LAND SUITABILITY ASSESSMENT FOR URBAN DEVELOPMENT IN SOKOTO METROPOLIS, SOKOTO STATE, NIGERIA

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DECLARATION

I declare that this Dissertation work entitled "LAND SUITABILITY ASSESSMENT FOR URBAN DEVELOPMENT IN SOKOTO METROPOLIS, SOKOTO STATE, NIGERIA*"* has been carried out by me in the Department of Geography, Faculty of Physical Science, Ahmadu Bello University, Zaria. The information derived from all the literatures have been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution

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CERTIFICATION

This dissertation Work has been read and approved by my supervisor as meeting the requirement for the of award of the degree of Masters of science in Remote sensing and Geographic Information System of the Ahmadu Bello University Zaria, Kaduna State.

Dr. A.K Usman Chairman, Supervisory Committee	_____ Signature	_____ Date
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Dr. A.K Usman Head of Department	_____ Signature	_____ Date
Prof. A. Z. Abubakar Dean, School of postgraduate Studies	_____ Signature	_____ Date

DEDICATION

With thanks and gratitude to almighty Allah I present and dedicate this thesis to my parents Alhaji Hussaini Shehu and Hajiya Aishatu Hussaini Shehu.

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ABSTRACT

Identification of potential sites for urban development in is one of the critical issues of planning. Site suitability analysis has become unavoidable for finding appropriate site for various developmental initiatives.This research work focused largely on land suitability assessment for urban development in Sokoto metropolis. Shuttle Radar Topographic Mission (SRTM) data of 90metres spatial resolution and land Sat-8 Satellite imagewere the data used for the study.SRTM data was used to produce the slope, aspect and drainage map for the study. Landsat 8 imagery was used to generate the land use and land cover through supervised classification. A Multi-Criteria Evaluation (MCE) using the pair wise comparison in Analytical Hierarchy Process (AHP) was used to weigh each of the factor map that influence site suitability for urban development. A weighted overlay in ArcGIS spatial analyst tool was applied to produce the site suitability map. The result of the study shows that crop land occupies the highest land cover with 52.3% (294.4sq. km), irrigation land is next occupying about 21.3% (119.9sq. km) of the area. The urban built-up land occupies 11.5% (64.8sq. km), the bare surface 11.1% (62.4sq. km) while vegetation is the least with 3.8% (21.5sq. km). the result also revealed that from the available area of 131.2 sq. km (23.3%) of the land fall under very low suitable sites for urban development, 55.7 sq. km (9.9%) was found to be low suitable sites, 79.4 sq. km (14.1%) of the total area is moderately suitable, while 102.5 sq. km (18.2%) of the area is highly suitable and 194.2 sq. km (34.5%) is very highly suitable sites. Therefore, the study recommends that the North, West and Eastern part of Sokoto metropolis should be considered as suitable area for new urban development and development should be directed to them.

CHAPTER ONE

INTRODUCTION

1.2 BACKGROUND TO THE STUDY

The evaluation of suitability of land areas for a variety of land use for development purposes solely rely on terrain information. Studies have shown that there are only a few landscapes remaining on earth that are still in their natural state (Gardner and Kloptak, 2001). The earth surface is being continuously altered in some manners due to anthropogenic activities and man's influence on the fragile, yet interconnected resource base. This has had a profound effect on the natural environment, thus resulting into an observable change pattern in the land use and land cover over time (UN-Habitat, 2004).

Urban centers in less developed countries like Nigeria have witnessed tremendous changes in terms of population growth and aerial expansion. In the absence of proper urban management practices, uncontrolled and rapid increase in population pose enormous challenges to governments in providing adequate shelter to the millions of homeless and poor in urban areas. Urban growth due to in-migration has led to increase in population density. The migration of people from rural to urban areas for better job opportunities, better standard of living and higher level of education is expected to continue in coming future. This will lead to shortage of facilities and increasing demand of land for residential purposes (UN-Habitat, 2004).

In the last 200 years, the Earth's urban population has increased by over 100 times while the total population has increased only six times (Jain and Subbaiah, 2007).

According to United Nation's Population Division report, about 38 percent of the earth's population was living in urban areas and by 2025 this proportion is expected to rise to 61 percent. This implies that about 5 billion people out of a total world population of 8 billion will be living in urban areas (WRI 2010). This rapid increase in urban population accompanied by fast transforming urban economy lead to an ever-increasing load on the urban environment in terms of unplanned sprawl, inadequate housing facilities, traffic congestion, insufficient drainage, and lack of sewerage and other facilities (Liu, 1998).

Also, this growth is accompanied by increasing demand of land for future development. As urban regions grow, more land will be needed to satisfy further growth of urban population in the future. Much of the increased demand of land for urban development is met out of the surrounding agricultural land. Increase in population also means increase in demand of food. It is therefore, very important that the best and most suitable land remains under agricultural uses. Not only this urban expansion in the ecologically fragile areas be avoided. In this context it is very important to plan for appropriate and judicious allocation of lands for urban development to overcome the problems arising out of rapid growth of any urban center. This requires a careful planning for land allocation (Li and Yeh, 1998).

Land suitability refers to the ability of a particular type of land to support a specific use, and the process of land suitability classification involves the evaluation and grouping of particular land areas in terms of their suitability for a defined use (Prakash, 2003). Land suitability analysis is thus concerned with evaluation of the fitness of a given tract of land for a defined use (Steiner, McSherry and Cohen, 2000). In other words, it is the process to determine whether the land resource is suitable for some specific uses. It is

also undertaken to determine the suitability level. In order to determine the most desirable direction for future development, the suitability for various land uses should be carefully examined with the aim of directing growth to the most appropriate sites. Establishing appropriate suitability factors is the construction of suitability analysis. Initially, suitability analysis was developed as a method for planners to connect spatially independent factors within the environment and, consequently to provide a more unitary view of their interactions. Suitability analysis techniques integrate three factors of an area: location, development activities, and biophysical/environmental processes (Miller, Collins, Steiner and Cook, 1998). Land use suitability analysis aims at identifying the most appropriate spatial pattern for future land uses according to specific requirements, preferences, or predictors of some activity (Collins, Steiner and Rushman, 2001).

Acquiring new site for urban development or improvement is becoming increasingly challenging, particularly in a growing real estate market and with stringent environmental standards or regulations. The results of the site suitability analysis produce a detailed display of the most-suitable areas for consideration of placement of a certain facility, while filtering out unusable or less desirable sites. Certain aspects are more important than others in determining the best location for each facility. The selection of suitable sites for specific uses must be based upon a set of criteria depending on local norms. A scoring system can be applied to the various aspects of suitability to assess the overall suitability for a specific urban use (Kumar and Shaikh, 2013).

The issue of suitable location or place for an activity is a recurrent one in spatial behaviour. Every individual wants to choose a place of abode that is as close as possible to his working environment. The entrepreneur searches for a location for his services

that maximize his profit. A municipal Government searches for place to provide services in such a way that a majority would benefit. These and other examples highlight the importance that the choice of a suitable land based on evaluation of its fitness, has on the realization of certain objectives.

As demand for limited urban land increases, low income groups are being compelled to occupy illegal, un-serviced suburbs often at the periphery of the city as observed in Sokoto town, where the land tends to be vulnerable to both natural and man-made hazards. Arid and semi-arid land has been listed in Agenda 21 of the United Nations Conference on Environment and Development (UNICED) and the world dissertation Atlas, among the fragile ecosystem of the world. Significant proportion of land areas in Sokoto State is dry land. Sokoto has experienced urban expansion which has accelerated in the past years due to rapid economic development and population growth. This trend is on the increase. Therefore, evaluating the surrounding land area suitability for urban development is an urgent need. In order to meet this requirement, the sustainable management of the land peripheral requires serious attention.

Previous studies of this nature have had some problems due to lack of enough data. But with the introduction of Remote sensing and GIS relevant data and techniques are now available for effective land suitability evaluation and mapping.Remote sensing technology has been the subject of research in a variety of contexts and situations and has been successfully introduced as sole, complementary or corroborative source of data for many applications (Batty and Howes 2001). Remote Sensing technology has great potential for acquisition of detailed and accurate land use information for management and planning of urban regions. However, the determination of land use data with high

geometric and thematic accuracy is generally limited (Herold, Conclelis and Clarke, 2002). The technique of Remote Sensing provides a powerful tool for studying urban issues, like Suitability analysis land use/cover changes, urban growth modelling, urban sprawl etc.

1.2 STATEMENT OF THE RESEARCH PROBLEM

Urban areas are continuously expanded to serve the needs of growing populations and to improve their living standards. Planned settlement can be defined as habitable living environment for the people. It provides comfortable dwelling unit: dwelling conditions, efficient infrastructure, social-wellbeing, and improve living standards and quality of life for inhabitants in the area. Unfortunately, the reality is often quite different. Haphazard and uncontrolled settlement expansion is the rule. In rapid urbanization the direct implication of the growth is often more and more dwellings, lands and urban services and facilities are inadequate (Bhatta, 2009).

As a results of this uncontrolled and therefore unpredictable demand, issues like shortage of housing, insufficient infrastructure and services, unplanned physical development illegal settlements are common in most of the urban centers. Especially in developing countries planning of housing and road locations are mainly evaluated based on factors such as socio-economic, political, land use policies and related infrastructure conditions. Therefore unexpected problems are frequently encountered during the implementation, which are coarsen additional cost and construction failures.(Kevin and Hack, 1985)

To adequately address these problems, all major factors that influence the process of urban settlement development must be thoroughly analyzed and understood. The process of urban settlement expansion is distinctly influenced the soils and related site conditions.One major problem that uncontrolled urban settlement expansion leads to the irreversible loss of prime agricultural land often quite unnecessarily. All this is caused by the fact that (a) specific requirement of the various urban settlement related land uses are insufficiently considered, and that (b) no systematic evaluation procedure is followed to match the various land requirements with soil properties and site characteristics of the various land units (Kumar and Biswas, 2014).

As a result of haphazard development of settlement, a number of problems such as unplanned settlements development in inappropriate locations, loss of irreversible agricultural lands due to expanding urban activities towards good agricultural lands, reduction of amount of water and water quality of the waterbodies and land degradation due to removal of vegetation, incompatible land uses and are distinguished within the area. For example, permanent houses are being built up in drainage valleys, which is causing severe storm water drainage problems and flooding during the rainy season. This way of settlement development will not only increases the cost of construction and maintenance of infrastructure in the area but also greatly affects the environment. Therefore, by considering the physical problem prevailing in the area, the research intends to look at problems relating to housing and local roads construction in terms of soils and site conditions.(Becht, 2000)

Many researches have been carried out on land suitability for development for example Ontumbi, (2014) assessed the land Suitability for Urban development in Kisii

Town, Kenya. The study considered of five factors, that is, slope, road proximity/accessibility and ecological sensitivity by using multi-criteria decision analysis (MCDA) method in decision making process. With the support of Geographic Information System (GIS) and multi-criteria. The main source of data were LiDAR image that was acquired in 2012. Interviews were also conducted with various stakeholders in urban planning in Kisii town. Direct observations were also done. The results showed that from the study approximately 18.46km^2 of the study area is very suitable and this is represented by nearly 26% of the study area. The area under suitable criteria for urban development is 31% represented by 22.01 km^2. In addition nearly 21% of the study area of moderate suitability for urban development and this is represented by 14.91km^2. Areas of least suitable for urban development are represented by 9.23km^2 which makes up 13% of the study area. Unsuitable areas for urban development consist approximately 6.39km^2 represented by 9% of the study area.

Kumar and Biswas (2014) analyzed the site suitability for urban development of a hill town using GIS based multi-criteria evaluation technique in Nahan Town, Himachal Pradesh, India. Factor considered include: slope, road proximity, land use, land values, soil and geomorphology factors. They data used was Cartosat-1 and LISS-IV and six thematic information layers were analyzed in ArcGIS 9.3 software to identify suitable areas in Nahan town. The study used GIS based Overlay Weight age Average (OWA) Sum and Weighted Linear Combination (WLC). The undulating terrain, steep slope, varied soil depth and high building cost give the impression to find out suitable sites for urban development in the Nahan Town. Six factors (slope, road proximity, land use, land values, soil and geomorphology) were identified for criteria evaluation. The showed that

0.1157km^2 falls under very low suitable, 1.6835km^2 under low suitable, 1.2090km^2 under moderately suitable, 0.3663km^2 under high suitable and 0.1248 km^2 under very high suitable. The result further revealed that highly suitable areas for urban development is either agricultural or forest type.

Chen (2016), assessed the land-use suitability for urban development in Bedingo, Regional Victoria. The study made use of GIS based land-use suitability analysis and its application in urban planning decision making in the study area. Geophysical, socioeconomic and cultural data are used to assess future urban growth suitability in Bendigo based on key goals such as Connected and Compact City (transport and connectivity), City of Equality (education, health services), Ecological City (environmental conservation), and Safe City (risk of disasters). The resultant suitability map indicates primary suitable lands for future urban growth are located adjacent to the established urban areas.

From the aforementioned works and other literature reviewed, none of the studies have attempted to assess the physical land suitability for urban development particularly in Sokoto metropolis using Remote Sensing, GIS and Multi-criteria evaluation. This is therefore the gap which this work intends to fill. The research questions that are critical to this investigation are the following;

1. What are the existing landuse and land cover type in the study area?
2. What are the factors influencing suitable site for urban development in the area?
3. Where are the potential suitable sites for urban development in the study area?

