AN ASSESMENT OF THE VULNERABILITY OF GWAGWALADA, FEDERAL CAPITAL TERRITORY, NIGERIA TO FLOODING USING REMOTE SENSING TECHNIQUES

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APRIL, 2010

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A THESIS SUBMITTED TO POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, IN PARTIAL FULFILMENT FOR THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY (M.TECH) IN GEOGRAPHY (REMOTE SENSING APPLICATIONS)

APRIL, 2010

DECLARATION

I declare that this work "An Assessment of the Vulnerability of Gwagwalada, Federal Capital Territory, Nigeria to flooding using remote sensing Techniques" is my own research work and has not been submitted at any institution before for whatsoever reason. Information derived from published and unpublished works of others have been duly acknowledged.

Oyatayo, Kehinde Taofik

M.TECH/SSSE/2005/1342

07/04/2010

Signature & Date

CERTIFICATION

This Thesis titled:" An assessment of the vulnerability of Gwagwalada, Federal Capital Territory, Nigeria to flooding using remote sensing techniques" by Oyatayo, Kehinde Taofik (M.Tech/SSSE/2005/1342) meets the regulations governing the award of the Degree of Master of Technology (M.Tech) of the Federal University of Technology, Minna and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

I dedicate this research work to God almighty for His favor upon my life and for bestowing upon me the capacity to conduct this research. The love of my life and wife Folashade Oyatayo and my mentor Christopher Ndabula, I dedicate this work to for their relentless effort and encouragement which made this research work a success and to my Mother Mrs. Wosilat Oyatayo who is an embodiment of Motherhood who toiled to set the educational foundation in my life.

ACKNOWLEDGEMENTS

I wish to acknowledge my supervisor Dr.Halilu Shaba for not been a Baby seated researcher and for been there at all times despite his tight schedule to guide and direct this research work. You gave me GIS soft ware and showed me the way to success, I would forever remain grateful and may God bless you abundantly. The roles and advices of the following course mates I acknowledge: Madam Sidikat Salau, Rotimi Fagbemi, Shuaib Bukar, Nnena Madu, Professional John Nwagwu who most importantly helped and contributed immensely to the success of this thesis and Mr. Innocent Bello who introduced me to the world of GIS data analysis. Also, not forgetting Dr. Adediran, Mr. & Mrs. Anthony Adebanjo, pastor & Mrs. Sunday Okoronkwo, Pastor Taiwo Daramola, Mr. Solomon Sofoluwe & Family, Dr. J.G. Laah, Mr. Shamsudeen, Mallam Salihu, and the entire staff of Geography Department, Federal University of Technology, Minna. The following family friends rendered moral and financial support in the course of running this research work: Mr. & Mrs. Christopher Ndabula, Mr. & Mrs. Mustapha David, Mr. & Mrs. Joshua Silas, Mr. & Mrs. Chidi Ani, and Mr. & Mrs. Lawani. My family members: Mr. & Mrs. Taiwo Oyatayo, Mrs. & Mrs. Idris Oyatayo, Muda and Kubura Adedeji and Mr. & Mrs. Lateef Idowu have all been symbol of strength to me and I say thank you. This acknowledgement would not be complete without acknowledging the positive role Mummy Princes (Mrs. Toyin Khairat Yusuf) has been playing in my life. I acknowledge the assistance rendered by the Management and staff of National Emergency Management Agency for allowing me asses to their Geographic Information System Laboratory and to the following staff of the Agency I acknowledge your contribution Mallam Hassan Ciroma, Mr. Godwin, Mr.Tunde

Olowookere, Mr.Tunde and Serah. I acknowledge the Management of Abuja Geographic Information System for providing me with the needed satellite data for this research and the Federal Capital Development Authority for providing me with topographic maps. I acknowledge the Management of National Space Research and Development Agency also for allowing me access to their laboratory.

