essence of planning is to regulate the changes taking place so that the systems actual trajectory matches the intention as closely as possible.

In ideal situation each new development or change of use must be examined for the total effect it is likely to have on the system and whether or not this would result in moving the system in the right direction. We can analyse the growth of Suleja and its environs from this point of view. The relocation of the new capital, Abuja, is an invasion into a new area that was growing slowly.

3.8.1 OBJECTIVE 1 (Assess land development and formal land supply within Suleja urban)

To achieve this object we analyzed the land allocation records and development permit issued. The questionnaire responses on development pattern were also used.

3.8.2 OBJECTIVES 2 (Examine space integration within suleja urban through traffic flow analysis)

To achieve this objective the volume of traffic between Suleja and Abuja through vehicles count along all the major entry points to Suleja was analysed. The traffic count was conducted between the hours of 6am to 6pm. It was conducted on working and weekend days.

3.8.3 OBJECTIVE 3 (Determine land use and space convergence within Suleja urban between 1987 to 2001)

Remote sensing data were used to determine the pattern and rate of growth of Suleja and environs. The following were used for the purpose of this work:

a. Land sat Thematic Mapper (TM) of 1987

b. Land sat Enhanced Thematic Mapper (ETM) of 2001

The aim of this analysis was to assess the continued spatial expansion of Suleja urban and then the different localities individually to ascertain the rate at which they grew. Images of the two dates were classified and the change calculated and compared. The whole Suleja and environs were first classified and then the five selected localities of Madalla, Dakwa, Dikko, Maje, Rafinsanyi and Suleja town were separately analysed to assess the rate of individual growth. Over the years, the growth of Suleja was looked upon as uniform. However ,the analysis of land sat images of 1987 and 2001 revealed a very striking result that showed that the growth is uneven between the various localities within and around Suleja. The reason why we segregated our analysis of Suleja urban growth was to allow us have better insight into where and how growth took place within the entire study area. Combined analysis would have deprived us of the possibility to see and understand the morphology of settlement growth around the FCT. As the following tables and figures showed the development occurred faster in the fringes of the town where there is little or no impact of government planning policies. The coordinates for the six localities in table 3.1.

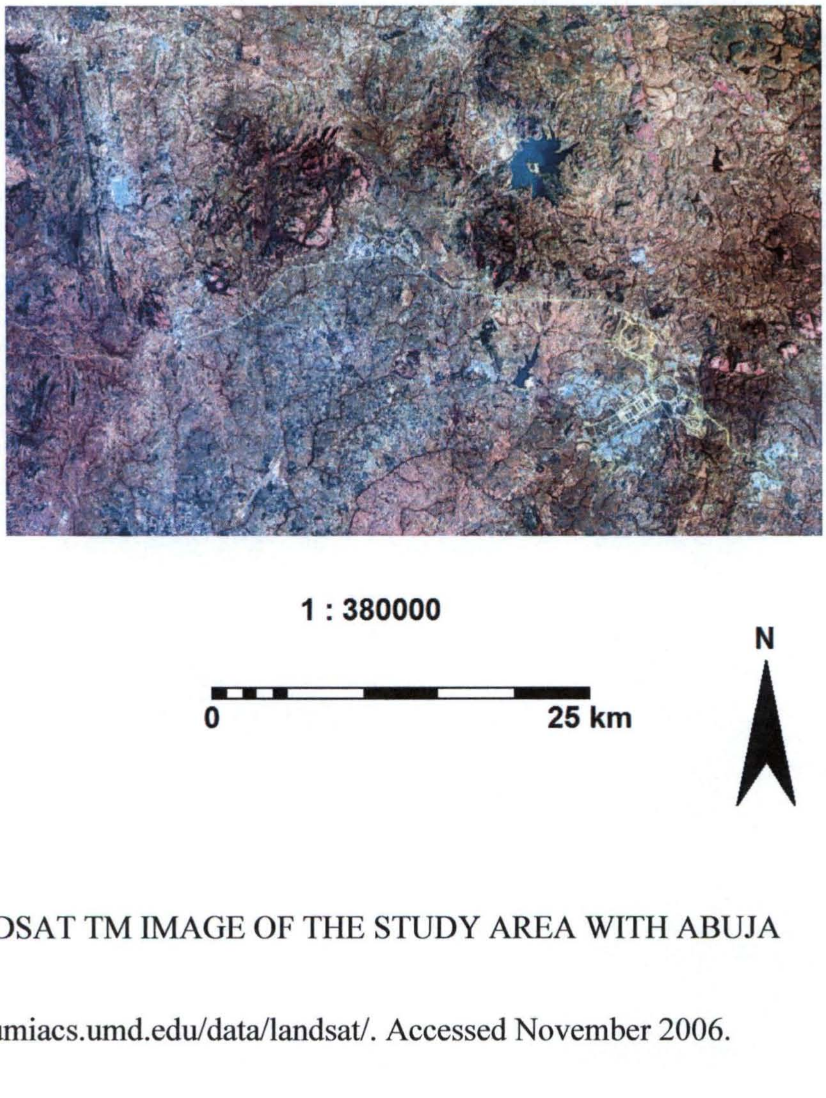


FIGURE 3.4. LANDSAT TM IMAGE OF THE STUDY AREA WITH ABUJA

Source: www.glcf.umiacs.umd.edu/data/landsat/. Accessed November 2006.

Figure 3.4 is the Landsat TM image of the study area including Abuja. It was used to for classification and growth analysis. This image serves as the base year data for the study.

Table 3.1: Coordinates of Localities

S/No	Locality	Upper coordinates	Lower coordinate
1	Dakwa	303610.50, 1016110.50	305235.00, 1014058.50
2	Dikko	301986.00, 1026171.00	303810.00, 1023891.00
3	Madalla	303040.50, 1008301.50	305662.50, 1004568.00
4	Maje	297483.00, 1024461.00	299620.50, 1022551.50
5	Rafinsanyi	300931.50, 1012291.50	302613.00, 1010895.00
6	Suleja Town	298366.50, 1021554.00	302299.50, 1013346.00.

Source: Author's work, 2006.

Landsat has a resolution of 30m which can be used for quantitative analysis like urban growth, Vegetation and large water body assessment. Figures 3.5 to 3.18 are the raw Landsat ETM and TM images subset according to the coordinates in table 3.1. These images were used for the classification and spatiotemporal change analysis.

FIGURE 3.5:1987 LANDSAT TM OF SULEJA AND ENVIRONS.

Source: www.glcf.umiacs.umd.edu/data/landsat/. Accessed November 2006

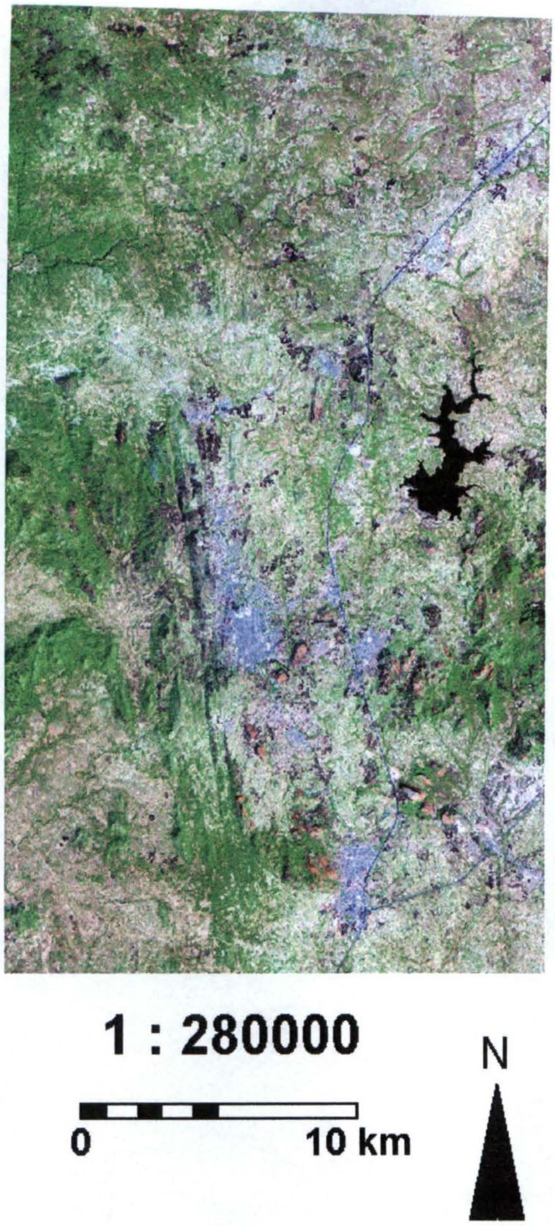


FIGURE 3.6:2001 LANDSAT ETM OF SULEJA AND ENVIRONS.
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November 2006

Suleja, we know, has been an important settlement in Niger state. In 1976 it acquired another status as the temporary base of Federal Capital Development Authority (FCDA). This, as highlighted earlier, attracted people to the town. However with the final movement of the seat of government in 1991, Suleja's situation became more aggravated due to the high influx of people that moved with the final movement.

The main image of the study area was used to isolate the six settlements in the analysis of growth pattern. Figure 3.7 to 3.18 are the raw images of the six localities for both

1987 and 2001 obtained by sub setting figures 3.5 and 3.6. Figure 3.4 is the Landsat image of the study area including. The changes in the two dates would be more apparent after image classification and analysis.

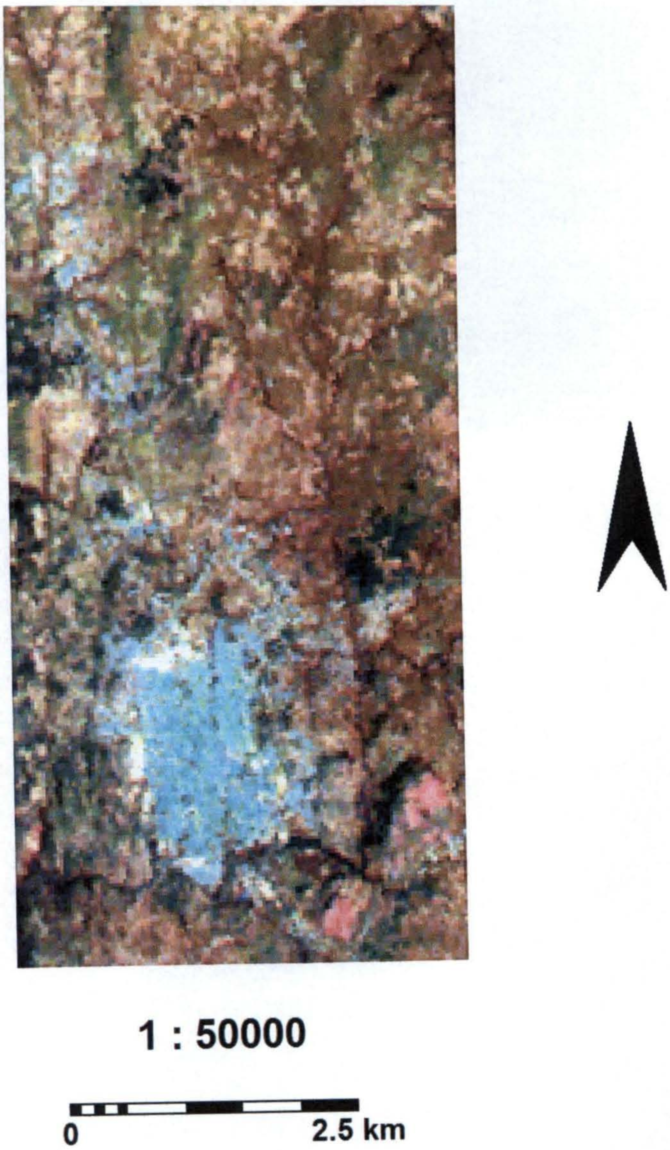


FIGURE 3.7: 1987 LANDSAT TM OF SULEJA TOWN.
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November, 2006.

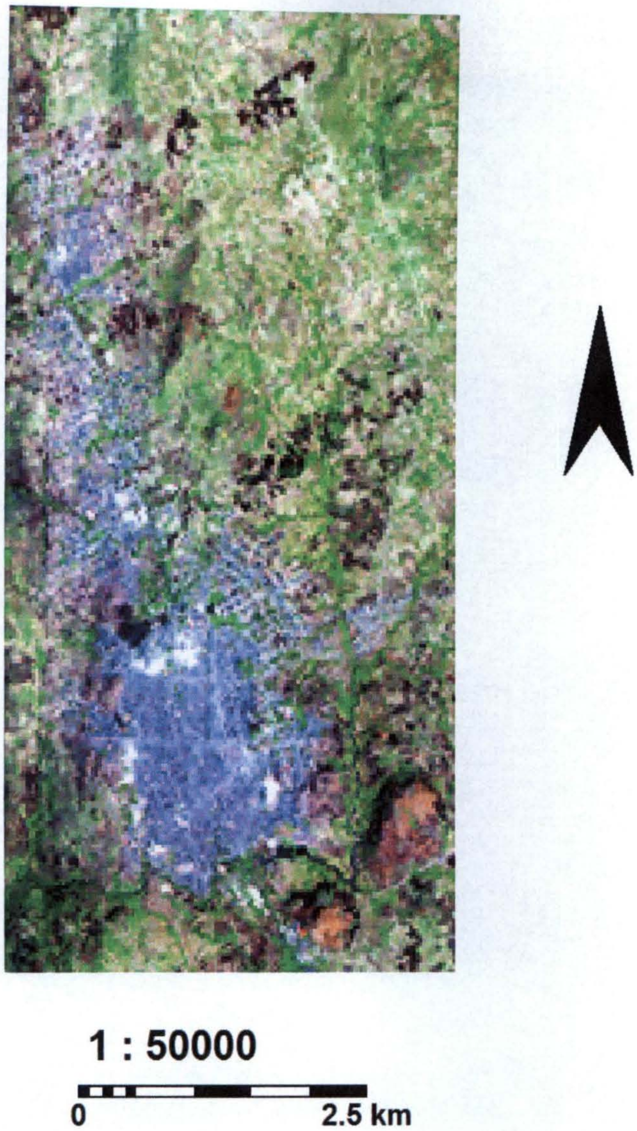


FIGURE 3.8: 2001 LANDSAT ETM OF SULEJA TOWNS
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November 2006.

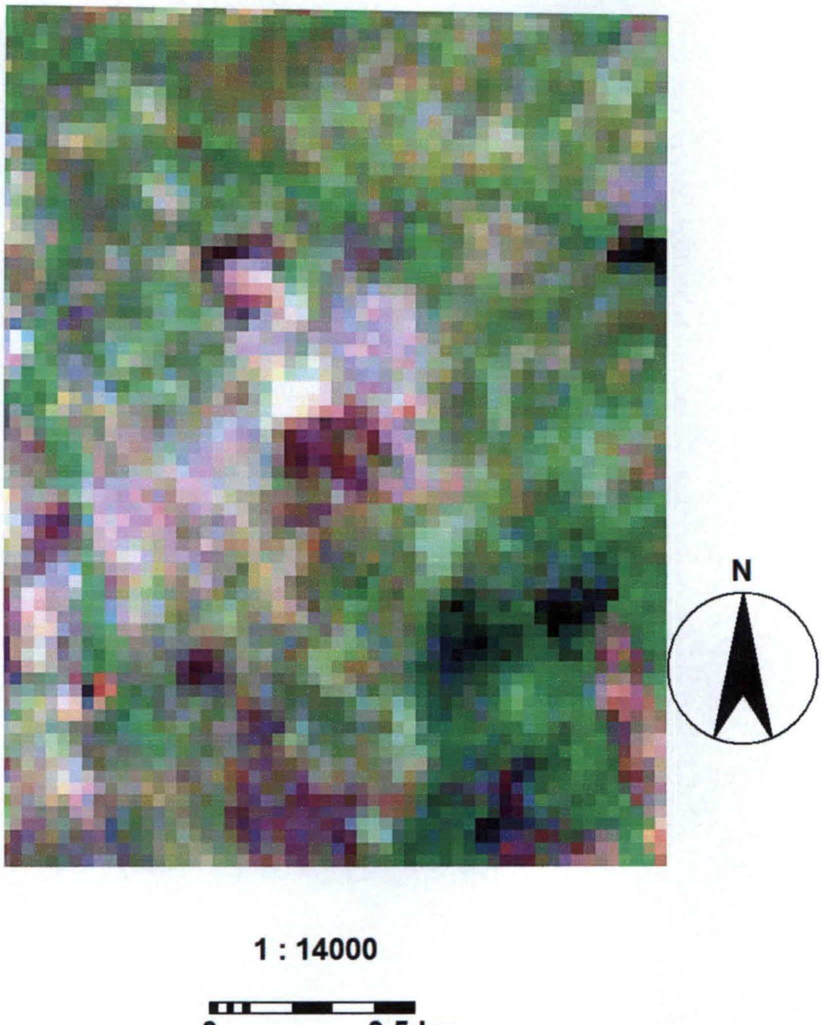


FIGURE 3.9: 1987 LANDSAT TM OF DAKWA.
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November 2006.

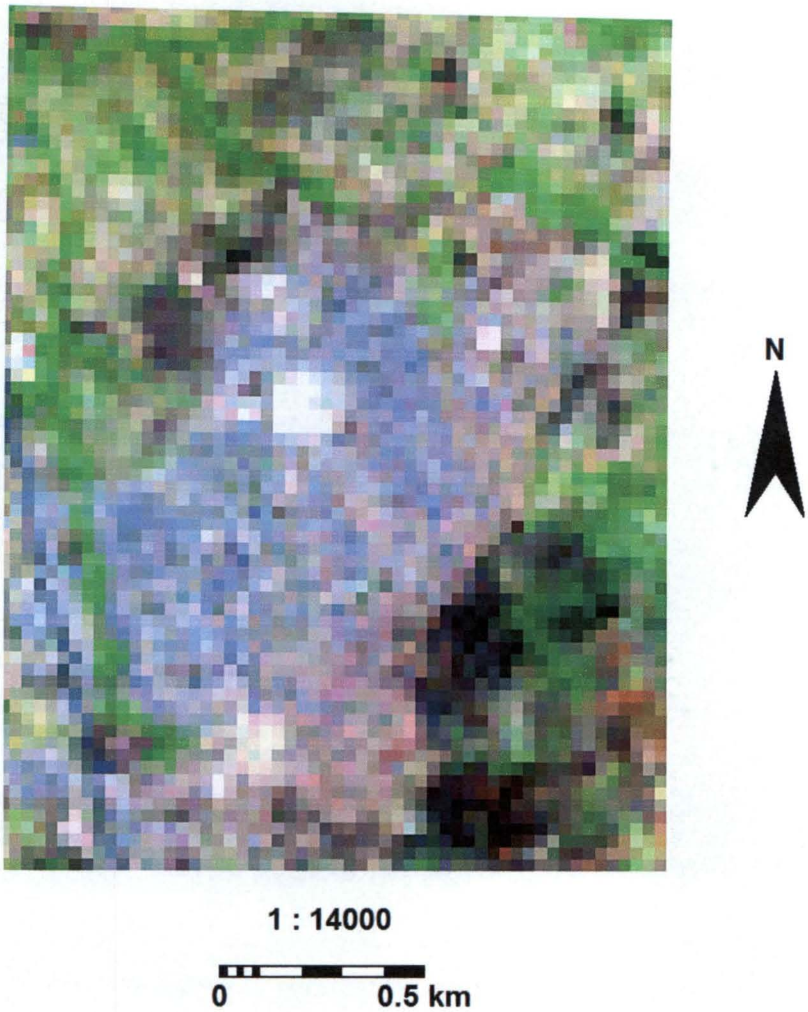


FIGURE 3.10: 2001 LANDSAT ETM OF DAKWA.
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November 2006.

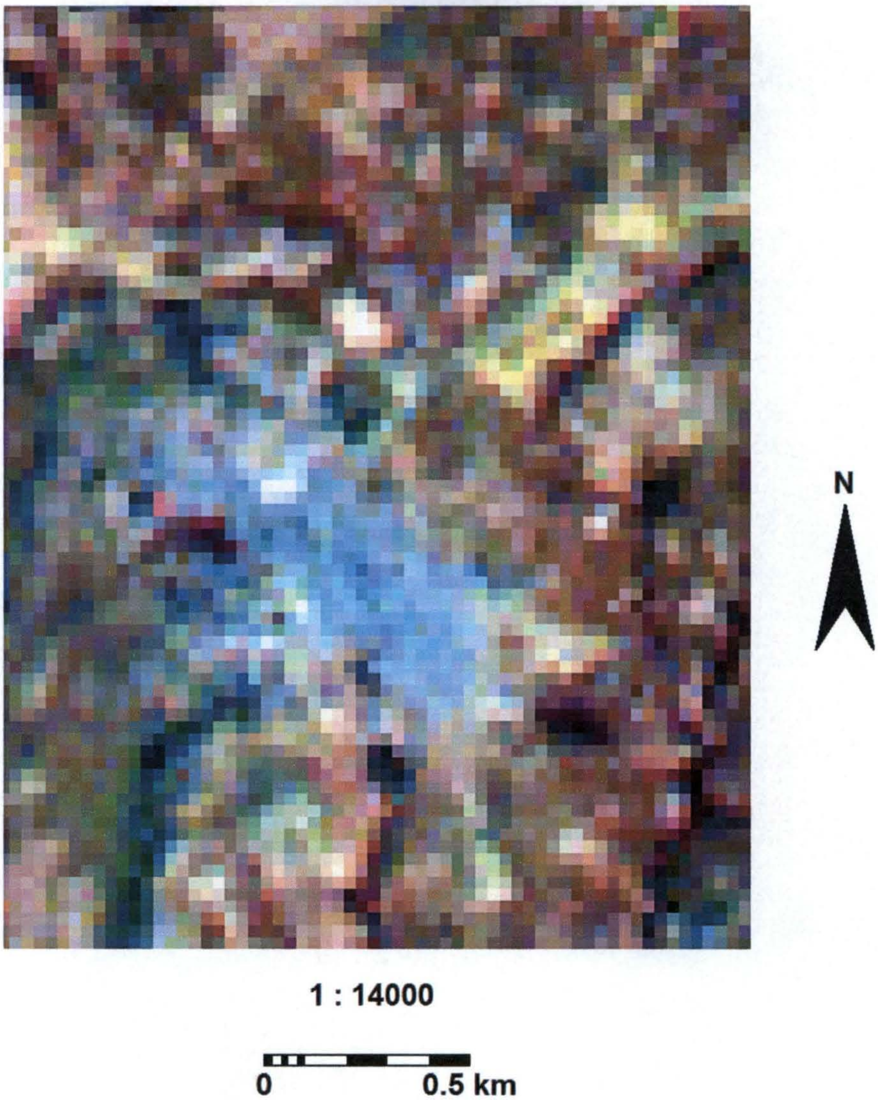


FIGURE 3.11: 1987 LANDSAT TM OF DIKKO TOWNS.
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November, 2006.

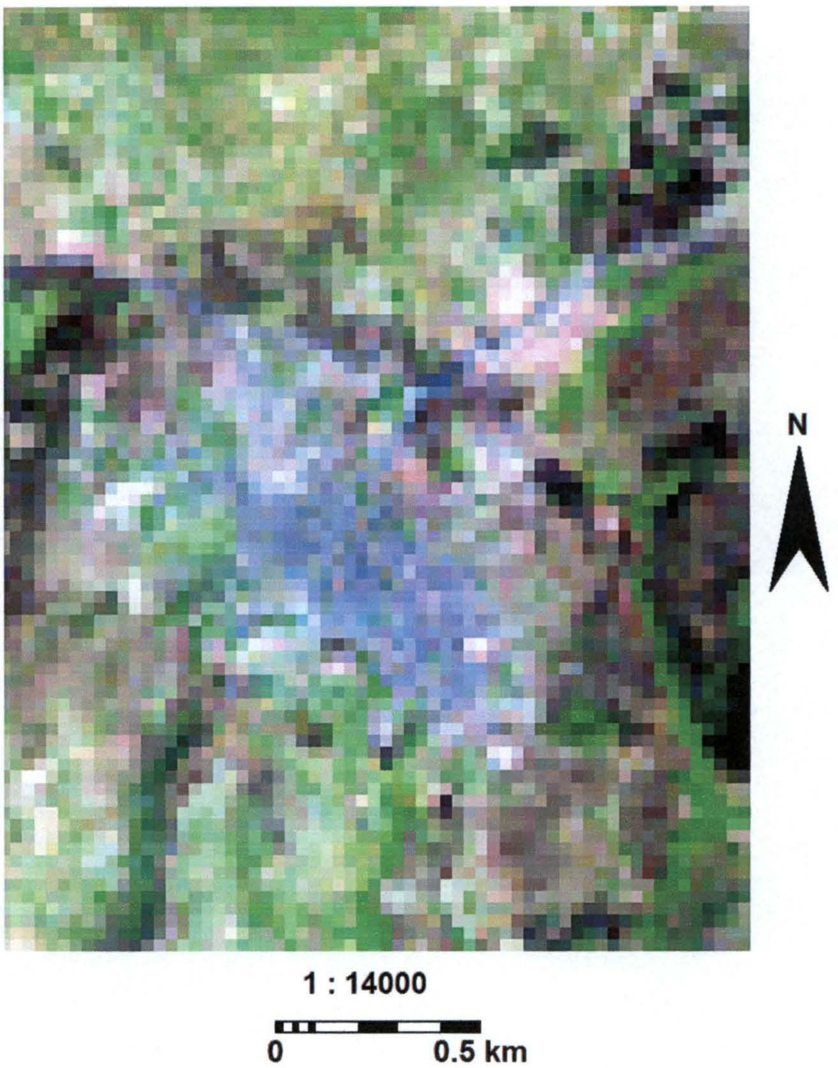


FIGURE 3.12: 2001 LANDSAT ETM OF DIKKO TOWN
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November, 2006.