1.3 AIM AND OBJECTIVES

The aim of this research project is to assess site suitability for urban development in Sokoto town, for sustainable urban development with minimum impacts on the environment. The objectives of this study are to:

i. examine the existing Landuse and land cover types in the study area
ii. examine the factors influencing land suitability for urban development in the study area
iii. determine the suitable sites for new urban development in the study area

1.4 SCOPE OF THE STUDY

The spatial and content scope and of the present study is to assess the land suitability for urban development for entire Sokoto metropolis which comprises of Sokoto north,Sokoto south and Wammako local government areas. The land suitability for the urban development was carried out using geospatial technique and factors such as accessibility, slope, aspect, drainage density and land use and land cover were considered. The study assessed the land suitability in the area in the year 2016.

1.5 JUSTIFICATION OF THE STUDY

Previous attempts by Sokoto State government to document the growth pattern of Sokoto town have not been successful as it was solely based on aerial photographs. In recent times the dynamics and management of landuse and landcover require a more sophisticated system such as remote sensing and Geographic Information Systems (GIS), which provide a general synoptic coverage of large areas than aerial photographs. The environment being a vital asset of the people is important to individuals, their community and the nation as a whole. In the same vein, individuals, communities and

organization must learn about the environment and in particular appreciate the role they can play in preserving the environment for posterity and sustainable development.

However, land has been regarded as a finite resources but population continues to grow year after year, requiring more land for housing and other urban uses such as agricultural area for food production, more forest for timber production and watershed protection. Therefore, it becomes pertinent to acknowledge the need to allocate land judiciously and discriminately for sustainable. Land is also viewed as a shared natural resources, much like air and water, which need to be conserved and cared for with due regards for its effect on the society as a whole and for the condition in which it will be passed on to the future generation.However, the paradigm of sustainable development is now present in mainstream planning practice. Traditional modeling disciplines have been replaced with new ways of thinking due to ever increasing requirement to integrate modeling platforms (Stefan, 2007). Traditional models such as landuse, land suitability analysis etc, are faced with more complex and demanding data formats from different sources, thereby causing significant barriers for the requirement of integration, particularly interns of the increasing demands to incorporate spatial datasets formats. Consequently, the integration paradigm requires to integrate new information that comes from the environmental monitoring and carrying capacity analysis (Berke and Godschalk, 2006). New innovative system approaches are required to provide interoperable tools that are suitable to integrate the task of environmental modeling to ensure reliable and consistent information. At the same time, Geographic Information Science has evolved to deliver the much needed framework for the implementation of

landuse assessment (Guhaatha, 2003). Using these methods for building landuse and assessment scenarios also has advantages in terms of consistency and transparency.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 INTRODUCTION

This chapter explained some of the concept relevant to the study which also provided some kind of basic foundation upon which the study was built. A great deal of literature relevant to the subject matter have been reviewed.

2.2 CONCEPTUAL FRAMEWORK

2.2.1 Concept of urban area

There is no any universally agreed definition or criteria of classifying settlement in rural and urban or country side. Different threshold or parameters are used in defining settlement which varies from one country to another; and also varies over time within a county. The parameters used in classifying settlements in-to urban are; administrative and political functions, population size or density, economic function and presence of urban characteristics. The classification of settlement in to urban and rural area depends on countries level of development, population size and density. Another problem associated with settlement classification; is defining extent of urban area; as most of the developing countries urban fringe exhibit characteristics of rural settlement as well as the rural areas engulfment into urban development process, this leads to a shift away from the

assumption of the mainstream paradigms to a new conceptual landscapes where rural-urban links are being redefined (Geiman, 1999).

A sharp distinction between urban and rural settlement, is general assumed that the livelihoods is increasingly accepted as criteria in many regions of the developing world, including its large countries the boundaries between urban and rural are getting blueweed. Therefore, according to Herold (2003) "The definition of urban extent still remains problematic and individual studies most determine their own rules for differentiating urban from rural land."

The variation in criteria of urban/rural areas classification, among different region of the world, makes generalization very problematic if not impossible. In most of the sub-Saharan African countries the classification are largely on administrative, demographic and infrastructural basis, as a result several small settlements where classified as urban (Gado and Guitart 1996). In Benin Republic, the National Institute of Statistics and Economic Analysis, classified any settlement with a population of 10,000 or more and with at least four (4) of the following: post office, tax office, public, treasury, bank, running water and electricity supply, health centre and secondary school as urban (Tingbe-Azalou, 1997) while in Nigeria any settlement with a population of 20,000 inhabitants can be regarded as an urban (Adeleke, Ahmed and Leon, 2002).

2.2.2 The concept of urban growth

The concept of urban growth entails either relative or absolute increase in the number of people who live in town and cities, which leads to structural and functional changes. The urban population growth can be as a result of natural increase and net migration or reclassification of rural settlement into town and cities.

Urban planners and decision makers have widely accepted the fact that urban system is highly complex. Cheng and Masser (2002) argue that if urban growth can be considered as a complex system, then there is a need for finding the universal and unique characteristics that can distinguish it from other complex systems, and this can only be done by answering four (4) relevant questions;

i. Where is urban growth occurring from system perspectives?
ii. What is the complexity of urban growth?
iii. What should be understood in supporting urban development?
iv. How can urban growth complexity be modelled?

Urban development consist of physical expansion and functional changes. i.e. change in space and major land use activities. Therefore space and activity should be considered as basic units (elements) of urban growth system.

Cheng and Masser (2003) defined urban growth as a system resulting from complex dynamic interactions between, the spatial, conceptual, socio-economic and physical/ecological system. The interaction between these three systems resulted in urban growth, the spatial/conceptual system provides planning control requirement for urban growth, while socio-economic and physical/ecological systems contributes activities/stimulant factors for development respectively.

2.2.3 Urbanization

The urbanization process can be said to be transformation of landscapes, characterized by rural life styles into urban landscapes and determines lateral and structural changes that result into a new landscape patterns. According to Rimal (2011) urbanization is an increased system modernization process, which modifies the socio-

economic activities and revolutionizes the landuse practice in accordance with time frame. Also, Modica(2012) define urbanization as a complex diffusion process, that result in to dramatic spreading and variously affecting rural landscape at varying spatial scales.

The rate of urbanization is the increase in proportion of urban population overtime, calculated as the rate of growth of the urban population minus that of the total population. Urban population can grow either at faster rate or slow than the total population. Urbanization is a settlement change process from rural to an urban experience as towns and cities grew bigger more and more people came to them mostly from rural areas in search for jobs, opportunities and other forms of prosperity. Most of the cities experience growth in population through migration than natural increase, the movement of people into urban centers, is an objective anticipation and desire to have a better life as towns and cities are places where needs, ideas, ambition and aspiration of humanity are mostly realized.

2.2.3.1 History of urbanization

The beginning of urbanization can be traced back to renaissance time in 16th century. Turkish assaults resulted in movement of Christians from the east to western European countries. As a result trade grew and European cities along the coast developed greatly. A further boost for urbanization was created with the arrival of the "Industrial Revolution" population of cities in Europe and USA started to increase significantly in the 18th and 19th centuries. An example of a dramatic increase in extent of population of cities in Chicago in USA, which population increased from 15 people to about 20 million within a span of78 years. However urbanization started in Asia only in the half of the 20th century

and in the second half of 20th century in Africa, when the countries got independence from colonial rule (Greenwood, 2009).

In Nigeria, since the mediaeval periods, Nigerian ancient cities of Hausa state and the Kanuri Empire had a long trading connection with North African Arabs and Europe through trans-Sahara trade. The most significant of these trading and artisan towns were Kano, Zazzau, Sokoto, Katsina (in the Hausa states), while Gazargamu and Ibadan in the Kanuri and Yoruba empires respectively (Endsjo, 1973). The construction of railway which started in 1898, by British Colonial Administration and later, roads linked up towns. Thus some towns were developed in connection with mining activities, most importantly, Enugu and Jos. The creation of administrative capitals saw the emergence of new towns and cities in Nigeria. The creation of new northern Nigeria capital Kaduna, followed by subsequent creation of 11 states in 1967, the creation of local government and new states 1976, followed by creation of several states and local government by Military Administration up to present 36 states and 776 local government Headquarters, of these states and local government with the exception of few are urban areas by Nigerian government standard of 20,000 inhabitants (Adeleke, Ahmed and Leon,2002).

2.2.3.2 Urbanization process

In 19th century only 20% of the world population were living in urban areas, this varies to less than 5% in most of the third world countries, advancement in technological and scientific discoveries in 20th century brings about great drift from rural area which was further fuelled by advancement in medical services that rises the global life expectancy from 35 years to 65 years that increased the natural growth, the combine

effect of rural urban migration and natural increase made 21st century a city century that change the face of urban geography studies of the world to new regional system, as a result of massive conurbation of more than 20 million people known as "mega-cities" Commission on Growth and Development (CGD, 2009).

The global urbanization process increasingly includes indigenous people. Although globally the majority of indigenous people still live in rural areas, the limited available data shows that more and more of them are migrating to urban areas. This migration can be temporary or permanent. ''Urbanization is affecting indigenous people in many countries both developed and developing with diverse impacts" (UNFA, 2007). Urban demographic expansion reaches its peak across the world in 1950s when annual growth rate was put to over 3%. An overall population growth deceleration was experience including developing countries between 1960 and 2010 from an annual growth rate of 4.2% in early 1960s to 2.5% in 2010. Continuous fall in urban growth rate is expected to about be 1.2% between 2045 and 2050 (Malanima, 2000). Therefore regarding the future trends of urbanization new urban growth dimension can be expected, with a continuity in pattern, as "the pace of urbanization across the world is not accelerating even in the developing world" urban population at a global scales is project to growth at an average annual rate of about 1.5% of between 2025 to 2030 Ethiopian Office of the high commissioner for human right (OHCHR, 2007).

2.2.3.3 Urbanization in Nigeria

The evolution and growth of Nigerian urban centers, has undergone three main stages or phases of development; which all the phases left their mark on Nigeria urban

landscape, these phase or stages include the pre-colonial city that consisted of traditional family compound, especially in ancient cities of Kano, Zaria, Ibadan, Benin etc. The second phase, is the colonial era, during which the European quarters at the traditional cities outskirt separated by a green belt emerged. The third phase is the post-independence stage, during which migrant sub-urban settlement eventually developed in between the European quarters and traditional settlement, mostly known as Sabon-Gari in Hausa states. Subsequently the traditional settlement developed into slums as a result of increase in population coupled with the cultural attachment of the indigenous city inhabitant, of avoiding the migrant settlement (Mabugunje, 1968).

Nigeria like other developing countries experienced a rapid rate of urbanization, which is described on the basis of the population increase. Thus Nigeria pre-colonial cities are still the longest cities, policies of several administrations, including colonial administration; give birth to several new town and cities. The administrative reorganization of the four regions in to twelve (12) states, and the growth as well as the change in distributional pattern of federal monitory allocation, marks a significant milestone in emergence and growth of several cities and towns (Endsjo, 1973).

2.2.3.4 Nigerian urbanization and Sustainable urban development

Urbanization is a transformative process from rural to an urban experience. The level of country urbanization determines its level of development and economic growth in most case (UNFPA, 2007). Therefore it can be easily concluded that urbanization is inevitable as it is part of an old “recent” human population history.

According to the (UN, 2010) report on state of African cities, observes that "urbanization has been associated with improved human development which brings incomes and better living standards". But rapid urbanization can be said to be a curse as well as blessing, unless strong and immediate and decisive policy action is taken, the phenomena could be burden from opportunity to a region.

The case study of the evolution of urban centres in the Nigerian Savannah could discover some evolved processes which have profound effect on contemporary urban life. By focusing on the achievements of the urbanization it becomes obvious that the evolved processes generate a rather broad spectrum, starting from dynamic town expansion based on high construction activities and its structural as well as functional development leading towards a spatial divergence of centrality, continuing with strong economic display and increased social living standard (Balzerek, 2003).

2.2.3.5 Importance of urbanization

To a larger extent a state level of urbanization is directly proportional to level of modernization, industrialization and development. It is obvious that economic growth, social and political change, technical and scientific progress and advancement indices are simultaneously advancing with the urbanization process as human development indications are strongly liked to urbanization (WUF, 2011).

Therefore despite the fact that the face and pattern of urbanization process differ from one region to another, it is truly a global phenomenon, despite its associated problem which are more pronounced in Third World countries, the benefits of

urbanization are obvious, which manifest in socio-economic indicators of urban dwellers of any region when compared with its counter rural dwellers.

Thus, the progress of urbanization has not been without it shares of problems: urban poverty, proliferation of slums and squatters settlements, inadequate infrastructures, poor access to social service and environmental degradsation among others. According to UNCHS (2002), cities and towns have been the nucleus of development and gateway to civilization as they facilitate the evolution of knowledge, culture and tradition as well as commerce and industry. Urban settlement when properly planned and managed, becomes a promise land for human development and protection of world natural resource, through their ability to support large number of people, while limiting their impact on natural enrichment.

2.2.3.6 Problems of urbanization

The increasing rapid urbanization in both developing countries with its associated problems of urban poverty, unemployment, inadequate facilities poor hygiene, growth of slums and ghettos and general environmental degradation is posing a serious challenge of urban management in most of developing countries. According to UNFPA, (1996) figures indicate that more than half of the world's population lived in urban areas, inhabiting only 3% of the earth's land area. The United Nation 1991 projection, by 2030 world urban population is expected to reach 65% of the total world population. This rapid face of urbanization despite been a driving agent (force) of economic growth, development and modernization, has a serious implication as both social and physical environment principally manifesting in human health, livelihoods and environment. Thus,

several arguments were being put forward as relative negative and positive effects of urbanization. The World Urban forum 6 (WUF 6, 2011) report, argue that socio – economic growth, technical and scientific development are direct impact of urbanization. Thus, according to first and second world urban forum reports, it is clear that managing rapid face of urbanization will be one of the most pressing concerns confronting humanity in the 21st century. Therefore, one can easily say that urbanization is both a cause of blessing, as it can only be problems when partly managed, thus a need for proper management and planning by decision makers.