ABSTRACT

gwalada town has been witnessing frequent flooding prominent among was that 03 and 2006 where lives were lost and property destroyed. This study was l at assessing the vulnerability of Gwagwalada, Federal Capital Territory to ng using remote sensing techniques. Topographic maps of Kuje sheets W1c, 207NW1f, Quickbird 2003 and Ikonos 2006 imageries were scanned and digitized onscreen using ILWIS 3.1 Academic GIS software. Thereafter, ed contours were interpolated to create a digital elevation model (DEM) side other GIS operations using Arcview 3.2a GIS software. DEM/elevation was used to categorize the study area into flood vulnerability levels. Themes created and labeled accordingly to produce a flood vulnerability map that was d on an unclassified Ikonos 2006 imagery. From the results obtained, the area was categorized into three flood vulnerability levels namely highly, less eas free from flood. Areas considered to be highly vulnerable to flood are on the banks of river Usuma and the vulnerability level to flood was observed decreasing northwards and southwards away from the banks of river Usuma. uildup change was mapped on the secondary data for 1981, 2003 and 2006 ively. The result on buildup expansion on Gwagwalada town shows that expansion is on the increase and this has lead to haphazard urban extension velopment trends, increased buildup encroachment on the flood plain and ibility to flood hazard, loss of productive agricultural lands and vegetation ithout taking cognizance of the suitability of the land for such development. rt of the study area is occupied by buildup. The recommendations from here households residing on the banks of river Usuma should as a matter of be relocated to areas not vulnerable to flood within the study area and also should ensure there is proper and efficient Land use planning and ons within the study area.

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supply and sanitation, vacant lands and urban land-use zoning .Planners and decision makers require adequate information on the extent of areas and facilities that are under different flood vulnerability levels for effective planning and management of flood hazard and for other urban management purposes. One effective way of obtaining such data/information is to make use of remote sensing and GIS techniques (Rao et al. 2006)

A critical concern of the world today is on landuse/landcover changes, especially due to rapid urban growth in drainage basins, because of the strong influence they have on environmental degradation (Abubakar et. al,2002; Gupta and Srivastava, 2004; Ndabula, 2006). Monitoring such changes and assessing their impact on the entire ecosystem cannot be overemphasized. This is largely because land surface have considerable control on the earth's energy balance, biogeochemical and hydrological cycles, which in turn influence climate and other systems that shape the earth (Abubakar et al, 2002).

A spatially explicit study and mapping of flood vulnerability levels and buildup expansion rate within Gwagwalada town would lead to a better understanding of the causes of the changes and their consequences on flooding. Such understanding will improve environmental management and planning decisions to ensure that ecosystems and changing landscape are suitably managed (Ndabula, 2006).

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND INFORMATION

Urban and suburban development alters watershed imperviousness and connectivity, resulting in alterations of the hydrologic and hydraulic runoff response. Storm water conveyance devices have been incorporated into most development to address the goal of flood water removal for protection of life and property (Theodore, 2006).

Drainage systems are designed to protect life, enable vehicular access, extend pavement life cycle and control the volume and velocity of storm water runoff to natural and human constructed drainage ways and receiving waters. Understanding of runoff/storm water behavior or characteristics is crucial in the engineering design of drainage systems (Theodore, 2006).

Urbanization or sprawling in drainage basins results in haphazard urban extension and development trends, changes in the spatial watershed landuse patterns, increased buildup encroachment on the flood plain and extreme susceptibility to flood hazard, loss of productive agricultural lands and forest cover, loss of surface water bodies, depletion in ground water levels and deterioration in the quality of these water due to increasing build *up area and* pollution. There is an urgent need to constantly monitor and map such changes and take corrective measures towards planning such as to prevent and mitigate floods, urban utilities and infrastructure, traffic planning, water

Maps designed to show landscape and flood plain extent provide an instant reference to the spatial relationships and origin of earth surface features. Maps showing flood vulnerability levels and buildup expansion rate are compiled from a variety of maps and mapping data, including topographic maps, land use map, soils, geologic, aerial photography and satellite imagery. Recent developments in landscape mapping centre on the use of digital elevation data to generate views of the earth surface that accurately depict topographic relief. Present mapping programs are rarely implemented with only planimetric considerations. The demand for digital elevation models is growing with increasing evidence of improvement in information extracted using elevation data. The incorporation of elevation and terrain data is crucial to many applications, particularly if radar data is being used to compensate for foreshortenings and layover effects and slope induced radiometric effects (CCRS, 2008).