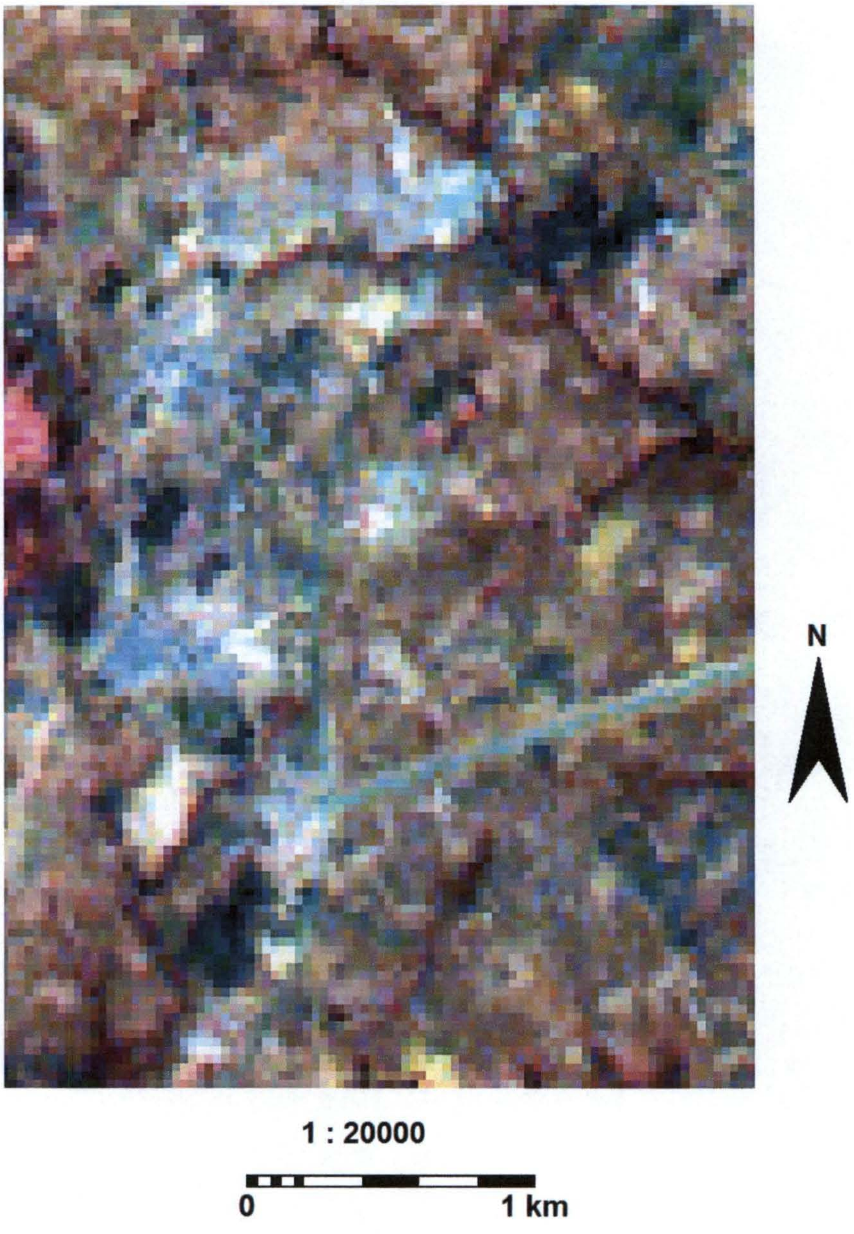


FIGURE 3.13: 1987 LANDSAT TM OF MADALLA.
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November, 2006.

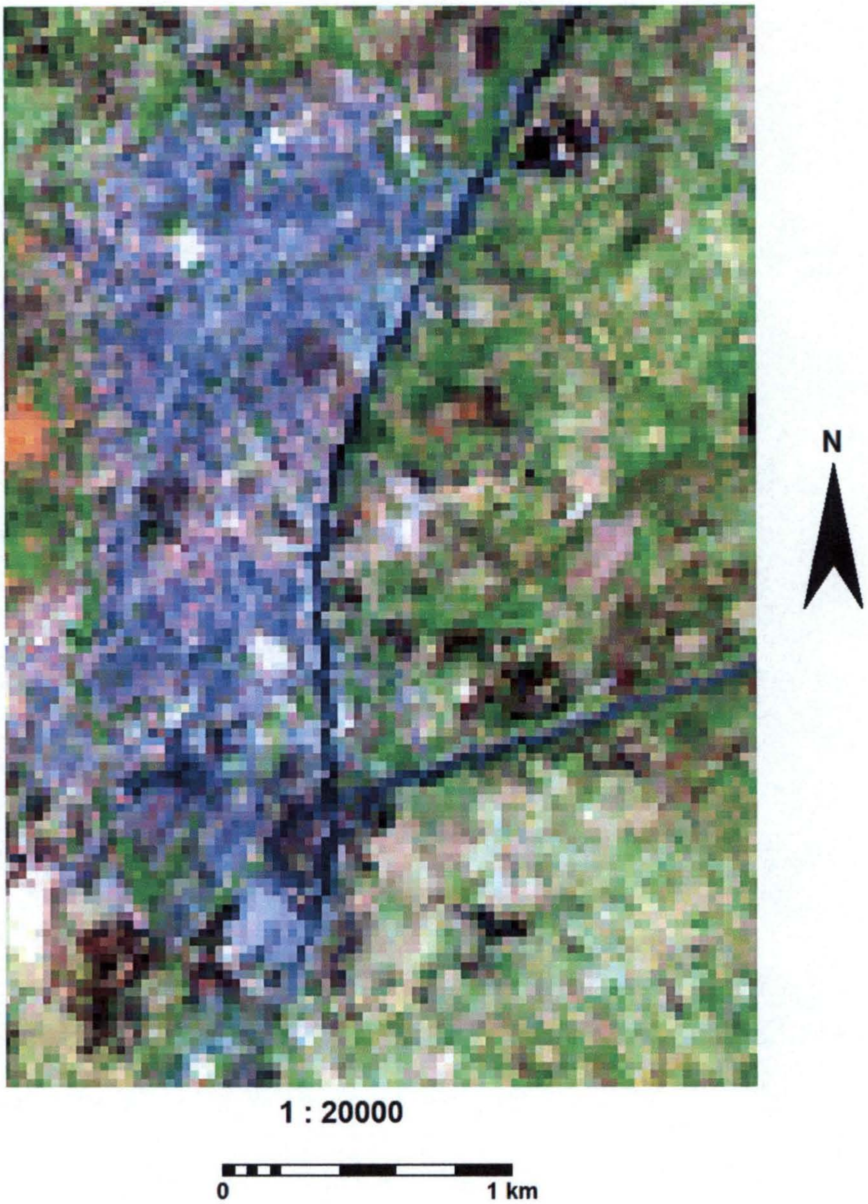


FIGURE 3.14: 2001 LANDSAT ETM OF MADALLA.
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November, 2006.

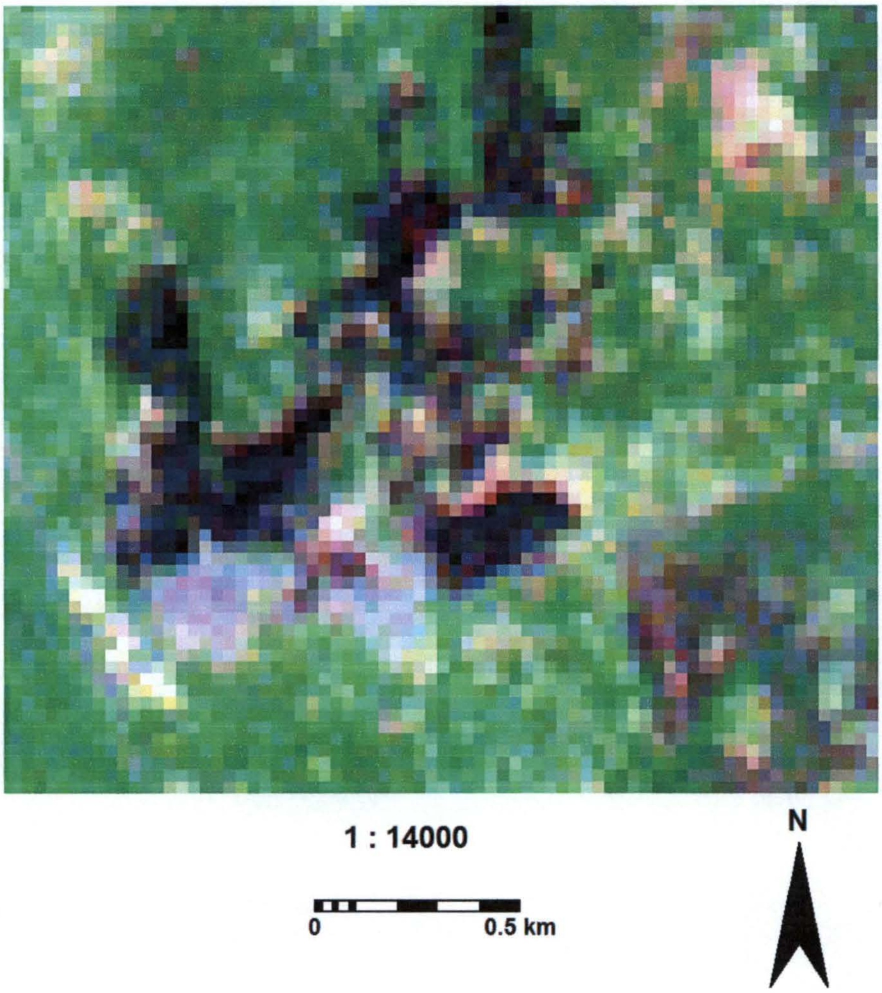


FIGURE 3.15: 1987 LANDSAT TM OF MAJE.
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November, 2006.

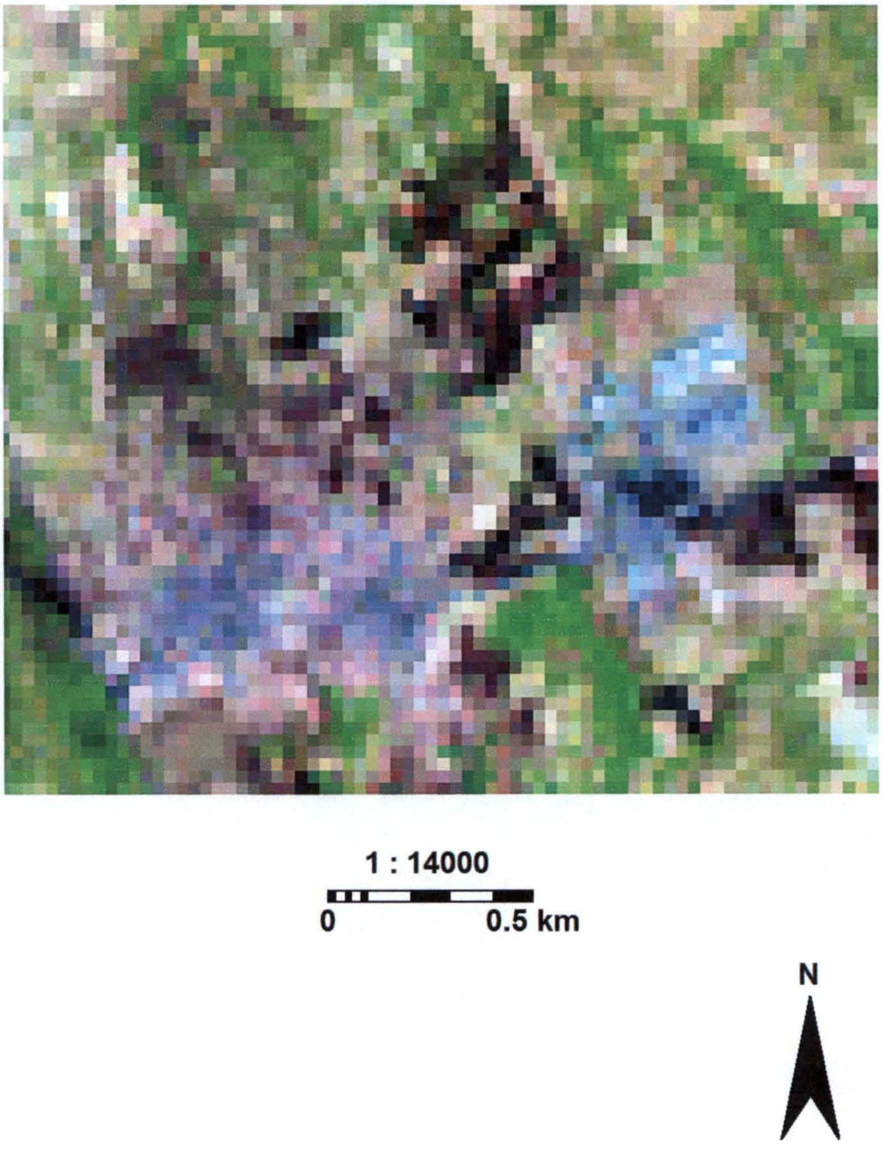


FIGURE 3.16: 2001 LANDSAT ETM OF MAJE.
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November, 2006.

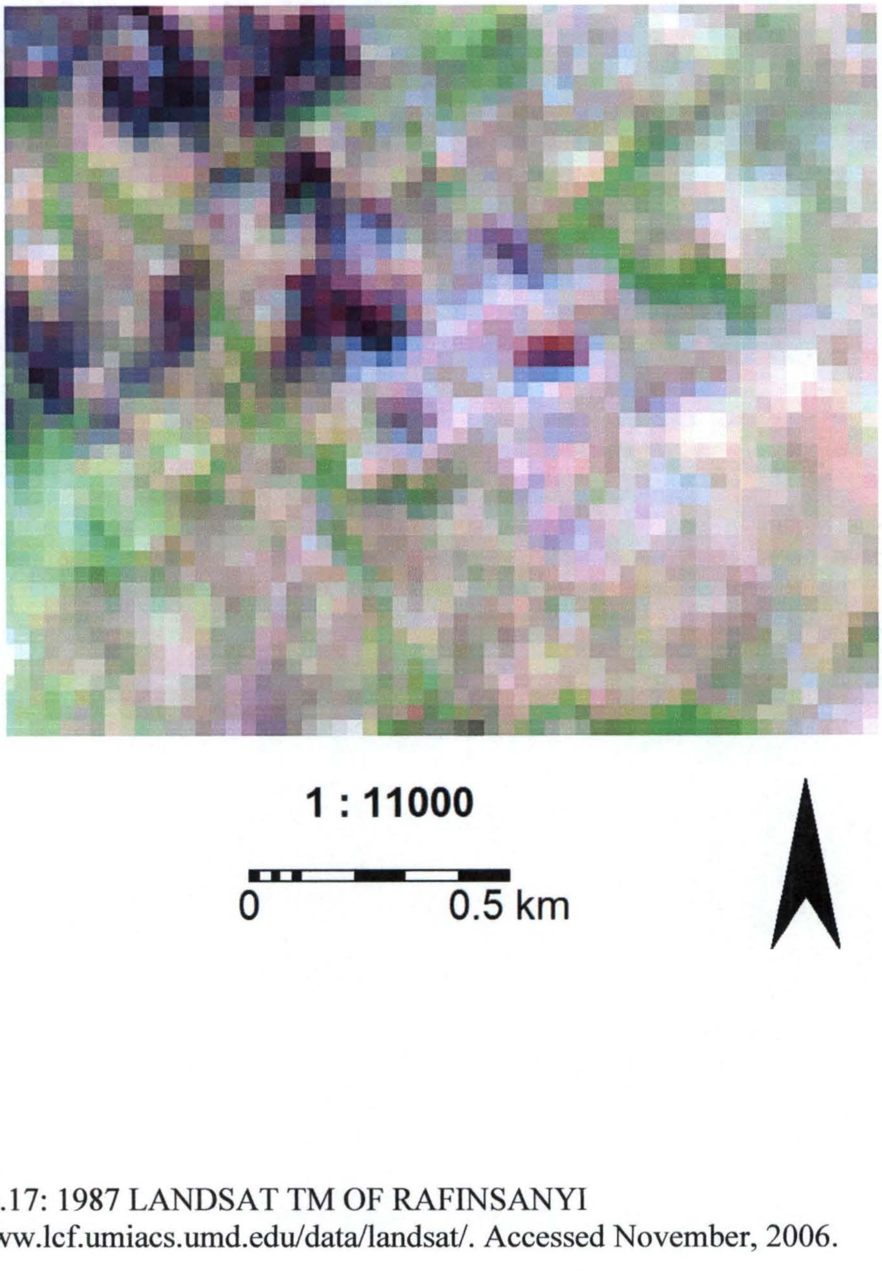


FIGURE 3.17: 1987 LANDSAT TM OF RAFINSANYI
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November, 2006.

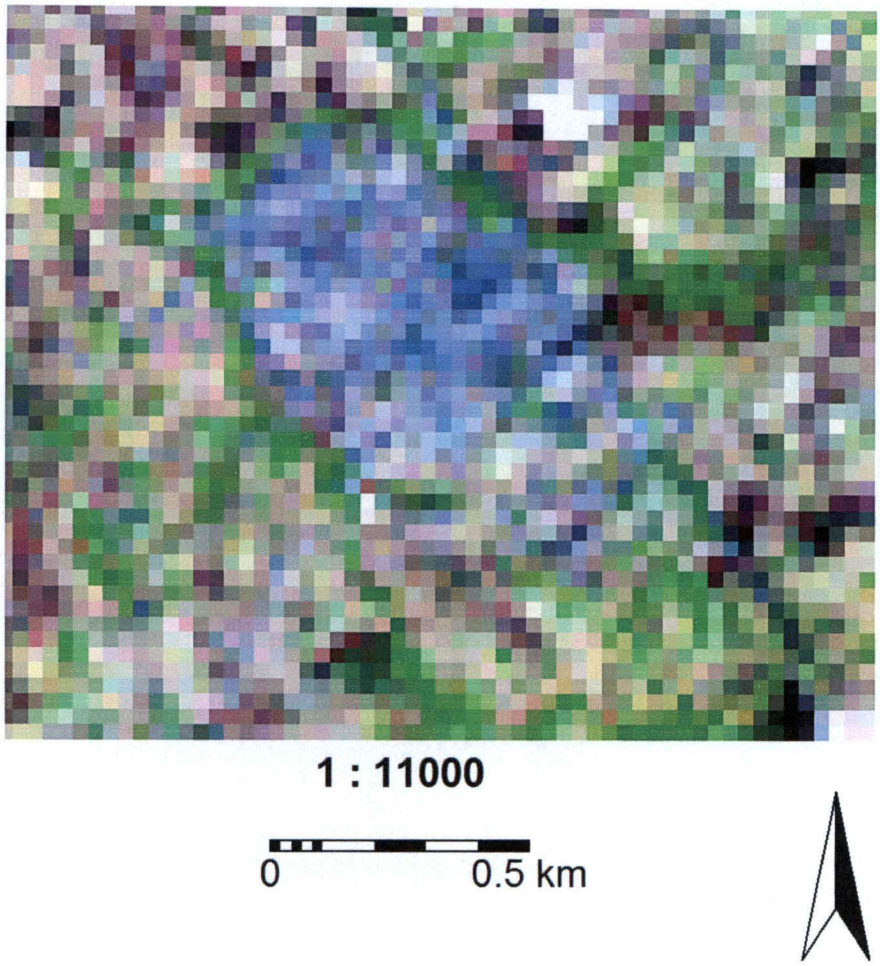


FIGURE 3.18: 2001 LANDSAT ETM OF RAFINSANYI.
Source: www.lcf.umiacs.umd.edu/data/landsat/. Accessed November, 2006.

Ilwis 3.1, AutoCAD, Arc view 3.6, Erdas and Idrisi software's were used at various stages in the analysis of the imageries. Ilwis was specifically used for image classification and growth assessment. The steps followed are stated below:

i- The images were imported into ilwis environment band by band,

ii- A map list was created from the bands, iii- A composite was formed using the 432 band combination which is a false colour composite,

iv- A sub set map of the study area was created using the coordinates

IV- Sample sites were created by training the sites for the various land uses.

vi- The sub map of the different dates were separately classified based on the following land uses;

a) Arable land,
b) Bare surface
c) Rocky outcrop/burnt surface
d) Settlement(built up) ,
e) Vegetation/green area
f) water body,

vii- The various land uses based on the classification were separately calculated to know the area coverage for 1987 and 2001

viii- The two classified images were crossed to extract areas of difference which would give changes over time.

ix- The result of classified image was used to assess the growth rate first for the whole study area and then for the individual localities. It should be noted that emphasis is given to only the built up area since that is the area of human occupation and influence. The following equation was used to estimate the growth rate between 1987 and 2001:

$$\text{Growth rate in built up area} = \sqrt[n]{\frac{BUA\text{-}2}{BUA\text{-}1}} - 1 \qquad \text{. . . . . (Eq 3.6)}$$

Where: ***n*** =number of years between the two dates

BUA1 =is the area of the Built up area in date 1

BUA 2 = is the area of the Built up area in date 2and

1 = is a constant

x- After the estimation of the growth rate between 1987 to 2001, projection was done to find the likely increase in the built up area by the year 2015 so as to provide a basis for possible immediate action. The following equation was used to project the area of built up extent of the different localities to the year 2015:

$$BUA\text{-}2=BUA\text{-}1(1+r)^{n} \quad \ldots\ldots\ldots\ldots \text{(Eq 3.6)}$$

Where: **BUA-1** = is the built up area 2001,

BUA-2 = is the built up area 2015

r is the rate of growth ,

n is the number years between 2001 to 2015 (14 years).

xii- The change in built up area was used as the independent variable to determine the major determinants of land use change through logistic regression.

3.8.4 OBJECTIVE 4 (Establish relationship between land use change and population)

Erdas imagine 8.0 was used in the analysis of the high resolution *iknos* image of suleja town for population estimation. The image was geo-referenced in ilwis and exported to erdas for the analysis.

The number of people in the sampled area was obtained by sampling the number of houses and average number of people per house. The total area of the sampled location marked red in figure 3.4 was calculated from the image. Idea on the population growth of an area would greatly assist in the planning of the area. The research estimated the population of the localities using remote sensing technique. The estimate was for the two dates and it was compared with the projected national figure.

The population of the study area was estimated using the house count method as demonstrated by Adeniyi (1987). The population was estimated thus;

EP=(BP)R1+(BP)R2+---------------------+(BP)Rn------(1)

Or EP=(dp)R1+(dp)R2+-------------------------(dp)Rn------ (2) .... (Eq 3.7)

Where;

EP=estimated population

B=number of buildings

P=average population per building

D=number of dwelling units

P=average population per dwelling unit

R! --------R2=different residential types.

The steps taken in this regard were as follows:

i- A large scale iknos image prepared by infoterra at a scale of 1: 5 was obtained from National Population Commission (NPC)

ii- This image was geo-referenced using hand held Garmin GPS. Identifiable points were chosen and their coordinates recorded

iii- An area within the town was identified on the image

iv- This area was sampled to obtain the average number of people per household

v- The image was used to estimate the land area of the selected site.

Based on this procedure we were able to obtain the average number of people per sqm. through;

$$\text{Average number of people} = \frac{\text{total area of the sample site}}{\text{Total number of people}} \quad \ldots\ldots\ldots\ldots \text{(Eq 3.8)}$$

Based on this we have;

$$\text{Average number of people} = \frac{\textbf{115937.04 sq m}}{\textbf{591 people}} = \textbf{44.26 sq m/person}$$

It is this area per person that was used to estimate the total population of the study area from land sat image of 1987 and 2001. The result obtained was compared with the projected official figure.

The same equation used in the analysis of the growth rate of built up area was used to estimate the growth rate in the population of the study area. The rate of growth in population was compared with the rate of growth of built up area. The population figure obtained from 2001 was projected to 2015 using the equation :

$$POP\text{-}2=POP\text{-}1(1+r)^{n} \quad \text{..... .. ..} \quad \text{(Eq. 3.)}$$

Where: **POP-1** = is the Population figure in 2001,

POP-2 = is the population figure in 2015

r is the rate of growth ,

n is the number years between 2001 to 2015 (14 years).

FIGURE 3.4: IKNOS IMAGE OF A PORTION (MARKED RED) OF SULEJA USED FOR POPULATION ESTIMATION

SOURCE: *NATIONAL POPULAATION COMMISSION, 2006.*

3.8.5 OBJECTIVE 5. (Recommend a strategy for effective monitoring of the growth of Suleja and environs in a sustainable and scientific method**).** Before making any recommendations we needed to go over the existing arrangement within the state and see how adequate it is. We therefore appraised the existing government efforts in the overall planning and development control activities in this area. The main areas of concern were:

i- Number and type of layout designed

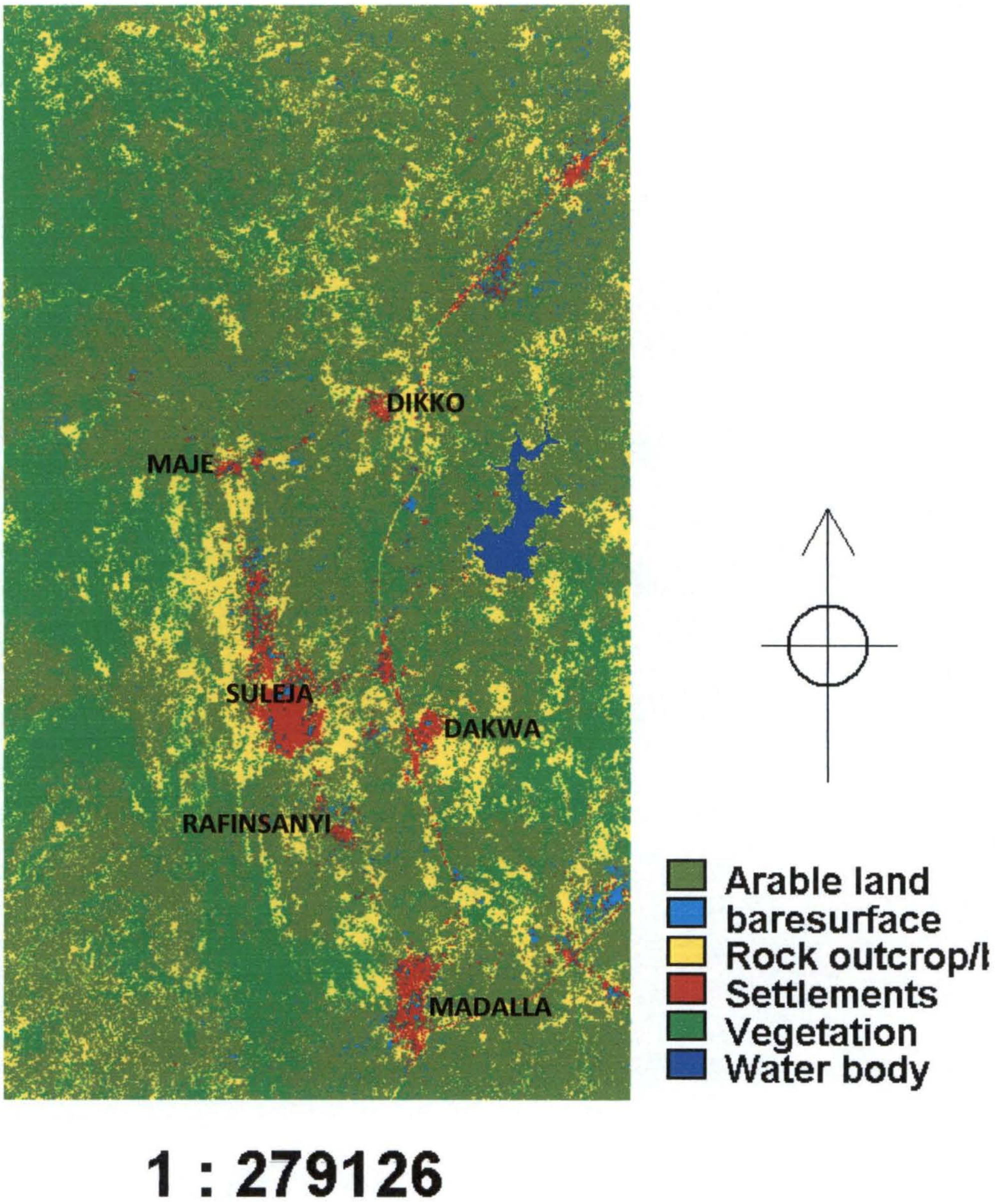


FIGURE 4.9: CLASSIFIED LANDSAT IMAGE OF TEH STUDY AREA (2001)

Source: Author's work, 2006.