The associated negative effects of urbanization are manifesting in both physical and social environment of the urban centers; which are direct results of poor planning of urban management. Management of urban centers requires multidisciplinary approached. The rate, patterns and trends of urban growth are the major inputs in urban planning and management. Despite the fact that urbanization is a catalyst of economic growth and development, the concern on the effects of expanding cities on public health, general livelihoods, and the physical environment, is attracting the attention of decision makers and scholars. United Nations conference on Environment and Development (UNCED, 1992), reports that implication of rapid urbanization and food securities is rural aggression population, others include unemployment, water supply, shelter and sanitation, especially solid and liquid waste disposal, that cities and towns are producing possess serious problems that are worth considering and hence requires the attention of concern authorities and individuals.

2.2.3.9 Disadvantages of urbanization in Nigeria

According to UN-HABITAT (2004), the situation of municipal services and urban infrastructures in Nigeria is frightening as their access is below African average. UNDP (1998), reports that about 75% of urban dwellers in Nigeria are living in slum/substandard housing characterized by overcrowding and lack of basic amenities. The deterioration of human settlement condition because of rapid urbanization in Nigeria has been reported. Mabogunje (1968) Observed that there is a tremendous population pressure on limited facilities which manifest on several environmental socio–economic problems that led to the emergence of squatter settlement, overcrowded habitations in housing, schools, recreational facilities, inadequate water and power supply, breakdown of waste disposal system and poor environmental sanitations among others are norms rather than exception in most of the Nigerian cities (Bhatta, 2009).

2.2.3.10 Urbanization and urban future

The increasing proportion of population residing in urban areas and the future of mankind lies in the growing magnitude of the urbanized areas. Decisions about the emerging future are made by all members of population and by all members of the society. But for whatever, underlying motive or purpose the consequence will leave their indelible stamp upon man's living and changing environment (Jackson, 1972). He further asserted that the future exist in the city of 1970s, and as circumstances moves forward inexorably into the city of tomorrow, society can bend, control, direct and lend the city as it now exists towards its horizon of doubt and uncertainty. The city of tomorrow is on architect's drawing board and planner's blue prints, if politician's embrace and in the minds of men today.

The African urban areas have a bright future in achieving sustainable development using participatory approaches (Ndung'u, 2002). He further asserted that participatory planning for sustainable African cities is indeed possible. It is an exorable fact that the decisions, which are now being made, can help shape, form and achieve the urban future (Jackson, 1972).

2.2.4 Urban Land Suitability

Land suitability refers to the ability of a particular type of land to support a specific use, and the process of land suitability classification involves the evaluation and grouping of particular land areas in terms of their suitability for a defined use (Prakash, 2003). Land suitabilityanalysis is thus concerned with evaluation of the fitness of a given tract of land for a defined use (Steiner, McSherry and Cohen, 2000). In other words, it is the process to determine whether the land resource is suitable for some specific uses. It is also undertaken to determine the suitability level. In order to determine the most desirable direction for future development, the suitability for various land uses should be carefully examined with the aim of directing growth to the most appropriate sites. Establishing appropriate suitability factors is the construction of suitability analysis. Initially, suitability analysis was developed as a method for planners to connect spatially independent factors within the environment and, consequently to provide a more unitary view of their interactions. Suitability analysis techniques integrate three factors of an area: location, development activities, and biophysical/ environmental processes. Land

use suitability analysis aims at identifying the most appropriate spatial pattern for future land uses according to specific requirements, preferences, or predictors of some activity.

Acquiring new site for urban development or improvement is becoming increasingly challenging, particularly in a growing real estate market and with stringent environmental standards or regulations. The results of the site suitability analysis produce a detailed display of the most-suitable areas for consideration of placement of a certain facility, while filtering out unusable or less desirable sites. Certain aspects are more important than others in determining the best location for each facility. The selection of suitable sites for specific uses must be based upon a set of criteria depending on local norms. A scoring system can be applied to the various aspects of suitability to assess the overall suitability for a specific urban use (Kumar and Shaikh, 2013).

2.2.5 Factors Suitable for Urban Development

Land Suitability analysis for urban development requires consideration of a comprehensive set of factors and balancing of multiple objectives in determining the suitability of a particular area for a defined land uses (Karmal and Venkata, 2007). Specific factors can be chosen for specific kinds of development. The factors used for land suitability analysis for urban development include but not limited to: topography, land use, drainage and accessibility.

2.2.5.1 Topography

Topography is considered one of the most frequent required criteria for determining the land use suitability. Topography is represented by both elevation and

slope. For elevation; the lower the land the more the suitability, since low areas have more accessibility for basic facilities, such as transportation and water supply which is more difficult and expensive to be accessible for higher lands. Topography is the shape of the ground formed by highlands, slopes, rivers, swamps, coast, and river network which have their own aesthetic values. According to the Physical Planning Handbook (2008) a hill area is an elevated land that has a slope of more than 12 degrees while a highland areas are land situated more than 150 meter from sea level and slope that exceeds 25 degrees. Hilly areas are natural assets that can be developed as tourist attractions sites such as hotels, apartments, condominiums, and multi storey housing. Development in hilly areas requires several physical criteria that must be observed not to endanger stability, balance and harmony of natural environment. The Physical Planning Handbook outlines the following development criteria with slopes areas:

i. Between 5 degrees to 15 degrees are considered as medium slopes and could be developed with the implementation of slopes control measures.
ii. Between 15 degrees to 15 degrees could be developed with the implementation of control measures.
iii. Areas with slopes that exceed 25 degrees are not allowed any development these are considered critical for safety of human settlements.

Slope is an important criterion in hilly terrain for finding suitable sites for urban development. Steep slopes are disadvantageous for construction. Steeper slopes increase construction costs, limit maximum floor areas and contribute to erosion during construction and subsequent use.

2.2.5.2 Land cover

Some land covers are least or not suitable for land use. Built -up area is not suitable for the future development because once a building is constructed, it remains there for minimum of 50-75 years. Thus barren land is considered highest suitable. For example, wetlands and granitic mountainous parts are least suitable, while gravelly and sandy plains are more suitable.

2.2.5.3 Drainage/Riparian analysis

High rates of urban developments in an area lead to increase of impervious areas which produce high quantities of storm water. There is need to protect the riparian reserves4 in the town. According to the Physical Planning Handbook (2008) a riparian reserve ranging from a minimum of 10m-60m should be provided. Development activities should not be located on the course of the main streamlines and a considerable buffer around these main drainage lines should be taken into consideration.

2.2.5.4 Accessibility/Road proximity

Road accessibility is one of the important parameters for urban development as it provides linkage between the settlements. Road is also an important criterion in land suitability for urban development suitability because of the need to transport people, goods and services.Construction of new road is expensive in hilly regions. Therefore, effort should be made to locate the major urban development nearer to any existing road if possible. The study area has been classified under two-type road viz: major roads and minor roads.Table of evaluation criteria were generated based on topography, roads infrastructure and constraint maps. Measurement indicators as used in the tables refer to

the factor of consideration used in modeling while the scale ranges are specific intervals for units of measurement (Guhaatha, 2003).

2.2.6 Analytic Hierarchy Process (AHP)

The Analytic Hierarchical Process (AHP) is one of the methodological approaches that may be applied to resolve highly complex decision-making problems (Saaty 1980). AHP was proposed in the 1970s by Thomas L. Saaty. Saaty, in his initial formulation, proposed a four-step methodology comprising modelling, valuation, prioritization and synthesis. At the modelling stage, a hierarchy representing relevant aspects of the problem (criteria, sub criteria, attributes and alternatives) is constructed. The underlying goal or mission is placed at the top of this hierarchy. Other relevant aspects (criteria, sub-criteria, and attributes) are placed at the remaining levels (Altuzarra, Maria, Jimenez and Salvador, 2007). The AHP method commonly used in multi-criteria decision making exercises was found to be a useful method to determine the weights, in comparison with other methods used for determining weights. When applying AHP, constraints are compared to each other to determine the relative importance of each variable in accomplishing the overall goal.

In day to day life the pair-wise comparison is undertaken to a certain number of options to select the most appropriate one from a given number of alternatives. However, this process includes errors and limitations. It is so because the capacity of the human brain does not allow evaluating each and every given alternative as a result selection is narrowed down to a fewer once. Though this reduces the load on our brain and makes the process extremely simple, the rationality of the process based upon intuitive selection

may produce unwanted results choosing a wrong alternative and overlooking the best solution (Kinoshita, 2005).

Evaluation of the suitability of lands for urban development plays a fundamental role in regional and urban land-use planning. Its major objective is to evaluate the advantages and disadvantages of certain areas for urban development, so as to find out places which are most suitable for urban development in the future. Land suitability analysis mainly deals with a large amount of data on several dimensions. Analytic hierarchy process (AHP) is a classical land suitability analysis procedure, which gives a systematic approach in making proper decisions for site selection and appropriate allocation of lands for different uses. It also suggests the integration of the GIS-based land suitability model for site selection (Mendoza, 1997).

Integration of GIS for land suitability analysis serves three objectives. First, to provide an introduction to geographical information technology along with an historical perspective on the evolving role of Geographic Information Systems (GIS) in planning. Second, to overview relevant methods and techniques for GIS based land-use suitability mapping and modelling. And finally to identify the trends, challenges and prospects of GIS-based land-use suitability analysis.

2.2.7 Scale for Pair Wise Comparison

In AHP all identified criteria are compared to each other in a pair-wise comparison matrix, which is a measurement to express the relative preference among the factors.

Thus, numerical values express a judgment of the relative preference of one factor against another. Saaty (1980) suggested a scale for comparison consisting of values ranging from 1 to 9 which describe the intensity of importance. In this a value of 1 expresses "equal importance" and a value of 9 is given to those factors having an "extreme importance" over another factors. Table 2.1 shows the scale used for the comparison. The factors under consideration were compared to each other using the pair–wise comparison matrix.

The selection of suitable sites is based upon a specific set of local criteria. The characteristics of a site (e.g., present land use, slopes, water availability, geology, geomorphology, etc.) influence its suitability for a specific land use type. To assess the overall suitability a scoring and weighting system is applied to the various aspects of suitability. Site suitability is the process of understanding existing site qualities and factors, which will determine the location of a particular activity. The purpose of selecting potential areas for residential development depends upon the relationship of different factors, like location of available sites, extent of the area, accessibility, etc. and site association factors like slope, soil etc. The analysis may also determine how those factors will fit into the design process to evaluate site suitability (Saaty, 1980).

Table 2.1 Nine point weighting scale for pair-wise comparison

Intensity of Importance	**Definition**	**Explanation**
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another

4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	

Source: Saaty, (1980)

2.2.8 Land Suitability Analysis

The literature on land capability and suitability analysis is sparse. There is no doubt that land capability analysis may have been in use since humans first searched for suitable sites for various activities (Gustafson, 1998). However, many of the works that have been done have not been published, or even if published no explicit mention was made on the method used (Gordon, 1985). There was relatively little work done in the subject that could be said to have a definite methodology (Lyle and Stutz,1983). For instance, there is evidence that ecologically –based planning methods already existed during the part of the last century and indication that there is a respect of available natural resources accompanied by much concern for the quality of the environment ‘’ (Navah and Lieberman, 1984).

2.2.9 HistoricalDevelopment of Land Capability and Suitability Analysis

Land capability analysis has undergone considerable evolution, redefinition, and development since the turn of this century. Trowbridge (1979) indicates that trial-and-error techniques were among the early clearly identifiable regional methods of the 20th century.

These methods, planning decisions were made partially from common sense and experience as well as through a series of related actions and reactions. It was difficult to specifically relate two complex series of decisions because these approaches were nonreplicable. It was also difficult to arrive at agreement about the existence of the same environmental qualities in a particular region because of partial or biased observations and the colouring of human judgments by individual's experiences (Navah and Lieberman, 1984). As planning decision-making at the regional level became more complex, the need for a more comprehensive land use approach increased. As a result hand- drawn overlay and their histories have been traced by Steinitz (2003) as summarized below.

The earliest evidence of the use of data overlays as an analysis technique was found in a study done by Warren Manning in 1912 for the town Billerica, 22km northwest of Boston (Steinitz, 2003). Manning used soil and vegetation information together with topography, and their combined relationship to land use to prepare at least four different data maps of the town and one plan showing recommendations and changes in the town's circulation routes and land use pattern(Karmal and Venkata, 2007) . After Manning, there were indication that the overlay technique was applied in several studies (e.g. the city plan for Dusseldorf in 1912, and The Doncaster Regional planning scheme

in 1922).No notable advances in the technique were realized until the development of the sieve mapping technique in England (Lyle and Stutz, 1983). The sieve mapping technique was first described by Jacqueline Tyrwitt (Hammond and Walker, 1984).This survey probably provides the first explicit discussion of the "overlay technique' (Steinitz,2003). In the view of Tyrwitt, all maps are drawn on transparent papers to the same scale and referenced to common control features. Maps are combined and analyzed into one map which defines land areas that, for various reasons, should not be developed. This technique was widely used in the large-scale planning of the British new towns and other development projects after World War II (Lyle and Stutz, 1983).

During the 1950s, there was again little development in the overlay technique for land planning and design purposes. This trend was then changed considerably in the 1960s, where many more examples of using overlay analysis techniques were later observed. In 1961, G. Angus Hills, a Canadian forester, developed a plan for Ontario province, which is an early North American examples of employing a more sophisticated data overlay technique (Navah and Lieberman, 1984). Beginning in the 1940s, Hills was concerned with ecologically-oriented planning for forestry, fish, wildlife, and recreational land management (Steinitz,2003). He developed an approach to a land classification system which is based on physiographic characteristics. In Hills' technique, regions are broken down hierarchically into consecutively smaller units of physiographic differentiation based on a gradient scale of climate (macro and micro) and landform features (e.g. landform, soil and geology). The smallest unit and first phase of classification is the physiographic site type, which is then compared to a predetermined set of general land use categories to determine its potential use. The potential uses are

ranked at two levels: local and community. At the local level, i.e. the second phase of the system, the land units are "ranked on a scale of values corresponding to the degree of potential or limitation form each use or activity''. The ranking is based on the highest intensity and quality of use that can be accommodated without deteriorating the site. This ranking also indicates the capability class of each unit. Based upon this capability classification, these units are then regrouped into larger geographic areas called landscape units. The resulting units are again ranked to determine their relative potentials for dominant and multiple uses.

Philip Lewis, a landscape architect at the University Of Wisconsin- Madison USA, is another individual who was active in land use and resource analysis using the overlay analysis technique (Gordon, 1985). All these factors are mapped on transparent overlays and combined to produce a composite map that reflects the major patterns of land suitable for a particular purpose. Lewis assigned points to those areas that possessed the resource necessary for a particular use reflecting the values of those resources. These points were then totaled depicting areas of prime environment importance.

Further advancement in the overlay technique is the ecological inventory process of IandMcHarg, a landscape architect and planner from the University of Pennsylvania. McHarg's approach requires the gathering of information on the basic natural as well as man- made attributes of the study area (Gordon, 1985). Each element of the area is mapped and photographed as a transparent overlay. Each land area is then ranked relative to its suitability for one or more land uses. The rankings are given on a scale of 1to7, and are represented on overlay map where the lightest shading or color indicates the most suitable ranking for that resource for the particular land use under consideration and the

darkest shades indicate the most suitable locations. The overlays are then combined to obtain the overall rankings, showing those areas with the most suitable conditions.

The hand-drawn overlay method has limitations too. It has been frequently criticized for the practical difficulties of superimposing a large number of maps, also known as the "blobs'' problem (Gordon, 1985). It is also difficult to update/revise the maps for other analyses using different criteria. These problems have been greatly eliminated by recent methods as well as with the introduction of computer-assisted planning methods such as the geographic information system (GIS) to be discussed in later sections.

2.2.10 Existing Land Capability and Suitability Analysis Methods

Land capability and Suitability analysis has been used since early in the 20th century. It has since then undergone considerable evolution, redefinition, and development. At the present time, there exists a wide variety of land capability and suitability analysis techniques.

McAllister (1980) classifies these techniques into two groups: qualitative and quantitative. In the opinion of McAllister (1980), the qualitative approach classifies " land into ecological types to which land use principle are applied determining suitability'', while the quantitative approach uses the conventional method of assigning ratings and calculating a grand index of land suitability.

Hopkins (1973) in his comprehensive review of land capability and analysis techniques, on the other hand, divides these techniques into two broad classifications: gestalt and combination. The gestalt techniques are generally the earliest versions of land

capability and suitability analysis. The combination techniques, which reflect the evolution of more sophisticated techniques, are further broken down into categories which includes: mathematical combinations (ordinal, ordinal with ordinal indices, linear, and nonlinear), the explicit identification of region (factor combination and cluster analysis), and logical combinations (rules of combination and hierarchical combination). Chapin and Edward(1989) identify land capability and suitability analysis techniques based upon Hopkins's classification. In contrast to gestalt methods, Chapin and Edward(1989) identify the simplest suitability analysis as the one based on single environmental characteristics such as the detailed soil classifications.

A more recent review of land capability and suitability analysis techniques is given by Anderson (1987) He reviews seven techniques: pass/fail screening method, penalty point assignment method, graduated screening, weighted factors, composite rating, direct assignment, and weighted composite rating method. All of these techniques can actually fall under the combination methods of Hopkins' classification, although they were given different names by the author. For reasons of simplicity, the review of land capability/suitability analysis techniques that will follow will be largely based upon Hopkins' broad classification systems and his elucidating review.

2.2.10.1 Gestalt methods

The gestalt method views a region or site as a whole whose properties and reactions to development cannot be derived through consideration of its individual characteristics. The basic principle of the method is that the analyst divides the region into homogeneous areas by analyzing the internal relationship of the whole region

directly through field observation, implicitly using clues such as topography, vegetation and substrate to establish distinct units. It is not possible to combine the individual factors (e.g. topography, soil, vegetation, etc.). This method has also been known as the landscape or "holistic'' approach (Anderson, 1987) to land capability/suitability analysis. This method can be described in 3stps (Hopkins, 1973). The study area is first partitioned into homogeneous regions based on implicit judgment. Then a table is developed that verbally describes the effects or problems that will occur in each of the areas if each of the potential land uses is located there. The third set is to draw a set of maps, one for land use, that show the homogeneous regions in terms of their suitability.

Several of the earlier land capability and suitability studies may have used the gestalt method. These include the works of Warren Manning, Angus Hills, Phillip Lewis, and Abercrombie and Johnson. The works of the first 3 authors have been reviewed in the previous section, and will not be repeated here. Abercrombie and Johnson (1922) used this method in a study involving the mapping of circulation patterns, accessibility, and topographic areas such as "Lowlands'' Abercrombie and Johnson then synthesized this information by some techniques, possible map overlays, and recommended the general land use and circulation patterns. The map overlays did not produce direct suitability results. Instead they facilitated the mental synthesis and analysis of relationships typical of the gestalt method (Steinitz, 2003).

The gestalt method is relatively simple since it is based on direct observation and does not require the consideration of individual factors such as slope, soils, vegetation, etc. It views the site as a whole, thus has the capability to handle interdependence among factors. The method however suffers from the implicit, hence subjective, nature of

judgments regarding land homogeneity and suitability (Anderson, 1987). It requires the planner to have longstanding local experience. Since it views a region as a whole without identification of individual factors, it is difficult for others to scrutinize or confirm the land suitability's generated using this method. It may also be difficult for the planner to convince others or decision makers of the validity of suitability results (Hopkins, 1973). Due to these limitations and the frequent necessity to present and communicate results from planning analysis to other professionals and the general public, it was necessary to devise more explicit methods of combining factors in order to discover land suitability. The combination methods presented in the next section were derived in response to this need.

2.2.10.2 Combination methods

The combination methods, which are parametric in nature, reflect the evolution of more sophisticated techniques. In these methods, individual landscape/environmental parameters or attributes are separately mapped and rated for suitability, which are then combined into a grand (composite) index of suitability (Anderson, 1987). The basic assumption is that these methods yield valid suitability ratings because of the properties of the methods (Hopkins, 1973). The methods can be further broken down into 3 categories which include: mathematical combinations (nominal, ordinal with ordinal indices, linear and nonlinear), the explicit identification of region (factor combinations and cluster analysis), and logical combinations (rules of combination and hierarchical combination).

2.2.10.3 Hierarchical combination method

The basic concept of this method is that composite rating can be generated hierarchically. It evaluates and rates combinations of types from subsets of highly related (interdependent) factors. The combinations are further combined into higher order combinations and then given overall ratings.

An excellent example of the use of the hierarchical combination method is the study for a highway corridor by Alexander and Manheim in 1962 (Alexander and Manheim, 1962). Alexander and Manheim use 26 different factors (criteria) depicting the desirability for highway location of each specific requirement of the highway study. They propose a formal "tree" (hierarchical) procedure for combining and weighing of factors. The implication of the tree structure is that "the designer starts with the groups of requirements at the lowest level of the tree, and then proceeds upwards, gradually considering each of the groups at higher levels" (Alexander and Manheim, 1962). The factors were first combined to produce smaller subset of maps representing overall suitability for that combination. These subsets were further combined to produce yet another smaller subset of maps, and the process continued until a final composite map was developed.

This method shares most of the strengths and problems of the rules of combination method described earlier. However, it has the advantage that fewer factor combinations ultimately need to be rated (Mendoza, 1997), and partly avoid the problem of non-comparability of rating scales in the linear combination methods described earlier (Alexander and Manheim, 1962).

2.2.11 Recent Development in Land Capability and Suitability Analysis

Rogoff (1980) developed a set of procedures to numerically rate soil potential for several urban land uses. Unlike the approaches reviewed earlier, they apply (introduce) different corrective measures to soils with severe limitations. By applying these measures, they found that the land suitable for these uses may be increased. The implications of this study are that land originally thought unsuitable for urban development may actually be suitable provided that certain corrective measures are applied to overcome such limitations. This raises the question of the possible impacts of new, innovative technologies upon the existing land capability/suitability analysis. This approach can also be extended to other factors such as slope, etc.

Lyle and Stutz (1983) propose a land suitability method that is defined by analyzing the interactions among three sets of factors: location, developmental actions, and environmental effects. This means that given certain developmental actions to be carried out and the specified environmental effects to be controlled, one can then find the most or least suitable location (sites) for those actions. This approach considers ecological factors as the fundamental determinants of land use patterns. The concept of the approach incorporates a close connection between land suitability analysis and environmental impact prediction.

The interaction describing the developmental actions is basically human activities occurring on the land which may bring changes to the environment. This can be divided into 2 categories: capital and operational. Capital actions are those that invest energy and natural resources in physical alterations and additions to the landscape. The developmental actions were listed and described in a series of charts or tables to provide

simplified comparisons of environmental effects brought about by different methods of producing the developmental actions.

Information describing environmental effects is analyzed using a flow diagramming technique which is based on the symbolic language for tracing energy use. The interactions among factors are identified by means of a transformation key chart. This chart lists the developmental actions with which each transformation interacts (Margaret and Paul, 2006). Lyle and Stutz (1983) have successfully used this approach in several real life projects such as the San Diego Coastal Plain project, and the Vandenberg Air Force Base project.

The suitability maps are generated based upon a combination of 3 methods: the linear, and nonlinear combination in conjunction with the rule of combination methods. The authors observed that the suitability-assessment process has 3 major characteristics: 1). The task of selecting meaningful ratings, weights, and methods of combination is too complicated and tedious to be done manually, 2). "Expert judgment and knowledge are common and necessary ingredients of the assessment process", and 3). "factor combination is often best achieved through the use of an explicit set of rules and verbal logic". The problems with these characteristics are resolved using rule-based expert systems (RBS), a computer program designed to use domain-specific knowledge gathered from human experts to perform problem-solving tasks in a manner similar to humans. In this case, the role of the RBS is to provide recommendations on the set of ratings, weights, and combination strategies to be used in the land capability and suitability analysis. This recommendation is derived from an interactive question and

answer session with the user. The resulting suitability maps serve as data for the multi objective programming models, the third component of the ISIS.

The multi objective programming models are used to define the geographic areas best suited for a single facility or land use. The model is based on the assumption that parcels of land are of the same size and shape, and arranged in a regular grid configuration, which is well suited for implementation in a grid-based GIS. The "best" site is identified by first finding an initial non-inferior solution. Depending upon the preference of the decision-maker, another non-inferior solution can also be identified by improving the value of one objective at the expense of deteriorating the value of another objective. The procedure continues moving from one non-inferior solution to another until a solution is found that is consistent with the preferences of the decision maker.

In order to describe the suitability for the location of each land use, the model makes an explicit distinction between two sets of criteria: the site criteria, and the situation criteria. Site criteria are "those that involve relationships between a proposed land use and the characteristics of the existing study area". Situation criteria, on the other hand, are "those that involve relationships between a proposed land use and the other proposed land uses".

2.4 **LITERATURE REVIEW**

Klaverblad (1992) evaluated land suitability for urban related land uses in relation to the regional physical planning of West Java, Indonesia using GIS. The study area was divided into four different suitable categories viz. high suitable, moderate suitable, low suitable and not suitable. The scores derived by these four levels of suitability are 8, 7-6,

5 and 0 respectively. The study found that the high suitable zone covers a geographical area of 10943.53 hectares of land in absolute terms and accounts for 17.23 percent of that total suitable area. The area was further found to be surrounded by existing built up area of the city except some portion in the southern part of the city which were surrounded by other land uses.

Ontumbi (2014) assessed the land Suitability for Urban development in Kisii Town, Kenya. The study considered of five factors, that is, slope, road proximity/accessibility and ecological sensitivity by using multi-criteria decision analysis (MCDA) method in decision making process. With the support of Geographic Information System (GIS) and multi-criteria. The main source of data were light detection and rangingLiDAR image that was acquired in 2012. Interviews were also conducted with various stakeholders in urban planning in Kisii town. Direct observations were also done. The results showed that from the study approximately 18.46km^2 of the study area was very suitable and this is represented by nearly 26% of the study area. The area under suitable criteria for urban development is 31% represented by 22.01 km^2. In addition nearly 21% of the study area of moderate suitability for urban development and this is represented by 14.91km^2. Areas of least suitable for urban development are represented by 9.23km2 which makes up 13% of the study area. Unsuitable areas for urban development consist approximately 6.39km^2 represented by 9% of the study area.