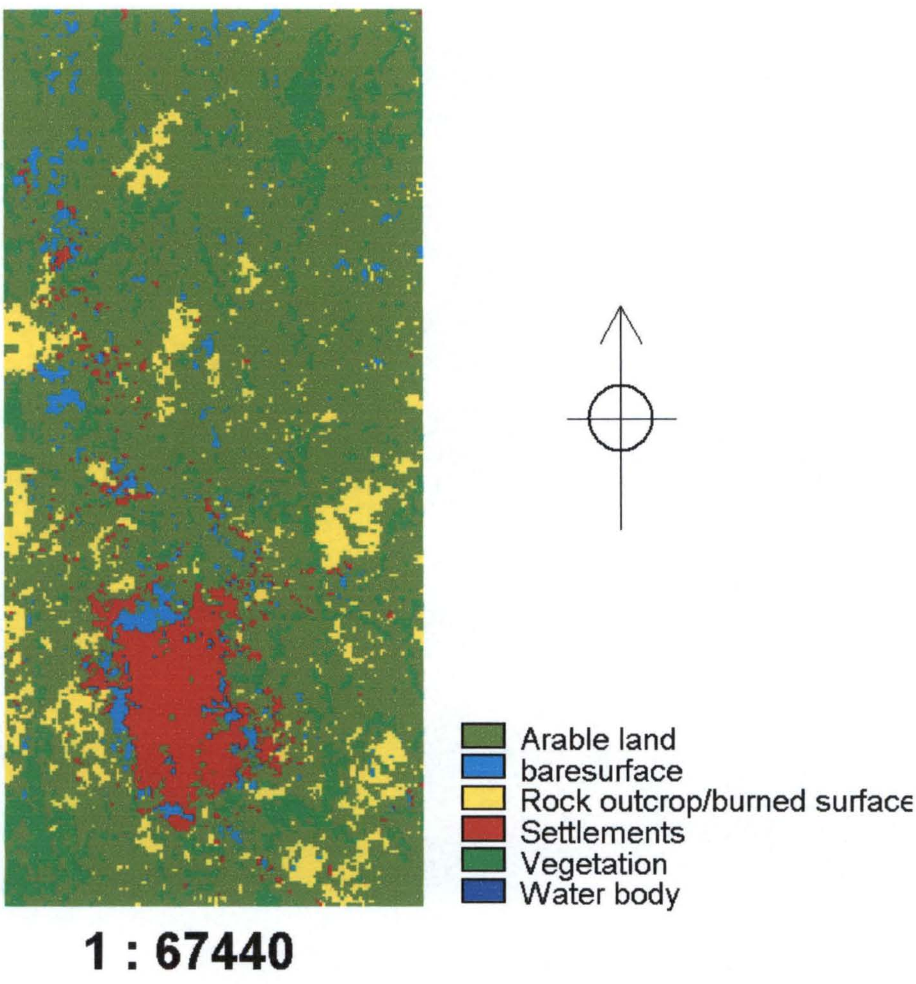


FIGURE 4.10: CLASSIFIED IMAGE OF SULEJA TOWN (1987)

Source: Author's work, 2006.

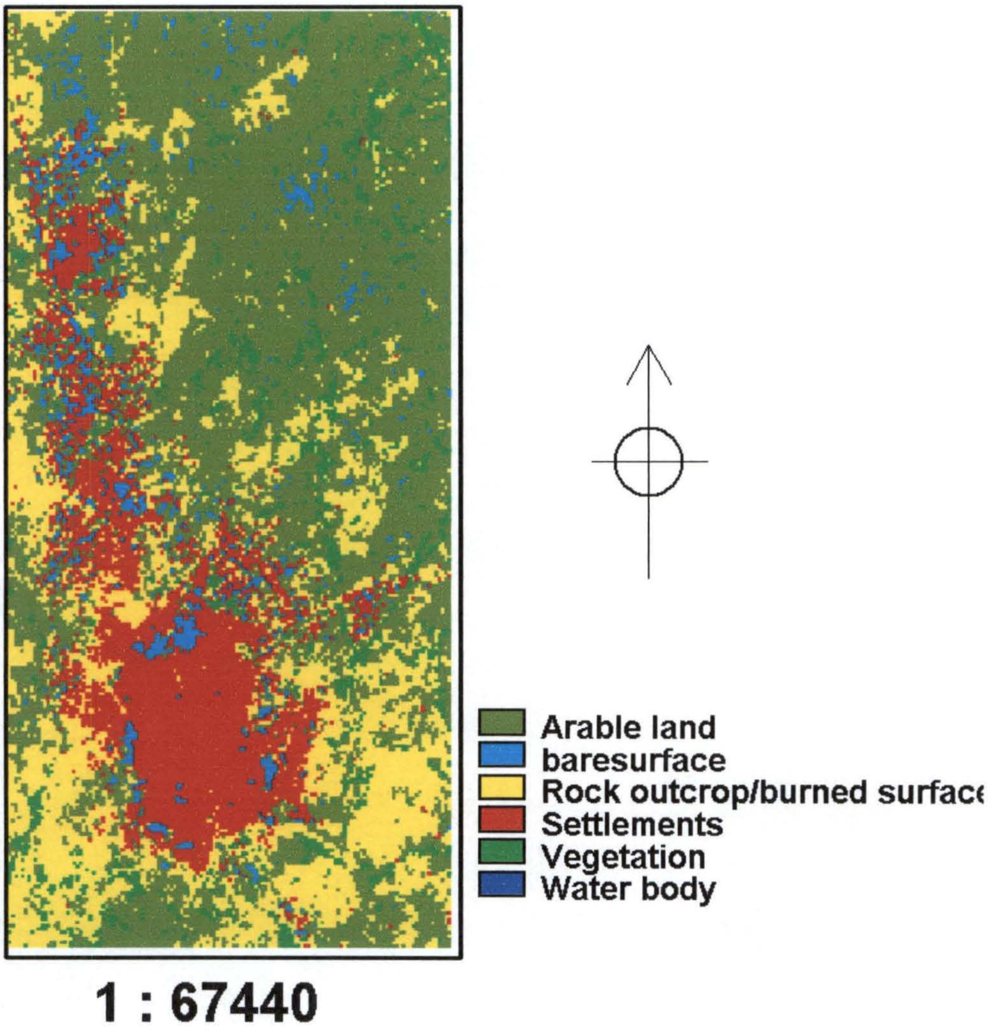


FIGURE 4.11: CLASSIFIED LANDSAT ETM IMAGE OF SULEJA TOWN (2001)

Source: Author's work, 2006.

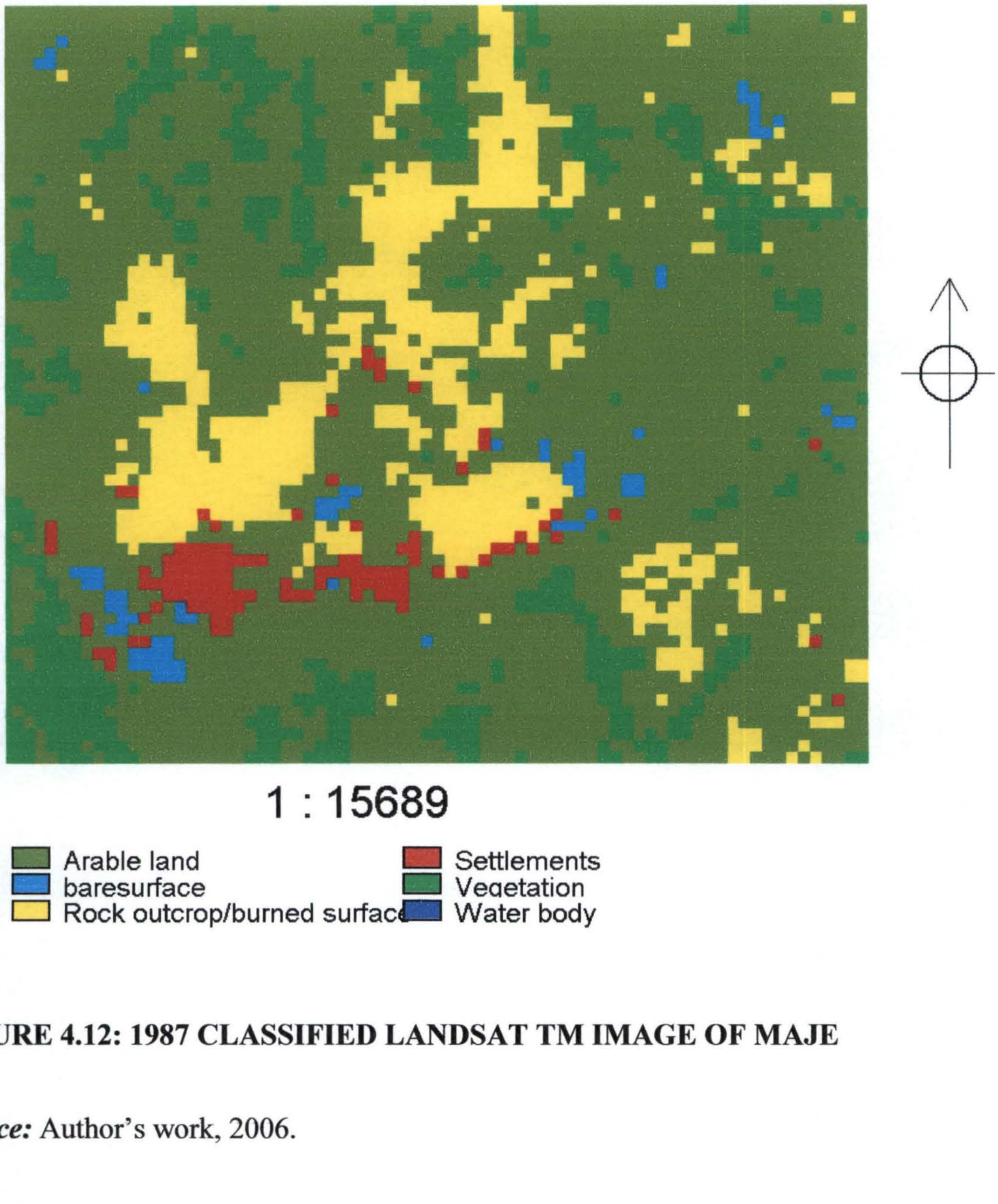


FIGURE 4.12: 1987 CLASSIFIED LANDSAT TM IMAGE OF MAJE

Source: Author's work, 2006.

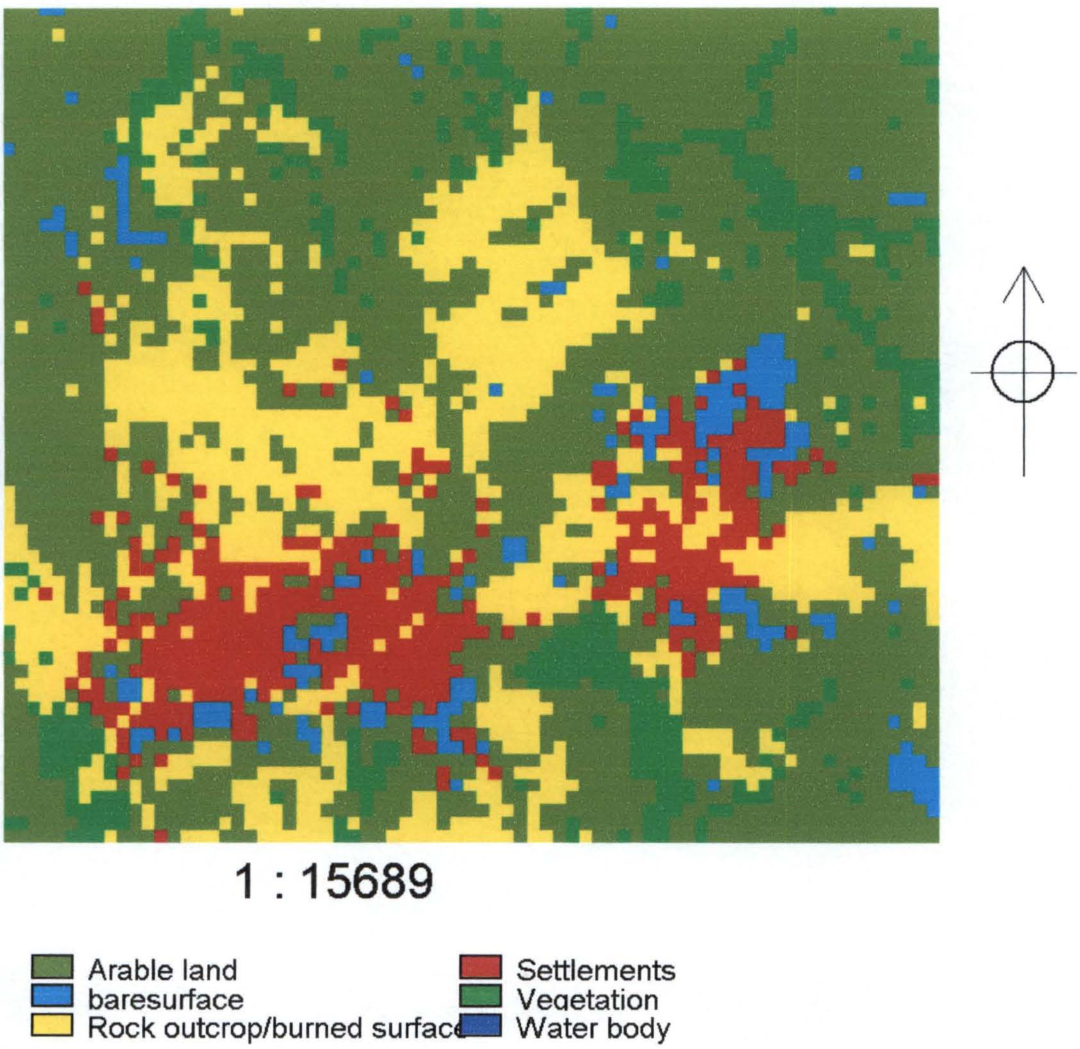


FIGURE 4.13: 2001 CLASSIFIED LANDSAT ETM IMAGE OF MAJE

Source: Author's work, 2006.

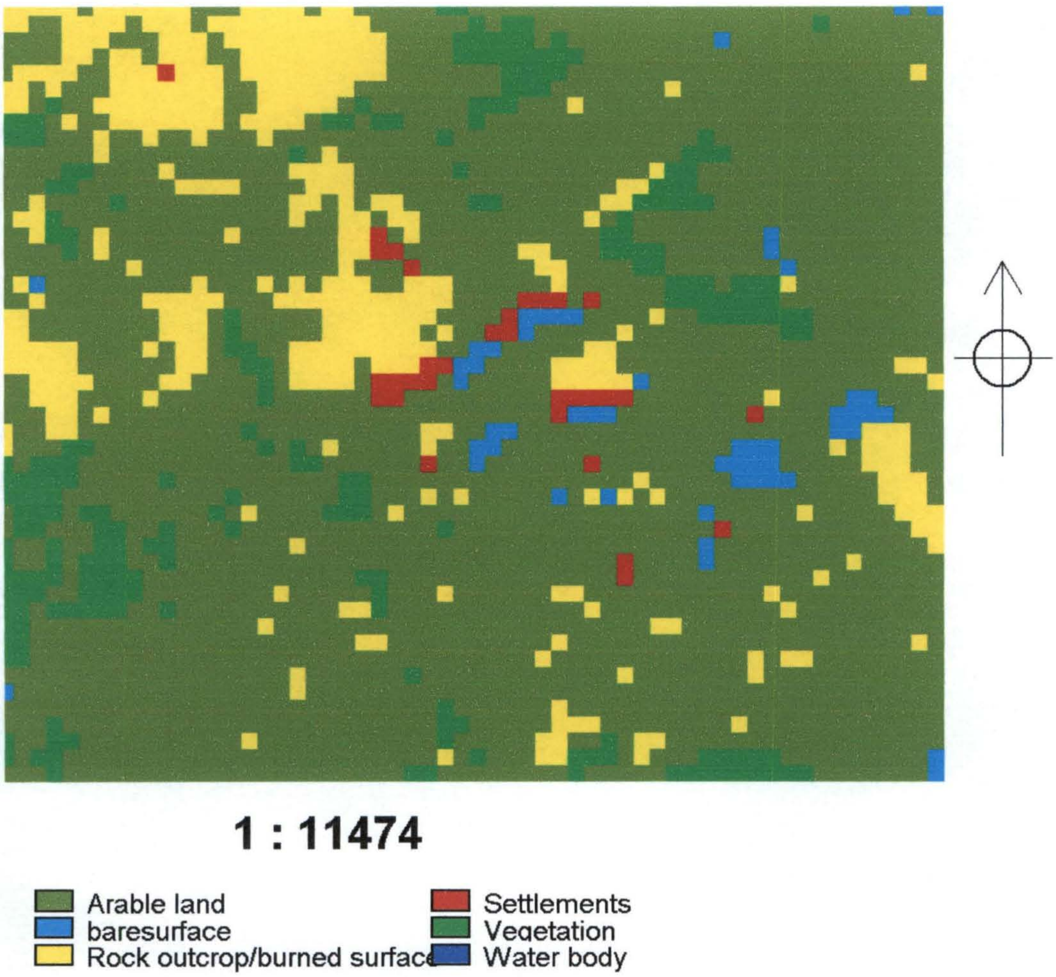


FIGURE 4.14: 1987 CLASSIFIED LANDSAT TM IMAGE OF RAFINSANYI

Source: Author's work, 2006.

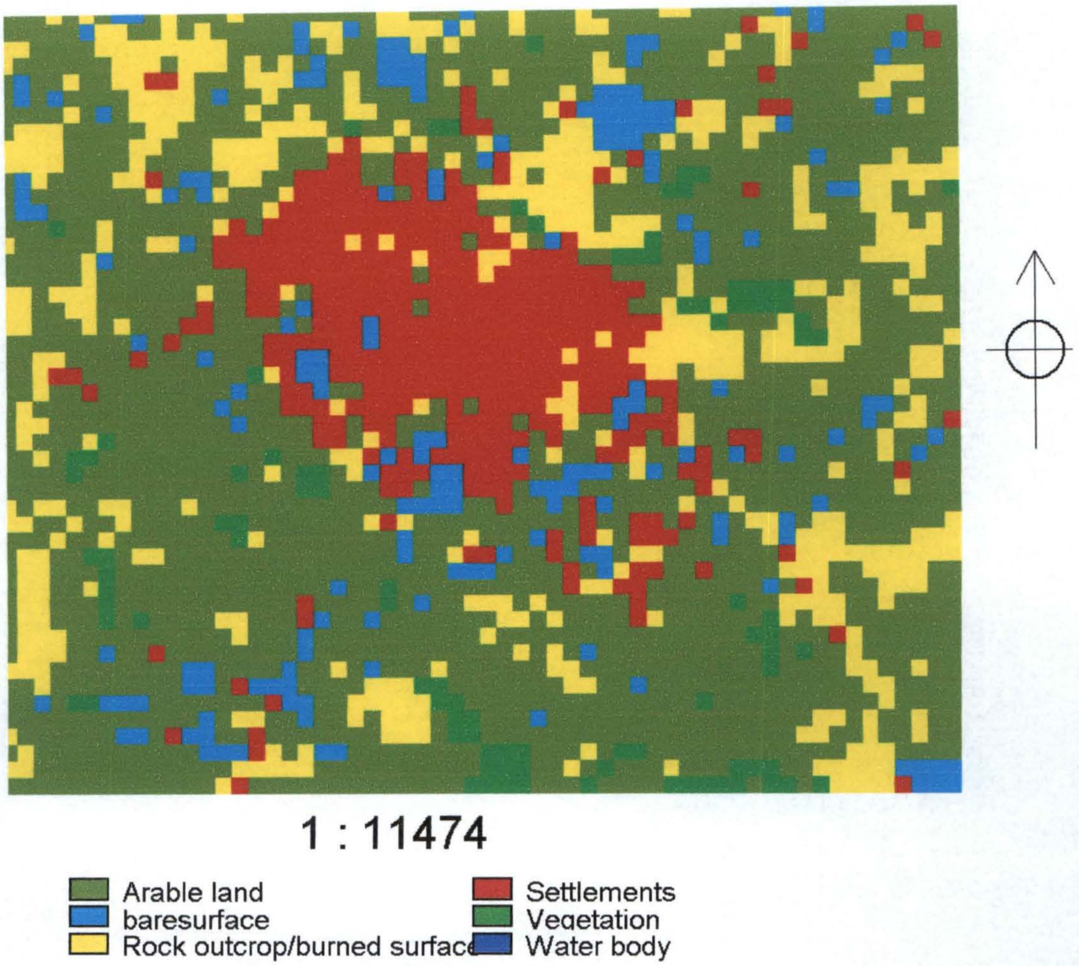


FIGURE 4.15: 2001 CLASSIFIED LANDSAT ETM IMAGE OF RAFINSANYI

Source: Author's work, 2006.

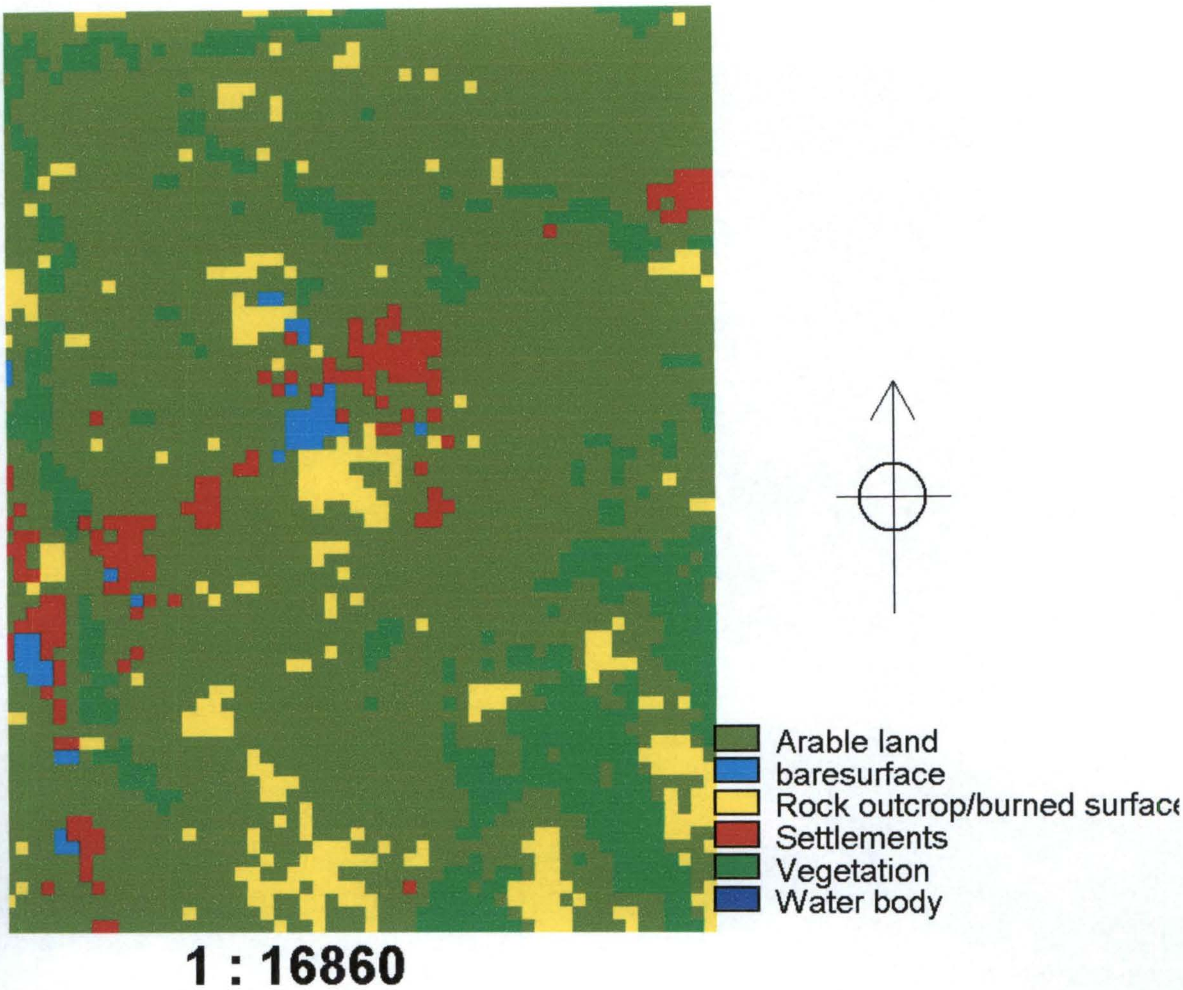


FIGURE 4.16: 1987 CLASSIFIED LANDSAT TM IMAGE OF DAKWA

Source: Author's work, 2006.

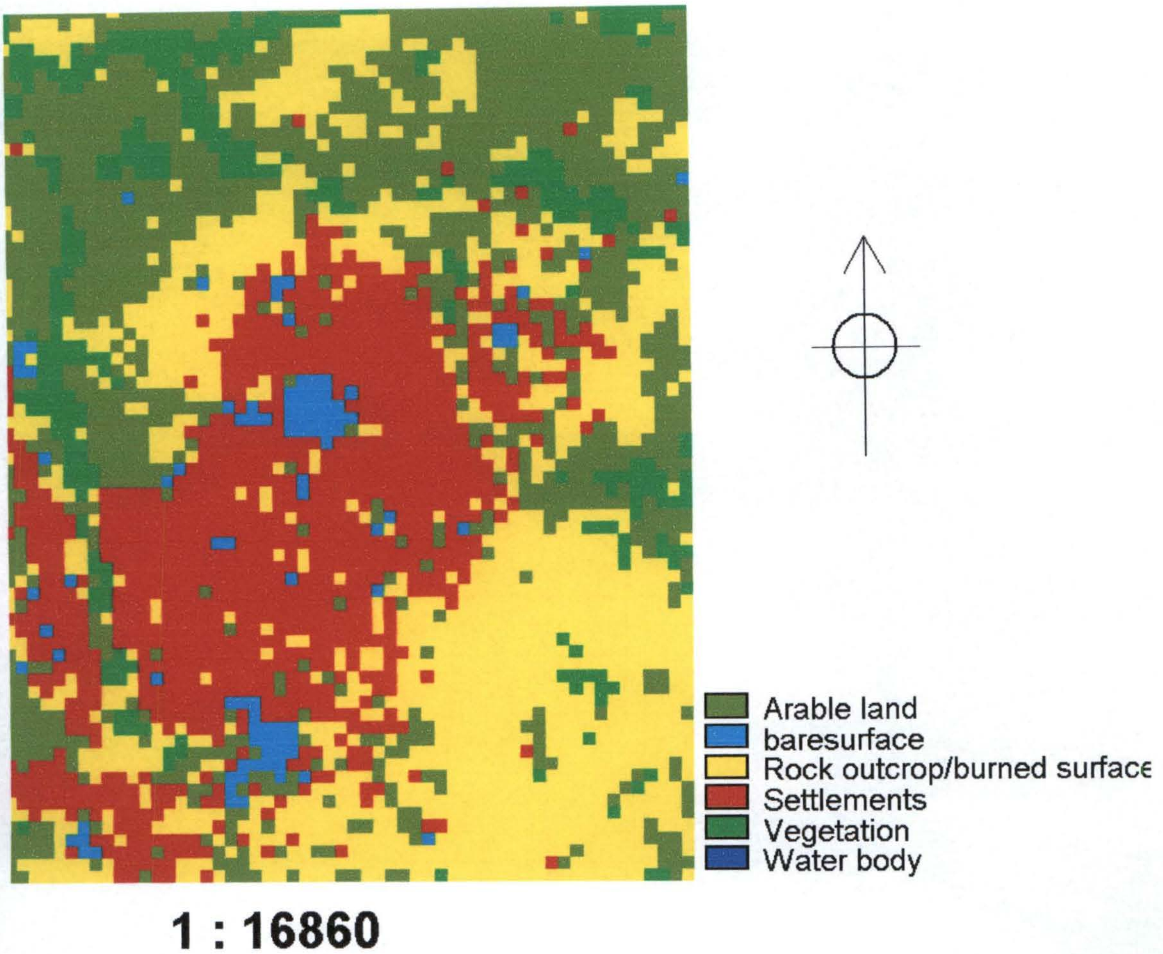


FIGURE 4.17: 2001 CLASSIFIED LANDSAT ETM IMAGE OF DAKWA

Source: Author's work, 2006.

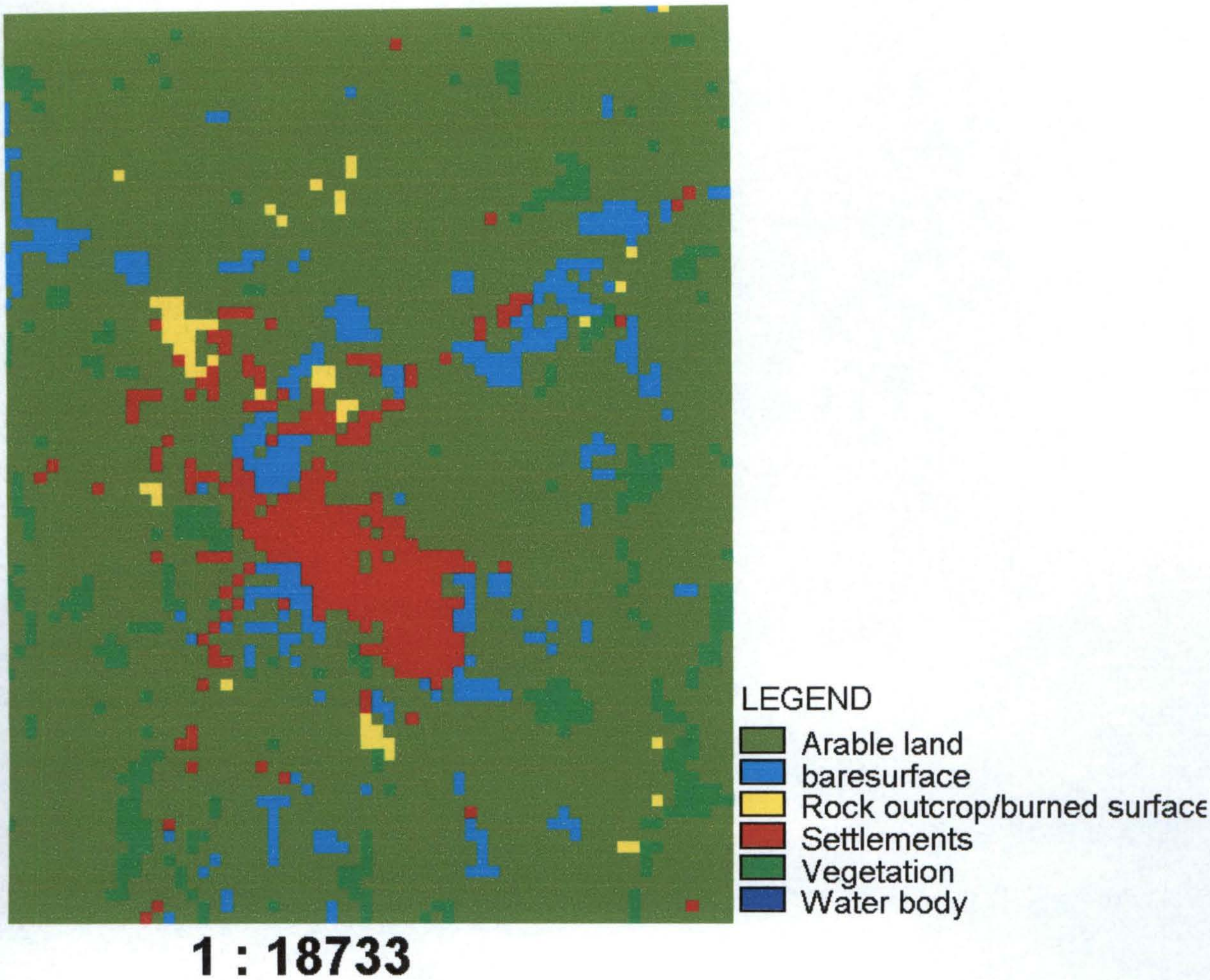


FIGURE 4.18: 1987 CLASSIFIED LANDSAT TM IMAGE OF DIKKO

Source: Author's work, 2006.

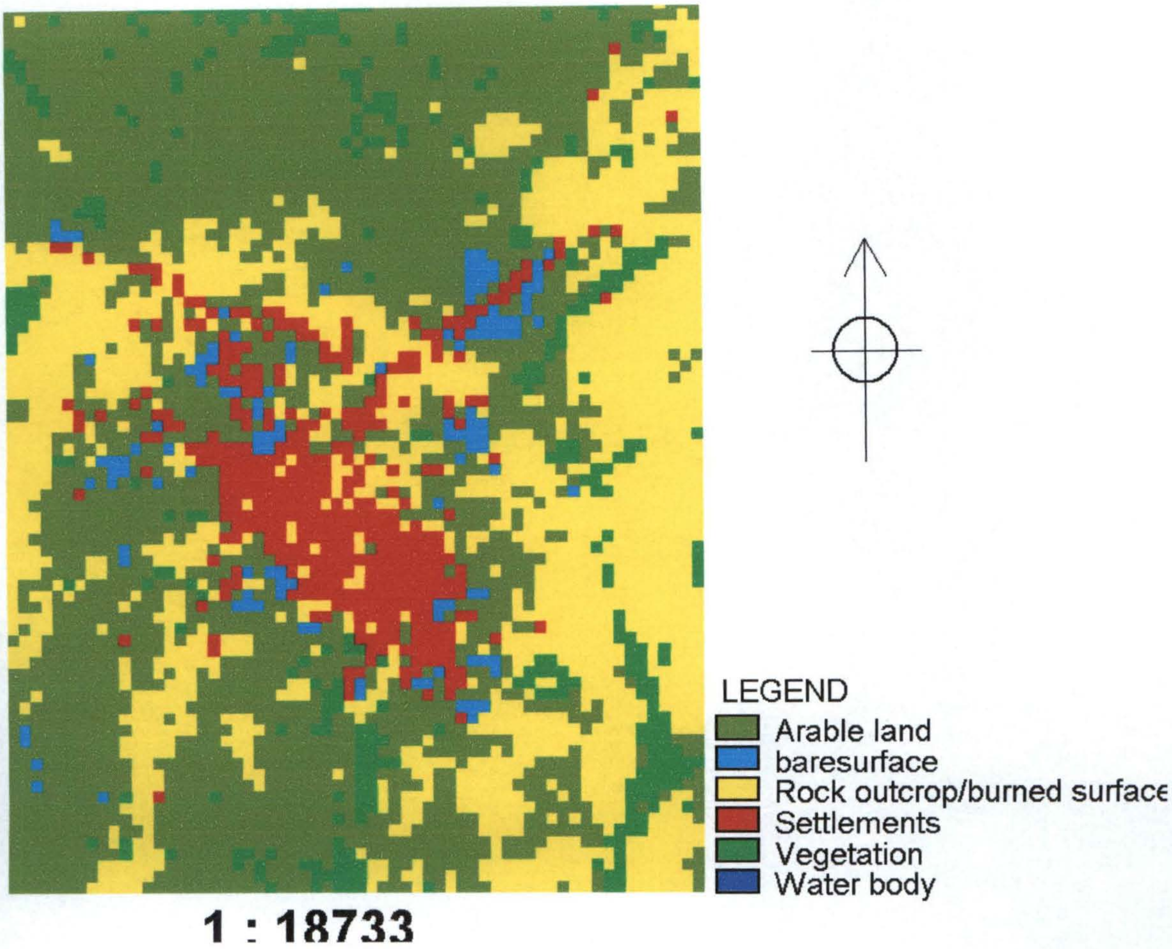


FIGURE 4.19: 2001 CLASSIFIED LANDSAT ETM IMAGE OF DIKKO

Source: Author's work, 2006.

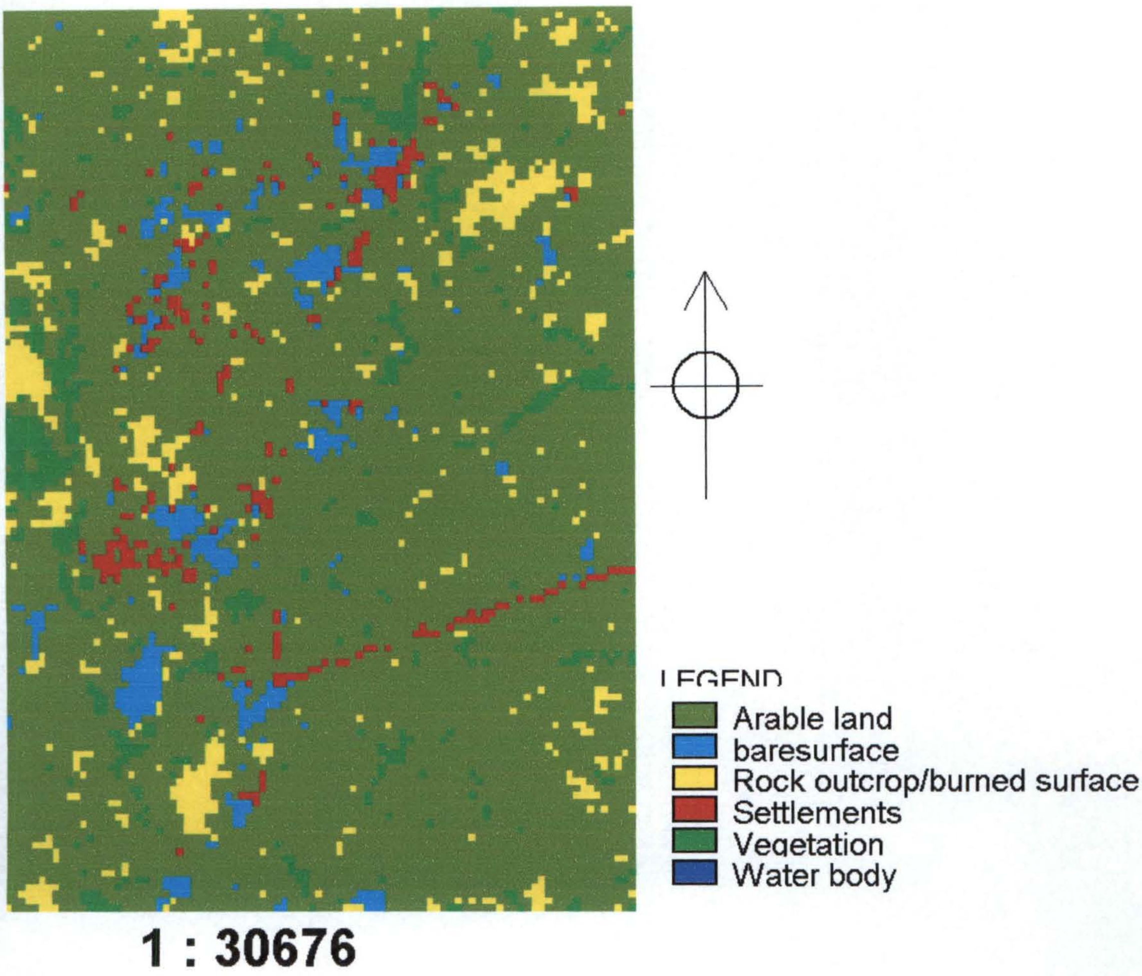


FIGURE 4.20: 1987 CLASSIFIED LANDSAT TM IMAGE OF MADALLA

Source: Author's work, 2006.

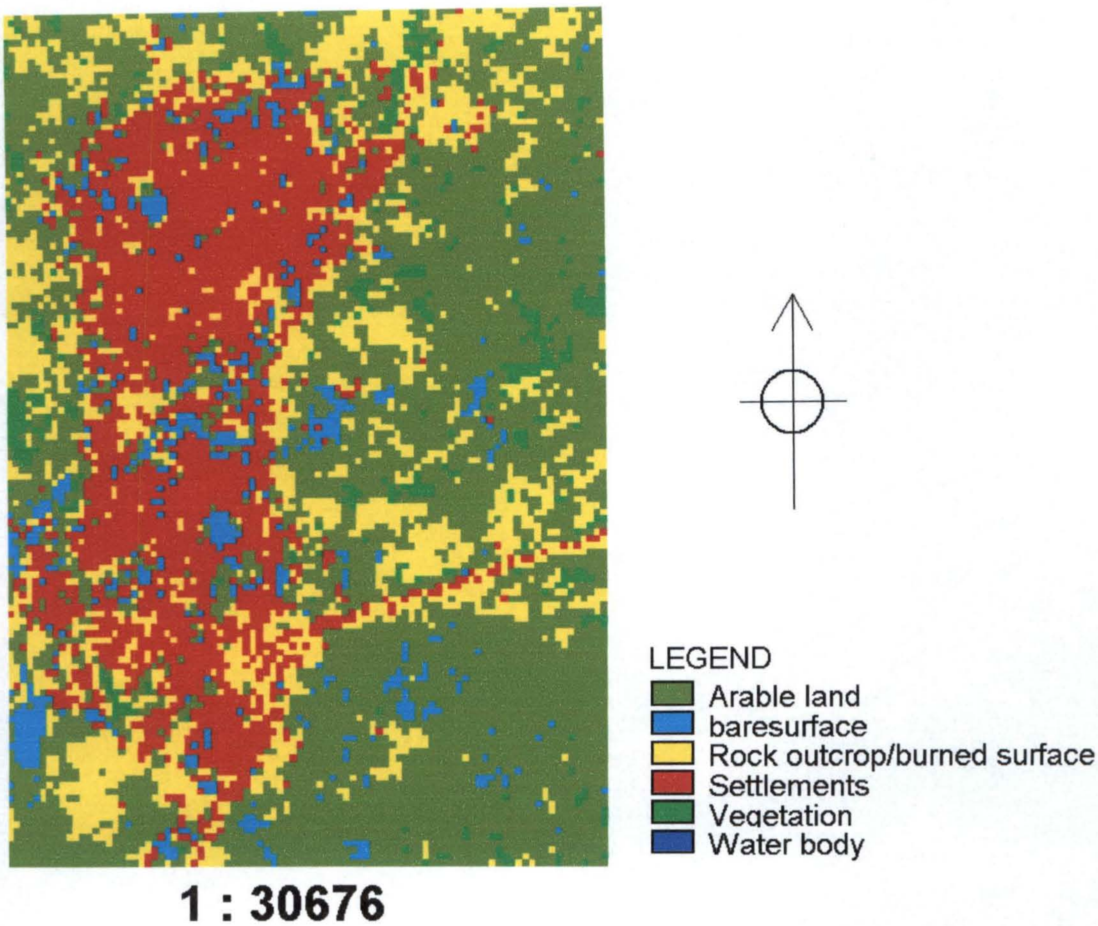


FIGURE 4.21: 2001 CLASSIFIED LANDSAT ETM IMAGE OF MADALLA

Source: Author's work, 2006.

TABLE 4.1: COMPARISON OF LAND USE CHANGES OF MADALLA BETWEEN 1987 T0 2001

LAND USE CLASS OF MADALLA	AREA IN KM^2 IN 1987	AREA IN KM^2 IN 2001	% CHANGE
ARABLE LAND	794.1	470.7	-3.67
BARE SURFACE	38.3	51.5	2.14
ROCK OUTCROP/BURN SURFACE	69.2	205.5	8.08
BUIILT UP AREA(SETTLEMENT)	22.4	215.4	17.55
VEGETATION	55.	35.8	-3.02
WATER BODY	0	0	0

Source: Author's work, 2006.

TABLE 4.2: COMPARISON OF LAND USE CHANGES OF SULEJA MAIN TOWN BETWEEN 1987 T0 2001

LAND USE CLASS OF SULEJA	AREA IN KM^2 IN 1987	AREA IN KM^2 IN 2001	% CHANGE
ARABLE LAND	2233.6	1,554.8	-2.55
BARE SURFACE	121.0	142.1	1.15
ROCK OUTCROP/BURN SURFACE	283.0	840.4	8.08
BUIILT UP AREA(SETTLEMENT)	214.8	486.9	6.02
VEGETATION	376.0	204.0	-4.27
WATER BODY	0	0	0

Source: Author's work, 2006.

TABLE 4.3: COMPARISON OF LAND USE CHANGES OF MAJE BETWEEN 1987 T0 2001

LAND USE CLASS OF MAJE	AREA IN KM^2 IN 1987	AREA IN KM^2 IN 2001	% CHANGE
ARABLE LAND	277.1	223.2	-1.53
BARE SURFACE	6.2	16.2	7.1
ROCK OUTCROP/BURN SURFACE	59.2	91.7	3.18
BUIILT UP AREA(SETTLEMENT)	9.5	35.7	9.92
VEGETATION	56.1	41.3	-2.16
WATER BODY	0	0	0

Source: Author's work, 2006.

TABLE4.8: COMPARISON OF GROWTH IN BUILT UP AREA AND DISTANCE FROM ABUJA

LOCALITY	DISTANCETO ABUJA IN KM	SETTLEMENT SIZE(BUILT UP) IN KM^2 IN 1987	SETTLEMNT SIZE (BUILT UP) IN KM^2 IN 2001	% CHANGE
MAJE	59	9.5	35.7	9.92
SULEJA	47	214.8	486.9	6.02
MADALLA	33	22.4	215.4	17.55
DIKKO	53	23.7	32.2	2.21
RAFIN SANYI	44	2.6	30.9	19.34
DAKWA	41	13.1	81.9	13.99

Source: Author's work, 2006.

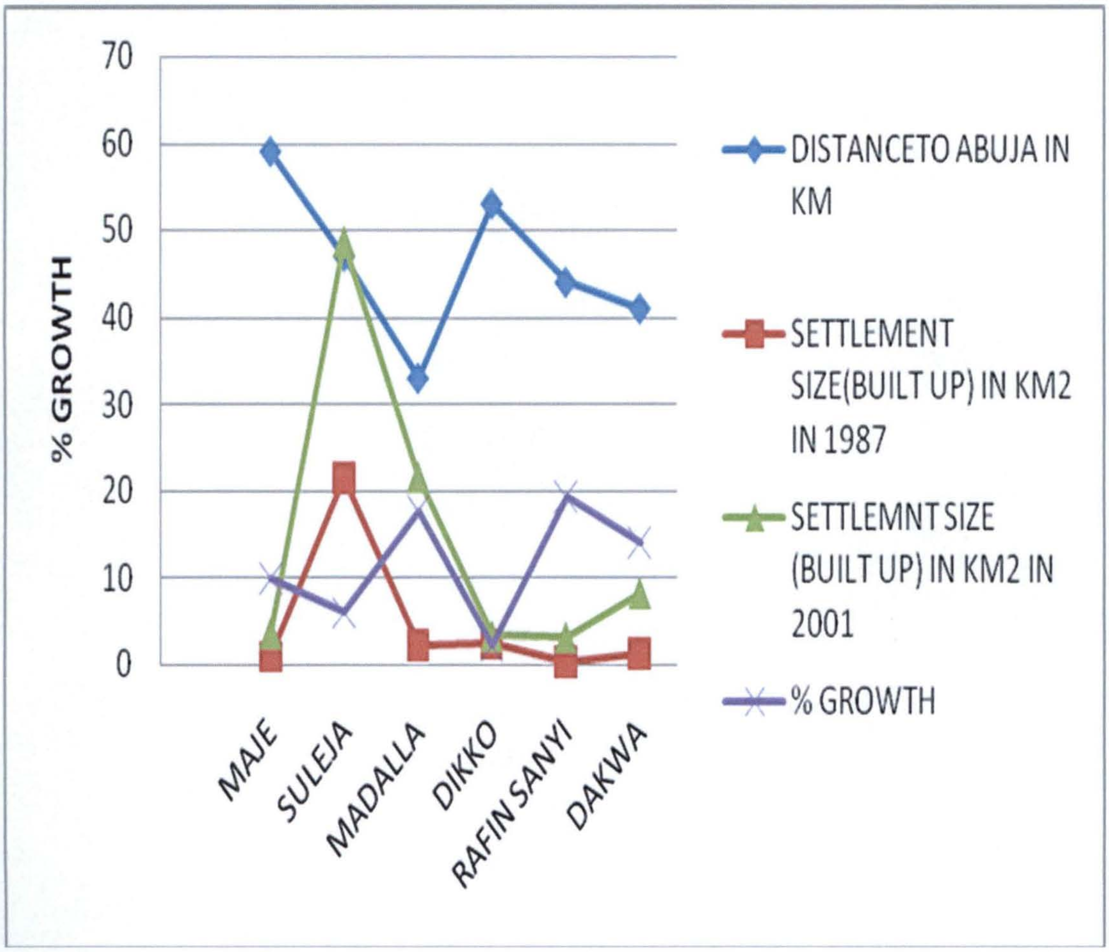


FIGURE 4.23: GROWTH RATE OF SETTLEMENTS AND DISTANCE

Source: Author's work, 2006.

TABLE 4.9: PROJECTION OF BUILT UP AREA FROM 1987 TO 2015

LOCALITY	SETTLEMENT SIZE(BUILT UP) IN KM^2 IN 1987	SETTLEMNT SIZE (BUILT UP) IN KM^2 IN 2001	PROJECTION OF SETTLEMNT SIZE (BUILT UP) IN KM^2 IN 2014
MAJE	9.5	35.7	134.9
SULEJA	214.8	486.9	1,103.75
MADALLA	22.4	215.4	2071
DIKKO	23.7	32.2	43.72
RAFIN SANYI	2.6	30.9	367.2
DAKWA	13.1	81.9	512.18
TOTAL	**286.3**	**883**	**2,724.26**

Source: Author's work, 2006.

The classified images were used to obtain the change by subtracting the1987 image from the 2001. The resultant image is the change map figure 4.24 which is the focus of the study. Figure 4.24 served as dependent variable input in the model. The study sought to establish the effects of the independent variables of (1) Time to Abuja, figure 4.25 (2) Topography (DEM), figure 4.26 (3) population, figure 4.27 (4) Distance from locality, figure 4.28 and (5) Distance to Road, figure 4.29. The results of the regression showed which of the five independent variables played more role in the change from non-built up to built up.

FIGURE. 4.24: THE CHANGE MAP OF THE STUDY AREA WHERE 0=NO CHANGE AND 1=CHANGE
Source: Author's work, 2006.

The raster maps of the independent variables were obtained for the study area alone but tying them to Abuja. The raster maps, cost raster surface and vector maps of the digitized road were used to generate the time to Abuja map (fig4.25). This is an important variable used in the modelling. The map represents the time needed to get to Abuja from Suleja.

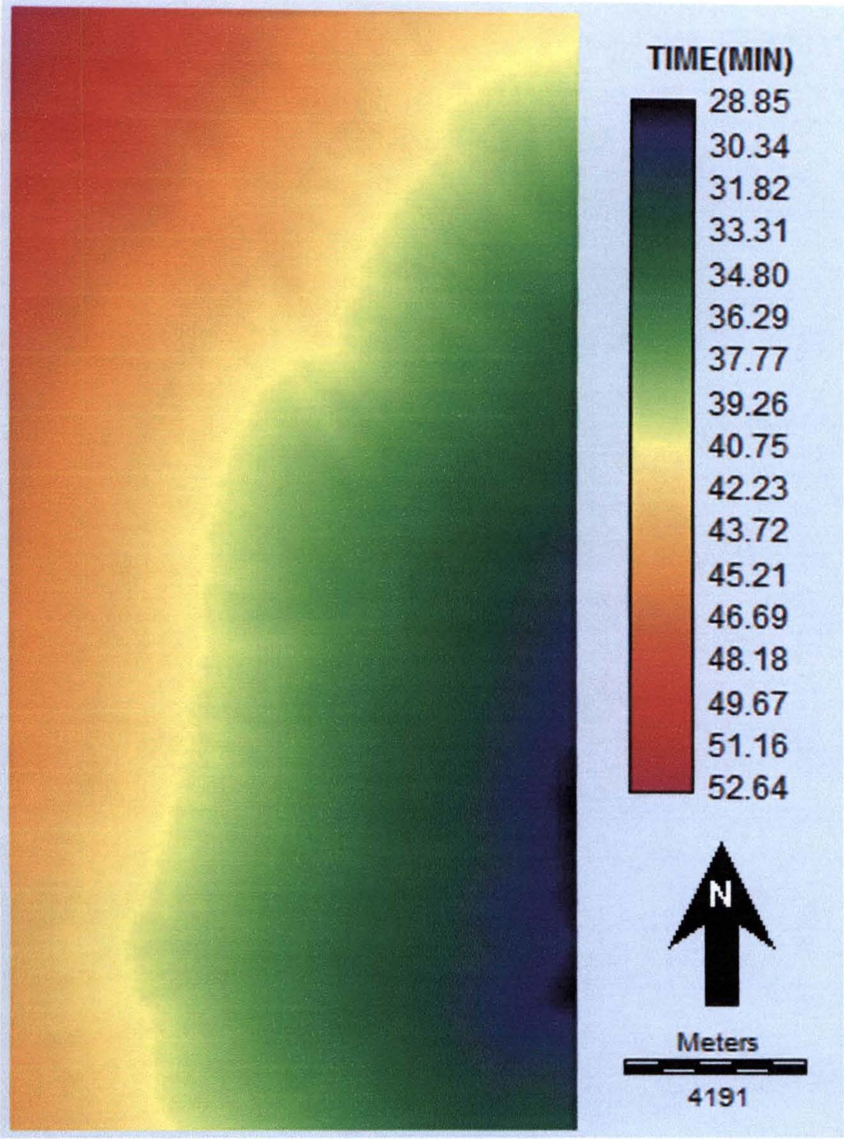


FIGURE 4.25: RASTER MAP OF TIME TO ABUJA

Source: Author's work, 2006.