Kumar and Biswas (2014) analyzed the site suitability for urban development of a hill town using GIS based multi-criteria evaluation technique in Nahan Town, Himachal Pradesh, India. Factor considered include: slope, road proximity, land use, land values, soil and geomorphology factors. They data used was Cartosat-1 and LISS-IV and six

thematic information layers were analyzed in ArcGIS 9.3 software to identify suitable areas in Nahan town. The study used GIS based Overlay Weight age Average (OWA) Sum and Weighted Linear Combination (WLC). The undulating terrain, steep slope, varied soil depth and high building cost give the impression to find out suitable sites for urban development in the Nahan Town. Six factors (slope, road proximity, land use, land values, soil and geomorphology) were identified for criteria evaluation. The showed that 0.1157km^2 falls under very low suitable, 1.6835km^2 under low suitable, 1.2090km^2 under moderately suitable, 0.3663km^2 under high suitable and 0.1248 km^2 under very high suitable. The result further revealed that highly suitable areas for urban development is either agricultural or forest type.

Chen (2016), assessed the land-use suitability for urban development in Bedingo, Regional Victoria. The study made use of GIS based land-use suitability analysis and its application in urban planning decision making in the study area. Geophysical, socioeconomic and cultural data are used to assess future urban growth suitability in Bendigo based on key goals such as Connected and Compact City (transport and connectivity), City of Equality (education, health services), Ecological City (environmental conservation), and Safe City (risk of disasters). The resultant suitability map indicates primary suitable lands for future urban growth are located adjacent to the established urban areas.

Tomline and Johnston (2000) develop a dynamic modeling approach to land capability/suitability analysis and land use allocation using geographic information systems as part of the ORPHEUS project sponsored by Prime Computer Inc. The approach is in the form of a cartographic model, i.e. a series of map transformation

proceeding from basic data and sitting criteria to a general land use plan. The model is organized on a land-use-by- land-use basis, and comprised of 2 components: the descriptive component, and the prescriptive component. The purpose of the descriptive component is to describe the characteristics of different sites and situations in terms of their relative suitability for the location of a particular land use. The purpose of the prescriptive component is then to move from a description of locational suitability to a prescription of how best to achieve the land use allocation.

Land capability and suitability analysis has been criticized for not producing an optimal land use plan as its output. Diamond and Wright (1988) formulated their models as land use optimization models in an attempt to overcome this problem. Anjomani (1984) formulated his capability model as a linear assignment model based on the model developed byHopkins (1973). The objective function of the model is to minimize negative effects by maximizing the overall development suitability.

Diamond and Wright (1988) developed a decision support system that consists of three distinct decision making technologies: a geographic information system (GIS); a rule-based system (RBS); and a multi objective programming model (MPM) that are linked together in the form of an integrated spatial information system (ISIS). The role of the GIS is to provide information to the decision models in the form of composite suitability maps depicting the relative suitability of any given parcel or region for achieving a particular objective. A separate suitability map is generated for each objective.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 INTRODUCTION

This chapter deals with the method and techniques used for data collection an analysis as required for the study. The variables and or parameters considered under the study include location, drainage, climate, economic activities, soil and vegetation.

3.2 THE STUDY AREA

3.2.1 Size and Location

Sokoto, the capital of Sokoto State, lies between Latitudes 12^{o} 56' 0'' N - 13^{o} 12' 0''N and Longitudes 04^{o} 56' 0'' E - 05^{o} 16' 0'' and altitude of 272m above mean sea level. It is located in the extreme northwestern part of Nigeria see figure 3.1. Modern Sokoto lies along the Sokoto – Kebbi River east of the Rima River. The town, some 80 km south of the Republic of Niger border lies on a traditional caravan rout that leads northwards across the Sahara. The city has an urban planning area of 97,000 hectares and it has always been a centre of learning and scholarship.

3.2.2 Weather and Climate

The weather and climate of the study area is largely controlled by two air masses i.e. the tropical maritime and the tropical continental. In tropical maritime the source region for this air mass is warm waters of the Atlantic Ocean between the Azores and Bermuda. The predominant wind direction across the British Isles, in a tropical maritime air mass, is south-westerly. Tropical maritime air is warm and moist in its lowest layers and, although unstable over its source region, during its passage over cooler waters becomes stable and the air becomes saturated. Consequently when a tropical maritime

air mass reaches the British Isles it brings with it low cloud and drizzle, perhaps also fog around windward coasts and across hills. To the lee of high ground though, the cloud my break up and here the weather, particularly in the summer months, can be fine and sunny geographical (Ekpoh and Ekpenyong, 2011).

In tropical continental the air mass originates over North Africa and the Sahara (a warm source region). It is most common during the summer months June, July and August, although it can occur at other times of the year. The highest temperatures usually occur under the influence of tropical continental air (over 30 °C by day and around 15 to 20 °C at night). Visibility is usually moderate or poor due to the air picking up pollutants during its passage over Europe and from sand particles blown into the air from Saharan dust storms. Occasionally, the Saharan dust is washed out in showers producing coloured rain and leaving cars covered in a thin layer of orange dust (Ekpoh and Ekpenyong, 2011).

3.2.3 Relief and Drainage

Sokoto State is located within the Illumedien basin, which is surrounded in the east and south by the Precambrian basement complex. Within the State, there is no outcrop of basement complex. It is rather covered by a series of sedimentary rocks which have been deposited over the basement complex. The sediments were laid down under the varied environmental situation ranging from continental to marine events (Ekpoh and Ekpenyong, 2011). Sokoto State is drained by the Rima River and its tributaries, most of which rise in the southeastern part of the state and in the neighboring Kaduna State. The Bunsuru and Gangere Rivers flow in a northerly direction, joining the Rima near SabonBirni. The Sokoto, Zarnfara and Kaduna tributaries, on the other hand,

flow west wards to join the Rima. In their upper reaches, all the tributaries flow over basement complex rocks. Their valleys are rather narrow and restricted until the rivers enter the area of young sedimentary rocks, where they flow through broad valleys (Africa Atlases, Nigeria, 2002).

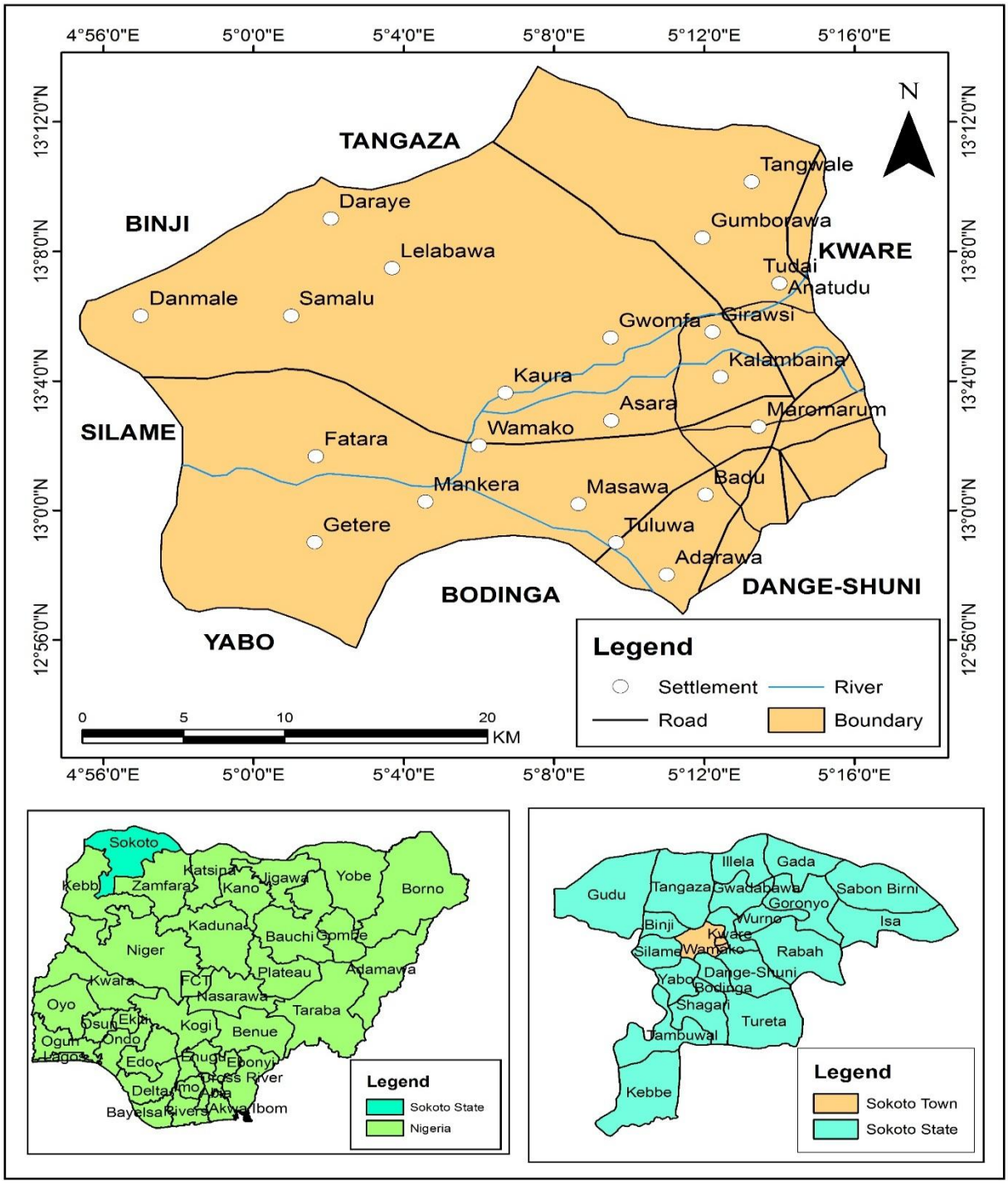


Figure 3.1 Sokoto metropolis (The study area)

Source: Adapted from map of Sokoto State

3.2.4 Population and Pattern of distribution

Sokoto has a population of 3,666,999. The demographic features of the population show that over 55 per cent of the population is under 15 years of age while the economically active labour force (15- 64 years) is nearly 40 per cent of the population (NPC, 2007). This shows a high youth dependency ratio. Three critical factors are important in the distribution pattern of population in Sokoto State. These are the history of the state particularly that of the former Sokoto Caliphate, the availability of water and fertile soils as well as the development of urban areas arising from state and local government creations. One of the most striking characteristics of the population distribution in the state, like other states, is its unevenness and variable density. For example, while the Tureta and Gundumi forest reserve areas are sparsely populated, high densities of over 300 per sq.km can be found within the Sokoto home districts.

3.2.5 Road Network

The most dominant transport system available in the study area is the road transportation. The area is connected to different parts of the country and even other countries (Niger) via road which can be categorized into federal, state and local government roads (Truck A, B and C respectively). Intercity transport is conducive with commercial buses, taxis, tricycles and motor cycles due to the available road network connecting all parts of the city. This road network in the city have experience several changes over time due to changes in land uses (Ohamobi, 2012)s.

3.3 MATERIALS AND METHODS

3.3.1 Reconnaissance survey

A reconnaissance survey was carried out. The purpose was to get the researcher acquainted with the study area. During the survey, observation was made on type of land cover (prominent features such building, roundabout, institutions etc.) available in the study area and their coordinate were taken with aid of Global Position System in order guide the researcher for the analysis.

3.3.2 Types and sources of data

Both primary and secondary data were utilized in this study. Primary data that were used are satellite imageries (LANDSAT and Shuttle Radar Topographic Mission, SRTM). Other literature were sourced from newspaper, journal, textbooks etc.

Table 3.1: Data Types and Sources

S/No	Type of Data	Spatial Resolution	Date	Source	Purpose
1.	Quick Bird Image	0.5m Spatial Resolution	2014	Sokoto Ministry of Land and Surveys	To verify road network
2	Landsat-8 image	30m Spatial Resolution	2015	United State Geological Survey Website (USGS)	Land cover
3	SRTM-90m	90m Spatial Resolution	2015	United State Geological Survey Website (USGS)	Elevation, slope, aspect and drainage

Source: Author's Compilation

3.3.5 Data processing

3.3.5.1 Image Processing and Classification

a. Image Pre-processing

Since the Landsat 8 imagery is digitally processed within that is they were ortho-rectified there was no need for any geometric and radiometric corrections. However, the images were obtained in different layers and the layer were stacked together using ERDAS imagine 9.2 software; A subset of the study area were obtained using the ERDAS imagine software subset tool. In addition, the images was geo-referenced using ERDAS imagine 9.2 software geo-referencing tool.

b. Classification

ERDAS imagine software was used for the pixel-based classification. Supervised classification was performed using maximum likelihood classifier since it is a landuse and land cover classification which will produce the output raster layer. The three images was classified into different land cover types. Supervised classification allows natural spectral clusters to be distinct with high degree of objectivity (Ahmed, 2011). This method of classification involves the procedure of identifying pixels possessing the same spectral features. ERDAS imagine software will be used in digitally processing and identifying the spectral clusters on the Landsat images. By carrying out this classification, the signature editor was used via the classifier icon of the ERDAS IMAGINE to identify the spectral

signature of different features. Maximum likelihood algorithm was used to classify the images and the digital numbers of the pixels were grouped with pixels arranged and organized otherwise known as land cover classes such as built-up area, vegetation, bare surface, etc.

c. Classification Scheme

To extract valuable information from the images, development of a land cover classification system was done in order to get the classes of interest. The images was be classified as shown in the table below.