The DEM generated from Shuttle Radar Topography Mission data (SRTM) was also rasterized and added as a variable (figure 4.26). In this case we tried to show if the height or topography would have any effect on the growth rate and pattern of Suleja town.

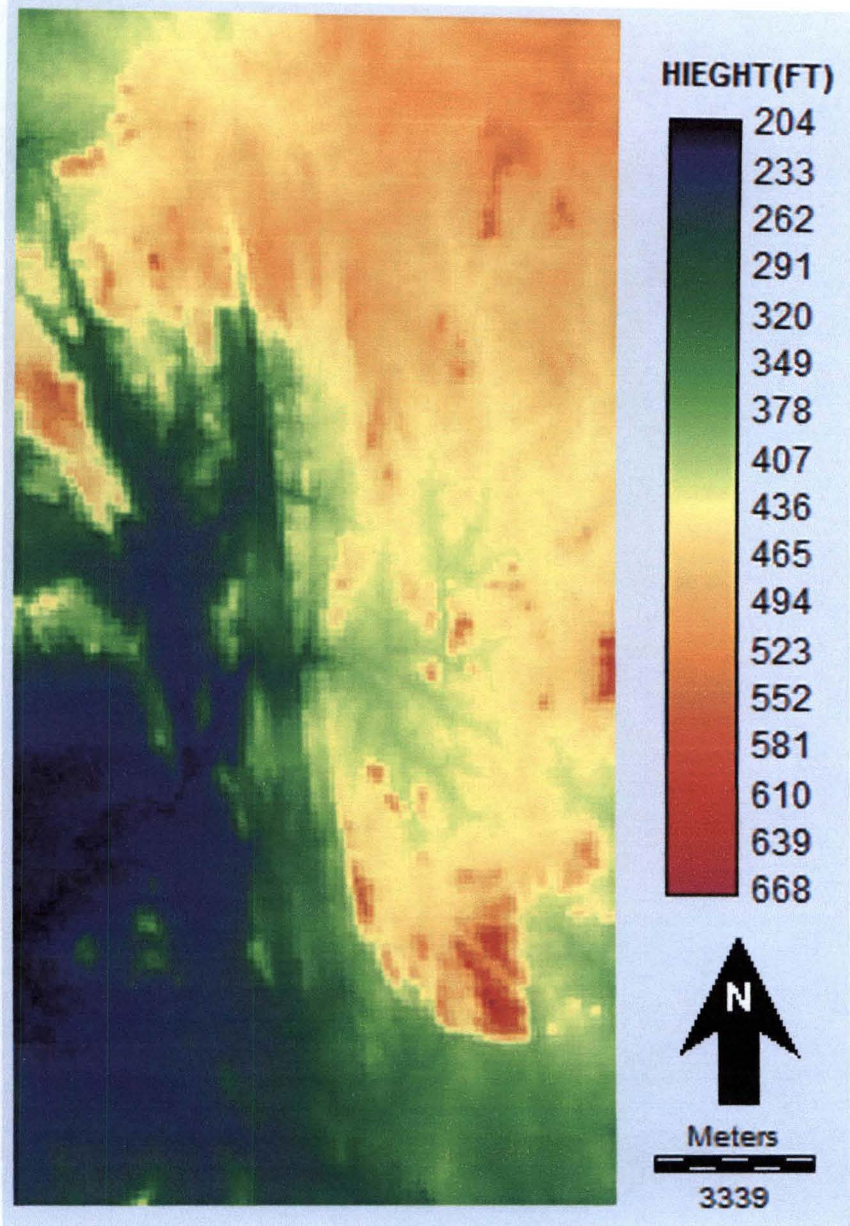


FIGURE 4.26: DEM OF THE STUDY AREA

Source: Author's work, 2006.

The next variable added was the population change over the 14 years. To get the population for the model we subtracted the population figure of 1987 from that of 2001. The difference is what we used in our model. As stated in the methodology, the population surface of all the wards in this study was mapped to get the image used in the model (figure.4.27)

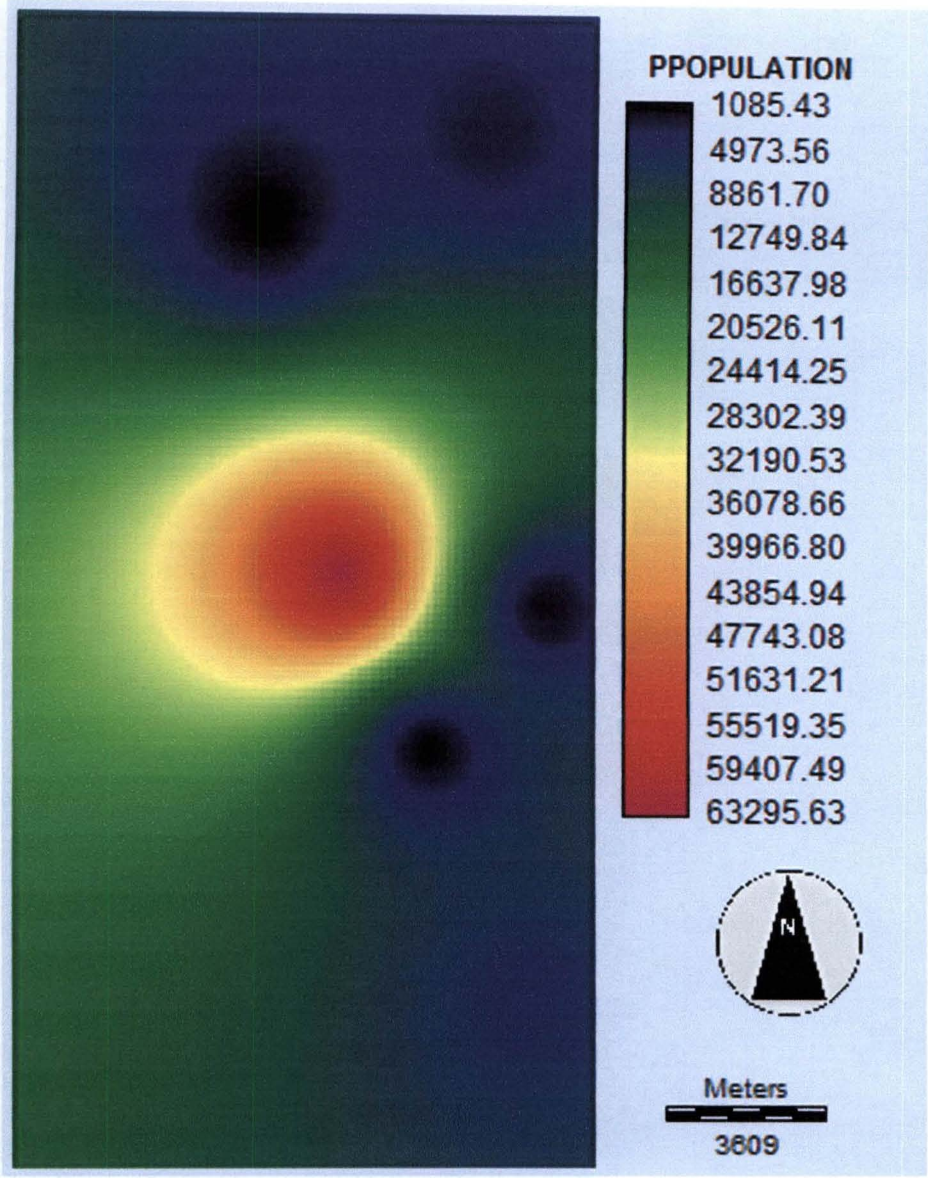


FIGURE 4.27: POPULATION MAP OF THE STUDY AREA

Source: Author's work, 2006.

We mapped the sphere of influence of the localities used in this study by applying distance factor of each locality to the other and we mapped the time it will take to roads (fig. 4.28). From the map it can be seen that all the localities are within 0- 21 minute away from each other.

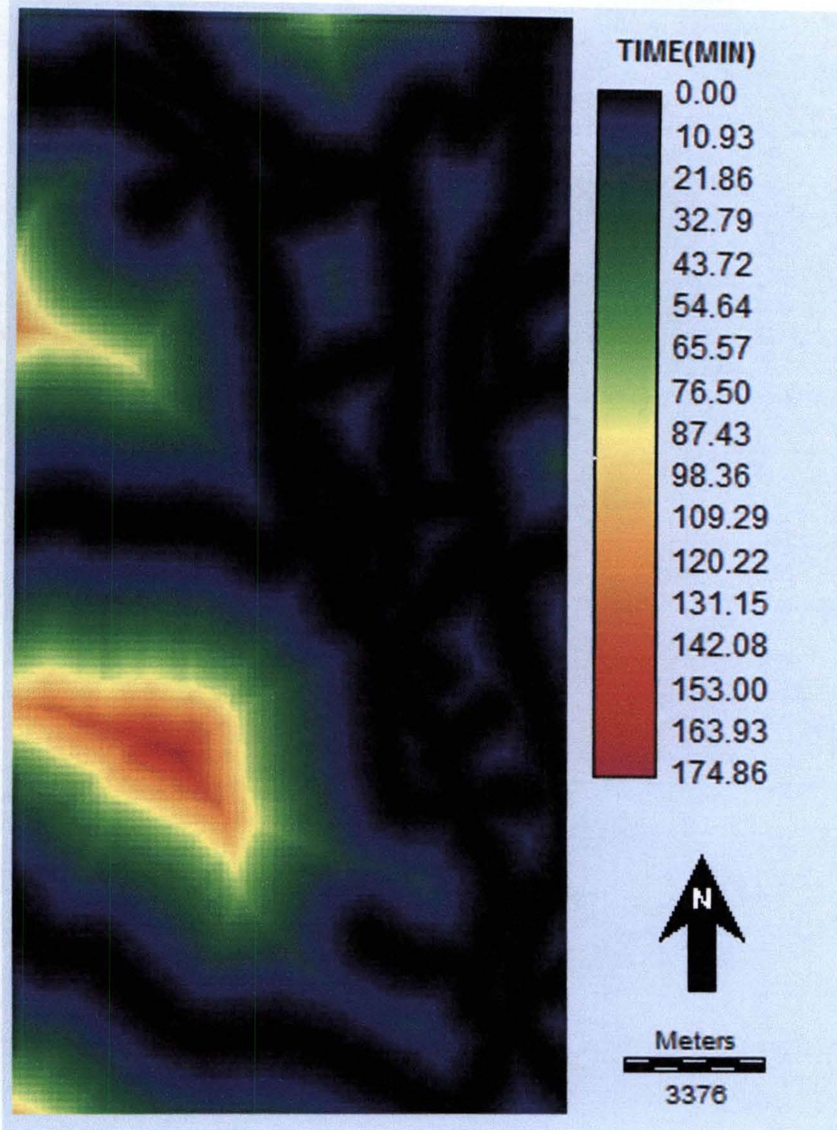


FIGURE 4.28: LOCALITIES SPHERE OF INFLUENCE

Source: Author's work, 2006.

The last variable used in the logistic regression is distance of a place to road. This was obtained from the cost raster surface generated using the frictional elements which is time. The more accessible a place is the more it is likely to change from undeveloped to developed. From our map (figure 4.29) all the localities are within 0 to 6 minutes drive from roads which would have great influence on the growth of these settlements.

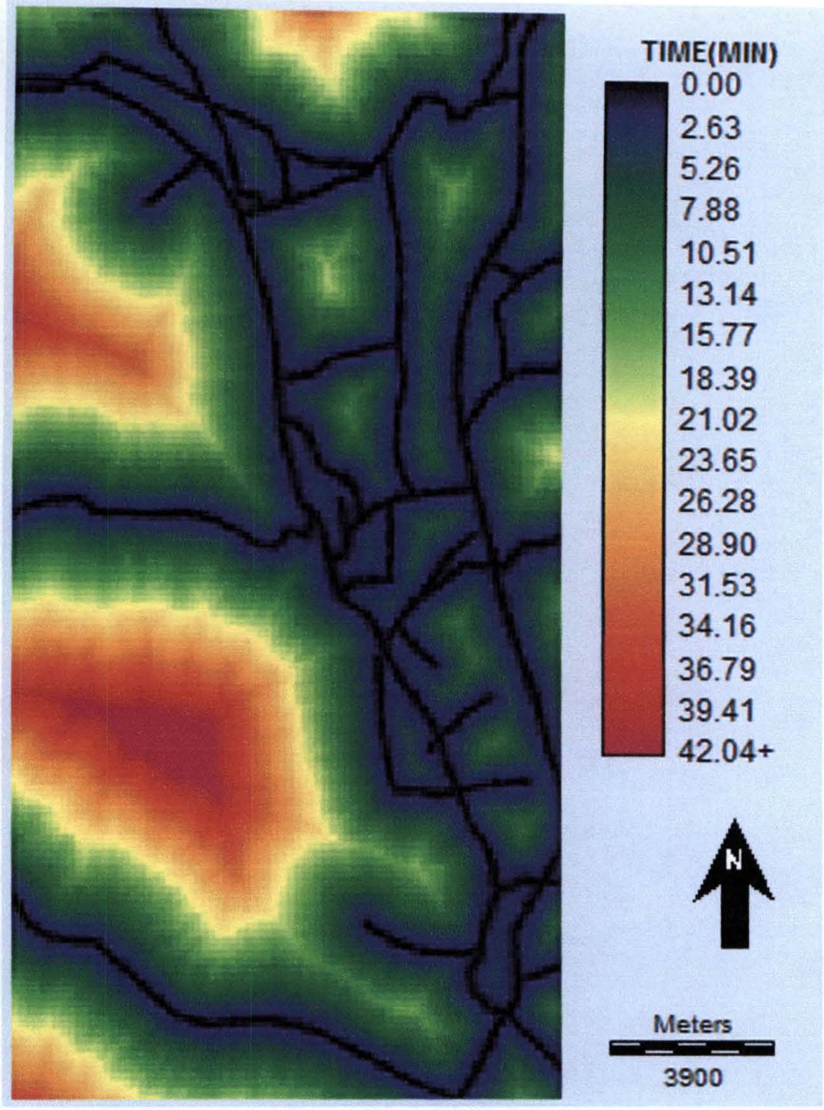


FIGURE 4.29: DISTANCE TO ROAD MAP

Source: Author's work, 2006.

The five variables were used in the logistic regression to ascertain the factors influencing growth of the study area. The principal goal of modelling land use transformation was to uncover the chief determinants of urban land use change and to explore the relationship among the factors of development and urban spatial structure. Idrissi software was used for the regression. Change was used as the dependent variable and the remaining five variables (distance to road, time to Abuja, DEM (topography), population and locality) as independent variables. The dependent variable of logistic regression could be binary or categorical. The independent variables of logistic regression could be a mixture of continuous and categorical variables. Normality assumption is not needed for logistic regression. Hence, logistic regression is advantageous compared to linear regression and log-linear regression. It is an approach to extract the coefficients of explanatory factors from the observation of land use conversion, since urbanization does not normally follow normal assumption and its influential factors are usually a mixture of continuous and categorical variables. Idrissi software is used in the regression analysis to find out the probability of change.

In an attempt to ascertain the level of influence of each and all the independent variables, we first applied the five independent variables in the regression and then applied each of the independent variables to see how they affect land use change. Figure 4.30 is the result of the regression using the five independent variables. This regression was performed using Idrissi software.

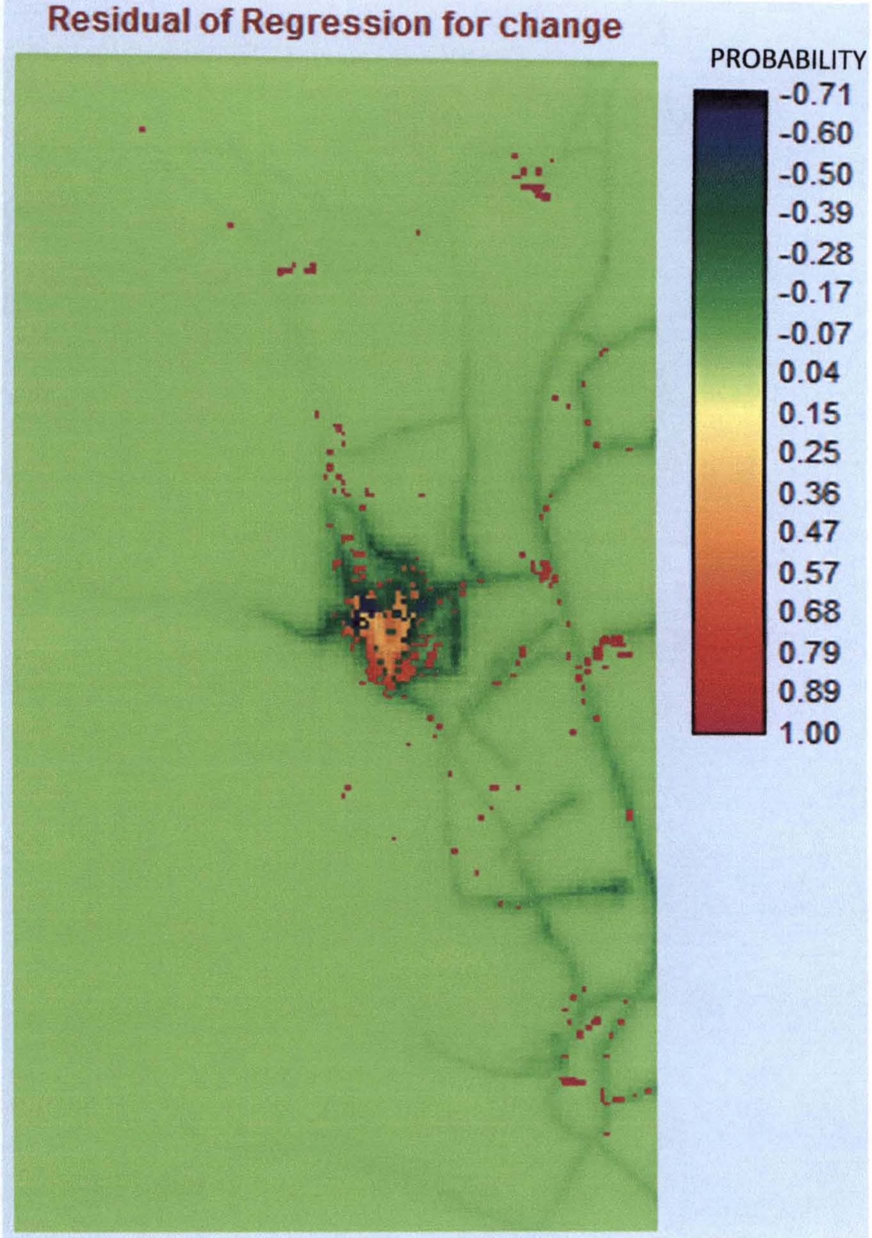


FIGURE 4.30: REGRESSION MAP USING FIVE INDEPENDENT VARIABLES

Source: Author's work, 2006.

The goodness of fit or what is referred to as Relative Operating Characteristic (ROC) of the regression is 0.9452. As stated earlier, ROC of 1 represents a perfect fit while ROC of 0.5 indicates a random fit. The result of the regression 0.9452 shows a very good fit and indicates a strong relationship between the independent variables and land use change.

However, we ran the regression for each of the five independent variables to see how strong and influential each of these variables are on the dependent variable, change. The idea for this was to enable us identifies the variables that influence growth the more so that policy makers can channel efforts towards addressing the negative effect of unplanned growth within the study area.

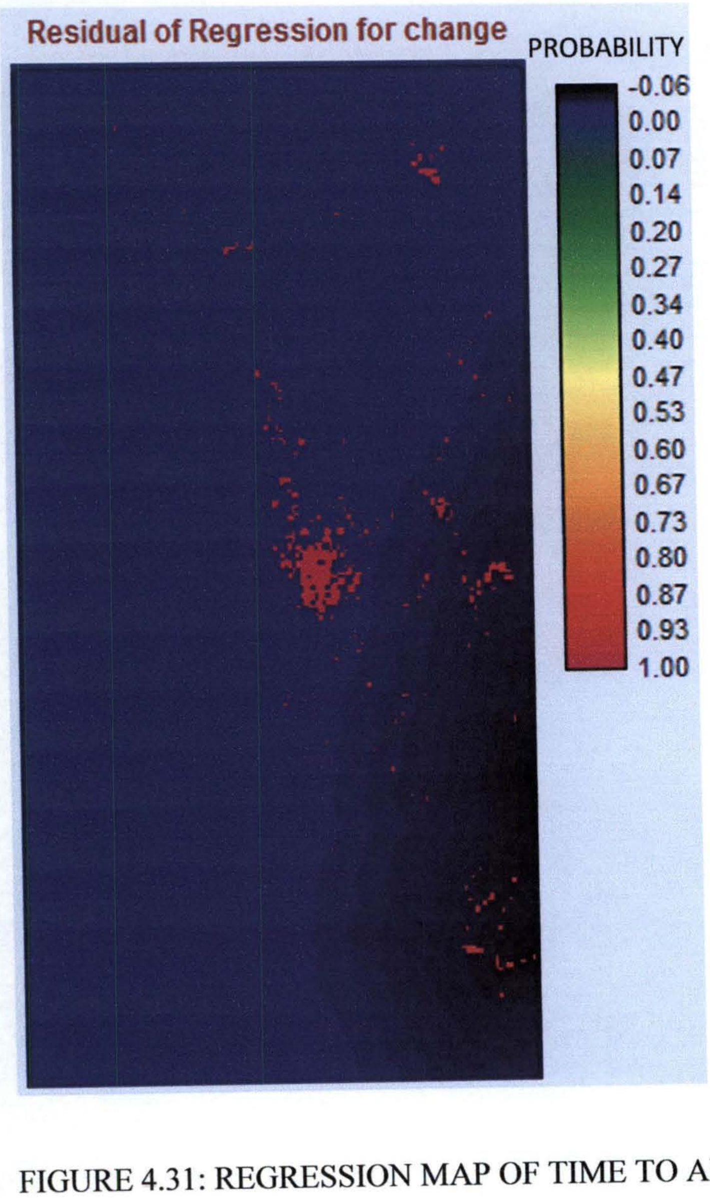


FIGURE 4.31: REGRESSION MAP OF TIME TO ABUJA

Source: Author's work, 2006.

Figure 4.31 is the result of the logistic regression using time to Abuja as the independent variable. The ROC is 0.7401 which is still higher than 0.5 but lower than the

ROC for the combined five independent variables. The implication of this result is that impact of distance from Abuja to Suleja even though very significant is not as strong as when the five variables are combined. This means that there are a combination of factors that influenced the growth of Suleja. We would see the individual contributions of the other four variables based on their ROC.

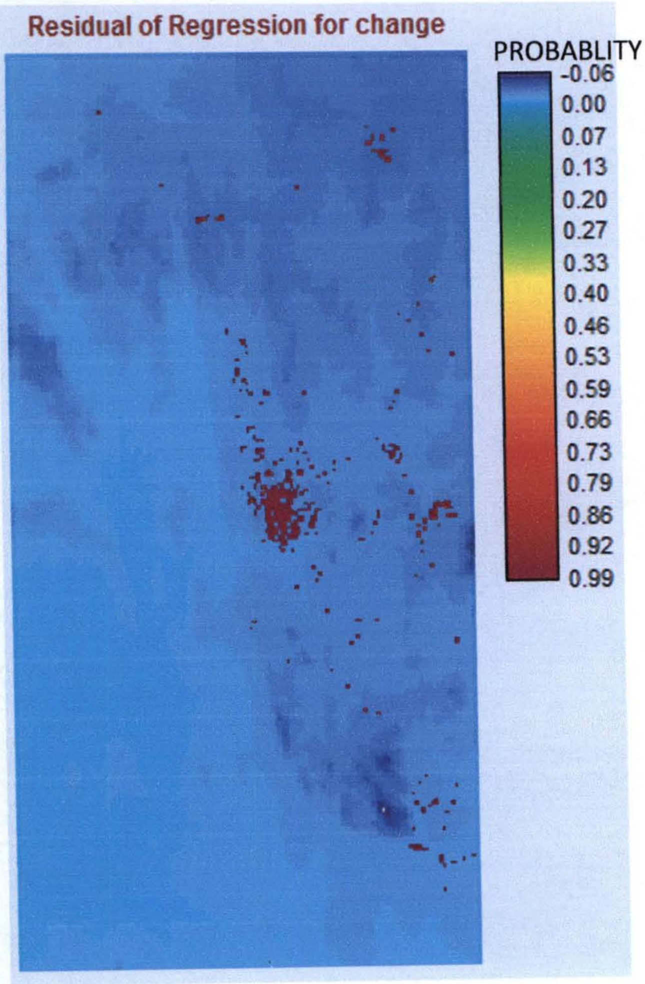


FIGURE.4.32: REGRESSION MAP OF DEM

Source: Author's work, 2006.

Figure 4.32 is image of logistic regression of DEM as the only independent variable. The ROC is 0.5799 which shows that the influence of DEM on development is lower but still above 0.5. It also showed that even though its influence is lower it does not hinder growth. This is true of the study area where people develop on slopes and rugged topography. The result could be attributed to the pressure for developable land by workers in Abuja. It also showed us that we should take serious concern about the planning of not only the relatively flat areas but all areas within the study area.