Table 3.2: Land Use and Land Cover Classification Scheme

Classes	**Description**
Built-up	Residential, Commercial, Industrial
Bare surface	Exposed soils, and areas of active excavation and production
Cultivated land	Cleared forest lands and deforested area, Farm lands
Vegetation	Any species of plants (flora), forest
Water bodies	River, lakes and reservoirs
Rock outcrops	Any type of rock identified

Source: (Jensen, 2005)

3.3.5.2 Vector data creation (Road Map)

High resolution QUICKBIRD (2012) imagery covering the study area was used and the subsetting of the image for the study area was carried out using Erdas Imagine 9.2 image processing software. The road map (vector map) was generated using ArcGIS 10.1 Software.

3.3.3.3 Generation of slope and aspect map

The slope and aspect was generated from the DEM extracted from the Shuttle Radar Topography Mission (SRTM) spatial resolution of 90 meters. The DEM was processed in ArcGIS version 10.1 environment using the slope and aspect function in the spatial analyst tool.

3.3.3.4 Generation of drainage density map

The drainage network was extracted from the digital elevation model through digitizing and then the drainage density map was generated using the line density tool in GIS environment.

3.3.4 Method of Data Analysis

Objective 1: To assess the nature of existing Landuse of Sokoto town. This was achieved by classifying the various land use and land cover in Erdas Imagine using supervised classification. The land use and land cover map was classified into built-up areas, vegetation, agricultural land, vacant land and irrigated land. The percentage areal coverage for the various land cover was determined and the results were presented on tables and charts.

Objective 2: which is to identify and map the main factors influencing land suitability for urban development in Sokoto town. The various thematic (information) layers such as slope, aspect, road proximity, land use/land cover (LU/LC), drainage density were generated in ArcGIS version 10.1. The weights of the factors were assigned to each layer by pair wise comparison using Analytical Hierarchy Process (AHP). Spatial Analytic Hierarchy Process (AHP) is a type of decision support system that combines

GIS and AHP to identify and rank areas that are suitable for urban development, through utilization of knowledge-based user preferences.

Objective 3:To identify the Suitable Sites for physical urban development in Sokoto town. In order to map out the suitable site for urban development in the study area, the criteria such as slope map, aspect, drainage, road proximity etc. were overlaid using the weight overlay within the GIS environment. The formula is given by Kumar and Shaikh, (2013):

$$\text{Suitability map} = \Sigma\ [\text{criteria map} * \text{weight}]$$

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter is concerned with examination of the type and nature of the existing land use and land cover pattern in Sokoto town, identifying the factor influencing land suitability for urban development in the study area and finally, suitable sites for new urban development were identified for the study area.

4.2 TYPE OF EXISTING LAND USE AND LAND COVER

Supervised classification was used to classify the 2015 Landsat-8 imagery into vacant land, vegetation, irrigation land, urban built-up land and farmland. The area coverage of the land use in the study is presented in Table 4.1.

Table 4.1: Area coverage of existing land use in Sokoto Town in 2015

Land Use	Area in Sq. Km	%
Vegetation	21.5	3.8
Bare surface	62.4	11.1
Irrigation	119.9	21.3
Cropland	294.4	52.3
Built-up Land	64.8	11.5
Total	**563.0**	**100.0**

Source: Author's Analysis, 2016.

Table 4.1 shows that out of the total area of 563sq. km, crop land occupies the highest with 52.3% (294.4sq. km), irrigation land is next occupying about 21.3%

(119.9sq. km) of the area. The urban built-up land occupies 11.5% (64.8sq. km), the bare surface 11.1% (62.4sq. km) and dominate in the northern part of the study area while vegetation is the least with 3.8% (21.5sq. km). Figure 4.1 shows the spatial distribution and pattern of the various types of land cover in the study area.

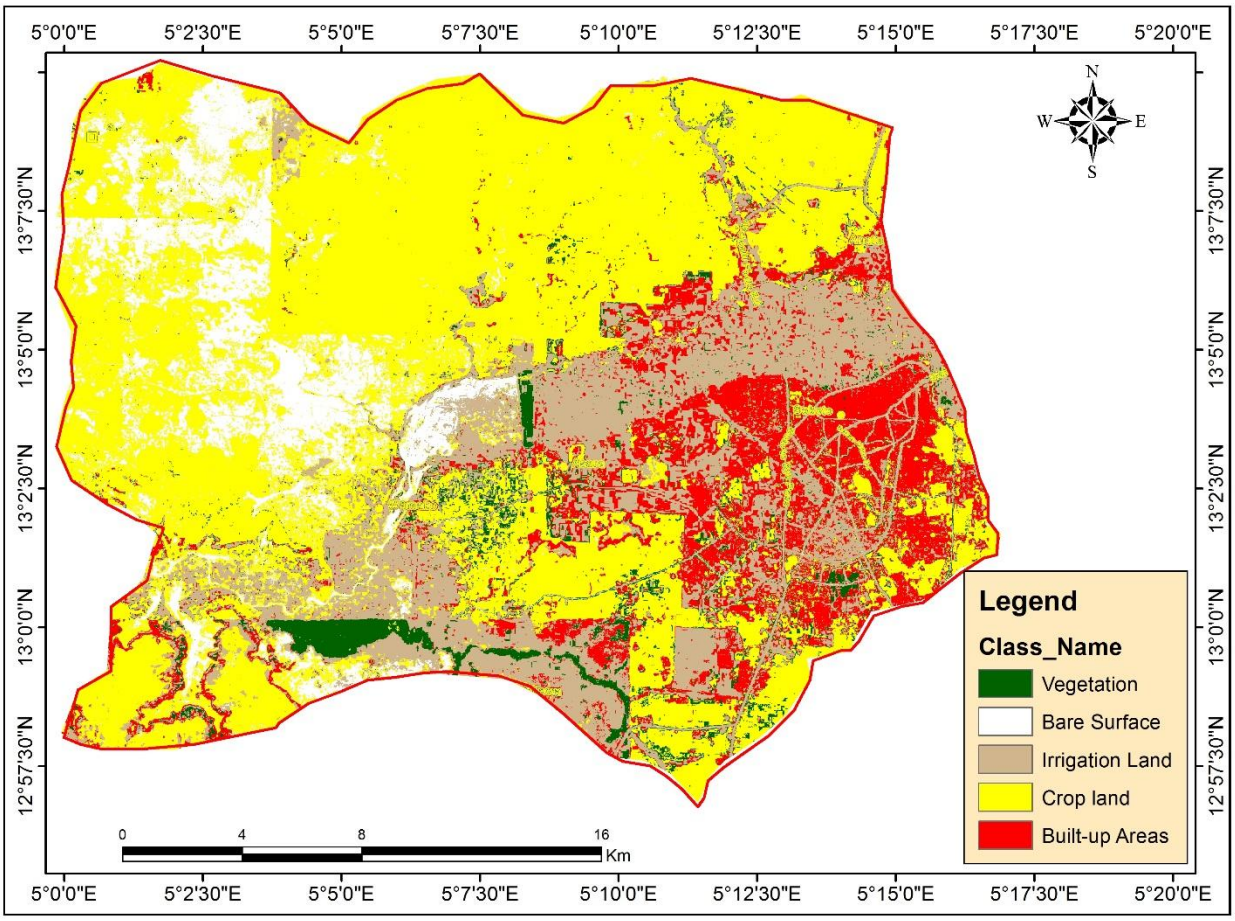


Figure 4.1: Land use and land cover of Sokoto Town in 2015

Source: Author's Analysis, 2016

Figure 4.1 shows that the study area is occupied by crop land (yellow) and bare surface (white) are around the western area. It can also be observed that the urban built-up land is in the eastern area and is clear from the classified map that the urban development has encroached into the irrigated land which most people considered as

flood plain as it lies on a lowland area. Further expansion of the town may lead development towards the flood plain. This means the residents within the flood plain or irrigation land are exposed to risk of flooding. And in order to avoid concentration of development around the flood plain expansion of the town should be directed to more suitable location.

4.3 FACTORS INFLUENCING LAND SUITABILITY FOR URBAN DEVELOPMENT

The factor influencing land suitability for urban development in the study area were examined using five factors adopted from Kumar and Kumar (2014). This factors include accessibility network, slope, aspect, drainage density and land cover of the area. A pairwise comparison was used for each factor using the Analytical Hierarchical process (AHP) to assign the weightages.

4.3.1 Proximity to Road Network

The road network was extracted from the QuickBird Imagery (2014) of Sokoto metropolis through digitizing with a line feature class. Buffering of 100m, 300m, 500m and above 700 as suggested by Physical Planning Handbook, (2008) was used to determine the access to road network for new urban development. Figure 4.2 represents the proximity to road network while Table 4.2 represent the suitability range using the pair wise comparison.

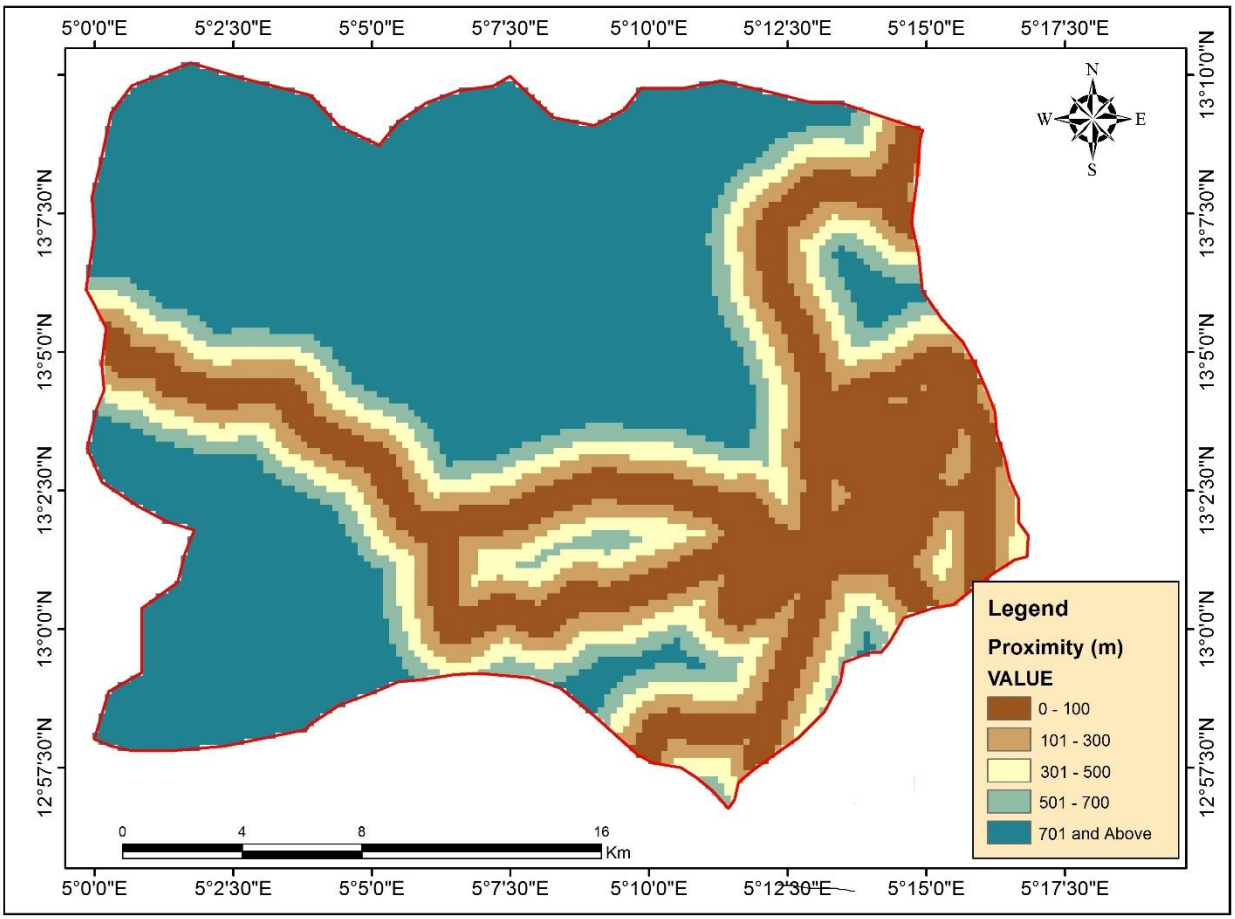


Figure 4.2: Proximity to road network of Sokoto Town

Source: Author's Analysis, 2016

Table 4.2: Suitability for proximity to road network

Proximity	Weightage	Suitability
0-100	0.49	Highly Suitable
101-300	0.20	Suitable
301-500	0.19	Moderately Suitable
501-700	0.08	Not Suitable
Above 701	0.04	Highly Unsuitable

Source: Author's Analysis, 2016

Accessibility is an important criterion in site suitability for all forms of development especially urban development. Construction of new road is expensive in hilly regions. Therefore, effort is made to locate the site to the nearest access road nearer to any existing road if possible. Moreover, in order to find out better accessibility to the existing road, buffer zones where created 100m according to the physical planning handbook (2008).

Considering the size of the study area, the result of the pairwise comparison shows that accessibility to existing road within the buffer zone between 0-100m have a very good suitability while 701m and have a very low suitability for urban development. This is because areas with high access to road network are suitable sites for urban development while place with no access or little access to road network have low suitability for urban development.

4.3.2 Slope

The slope map was derived from the Digital Elevation Model (DEM) generated from Shuttle Radar Topographic Mission 90m spatial resolution in ArcGIS 10.1 using the spatial analyst toolbox. Table 4.3 revealed the result of the pairwise comparison and Figure 4.3 showed the slope map of the study area.