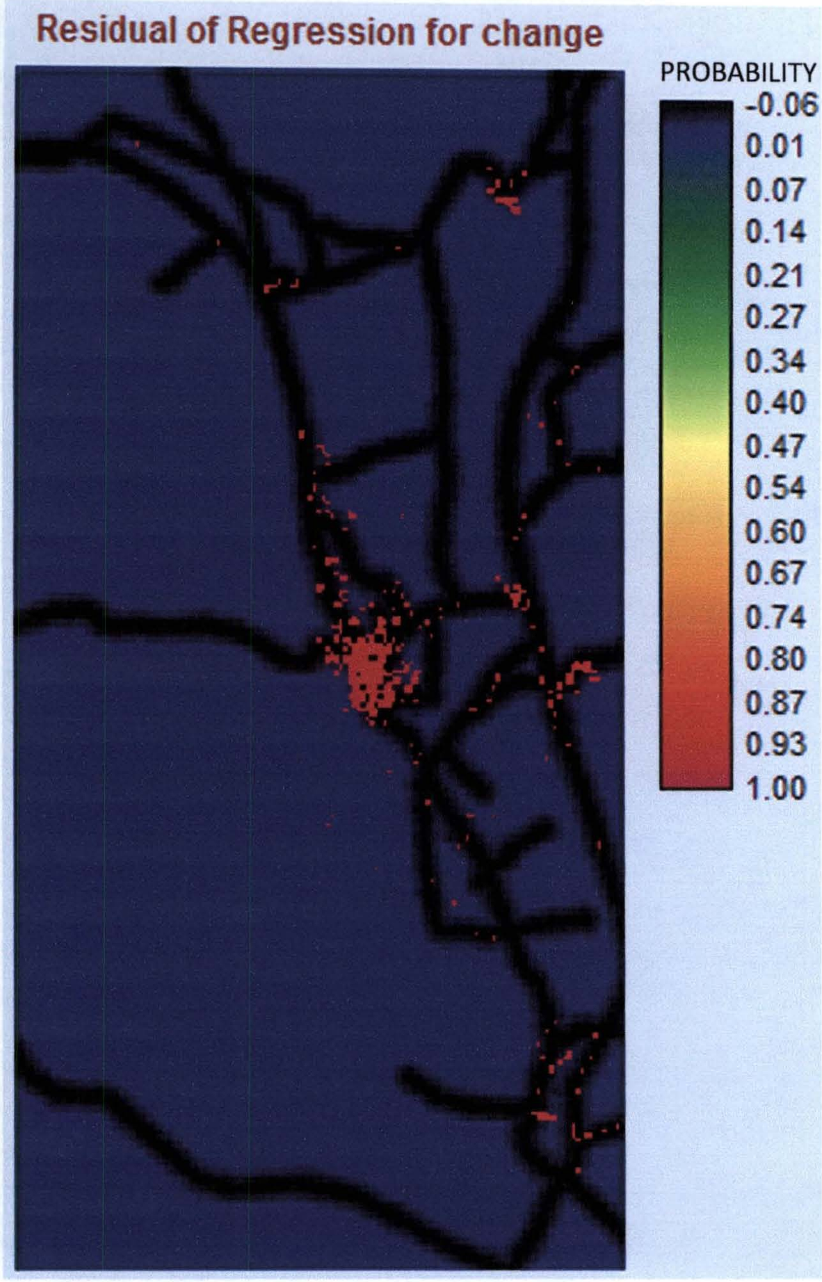


FIGURE 4.33: REGRESSION MAP OF SPHERE OF INFLUECNE OF LOCALTIES

Source: Author's work, 2006.

Figure 4.33 is the regression result for locality influence on growth which is strong looking at the ROC which is 0.8697. This result is still lower than the combined effect of the five independent variables which is 0.9452. However it is high enough to attract attention of policy makers that all the localities are important in influencing growth thus the need for comprehensive planning instead of limiting it to only the town of Suleja.

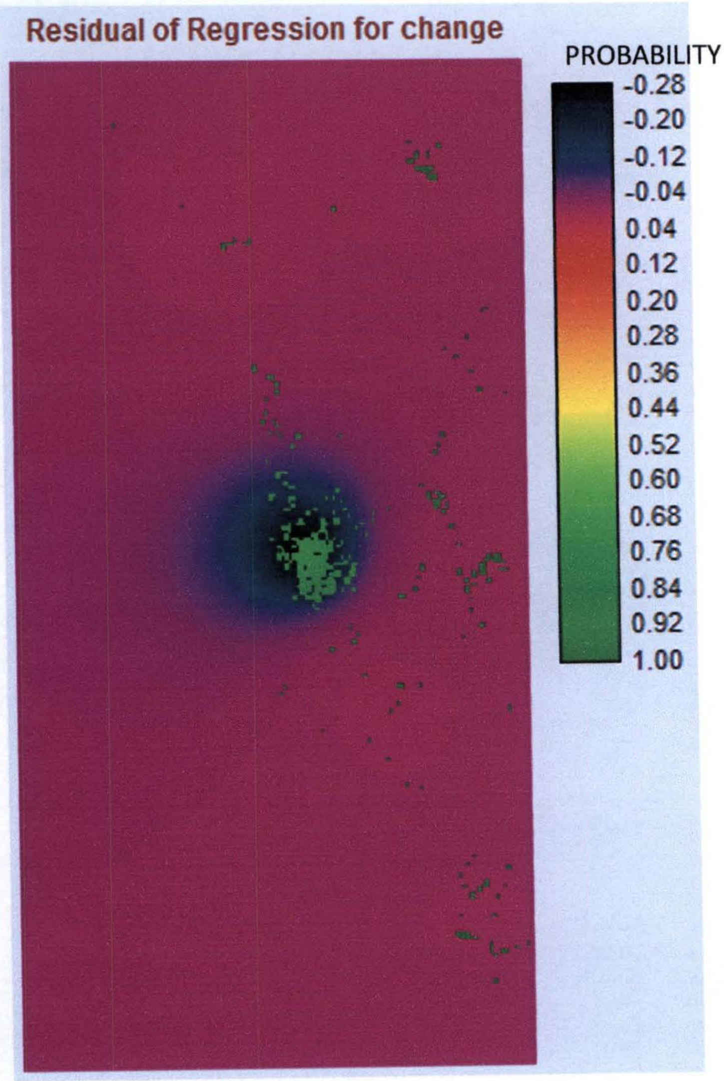


FIGURE 4.34: REGRESSION MAP POPUALTION

Source: Author's work, 2006.

Figure 4.34 is the result of the regression using population difference as the independent variable. The ROC of the regression is 0.6685 which shows that population difference is not as strong as localities. This could be explained from the point of view that we used the annual growth rate of 2.8 % to project 1991 census result instead of using remote sensing estimate. However the ROC of 0.6685 is still very relevant in influencing growth.

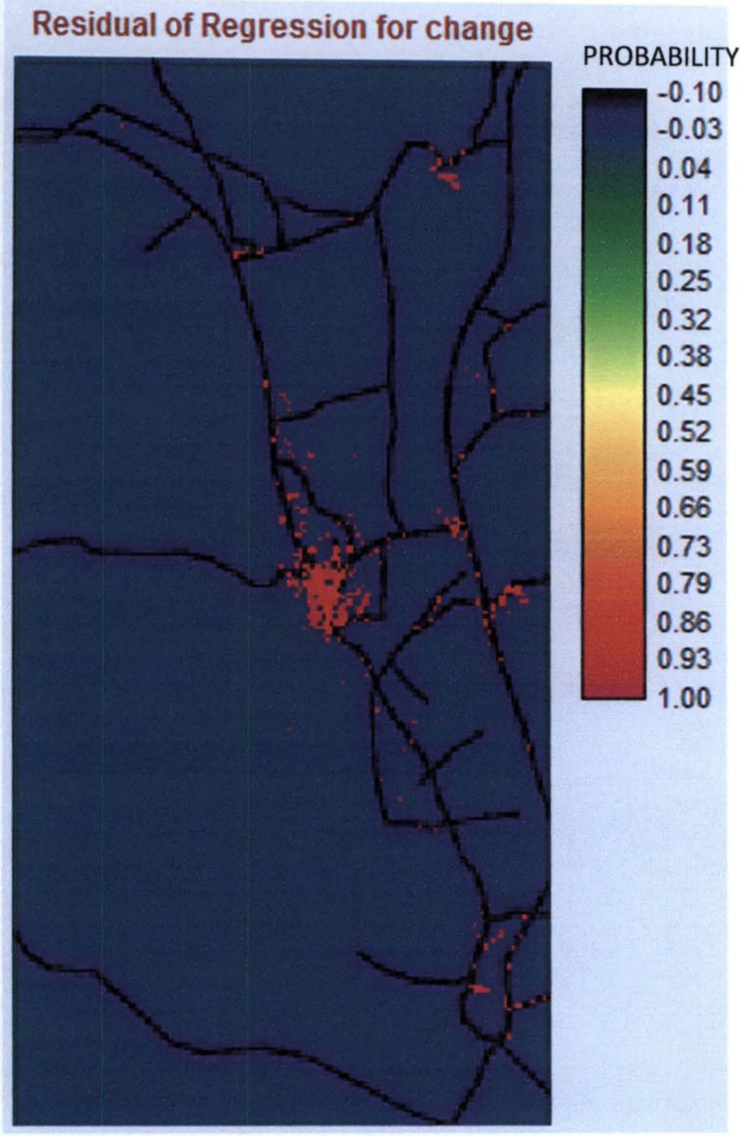


FIGURE 4.35: REGRESSION MAP OF DISTANCE TO ROADS.

Source: Author's work, 2006.

Distance to road is also an important independent variable that affects change in land use. The ROC of the regression is 0.8809 which is reasonably high and very significant shows how this variable can influence settlement growth. The more accessible a place is, the more it is likely to develop. Figure 4.35 is the regression, map of distance to roads.

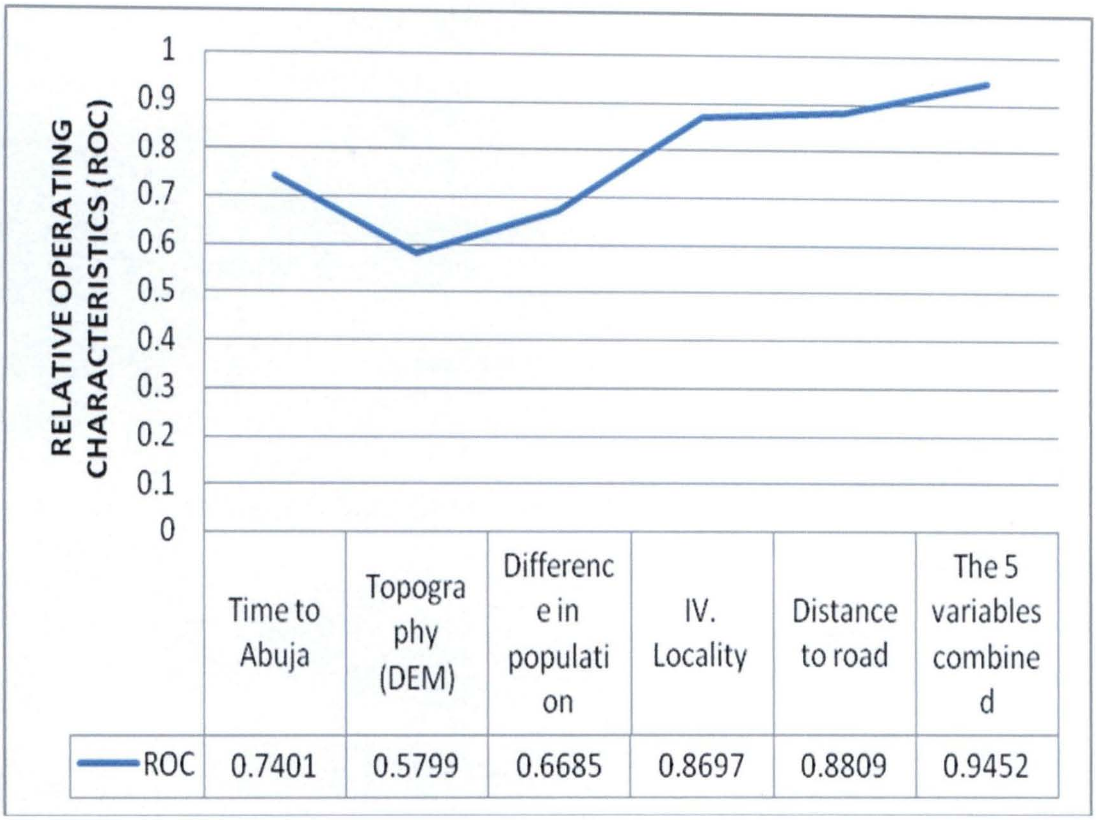


FIGURE 4.36: THE RELATIVE OPERATING CHARACTERISTICS OF THE FIVE INDEPENDENT VARIABLES.
Source: Author's work, 2006.

Figure 4.36 is the ROC of the five independent variables which showed that the ROC of the five variables combined (0.9452) is greater than for any of the variables individually. Figure 4.37 is the map of the probability of change of the study area. The closer a place is to Abuja the more likely it is to change from undeveloped to develop.

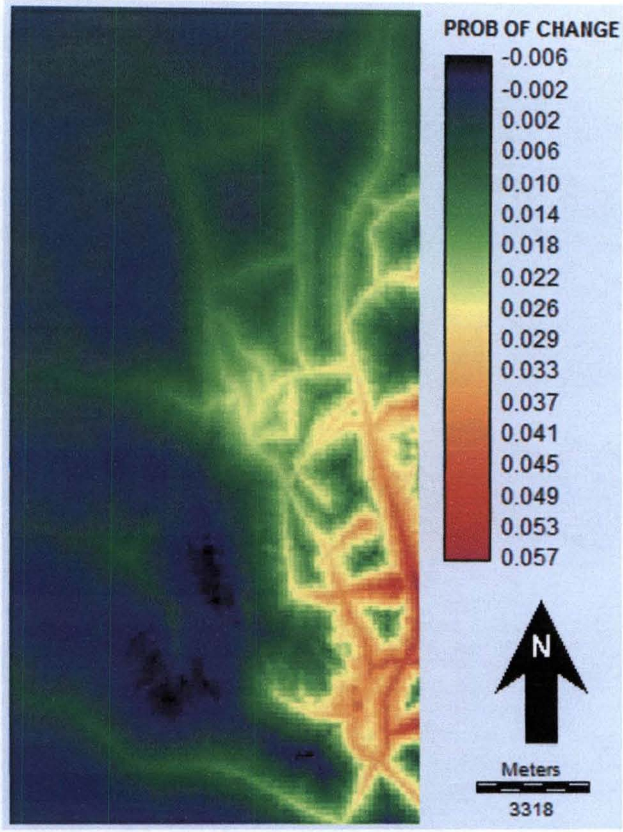


FIGURE 4.37: MAP OF PROBABILTY OF CHANGE IN LAND USE FROM VACANT TO BUILT UP
Source: Author's work, 2006.

4.2.4 RELATIONSHIP BETWEEN LAND USE AND POPULATION.

After the settlement growth assessment using remote sensing the built up area was used to estimate the population. The result was compared with the land use. As discussed in chapter three the equation of Adeniyi was used in the population estimation. The average number of people per square meter was obtained through:.

$$\text{Average number of people} = \frac{\mathbf{115937.04\ sq\ m}}{\mathbf{591\ people}} = \mathbf{44.26\ sq\ m/person}$$

The method used was discussed in chapter three. We used this figure of 44.26 sqm/person to multiply with the built up areas of each of the localities to have the population estimate. The estimate was for both 1987 and 2001. This result was compared with the official projection obtained by using the annual growth rate of 2.8 percent per annum. The estimated figure for

1987 and 2001 were compared with the built up area for 1987 and 2001.The result is presented in tables 4.10 and 4.11.

TABLE 4.10: COMPARISON OF POPULATION ESTIMATE THROUGH REMOTE SENSING WITH PROJECTION USING OFFICIAL GROWTH RATE FOR 1987

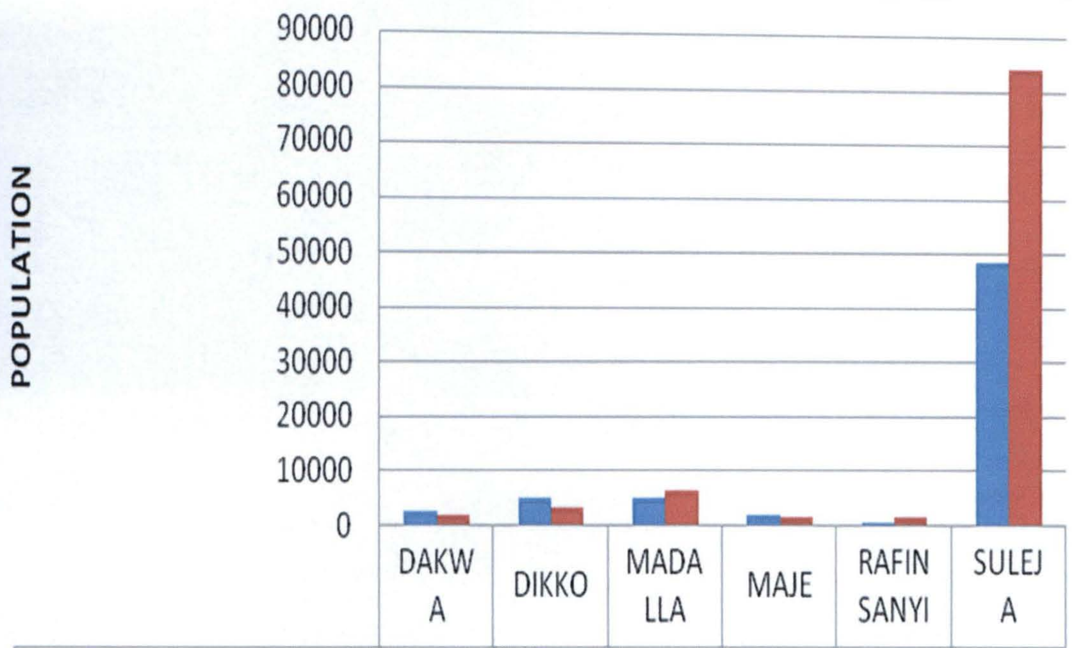
LOCALITIES	**1987 AREA IN KM^2**	**1987 POP. ESTM THROUGH (R/S)**	**1987 ESTIMATE USING OFFICIAL GROWTH RATE**
DAKWA	13.1	2,922	2,188
DIKKO	23.7	5,359	3,468
MADALLA	22.4	5,065	6,698
MAJE	9.5	2,147	1,639
RAFIN SANYI	2.6	589	1,655
SULEJA	215	48,522	84,169
TOTAL	**286**	**64,604**	**99,817**

Source: Author's work, 2006.

TABLE 4.11: COMPARISON OF POPULATION ESTIMATE THROUGH REMOTE SENSING WITH PROJECTION USING OFFICIAL GROWTH RATE FOR 2001

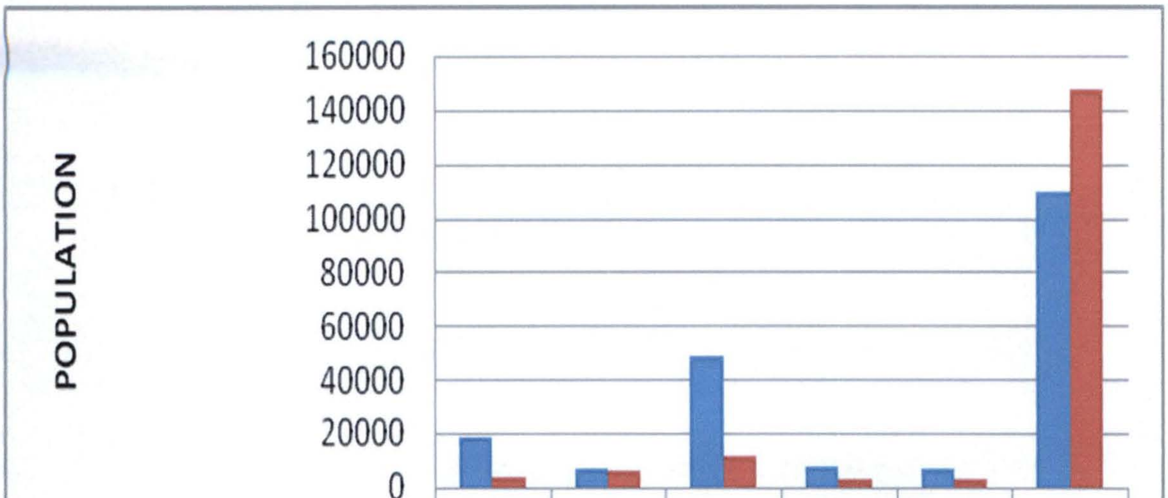
LOCALITIES	**2001 AREA IN KM^2**	**2001 POP. EST THROUGH R/S**	**2001 ESTIMATE USING OFFICIAL GROWTH RATE**
DAKWA	81.9	18,499	3,834
DIKKO	32.2	7,267	6,078
MADALLA	215.4	48,669	11,734
MAJE	35.7	8,074	2,723
RAFIN SANYI	30.9	6,974	2,900
SULEJA	486.9	110,001	147,481
TOTAL	**883**	**199,484**	**174,750**

Source: Author's work, 2006.



	DAKWA	DIKKO	MADALLA	MAJE	RAFIN SANYI	SULEJA
1987 POP. ESTM THROUGH (R/S)	2922	5359	5065	2147	589	48522
1987 ESTIMATE USING OFFICIAL GROWTH RATE	2188	3468	6698	1639	1655	84169

FIGURE 4.38: COMPARING POPULATION OF LOCALITIES THROUGH REMOTE SENSING AND CENSUS ESTIMATE IN 1987
Source: Author's work, 2006.



	DAKWA	DIKKO	MADALLA	MAJE	RAFIN SANYI	SULEJA
2001 POP. EST THROUGH R/S	18499	7267	48669	8074	6974	110001
2001 ESTIMATE USING OFFICIAL GROWTH RATE	3834	6078	11734	2723	2900	147481

FIGURE 4.39: COMPARING POPULATION OF LOCALITIES THROUGH REMOTE SENSING AND CENSUS ESTIMATE IN 2001

Source: Author's work, 2006.

TABLE 4.12: COMPARISON OF GROWTH IN BUILT UP AREA WITH POPULATION BETWEEN 1987 TO 2001

LOCALITIES	**% GROWTH IN BUILT UP AREA BETWEEN 1987 TO 2001**	**% GROWHT IN POPULATION THROUGH REMOTE SENSING ESTMATE BETWEEN 1987 TO 2001**
DAKWA	13.99	14.09
DIKKO	2.21	2.2
MADALLA	17.55	17.54
MAJE	9.92	9.92
RAFIN SANYI	19.34	19.31
SULEJA	6.02	6.02
TOTAL	**8.4**	**8.39**

Source: Author's work, 2006.

TABLE 4.13: POPULATION PROJECTION THROUGH REMOTE SENSING, 1987 TO 2015

LOCALITY	POULATION ESTIMATE 1987	POULATION ESTIMATE 2001	POULATION ESTIMATE 2015
MAJE	2,147	8,074	30,350
SULEJA	48,522	110,001	249,359
MADALLA	5,065	48,669	467,576
DIKKO	5,359	7,267	9,855
RAFIN SANYI	589	6,974	82,596
DAKWA	2,922	18,499	117,116
TOTAL	**64,604**	**199,484**	**616,250**

Source: Author's work, 2006.

4.3 QUESTIONARE SURVEY RESULT.

As earlier stated, questionnaire was administered to answer the research questions, among other things, whether;

I. Residents of Suleja are developing within planned areas

II. Residents of Suleja seek for approval before commencing development

III. The residents of Suleja are not aware of the impact of Abuja on the growth and development of Suleja.

IV. The efforts of government in physical planning are adequate in the study under the prevailing pressure from Abuja.

These were the research question we set out in chapter one

4.3.1 QUESTION ONE (building within layout)

On the question whether people of Suleja build within layout the result showed that most developments are not within layout. We subjected the response to statistical analysis using SPSS software and it shows that most developments are outside planned layout.

TABLE 4.14: STATISTICAL RESULT OF BUILDING WITHIN LAYOUT

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.035	.213		9.557	.000
	D'you own a house of your own?	-.184	.209	-.058	-.882	.379

a. Dependent Variable: Is your dev. within govt layout

SOURCE: SPSS Data analysis output, Author's work, 2006.

With a p-value of 0.379 (Table 4.14), the result of the analysis showed that most buildings are outside planned area. The implication of this is that buildings are not developed within layout thus most developments are carried out outside planned areas thereby creating unplanned development which affects both the quality and physical development of Suleja and environs.

4.3.2: QUESTION TWO (Seeking approval before development)

On the second question whether people seek for approval before development, our findings showed that people built without approval.

TABLE 4.15: STATISTICAL RESULT OF SEEKING BUILDING APPROVAL BEFORE DEVELOPEMENT

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.812	.052		34.984	.000
	LOCATION	-2.38E-02	.018	-.097	-1.340	.182

a. Dependent Variable: D'you obtain approval from planning authority

SOURCE: SPSS Data analysis output, Author's work, 2006.

With a P-value of 0.182 (Table 4.15), the response is that people do not seek for approval before development. The implication of this is that there is no control on the pattern of development in this area. The present situation of the study area could be attributed to this non compliance with physical planning regulations. The rate of non compliance is not uniform across the six localities as table 4.16 shows.

TABLE 4.16: PERCENTAGE OF COMPLIANCE WITH PLANNING REGUALATION ACROSS SULEJA AND ENVIRONS

			LOCATION						
			Suleja	Madalla	Rafin Sanyi	Dukwa	Diko	Maje	Total
D'you obtain approval from planning authority	Yes	Count	20	7	3	8	5	4	47
		% within D'you obtain approval from planning authority	42.6%	14.9%	6.4%	17.0%	10.6%	8.5%	100.0%
		% within LOCATION	18.3%	63.6%	20.0%	26.7%	41.7%	25.0%	24.4%
		% of Total	10.4%	3.6%	1.6%	4.1%	2.6%	2.1%	24.4%
	No	Count	89	4	12	22	7	12	146
		% within D'you obtain approval from planning authority	61.0%	2.7%	8.2%	15.1%	4.8%	8.2%	100.0%
		% within LOCATION	81.7%	36.4%	80.0%	73.3%	58.3%	75.0%	75.6%
		% of Total	46.1%	2.1%	6.2%	11.4%	3.6%	6.2%	75.6%
Total		Count	109	11	15	30	12	16	193
		% within D'you obtain approval from planning authority	56.5%	5.7%	7.8%	15.5%	6.2%	8.3%	100.0%
		% within LOCATION	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	56.5%	5.7%	7.8%	15.5%	6.2%	8.3%	100.0%

SOURCE: SPSS Data analysis output, Author's work, 2006.

With the rate of development going on due to proximity to Abuja and the stringent development control in the federal capital, Niger state government needs to be more concerned with the spatial growth of the study area.

4.3.3 QUESTION THREE (Awareness of the causes of the present problem of Suleja)

The result of our field work showed that people are very much aware of the causes of the expansion of Suleja. Over 90% of the respondents showed that people know the cause of the present situation of Suleja as indicated in the table 4.17.

TABLE 4.17: STATISTICAL ANALYSIS ON PUBLIC AWARENESS OF THE IMPACT OF ABUJA ON THE GROWTH OF SULEJA.

			D'you think the proximity to FCT influences the growth of the town?	
			Yes	Total
Are you living with your family in Suleja	Yes	Count	357	357
		% within Are you living with your family in Suleja	100.0%	100.0%
		% within D'you think the proximity to FCT influences the growth of the town?	98.1%	98.1%
		% of Total	98.1%	98.1%
	No	Count	7	7
		% within Are you living with your family in Suleja	100.0%	100.0%
		% within D'you think the proximity to FCT influences the growth of the town?	1.9%	1.9%
		% of Total	1.9%	1.9%
Total		Count	364	364
		% within Are you living with your family in Suleja	100.0%	100.0%
		% within D'you think the proximity to FCT influences the growth of the town?	100.0%	100.0%
		% of Total	100.0%	100.0%

SOURCE: SPSS Data analysis output, Author's work, 2006.

4.3.4 QUESTION FOUR (Efforts of government in spatial growth of Suleja.)

Master plan: Niger state government has prepared a master plan to guide the overall development of Suleja and environ. Max Lock, a planning firm, prepared this document in 1989 .However, for it to be effective, specific planning schemes must be prepared at specific locations at the right time. Before any layout plan is designed proper acquisition must be carried out. Figure 4.40 is the master plan of Suleja and tables 4.18 and 4.19 are the records of layouts designed and building plans approved between 1976 to 2003.

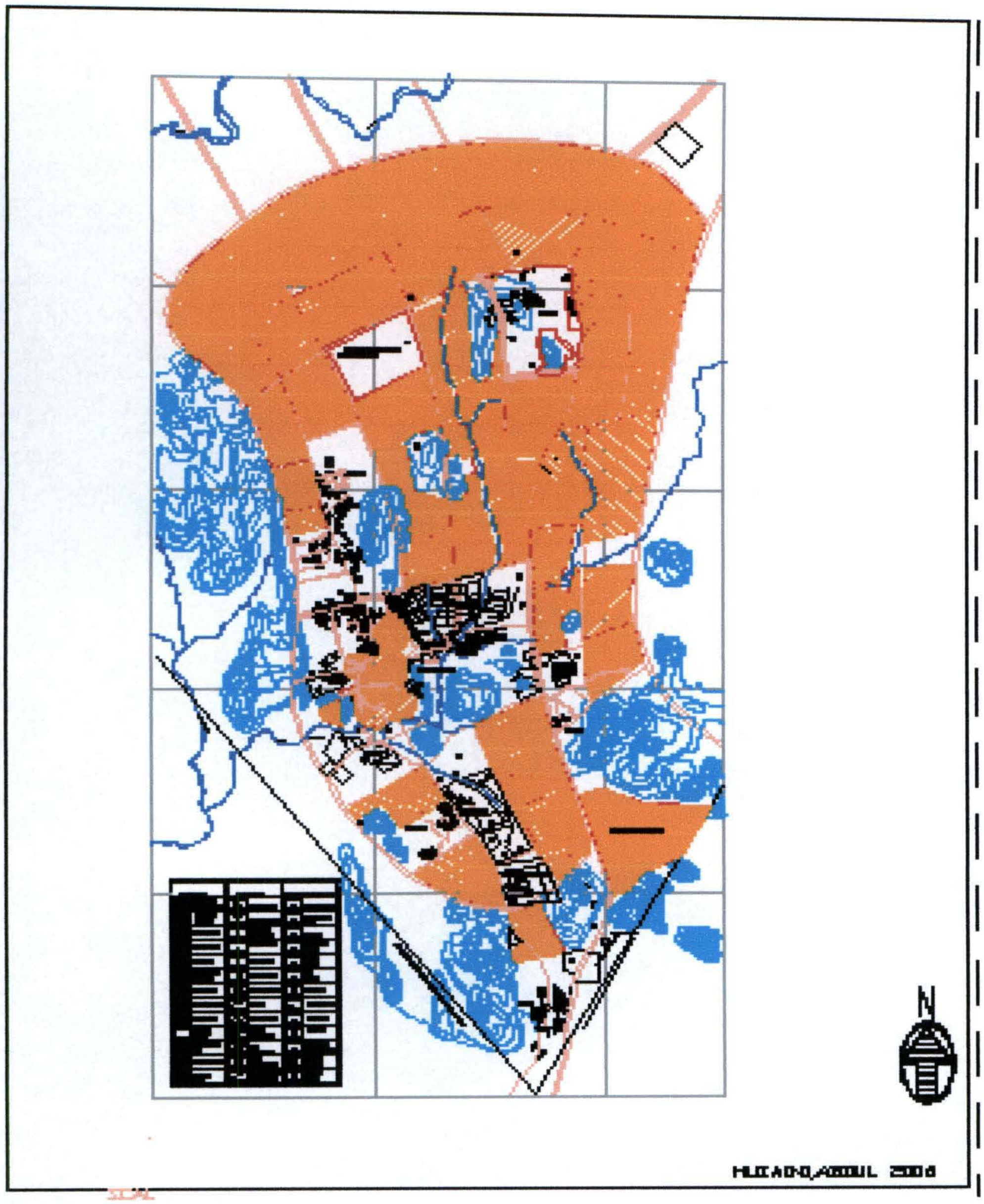


FIGURE 4.40: The SULEJA MASTER PLAN.

SOURCE: SULEJA MASTER PLAN BY MAX lOCK, 1987.

TABLE 4.18: Summary of Layouts Designed from 1978-2003

	Residential	*Commercial/industrial*
Fully develop layout	*5*	*1*
Partially develop	*5*	*1*
Undeveloped layout	*8*	*1*

SOURCE: *Niger State Ministry of Lands, Survey and Town Planning, Area Office, Suleja, 2003.*

Table 4.18 is the record of the various type of layouts officially prepared by Niger state Government and their level of development.

TABLE 4.19: Building plans approved between 1976-2003

PERIOD (YR)	**RESIDENTIAL**	**COMMERCIAL**	**RELIGIOUS**
1978-1998	**1,450**	**450**	**100**
1999-2003	**405**	**55**	**1**
TOTAL	**1,855**	**505**	**101**

SOURCE: *Niger State Urban Development Board, Zonal Office, Suleja (August, 2003)*

Table 4.19 is the record of building plans approved by Niger State Urban Development, Suleja.

CHAPTER FIVE

5.0 DISCUSSIONS, SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The main premise of this study was the analysis of the interactions and impacts of Abuja on the physical development of Suleja. The objectives set out in this work were:

I. To assess land development and formal supply within Suleja urban ,

II. To examine space integration within Suleja and environs through traffic flow

III. To determine land use changes and space convergence within Suleja and environs between 1987 to 2001 and apply quantitative methods for a comparative measurement of long term temporal urban growth of Suleja;

IV. To establish relationship between land use and population.

V. To recommend a strategy for effective monitoring of the growth of Suleja and environs in a sustainable and scientific method.

In this section we discussed objectives I to IV through:

1. Analysis of the official layouts, building permit records of the Government ,
2. Analysis of the traffic count results,
3. Direct application of remote sensing and other forms of secondary data, like traffic and development permits information , to see how the growth of Suleja has been over the period ,
4. Applying empirical methods to see the pattern of this growth and to understand what factors have more influence on the growth of Suleja.

In chapter four we analysed all the data gathered in this study. In that chapter we used these analyses and data to answer both research questions and to test the hypotheses.

1. How can the growth of Suleja be analyzed over the past years,
2. What are the spatial and temporal patterns and processes of Suleja's growth,
3. How effective are government policies and development control in ensuring orderly development?
4. The residents of Suleja are not aware of the impacts of Abuja on the growth and development of Suleja.

5.2 OBJECTIVE ONE: (LAND DEVELOPMENT AND FORMAL LAND SUPPLY)

Orderly development can only be achieved through deliberate planning. The number of layouts designed in the area (Table 4.18) and building permit issued (table 4.19) do not correspond with the reality on the ground. Majority of the people are developing outside planned area and without approval as indicated by table 4.14 and table 4.15. Table 4.16 showed that over 75.6 % of development is outside layouts and without official approval. The distribution varies with location with the highest compliance level of 10.4% in Suleja, followed by Dakwa which has 4.1 %. All other localities are less than 4%. The implication of this development is that the formal land supply is grossly ineffective in directing the pattern of growth which would lead to informal land transfer mostly in unplanned manner and on areas that might not be fit for occupation. The resultant effect is unplanned expansion with all its consequences.

5.3 OBJECTIVE TWO: (SPACE INTEGRATION)

The interaction between Suleja and Abuja is very important in the understanding of the growth pattern and causes of land use change. In this work traffic survey was conducted in strategic areas to find out the volume of traffic. The number of vehicles leaving or entering Suleja from four major points was obtained. The points are;

i. Maje high point (Zuma FM)

ii. Kaduna road junction (Bakin iku)

iii. Madalla town

iv. Abuja – Kaduna road at Madalla.

The count was for both work days and weekend days. This was done so as to see the variation with time of the day .The count was from 6 am to 6pm.

Figure 4.1 is the graph of the traffic count for the first working day. It shows the traffic flows between the hours of 6AM to 6PM. The traffic is heavy along Suleja – Madalla in the morning reaching its peak between 8am to 9am. The traffic drops afterwards till around 4pm when the return trip to Suleja begins.

Figure 4.2 is the second working day traffic count to and from suleja. We expanded the survey points to include other places like Maje and Bakin iku. In Figure 4.1, the traffic pattern is similar rising on all roads to Abuja in the morning and decreasing towards Abuja in the evening but rises on the return trip to Suleja as from 4pm.

Figure 4.3 is the weekend traffic count on the routes to and from Suleja. It shows that the volume of traffic between the time of 7-9 am is lower out of suleja towards Abuja on weekends. This is because most of the people are workers who use the weekends for resting.

From the graphs figs. 4.1 and 4.2, it shows that the traffic volume increased as from 6 am to 9 am towards Abuja and decreases from 3 pm to 6pm while on the opposite direction i.e from Abuja it rises as from 3 pm to 6pm and is at its lowest in the morning. The implication of this is that the function of the traffic is an indication of the role of Suleja as place of residence of workers in the Federal Capital Territory.

Another important indication of the interaction is the rate of change of the land use around Suleja and environs. Figures 4.8 to 4.21 show the growth rate of the various localities. The figures show that areas closer to Abuja grew faster than those farther away. From the figures Madalla (figures 4.20 and 4.21), Rafinsanyi (figures 4.14 and 4.15), Dakwa (figures 4.16 and 4.17) are changing more than areas farther away like Maje and Dikko. Between 1987 and 2001 the built up area in Madalla grew by over 17.55%; Rafinsanyi grew by 19.34 % and Dakwa grew by 13.99 %. However, the old settlements of Suleja and Dikko grew by 6.02% and 2.21% respectively. This is lower than the first three settlements that are on the fringes towards Abuja (Table 4.8).

5.4 OBJECTIVE THREE. (Land use changes and space convergence within Suleja and environs between 1987 to 2001)

Remote sensing as a tool can provide a very excellent opportunity to analyse the spatio-temporal changes and interaction between two or more areas. This is due to its synoptic coverage and temporal capabilities. We employed this tool to analyse the type and intensity of land use change in Suleja. As already discussed above, Suleja and environs experienced a rapid growth between 1987 to 2001. These changes are more obvious in areas along the road and those close to Abuja.

Apart from changes in built up areas, there was equally a change in the arable land from 1987 to 2001.Table 4.7 showed that all the localities experienced a decrease in arable land. Madalla, which is the closest to Abuja experienced a decrease of -3.67 % of its arable land to settlement expansion while Rafinsanyi had a decrease of -1.67 %. The locality with the least decrease in arable land and the farthest from Abuja was Maje which recorded a decrease of -1.53%. The implication of this decrease in arable land is that the main occupation of the people, farming, is threatened because as the arable lands continue to decrease so also would be the farmlands and farming activities in the area. This transition from arable to built up is very important to this study as it indicates the rate of conversion of land from non built up to built up which is the focus of the research. This could result in unemployment and other related problems. The rush by the natives to transfer their lands to people who would ultimately develop it might result in social crises arising from land disputes.

It is important to emphasise that the old towns of Suleja and Dikko experienced a relatively slower growth in the built up than the new settlements like Dakwa, Rafinsanyi and Madalla. The Land use classification results in figures 4.8 to 4.21 showed that between 1987 to 2001 (14 years) the rate of change of Madalla (figures 4.20 and 4.21) , Rafinsanyi(figures 4.14 and 4.15), Dakwa (figures 4.16 and 4.17) and Maje (figures 4.12 and 4.13) was more than double while Suleja (figures 4.10 and 4.11) and Dikko (figures 4.18 and 4.19) , which are old and traditional settlements grew only by about half over the same period.

This study has shown that as one gets closer to Abuja the rate of conversion of land from arable/vegetation to built-up increased. To be able to establish the facts of this growth, the independent variables were identified to show how each and all contribute to the change in built up area of Suleja and environs. For the assessment to be statistically significant, the Relative Operating Characteristics (ROC) must not be less than 0.5.

The concern of this study was on the built-up area and the factors that influenced the transition from non-built up to built up. The classified images of the entire study area of 1987 and 2001 (figures 4.8 and 4.9) served as the bases for the assessment of the change. The built-up image of 1987 was subtracted from the 2001 image to obtain the change in land use from undeveloped to built-up. The resultant image served as the change map (figure 4.24) which is the dependent variable input in the model. We wanted to know the combined effects of the independent variables of (1) Time to Abuja ,figure 4.25 (2)Topography (DEM), figure 4.26 (3)population, figure 4.27(4) Distance from locality ,figure 4.28 and (5) Distance to Road, figure 4.29.

The goodness of fit or what is referred to as Relative Operating Characteristic (ROC) of the above regression using the idrissi land change modeller was 0.9452. This shows a very good fit and indicates a strong relationship between the independent variables and land use change.

However, to be able to know which of the independent variables is more effective in influencing changes in land use, the regression was performed for each of the five independent variables against the dependent variable, change. The idea for this was to isolate the variables that influenced land use conversion more so that policy makers can channel efforts towards addressing the negative effects of unplanned growth within the study area.

Figure 4.31 is the result of the logistic regression using time to Abuja as the independent variable. The ROC is 0.7401 which is still higher than 0.5 but lower than the ROC for the combined five independent variables. The implication of this result is that impact of distance from Abuja to Suleja even though very significant is not as strong as when the five variables are combined. This means that there is a combination of factors that influenced the growth of Suleja.

Figure 4.32 is image of logistic regression of Topography (DEM) as the only independent variable. The ROC is 0.5799 which shows that the influence of DEM on development is lower but still above 0.5. It also showed that even though its influence is lower it does not hinder growth. This is true of the study area where people develop on slopes and rugged topography. The result could be attributed to the pressure for developable land by people. It also showed us that we should take serious concern about the planning of not only the relatively flat areas but all areas within the study area.

Figure 4.33 is the regression result for locality influence on growth which is strong looking at the ROC which is 0.8697. This result is still lower than the combined effects of the five independent variables which is 0.9452. However it is high enough to attract attention of policy makers that all the localities are important in influencing growth, thus the need for comprehensive planning instead of limiting it to only the town of Suleja.

Figure 4.34 is the result of the regression using population difference as our independent variable. The ROC of the regression is 0.6685 which shows that population difference is not as strong as localities. This could be explained from the point of view that we used the official 1991 census result and projecting it using the official growth rate of 2.8 instead of using remote sensing estimate. However the ROC of 0.6685 is still very relevant in influencing growth.

Distance to road, figure 4.35, is also an important independent variable that affects change in land use. The ROC of the regression is 0.8809 which is reasonably high and very significant and shows how this variable can influence settlement growth. The more accessible a place is, the more it is likely to develop.

From the above it is shown that the combined effects of the five independent variables are stronger (ROC 0.9452) than for individual variables which range from 0.8809 for distance to road to the lowest which is 0.5799 for topography.

From the analyses it was found out that the areas experiencing fastest growth are those along the major roads outside the traditional area. These are areas where government presence is minimal and land is acquired traditionally without planning. The implication of this is development without approval which usually leads to haphazard development. Table 4.18 shows the number of building plans approved by the planning authority within the period under review which shows the level of compliance with the existing planning regulations that stipulates that all developers must obtain permit before commencing any physical improvement of their land.

To be able to model the probability of a place changing from undeveloped to developed the conditional probability equation 3.3 below was used. Using idrissi map calculator the probability map of a land use changing from undeveloped to developed was generated.

$$\hat{p}(y = 1|X) = \frac{\exp^{(\hat{\beta}_0 + \Sigma_{i=1}^{n} \hat{\beta}_i x_i)}}{1 + \exp^{(\hat{\beta}_0 + \Sigma_{i=1}^{n} \hat{\beta}_i x_i)}}$$

This operation was performed using the maps generated as independent variables. The resultant image figure 4.51 shows how the probability decreases as one move away from the direction of Abuja. Based on the result one can conclude that settlements closer to Abuja would experience more growth and change than those further away. The probability of change decreases from 0.05 to as low as -0.006 as one move towards Minna.

5.5. OBJECTIVE FOUR (RELATIONSHIP BETWEEN LAND USE CHANGE AND POPULATION).

Based on the estimates from remote sensing using equation 3, Suleja had a very high increase in population between 1987 to 2001. On the other hand the population increase between 1987 to 2001 using the 1991 census figure as a base and 2.8 % as the annual growth rate we found that there was minimal change in population . From the result in tables

4.10 and 4.11, the population figure for Madalla in 1987 through remote sensing estimate was about 5,065 while using the 1991 census as a base and 2.8% as the growth rate the population was 6,698. The difference between the two dates was about 1,000 people.

On the other hand, the population figure for Madalla in 2001 through remote sensing estimate and 1991 census projection was 48,669 and 11,734 respectively. The growth in population of Madalla through remote sensing estimates between 1987 to 2001 was 17.54 percent (table 4.12). This follows a similar pattern with the growth in built up area of Madalla which grew from 22.4 Sq/km in 1987 to 215.4 Sq/km in 2001 (17.55%).

On the other hand, the population growth of Suleja town in 1987 based on remote sensing estimate was 48,522 while using the official growth rate of 2.8 % it was 84,169. It shows that the official projection was higher than the remote sensing estimate in 1987. The 2001 estimate through remote sensing was 110,001 while through the official projection it was 147,481. Comparing the figures on tables 4.10 and 4.11, it is clear that in the case of Suleja the rate of growth in population was higher through official estimate. This could be due to the fact that the traditional settlement had already grown and so there was not much change that could be shown using remote sensing. This shows some of the limitations of the use of remote sensing in highly dense and developed area. Out of all the six localities used, it was only the figure for Suleja that was higher through official estimate in 2001. All other localities had figures that were higher through remote sensing estimate when compared with official estimate. This growth in population followed similar patterns with growth in built up areas over the same period (table 4.12). By adopting this method, the government can, from time to time, compare the changes in built up area with population to plan for critical infrastructure and facilities since census taking in Nigeria is not as regular as it should be.

The study also projected the built up area change and population up to 2014 so as to give a guide to the trend. Table 4.9 shows the projected increase in built up area by 2014. Maje that was 9.5 sq/km in 1987, grew to 35.7sq/km in 2001 and it is projected to grow to 134.9sq/km by the year 2014. Suleja was 214.8sq/km in 1987 but grew to 486.9 sq/km in 2001 and is projected to 1103.75 sq/km by the year 2014. Madalla on the other hand was 22.4 sq/km in 1987; it grew to 215.4 sq/km in 2001 and is projected to grow to 2071 sq/km by 2014. This means that Madalla will be larger than the Suleja town by 2014. Dikko was 23.7 sq/km in 1987 and is projected to grow to 43.75 sq/km by 2014. Rafinsanyi was 2.6sq/km in 1987 and is projected to grow to 367.2 sq/km in 2014. Dakwa was 13.1 sq/km in 1987 but is projected to grow to 512.18 sq/km in 2014. From the tables it very clear that the growth rate varies and follow similar pattern with the previous analysis where accessibility and proximity to Abuja influenced the growth in built up area.

Similar pattern of growth is exhibited with the population of the study area. Table 4.13 is the projected population of the study area through remote sensing estimate. Maje was 2,147 people in 1987 but is projected to grow to 30,350 by the year 2014. Suleja was 48,522 in 1987 and is estimated to grow to 249,359 by the year 2014. Madalla was 5,065 in 1987, and is estimated to grow to 467,576 by the year 2014. Dikko was 5,359 in 1987 and is estimated to grow to 9,855 by 2014. Rafinsanyi was 589 in 1987 and is estimated to grow to 82,596 by the year 2014. Dakwa was 2,922 in 1987 and is estimated to grow to 117,114 by the year 2014. The implication of this is that as long as there is increase in built up area, there is going to be increase in population. Similar factors of accessibility and proximity to Abuja influence the population increase.

The hypotheses set out for the study were;

1- There is no statistical relationship between distance from Abuja and growth.

2- There is no statistical relationship between Distance from road and rate of growth of Suleja

3- There is no statistical relationship between population and rate of expansion of Suleja.

The need to test these hypotheses was focal to the main aim of the study. The Rate of growth of Suleja had for long been attributed to its proximity to Abuja. However there was very little empirical work to ascertain the variables that influence this growth based on the proximity. By testing these hypotheses we would be able to establish which factors are stronger in influencing the growth of Suleja.

The research hypotheses were tested statistically using the result of the regression. As earlier mentioned the Relative Operating Characteristics (R.O.C) compares observed values that are binary data over the whole range of predicted probabilities. Figure 4.36 is the graph of the ROC for all the independent variables used in the logistic regression. From the graph one can see that the effect of the independent variables is more when treated collectively than individually. The distance to Abuja and distance to road individually had ROC of 0.7401 and 0.8809 respectively. This implies that the closer a parcel of land is to the access road the more likely it is to develop. However the combined effects of the five variables is more effective in bringing change in land use as depicted by the ROC of the regression of the five independent variables (0.9452).

There was also a strong relationship between expansion in built up area and population. Using remote sensing estimate it was found that there is a close relationship between increases in built up area with increase in population. Table 4.12 showed that Madalla, Dakwa and Rafinsanyi grew in built up area by more than 14 % between 1987 to 2001. On the other hand, using remote sensing to estimate population growth, these three localities experienced an increase in population similar to the increase in built up area. From table 4.10, Madalla in 1987 was estimated to have a population of about 5,065 people and in

2001 the population rose to 48,669. On the other hand, Rafinsanyi was estimated to have a population of about 589 in 1987 but grew to 6,974 in 2001. The two localities experienced an increase in the built up area from 22.4 Sq/km in 1987 to 215.4 Sq/km (17.54%) in 2001 for Madalla and 2.6 Sq/km to 30.9 Sq/km (19.31%) in 2001 for Rafinsanyi respectively. This therefore showed that there is a strong relationship between increase in built up area with population.

Other research questions set out in chapter one were as follows:

I. Are the residents of Suleja building within planned areas?

II. Are residents of Suleja seeking approval before commencing developments?

III. Is the effort of government in physical planning adequate under the prevailing pressures from Abuja?

These are very critical in providing solution to the physical planning challenges associated with fast growing settlements like Suleja. To address this, the result of the questionnaire survey and data obtained from Niger state Government were used.

Unplanned expansion of settlement is always associated with problems. It is in this regard that governments establish organs to control development. In Suleja zone there is the Niger State Urban Development Board which is charged with the responsibility of enforcing development control laws and to issue permits to any developer within the area. Based on the question on building within planned area, the result of the analysis in table 4.14 showed that most of the developments are outside planned are. With a p-value of 0.379, the result of the analysis showed that most buildings are outside planned area. The titles over most of these lands are obtained from the natives which indicate unofficial transactions. From the records of the ministry there are a total of 21 layouts designed by the government as indicated in table 4.18 and out of these layouts only about 12 were properly acquired and compensated for. Most of the layouts are concentrated in the main town of Suleja while the fringe areas like

Madalla, Dakwa, and Rafinsanyi are left to grow organically which has a long term implication.

The second question was on building with approval. The results of the analysis in table 4.15 showed that majority of the people do not seek for approval from the government before commencing development. With a P-value of 0.182, the response was that people do not seek for approval before development. The implication of this is that there is no control on the pattern of development in this area. The present situation could be attributed to this non compliance with physical planning regulations. The rate of non compliance is not uniform across the six localities as table 4.16 showed. The total compliance level for the whole study area stood at 24.4% while the rest do not consult the authority before development. Out of this 24.4%, only Suleja had 10.4% which is the highest while the fastest growing area, Rafinsanyi accounted for only 1.6% which is the lowest. Madalla accounted for 3.6%, Dakwa 4.1%, Maje 2.1% and Dikko 2.6 %. The 4.1 % compliance recorded in Dakwa is attributable to the fact that there is a resettlement layout within the area.

The implication of the above result is that these areas would continue to grow in an unplanned manner which is inimical to any meaningful development and would make delivery of government facilities and services very difficult if not impossible. The long run consequence is emergence of slums that would reduce the efficiency of the environment and the people.

The result of the questionnaire survey also showed that the people of the area are aware of the fact that the rapid growth of their settlement is as a result of its proximity to Abuja. Table 4.17 indicates that over 98 % of the respondents agree that the growth of their settlement is attributable to its proximity to Abuja.

On the effort of government in planning in Suleja and environs, the result of the study showed that it is not adequate going by the rate of development. Table 4.18 showed that between 1978 to 2003 twenty one layouts were designed. Out of this number only 12 numbers are fully compensated for. The distribution of this layout is not even with nearly all the layouts concentrated in the main town leaving the fringe areas to grow on their own. Secondly the master plan of Suleja prepared in 1987 (figure 4.54) has not been implemented according to its provision and is due for a review. This is yet to be done. Thirdly, the development control activities of the State Urban Planning Board are not being felt in the fringe areas due to logistic problems and manpower shortages. The record of the Board in table 4.19 showed that between 1976 to 2003 the total number of building plans approved was 2,461 with 1,855 plans for residential,505 plans for commercial and 101plans for religious. This figure is not reflective of the rate of construction work going on within Suleja and environs. One striking result is the religious use which showed that between 1978 to 2008 the Board approved 100 plans for religious use while between 1999 to 2003 the Board approved only one for religious use. The explanation for this could be that the only religious groups that applied for approval were the churches and between 1999 to 2003 when the heat of sharia law was on, most churches felt that it would be difficult to get approval.

5.6 SUMMARY OF FINDINGS:

In summarising this work, we have tried to follow the objectives one after the other.

5.6.1 INTERACTION BETWEEN ABUJA AND SULEJA.

The study showed that there is a very high level of interactions between Suleja and Abuja. This can be seen in the traffic volume within time of the day and days of the week. From the work we have seen that there is a very high traffic volume between the hours of 6am to 11 am on workings days from Suleja towards Abuja. The traffic volume was also very high from Abuja to Suleja from 1-6 pm. This clearly showed that there are many people who reside in Suleja but work in Abuja. For instance the traffic into Suleja on working days from all the major entry points ranges from 148 to as high as 601 between the hours of 6am – 11am. This rises from as low as 209 to 717 between the hours of 1 pm to 6 pm. On weekends the traffic into Suleja from all routes ranges from as low as 48 vehicles to 405 vehicles between 6am to 11am and on the other end between 1pm to 6pm the figure for weekends ranges from 166 to 503.

On the other hand, the figure for outbound vehicles from Suleja on all routes on working days ranges from 233 to 936 between 6am and to 11 am and 166 to 503 between

1pm – 6 pm. On weekends it ranges from as low as 47 to 380 between 6am – 11am and 123 to 562 from 1pm – 6pm. It is important to note that the numbers of vehicles on both weekends and work days is higher on Madalla axis. This shows the importance of Madalla as the gate way to and from Abuja.

5.6.2 EXISTING PATTERN OF GROWTH OF SULEJA AND ENVIRONS.

From the analysis of Land Sat images of the area of 1987 and 2001 it showed that the growth of Suleja and environs varies with their distance from Abuja. Madalla, Rafin-sanyi and Dakwa which are 33km, 44km and 41km respectively had higher rate of growth than Suleja main town and Dikko. The growth rate for the six localities within the period 1987 - 2001 (14 years) ranges from as high as 19.34 percent in Rafinsanyi to about 2.21 percent in Dikko. However estimating the growth rate of the study area combined is not significant and does not show the rapid trend of growth of the fringe settlements like Madalla and Rafin sanyi. The scenario is well shown by the result of the analysis of the whole study area. The result shows that between 1987 and 2001, the percent growth of built up area of the study area combined was only 8.38 percent as against 19.34 percent for Rafinsanyi or 17.55 percent for Madalla during the same period (1987-2001).