Table 4.3: Suitability for Slope

Slope (degrees)	Weightage	Suitability
0-5.3	0.47	Highly Suitable
5.4-10.0	0.3	Suitable
10.1-19.1	0.14	Moderately Suitable
19.2-31.5	0.07	Not Suitable
31.6-58.7	0.03	Highly Unsuitable

Source: Author's Analysis, 2016

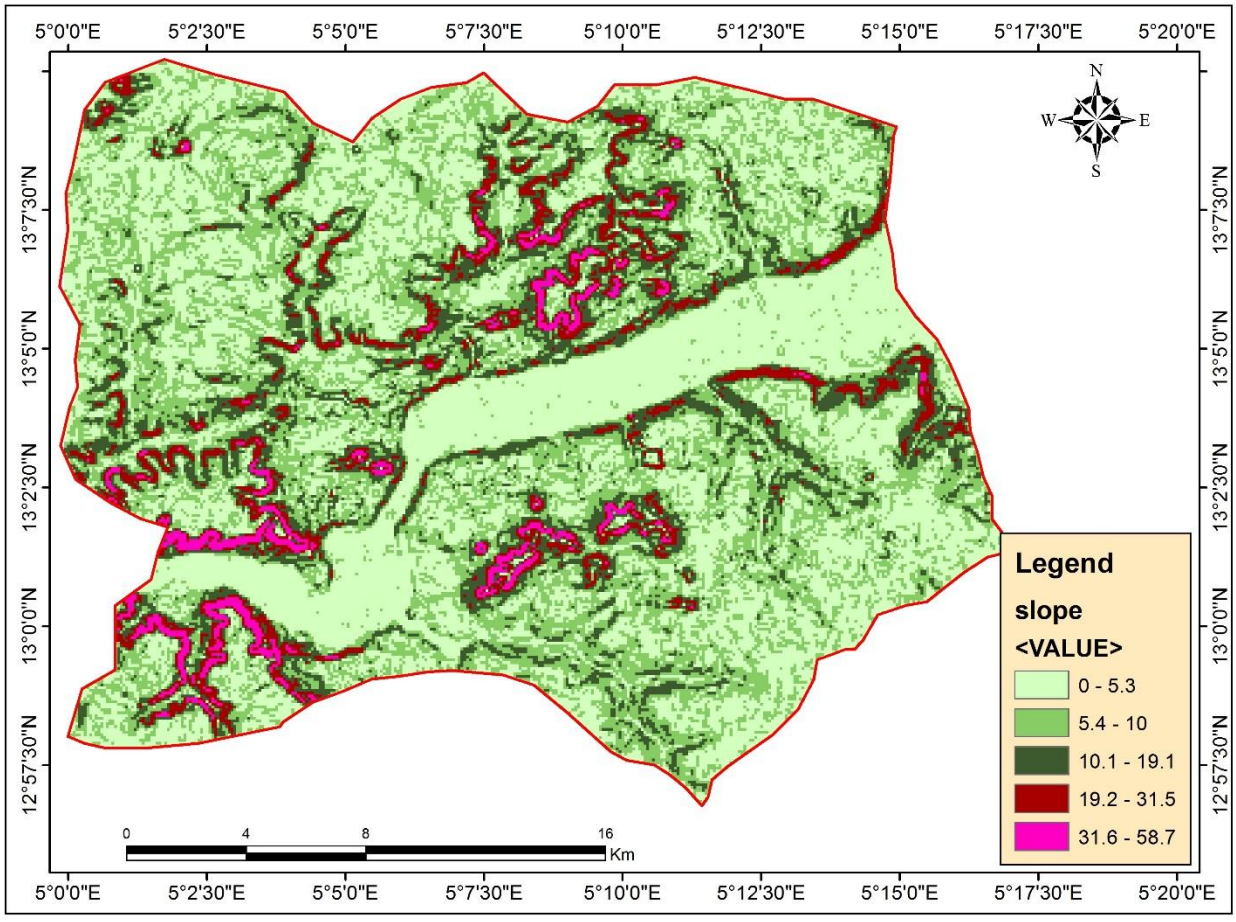


Figure 4.3: Slope map of Sokoto Township metropolis

Source: Author's Analysis, 2016

Slope is an important criterion for siting any development plan for example, hilly terrain for finding suitable sites for urban development. Steep slopes are disadvantageous for construction. Steeper slopes movement and communication costs, limit maximum floor areas and it influences erosion and other ecological problem. According to Rawat (2010) slope less than 10 degree is considered gentle slope having the highest intensity of importance. Slope greater than 10 degree has been classified as unsuitable because it increases the construction cost see Figure 4.3 and Table 4.3.

4.3.3 Aspect

The aspect map was derived from the DEM generated from the SRTM -90 and the result is shown in Figure 4.4 and the weighted is presented in Table 4.4

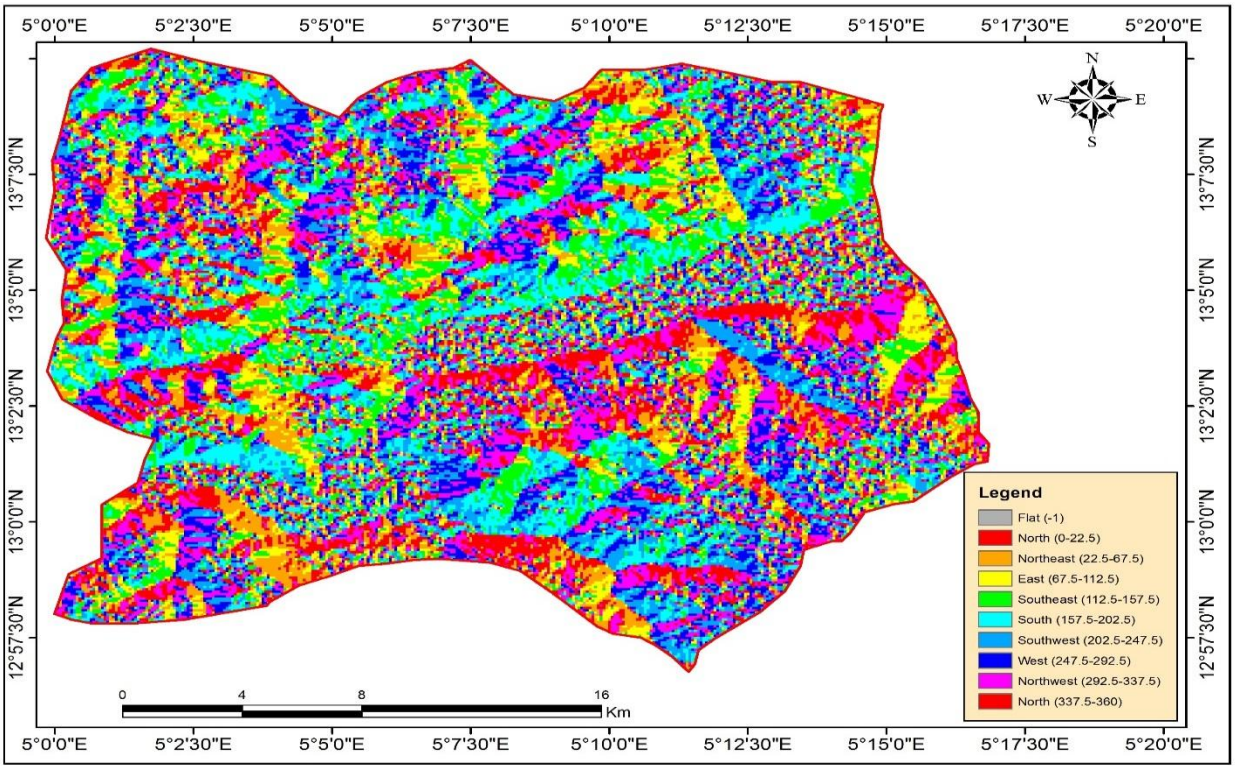


Figure 4.4: Aspect map of Sokoto Town

Source: Author's Analysis, 2016.

Table 4.4: Suitability for Aspect

Aspect	Weightage	Suitability
Flat	0.25	Extremely Good
South	0.20	Very Good
South-West	0.16	Good
South-East	0.12	Moderately Good
West	0.10	Moderate
East	0.08	Moderately Low
North-West	0.05	Low
North-East	0.03	Very Low
North	0.01	Extremely Low

Source: Author's Analysis, 2016

Aspect generally refers to the horizontal direction to which a mountain slope faces. In the northern hemisphere north facing slopes receive very little heat from the sun in mid-winter. Conversely, south facing slopes receive much more heat. Therefore, south facing slopes tend to be warmer than the northern sides. In hilly areas people prefer building their houses on the sunny faced slopes. Thus, southern facing slopes have higher intensity of importance. East facing slopes are mostly sunny in the morning when temperatures are colder while west facing slopes receives sun rays in the afternoon. Consequently, east facing slopes are colder than west facing slopes which to some extent determine the choice of location of settlement (Figure 4.4 and Table 4.4).

4.3.4 Drainage Density

The drainage density map of the study area was prepared from the DEM using density in ArcGIS environment and presented in Figure 4.5 and the pairwise comparison is shown in Table 4.5.

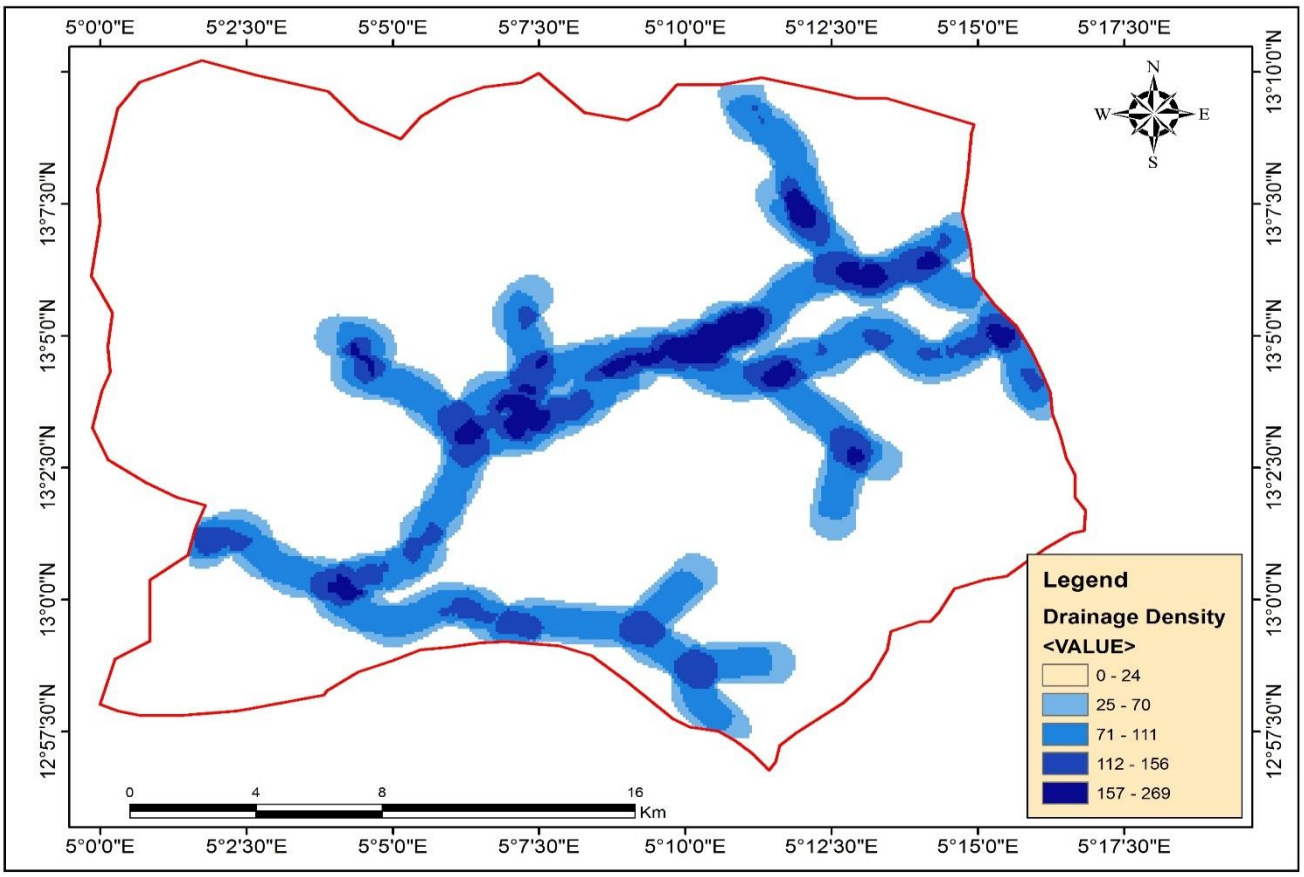


Figure 4.5: Drainage Density of Sokoto Town

Source: Author's Analysis, 2016

Table 4.5: Suitability for Drainage Density

Drainage Density	Weightage	Suitability
0-24	0.05	Very Low
25-70	0.07	Low
71-111	0.12	Moderate
112-156	0.26	Good
157-269	0.49	Very Good

Source: Author's Analysis, 2016

Drainage is another important resource for urban existence and growth. In Sokoto town, growing population and desire for good quality of is placing greater demands on good water resource of Sokoto town. Table 4.5 shown five categories of drainage density in the study area. The result shows that drainage ranging from 0 to 24 per meter have very low suitability for physical urban development while 157 to 269 per meter have very high suitability. This because the low the drainage density the lower the suitability for urban development vice versa.