Another interesting revelation was on the population growth over the same period. From the analysis the population through both the census estimate and remote sensing showed that the population growth followed the same pattern as in settlement growth. However at the fringes of the town like Madalla, Rafin-sanyi and Dakwa the rate of population growth was more through remote sensing estimate than using the census projection. For instance, the projected 2001 figure using 1991 census for the whole study area was 174,750 and through remote sensing was 199,484. The figure for 1987 through the annual growth rate was 99,817 and through remote sensing techniques was 64,604. The rate of growth over the 14 year period through remote sensing was 8.39 percent while through the normal annual growth rate it was 4.08 percent.

However, estimating the population of each of the six localities, it was found that the growth rate varied just as in the built up area. There is a strong relationship between population growth, distance from Abuja and accessibility. The implication of the result is that the rate of growth of both population and land area is uneven and greater at the periphery which calls for greater government intervention at these locations.

5.6.3. FACTORS RESPONSIBLE FOR THE GROWTH OF SULEJA.

Since the decision to relocate the capital from Lagos to Abuja was made in the seventies, Suleja has been an important town close to the new capital. It has served as a temporary base of the Federal Capital Development Authority (F.C.D.A.) and it has been serving as the home for many workers of the federal capital. From the responses and type of development, it has been shown that the non adherence to planning regulations was the main contributor to rapid unorganized development in Suleja. This coupled with the fact that the policies of government in Abuja are so stringent many low income earners cannot afford to reside in the capital but have had to move to nearby towns like Suleja.

The result of the logistic regression showed empirically the underlying factors that influence the growth of Suleja based on its proximity to Abuja. The goodness of fit of our regression using the relative operating characteristics (ROC) with all the five independent variables showed a correlation of 0.9508 which indicates a near perfect fit. Furthermore, the result of our probability of change to occur using the probability of change equation showed a decreasing probability value to change as one moves away from Abuja.

5.6.4 THE EXISTING STRATEGY TO CONTAIN AND CONTROL THE URBAN GROWTH OF SULEJA AND ENVIRONS.

The analysis of the available records on planning and development control in Suleja has shown how inadequate existing strategies are. The master plan prepared by max lock is already out of tune with reality and thus needs a review. The layouts prepared by the state government are concentrated within Suleja main town while the fringes that experience faster growth are left with little or no control. From the study it has been shown how fast these fringes are developing and how people obtain their land from the natives in an unplanned manner. The records from the Ministry of Lands and the Niger State Urban Development Board do not reflect the rate of growth of the fringes. For instance, the number of approval granted is far less than what was observed on the ground. This was supported by our findings on the changes in built up areas between 1987 and 2001 using remote sensing techniques.

5.7 CONCLUSIONS

This work was aimed at better understanding of the pattern and rate of growth of Suleja and environs. The overall growth of the study area was not reflective of the individual rate of growth of the surrounding localities. It was observed that the accessibility and proximity to the federal capital affected the rate of growth of both the populations and the built up areas. The efforts of the government are concentrated in the main town where growth rate is minimal compared with the fringes like Madalla, Rafinsanyi and Dakwa. The fringes had little control and with high growth rate. This negatively affected the final make up of the towns. The physical expansion of Suleja and environs is very unprecedented yet it receives little attention.

The study also showed that most developers acquired their lands informally from the natives without any layout or secured tenure. The ease in land acquisition on the fringes encouraged the high rate of development. Within Suleja town, due to the presence of some form of control and high land value, people tended to move outwards to the fringes.

In the final analysis, the growth of Suleja and environs is uneven and the rate is higher on the fringes where there is little or no management provisions that will ensure orderly development. The implication is that we would have an unplanned and fast growing settlement along the fringes of Suleja close to the federal capital. This also means that more arable land will be converted into built up area which would lead to decrease in the available land for farming by the majority of the people of Suleja and environs.

5.8 RECOMMENDATIONS.

Since the decision to relocate the federal capital from Lagos to Abuja was taken in the seventies, Suleja has been in the centre of all the changes. The name of the new capital was taken from the old name of Suleja; the first base of the operational unit of the development of the new capital, F.C.D.A was in Suleja; and now with the final movement, Suleja serves as the most vibrant town outside the F.C.T. These, coupled with the weak development control outfit, weak control on land ownership procedure Suleja attracts people on a daily bases. In a situation like this, development cannot be halted and movement of people cannot be prevented since rapid growth does mean negative growth. These problems can be converted to asset and prosperity. It is in line with this that the following suggestions are given;

The growth of Suleja and environs, from the land use change analysis, is very rapid. To be able to manage the growth and also to benefit from this rapid development, there is the need to have an organized pattern of development where the natives are involved in decision making. Figure 5.1 is a schematic diagram of the growth of Suleja and the options available for effective control and orderly development. The position of this work is that as along as the federal capital remains in Abuja, the growth of Suleja and environs would continue to be affected. People would continue to move to Suleja due to all the factors of proximity, high land rate in Abuja and strict development control. The option for effective and desirable development is for the people to come together and effect change or to be indifferent and allow haphazard development. To be able to have a decent settlement the people must agree to take a collective decision to manage the way the area grows. If they choose to act they stand to have a positive growth but if they allow the situation to continue, the settlements around would continue to grow organically which would eventually affect their ability to live sustainably.

i. Population increase in the federal capital and stringent development control is pushing pressure to Suleja where there is less stringent control mechanism. This would lead to movement of people to surrounding localities like Suleja. If the communities collectively act together in an organised manner, the settlements stand to grow in an orderly manner, if on the other hand they choose to do nothing, they risk having unplanned growth that will affect them and the environment.

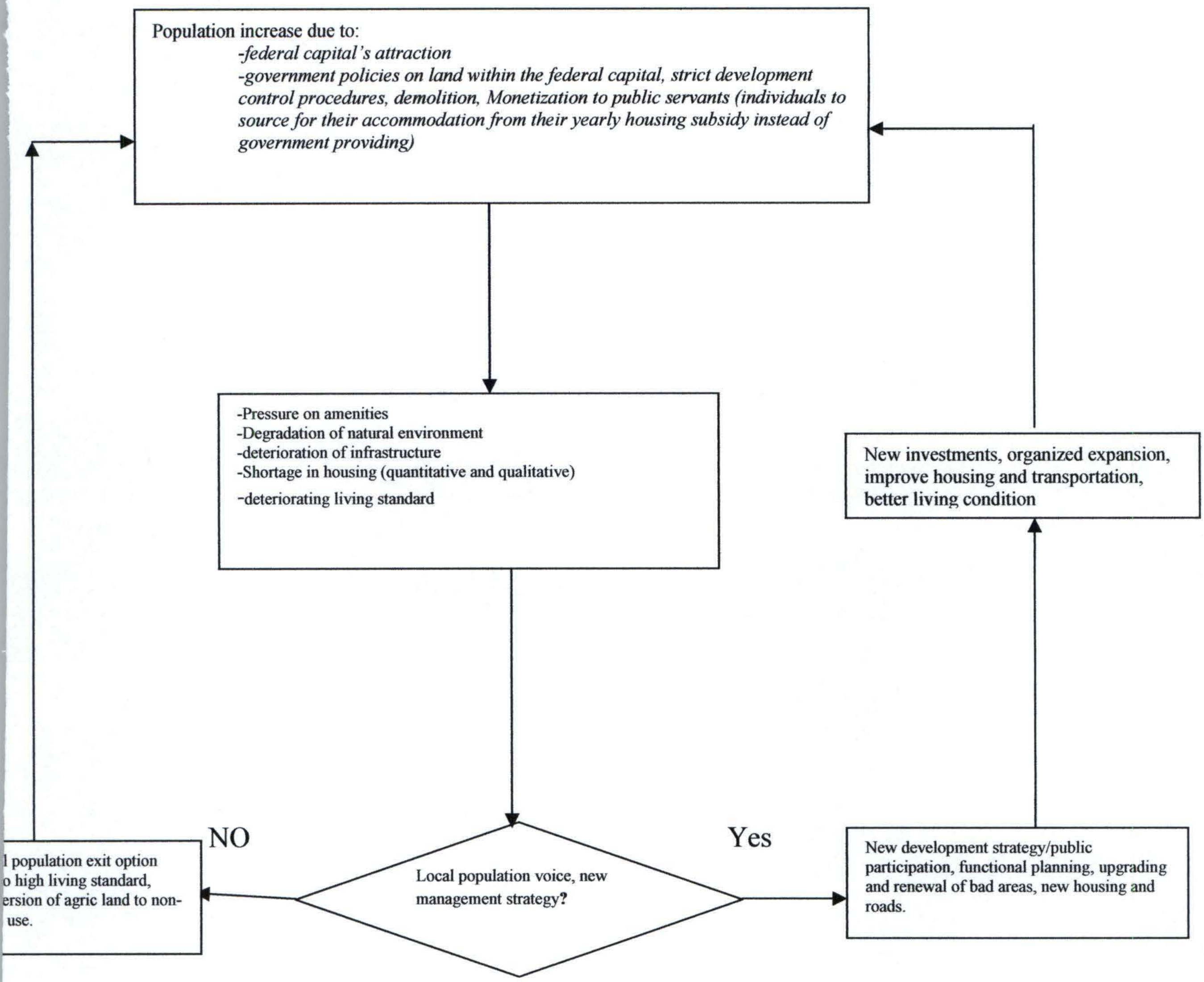


FIGURE 5.1: DECISION CYCLE FOR BETTER URBAN MANAGEMENT OF SULEJA AND EVIRONS.

Source: Author's work, 2006.

ii. There should be a detailed land use plan of Suleja and environ with all the necessary information and realistic strategy for implementation. This would aid in the planning and control of development in the area. It would also aid in the provision of infrastructure and utility. Specific areas like Madalla, Rafinsanyi and Dakwa should be given more attention due to the rate at which they are expanding.

iii. Land policy within Suleja should be coordinated so that there is uniform method of land acquisition and transfer.

iv. Development control activities should be intensified in all areas to prevent illegal development. Attention can be geared to ensuring that effective measures are put in place to increase compliance with planning regulations.

v. The concept of site and services should be encouraged especially on the fringe areas so that development is carried out within a planned set up.

vi. Niger State Government should, as a matter of urgency, take interest in what goes on in towns close to the F.C.T. and make a special case for Niger state to the Federal Government just like Nasarawa state did. Suleja is very close to F.C.T. and yet it gets no assistance from the Federal Government. The request could be in the area of provisions of infrastructure, utilities, and housing as is being done to Nasarawa State etc.

vii. There should be a change in the way and manner the issue of physical development of the F.C.T. is handled. Adjoining areas must be included in the overall design of the master plan of the F.C.T. so that there is a systematic development between the F.C.T. and neighbouring settlements as this study has indicated that the spatial expansion of the study area is as a consequence of its proximity to Abuja.

viii. Community participation must be encouraged to allow the people know the implications of unplanned development. The planning process must involve the people at all stages so that the people can key into the planning process.

ix. The fast growing areas like Rafinsanyi and Madalla should be considered for urgent re-planning, upgrading and provision of access roads. This would go a long way in reducing the impact of rapid unplanned expansion.

x. Niger State government should as a matter of urgency explore the issue of physical development of Suleja by preparing and implementing a comprehensive development proposal over the entire region from Madalla-Garam axis to Lambata

xi. Regular survey should be encouraged to ascertain the number and adequacy of certain services and facilities so that measures are taken in good time so as not to over-stretch them.

5.9 SUGESTIONS FOR FUTURE RESEARCH WORK

In this work we found out that the growth of Suleja and environs is not uniform but varies and that this growth is related to distance to Abuja and accessibility to the main roads. We employed remote sensing technique to estimate population using the house count method and we compared this estimate with the estimate using annual growth rate. It was found that any increase or expansion in built up area means an increase in population and that remote sensing technique may be a very reliable method because of its unbiased and real time capabilities.

To effectively monitor the rate of growth in our fast growing urban set-up higher resolution images like the quick bird or IKONOS are needed. With such types of images the detection of changes would be much easier. There is the need for a detailed research on other satellite towns outside the FCT using these images so as to have comparative information for better policy decisions.

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APPENDIX I: RESULTS OF LOGISTIC REGRESSION.

) RESULT OF LOGISITC REGRESSION OF CHANGE USNING ALL THE FIVE NDEPENDENT VARIABLES.

Regression Equation:

logit(change) = 0.7013 + 0.011936*DEM - 0.274473*timetoabj
+ 0.000079*pop + 0.152914*locality - 0.564714*disttoroad

Individual Regression Coefficient

Variables	Coefficient
Intercept	0.70125506
DEM	0.01193636
timetoabj	-0.27447263
pop	0.00007905
locality	0.15291417
distoroad	-0.56471436

Regression Statistics :

Number of total observations = 38634
Number of 0s in study area = 38218
Number of 1s in study area = 416
Percentage of 0s in study area = 98.9232
Percentage of 1s in study area = 1.0768

Number of auto-sampled observations = 3864
Number of 0s in sampled area = 3808
Number of 1s in sampled area = 56
Percentage of 0s in sampled area = 98.5507
Percentage of 1s in sampled area = 1.4493

-2logL0 = 585.4044
-2log(likelihood) = 356.5945
Pseudo R_square = 0.3909
Goodness of Fit = 1702.4136
ChiSquare(5) = 228.8099

Means and Standard Deviations

	Mean	Standard Deviation
DEM	385.437629	95.328098
timetoabj	39.582859	5.094029
pop	14345.686907	11417.181971
locality	17.533794	29.114936
distoroad	11.253213	10.573972
change	0.014493	0.119526

Classification of cases & odds ratio

Observed	Fitted_0	Fitted_1	Percent Correct
0	3806	2	99.9475
1	47	9	16.0714

Odds Ratio = 364.4043

Reclassification of cases & ROC (Sample-based computation when applicable):

(1) Select a new threshold value such that, after reclassification, the number of fitted 1s matches the number of observed 1s in the dependent variable

New cuttig threshold = 0.2279

Classification of cases & odds ratio by using the new threshold

Observed	Fitted_0	Fitted_1	Percent Correct
0	3771	37	99.0284
1	37	19	33.9286

Adjusted Odds Ratio = 52.3367

True Positive = 47.5000%

False Positive = 0.9716%

(2) ROC* Result with 100 thresholds (Sample-based computation when applicable):

ROC = 0.9452

* ROC=1 indicates a perfect fit; and ROC=0.5 indicates a random fit.

(2) LOGISTIC REGRESSION OF CHANGE USING TIME TO ABUJA AS THE INDEPENDENT VARIABLE

Regression Equation :

logit(change) = 2.2735 - 0.173062* time to Abuja

Individual Regression Coefficient

Variables	Coefficient
Intercept	2.27347602
timetoAbj	-0.17306191

Regression Statistics :

Number of total observations = 38634
Number of 0s in study area = 38218
Number of 1s in study area = 416
Percentage of 0s in study area = 98.9232
Percentage of 1s in study area = 1.0768
Number of auto-sampled observations = 3864
Number of 0s in sampled area = 3808
Number of 1s in sampled area = 56
Percentage of 0s in sampled area = 98.5507
Percentage of 1s in sampled area = 1.4493

-2logL0 = 585.4044
-2log(likelihood) = 548.5795
Pseudo R_square = 0.0629
Goodness of Fit = 3121.4075
ChiSquare(1) = 36.8249

Means and Standard Deviations

	Mean	Standard Deviation
timetoabj	39.582859	5.094029
change	0.014493	0.119526

Classification of cases & odds ratio

Observed	Fitted_0	Fitted_1	Percent Correct
0	3808	0	100.0000
1	56	0	0.0000

Odds Ratio = Not Applicable
Reclassification of cases & ROC (Sample-based computation when applicable):
(1) Select a new threshold value such that, after reclassification, the number of fitted 1s matches the number of observed 1s in the dependent variable
New cutting threshold = 0.0516
Classification of cases & odds ratio by using the new threshold

Observed	Fitted_0	Fitted_1	Percent Correct
0	3752	56	98.5294
1	56	0	0.0000

Adjusted Odds Ratio = 0.0000
True Positive = 0.0000%
False Positive = 1.4706%

(2) ROC* Result with 100 thresholds (Sample-based computation when applicable):
ROC = 0.7401
* ROC=1 indicates a perfect fit; and ROC=0.5 indicates a random fit.

(3)LOGISTIC REGRESSON OF CHANGE USING TOPOGRAPHY (DEM) AS THE INDEPENDENT VARIABLE

Regression Equation:
logit(change) = -6.6308 + 0.005893*DEM
Individual Regression Coefficient

Variables	Coefficient
Intercept	-6.63082541
DEM	0.00589284

Regression Statistics:

Number of total observations = 38634
Number of 0s in study area = 38218
Number of 1s in study area = 416
Percentage of 0s in study area = 98.9232
Percentage of 1s in study area = 1.0768

Number of auto-sampled observations = 3864
Number of 0s in sampled area = 3808
Number of 1s in sampled area = 56
Percentage of 0s in sampled area = 98.5507
Percentage of 1s in sampled area = 1.4493

-2logL0 = 585.4044
-2log(likelihood) = 571.2976
Pseudo R_square = 0.0241
Goodness of Fit = 3455.0730
ChiSquare(1) = 14.1068
Means and Standard Deviations

	Mean	Standard Deviation
DEM	385.437629	95.328098
change	0.014493	0.119526

Classification of cases & odds ratio

Observed	Fitted_0	Fitted_1	Percent Correct
0	3808	0	100.0000
1	56	0	0.0000

Odds Ratio = Not Applicable
Reclassification of cases & ROC (Sample-based computation when applicable):
(1) Select a new threshold value such that, after reclassification, the number of fitted 1s matches the number of observed 1s in the dependent variable

New cutting threshold = 0.0299

Classification of cases & odds ratio by using the new threshold

Observed	Fitted_0	Fitted_1	Percent Correct
0	3751	57	98.5032
1	55	1	1.7857

Adjusted Odds Ratio = 1.1965
True Positive = 4.5455%
False Positive = 1.4968%

(2) ROC* Result with 100 thresholds (Sample-based computation when applicable):

ROC = 0.5799

* ROC=1 indicates a perfect fit; and ROC=0.5 indicates a random fit.

(4) LOGISTIC REGRESSON OF CHANGE USING POPULATIOAN AS THE INDEPENDENT VARIABLE

Regression Equation :

logit(change) = -5.9668 + 0.000079*pop

Individual Regression Coefficient

Variables	Coefficient
Intercept	-5.96680210
pop	0.00007937

Regression Statistics:

Number of total observations = 38634
Number of 0s in study area = 38218
Number of 1s in study area = 416
Percentage of 0s in study area = 98.9232
Percentage of 1s in study area = 1.0768

Number of auto-sampled observations = 3864
Number of 0s in sampled area = 3808
Number of 1s in sampled area = 56
Percentage of 0s in sampled area = 98.5507
Percentage of 1s in sampled area = 1.4493

-2logL0 = 585.4044
-2log(likelihood) = 489.7156
Pseudo R_square = 0.1635
Goodness of Fit = 6120.1765
ChiSquare(1) = 95.6888

Means and Standard Deviations

	Mean	Standard Deviation
pop	14345.686907	11417.181971
change	0.014493	0.119526

Classification of cases & odds ratio

Observed	Fitted_0	Fitted_1	Percent Correct
0	3808	0	100.0000
1	56	0	0.0000

Odds Ratio = Not Applicable

Reclassification of cases & ROC (Sample-based computation when applicable):

(1) Select a new threshold value such that, after reclassification, the number of fitted 1s matches the number of observed 1s in the dependent variable

New cutting threshold = 0.1490

Classification of cases & odds ratio by using the new threshold

Observed	Fitted_0	Fitted_1	Percent Correct
0	3771	37	99.0284
1	37	19	33.9286

Adjusted Odds Ratio = 52.3367

True Positive = 47.5000%

False Positive = 0.9716%

(2) ROC* Result with 100 thresholds (Sample-based computation when applicable):

ROC = 0.6685

* ROC=1 indicates a perfect fit; and ROC=0.5 indicates a random fit.

(5) LOGISTIC REGRESSON OF CHANGE USING LOCALITY AS THE INDEPENDENT VARIABLE

Regression Equation :

logit(change) = -2.7892 - 1.195216*locality

Individual Regression Coefficient

Variables	Coefficient
Intercept	-2.78924607
locality	-1.19521607

Regression Statistics :

Number of total observations = 38634

Number of 0s in study area = 38218

Number of 1s in study area = 416

Percentage of 0s in study area = 98.9232
Percentage of 1s in study area = 1.0768

Number of auto-sampled observations = 3864
Number of 0s in sampled area = 3808
Number of 1s in sampled area = 56
Percentage of 0s in sampled area = 98.5507
Percentage of 1s in sampled area = 1.4493
-2logL0 = 585.4044
-2log(likelihood) = 472.8175
Pseudo R_square = 0.1923
Goodness of Fit = 15985.3994
ChiSquare(1) = 112.5868

Means and Standard Deviations

	Mean	Standard Deviation
locality	17.533794	29.114936
change	0.014493	0.119526

Classification of cases & odds ratio

Observed	Fitted_0	Fitted_1	Percent Correct
0	3808	0	100.0000
1	56	0	0.0000

Odds Ratio = Not Applicable
Reclassification of cases & ROC (Sample-based computation when applicable):
(1) Select a new threshold value such that, after reclassification, the number of fitted 1s matches the number of observed 1s in the dependent variable
New cutting threshold = 0.0576
Classification of cases & odds ratio by using the new threshold

Observed	Fitted_0	Fitted_1	Percent Correct
0	3744	64	98.3193
1	49	7	12.5000

Adjusted Odds Ratio = 8.3571
True Positive = 25.0000%
False Positive = 1.6807%

(2) ROC* Result with 100 thresholds (Sample-based computation when applicable):
ROC = 0.8697
* ROC=1 indicates a perfect fit; and ROC=0.5 indicates a random fit.

(6) LOGISTIC REGRESSON OF CHANGE USING DISTANCETO ROAD AS THE INDEPENDENT VARIABLE

Regression Equation :

logit(change) = -2.2523 - 0.576404*distancetoroad

Individual Regression Coefficient

Variables	Coefficient
Intercept	-2.25232995
distcetoroad	-0.57640359

Regression Statistics :

Number of total observations = 38634
Number of 0s in study area = 38218
Number of 1s in study area = 416
Percentage of 0s in study area = 98.9232
Percentage of 1s in study area = 1.0768

Number of auto-sampled observations = 3864
Number of 0s in sampled area = 3808
Number of 1s in sampled area = 56
Percentage of 0s in sampled area = 98.5507
Percentage of 1s in sampled area = 1.4493

-2logL0 = 585.4044
-2log(likelihood) = 459.3916
Pseudo R_square = 0.2153
Goodness of Fit = 3406.5324
ChiSquare(1) = 126.0128

Means and Standard Deviations

	Mean	Standard Deviation
disttoroad	11.253213	10.573972
change	0.014493	0.119526

Classification of cases & odds ratio

Observed	Fitted_0	Fitted_1	Percent Correct
0	3808	0	100.0000
1	56	0	0.0000

Odds Ratio = Not Applicable

Reclassification of cases & ROC (Sample-based computation when applicable):

(1) Select a new threshold value such that, after reclassification, the number of fitted 1s matches the number of observed 1s in the dependent variable

New cutting threshold = 0.0951

Classification of cases & odds ratio by using the new threshold

Observed	Fitted_0	Fitted_1	Percent Correct
0	3744	64	98.3193
1	49	7	12.5000

Adjusted Odds Ratio = 8.3571

True Positive = 25.0000%

False Positive = 1.6807%

(2) ROC* Result with 100 thresholds (Sample-based computation when applicable):

ROC = 0.8809

* ROC=1 indicates a perfect fit; and ROC=0.5 indicates a random fit.

APPENDIX II: QUESTIONAIRE ON THE SOCIO, ECONOMIC AND ENVIRONMENTAL CONDITION OF SULEJA.

A –Personal Data.

1-Age------

2-Type of employment

I-civil service

II-private practice

III-Others; Specify_________

3-Are you living with your family in suleja?

Yes __________

No __________

4-How many are you in your household?

I. *one person*
II. *two persons*
III. *more than three*

5-Where do you earn your living?

I. *-Abuja*
II. *-suleja*
III. *-Others specify---------*

6-What mode of transportation do you take to work?

I. *-public transport*
II. *-private transport*

7-How much do you spend on transportation per month?

I. *-Below N2000*
II. *-N2000-4000*
III. *-N4000-8000*
IV. *-N8000-16000*
V. *-above N16000*

B-Housing

1-Do you have a house of your own?

Yes ________

No_________

2-If yes, how did you come about it?

I. *-direct construction*
II. *-inherited*
III. *-Outright purchase*
IV. *–Others ;Specify ______*

3-Did you obtain approval from planning authority before development?

Yes ____________

No____________

4-If no to question, why?

I. *it is difficult*
II. *I'm not aware*
III. *It is expensive*
IV. *Any other reason, specify*

5-Is your development within a government layout or locally acquired.

I. *-government layout _________*
II. *-locally acquired __________*

6-If you don't own a house, where do you reside?

I. *Government allocated quarters*

II. Rented quarters.

7-What type of house do you occupy?

I. -bungalow
II. -room and parlour
III. -Single room

8-How much do you spend on rent per annum?

I. Below N45000
II. N45000- 90,000
III. N90, 000-150,000
IV. N150, 000-200,000
V. Above 200,000

C-Environmental condition

1-Are you satisfied with the condition of where you reside?

Yes ________________

No ________________

2-If yes to question, what makes the area conducive?

I. There is water and electricity
II. There is a good road
III. The area is relatively free from crime
IV. There is recreational facilities
V. Any other reason; (specify) ________

3-What in your opinion affect the quality of your living environment most seriously?

I. Bad road
II. Non availability of water and electricity
III. High crime rate
IV. Congestion

4-How do you dispose your waste?

I. Incineration
II. Regular collection
III. Indiscriminate disposal

5-Select the most important factor that you think reduces the quality of the living environment around you?

I. Solid waste problem
II. Improper /non availability of drainage
III. Poor or lack of planning
IV. Poor quality buildings
V. Lack of accessibility.

D-Location and government impact on the growth pattern of suleja.

1-Do you think the proximity of suleja to the federal capital influences the growth of the town?

Yes ________

No ________

2-Should the Federal Capital Development Authority (FCDA) assist in the development of suleja?

Yes ________

No ________

3-If you are to choose which area do you feel should be handled by the federal capital authority?

I. *Housing*
II. *Water*
III. *Road*
IV. *Health care*
V. *Others,(specify)*

4-Are you satisfied with the effort of the state and local governments in the development of Suleja?

Yes __________
No __________

5-If no to question, what do you think the state government and local government should do to improve the image of the town?

I. *Provide roads*
II. *Increase the housing stock*
III. *Provide adequate water and electricity*
IV. *Improve the health sector*
V. *Others (specify)*