4.3.5 Land use and Land Cover

Land Use and Land Cover map has been prepared by using Landsat 8 imagery. The land use/cover information help in formulation of policies and programmes for urban development. It has been observed that 52.3% area is under agriculture land. The land use/land cover map and area of existing land use type is shown in figure 4.6. The pairwise in Table 4.6 carried out based on the criteria given by (Kumar and Biswas 2014).

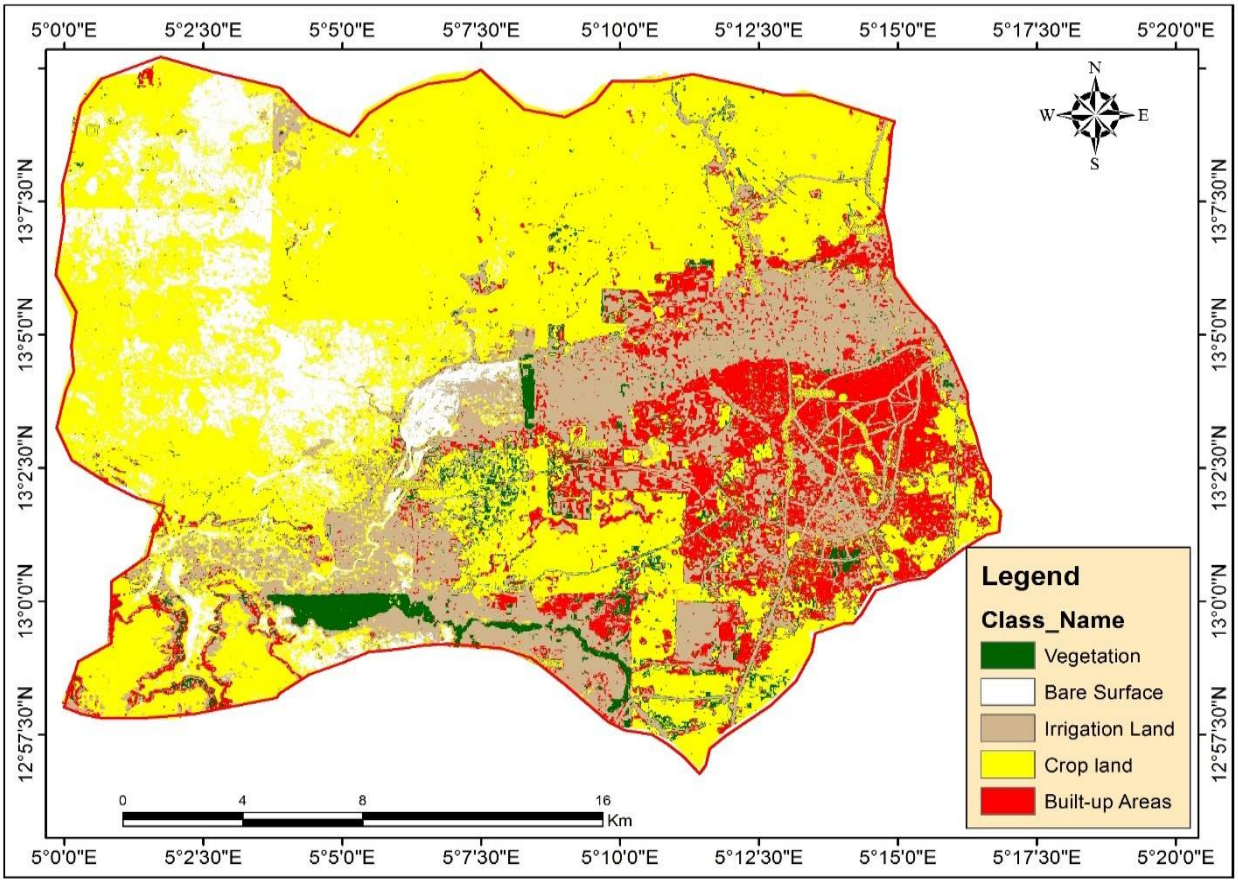


Figure 4.6: Land use and land cover of Sokoto Town

Source: Author's Analysis, 2016.

Table 4.6: Suitability for Land use and Land cover

LULC	Weightage	Suitability
Bare Surface	0.56	Very Good
Crop land	0.23	Good
Vegetation	0.11	Moderate
Built-up Land	0.07	Low
Irrigation Land	0.03	Very Low

Source: Author' Analysis, 2016.

Land use and land cover map of Sokoto town has been categorized as crop land, bare surface, built-up and vegetation. Once a building is constructed, it remains there for minimum 50 to 75 years and built-up areas have low suitability for new urban development. Irrigation land is not suitable for built-up area development because of the closeness to a river bed. Thus Vacant land and farm land is considered to be the highest suitable for development purpose (Kumar and Kumar 2014).

4.4 SUITABLE SITES FOR NEW URBAN DEVELOPMENT IN THE STUDY AREA

Suitability analysis is the process that involves use of criteria maps in combination with the standardized criteria weights and subjecting them to various processing modules in ArcGIS to obtain ranked suitability map. In an attempt to determine the suitable sites for new urban development for Sokoto town, all the thematic maps of the factors influencing urban development in the area were weighed and integrated in the order suggested by Kumar and Biswas (2014). Table 4.7 represents the weight of the factors influencing urban development and figure 4.7 represents the suitability of new urban site within the study area.

From Table 4.7 it can be seen that slope was weighed the highest with (0.5) followed by proximity to road network (0.26), land use and land cover is weighed (0.13), drainage density was weighed to be (0.07). The least contributor to urban development in the study area is the direction slope (aspect) was weighed (0.04).

Table 4.7: Pairwise comparison matrix and weights of factors influencing urban development

Criteria	Slope	Road Proximity	Land Cover	Drainage Density	Aspect	Weights
Slope	1	3	4	8	9	0.5
Road proximity	0.33	1	3	4	8	0.26
Land use/cover	0.25	0.33	1	3	4	0.13
Drainage Density	0.12	0.25	0.33	1	3	0.07
Aspect	0.11	0.12	0.25	0.33	1	0.04

Source: Author' Analysis, 2016.

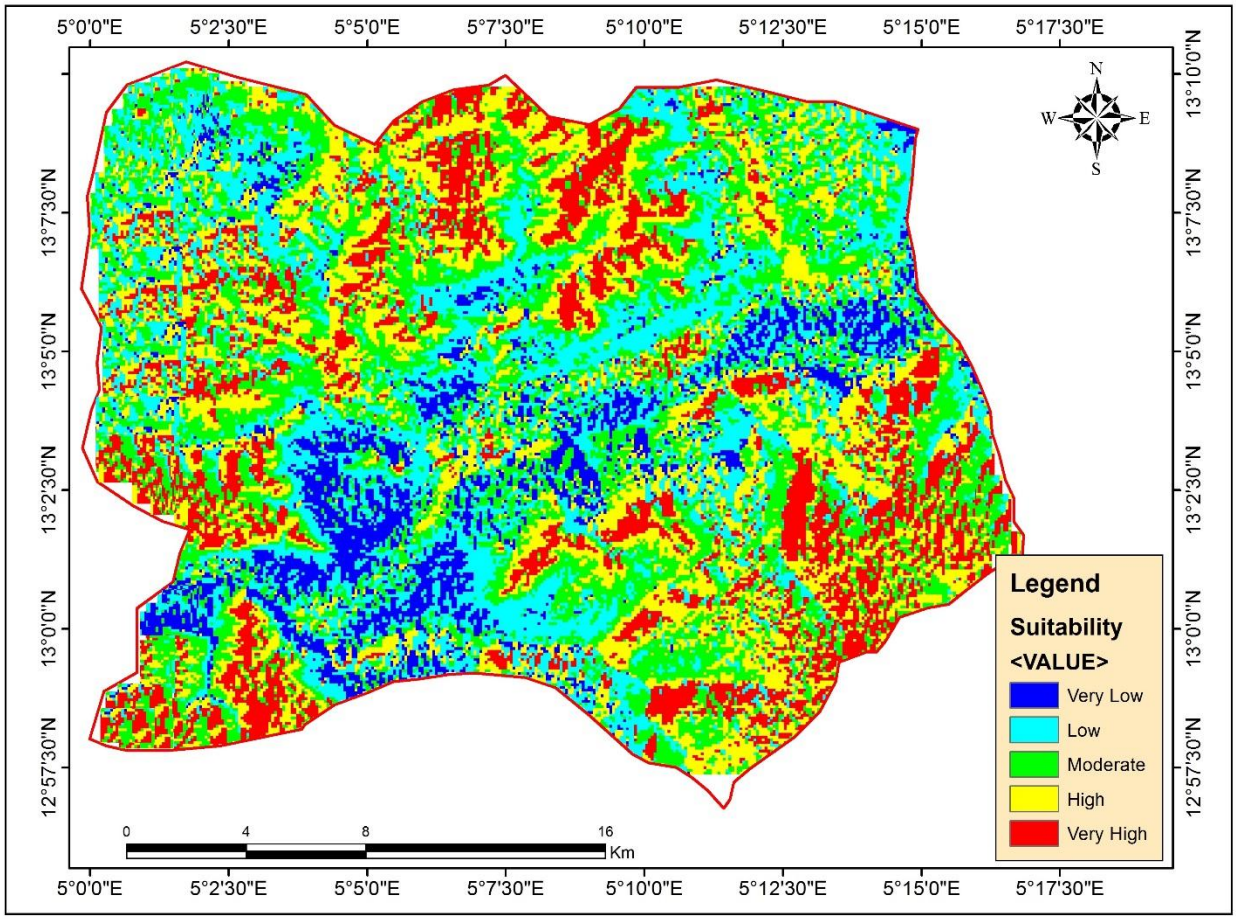


Figure 4.7: Spatial distribution of suitability for urban development.

Source: Author' Analysis, 2016.

Table 4.8: Area Coverage of Suitable areas for Urban Development.

Suitability	Area in Sq. Km	%
Very Low	131.2	23.3
Low	55.7	9.9
Moderate	79.4	14.1
High	102.5	18.2
Very High	194.2	34.5
Total	**563.0**	**100.0**

Source: Author's Analysis, 2016

The integration of five (5) effective criteria (factors) was done using the ArcGIS weighted overlay to produce the site suitable for urban development. The suitable sites was classified as very low (blue), low (light blue), moderate (green), high (yellow) and very high (red) as shown in Figure 4.7. The result shows that out of the total area of about 563.0 sq. km the available area of 131.2 sq. km (23.3%) falls under very low suitable, 55.7 sq. km (9.9%) under low suitable, 79.4 sq. km (14.1%) under moderately suitable, 102.5 sq. km (18.2%) under high suitable and 194.2 sq. km (34.5%) under very high suitable. The result also shows that highly suitable areas for urban development is either bare surface or cropland type and the low suitable areas is mostly irrigation land. It further seen from the result that areas characterized by very high suitability were found within the fringes of the north, west and the east while the very suitability dominates the central area.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents the summary of findings, conclusions drawn from the findings and recommendations made. It highlights issues that were revealed during the research with regards to land suitability as regards to urban development.

5.2 SUMMARY OF FINDINGS

Land suitability for urban development was carried out under this study by considering several factors that include land use/land cover, drainage density, proximity, slope and aspect. These factors were weighed according to their suitability to development using the analytical hierarchy process (AHP). Finally, a weighted overlay was done in ArcGIS environment using the spatial analyst tool to produce the suitability map for new urban areas. The findings of the study shows that:

Urban built-up land is in the eastern area and the land use/land cover map shows that urban development has encroached into the irrigated land which also considered as flood plain as it lies on a lowland.The slope, proximity to road network, drainage density, land use/land cover and aspect are the major determinant for urban development.

From the AHP pairwise comparison, slope was weighed the highest with 0.5 on a scale of 1, proximity to road network is the next with 0.26, land use/land cover, drainage density and aspect were weighed 0.13, 0.07 and 0.04 respectively.

The available area of 131.2 sq. km (23.3%) falls are very low suitable sites, 55.7 sq. km (9.9%) was found to be low suitable sites, 79.4 sq. km (14.1%) of the total area is moderately suitable, while 102.5 sq. km (18.2%) of the area is highly suitable and 194.2 sq. km (34.5%) is very highly ssuitable sites.

5.3 CONCLUSION

Land suitability map for urban development for Sokoto town was extracted using weighted overlay techniques. The application of GIS and AHP in the process of land suitability analysis was found to be an effective way for the urban land suitability assessment. This assessment creates an index of the influencing factors for the land-use suitability based on the literatures reviewed. Overlay mapping was applied in GIS and was used to obtain the final suitability map. On the other hand, the AHP method was used to combine attribute scores with weights or preferences that should be used in the process of weight value calculations, so we can avoid some subjective ideas affecting the results and combine the quantitative and qualitative methods.

From the result of the study, it can be concluded that slope (0.5) have the highest suitability for urban development and irrigation land have the least (0.04). Very high suitable zone covers a geographical area 194.2 sq. km of land in absolute terms and accounts for 34.5% of that total suitable area. The area is surrounded by exiting built up area of the city except some portion in the northern part of the city.

5.4 RECOMMENDATIONS

Based on the findings of this study, the following recommendation were made:

i. The North, West and Eastern part of the study should be considered as suitable area for new urban development and development should be directed to them.

ii. Land use suitability analysis should be carried out in order to overcome the problem of limited land availability against drastic growth of urbanization.

iii. Land suitability analysis for urban areas can encourage public participation in the urban decision making process and assist various planners and authorities to formulate suitable plan for sustained development of the region.

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