Mapping constitutes an integral component of the process of managing environmental resources, and mapped information is the common product of the analysis of remotely sensed data. The mapping and depiction of landscape by showing their form, distribution, constituent materials, age and origin are of considerable interest to a wide range of disciplines including geomorphology, hydrology, civil engineering, geology and urban planning. Traditionally, ground surveys had been the primary source of information of such mapping, supplemented by information from topographic and other thematic maps. However, in recent years, an increasing role of such surveys has been played by remotely sensed imagery; mainly from air craft (CCRS, 2008). The advantages of aerial photographs include excellent depiction of topography, rapid familiarization with a study area and availability of stereoscopic capability which provide an excellent base upon which the user can work. With the advent of space borne sensors, ranging from handheld cameras to line scanners and radars, earth scientist have been given a new perspective from which to study the earth surface(Jones,1987). Lillesand and Keiffer (1987) described the advantages of satellite acquired imagery. These include synoptic scale coverage, multi spectral and multi date capacity and as a result, imagery from such sources is of great interest to earth scientist.

1.2 STATEMENT OF THE PROBLEM

Results of researches carried out on the effects of urbanization on drainage basins e.g. (Neller, 1988; Shakirudeen (2004); Noorazuan et al, 2005; Theodore, 2006) shows that landuse/landcover changes in urban and semi urban drainage basins adversely affect these drainage basins ecosystems causing them to be one of the most dynamic systems. Also urban stream channels are very unstable, exhibiting extensive deposition of sand bars, expansion of floodplains, reduced channel capacities to regulate stream flow, increased run-off / stream flow (Neller, 1988).

In the long-run these urban dwellers are exposed to increasing flood risk and community vulnerability due to the fact that these settlements have encroached on the floodplain and equally because of changing landforms in the basin. Reports on perennial flooding episodes on the local scenes in 2006 such as the flooding in Gwagwalada, Kubwa, Karshi, Games village all in Abuja, Nigeria and especially the River Ogunpa disaster in Ibadan of 1980 where more than 100 bodies were retrieved from the debris of collapsed houses and 50,000 people were left homeless and property worth hundreds of millions of Naira lost (This Day online, 2009), among others confirm these researches.

The attempt by the former minister of the FCT Administration Mallam Nasir el-Rufai to reverse the distortion of the Abuja master plan through demolition of illegal structures lead to the dispersion of thousands of poor residents of the territory, mainly civil servants, petty traders, artisans, and peasants into unplanned settlements not largely affected by the demolition blitz. This culminated into increase in population in most of the satellite towns of the FCT. Gwagwalada town is the largest satellite town in Abuja and is about forty kilometers from the city centre of the Federal Capital Territory (Balogun, 2001). It is located within the catchments of River Usuma. Most part of the settlement is unplanned and the suitability of the land is not taken into consideration in most instances before putting the land to use. This shows total ignorance to the consequences of this unplanned rapid growth, particularly buildup encroachment on the floodplain. The area has over the years witnessed frequent flooding, particularly the inundation of the town by water in 2003 and 2006 where lives were lost and properties worth millions of Naira was damaged (The Sun online, 2009).Besides, the old existing topographic maps are not updated to reveal these fast changes in the landscape of Gwagwalada town. Therefore, the need for this research which highlights the advantage of Remote Sensing Techniques in view of its robustness, timeliness and synoptic view for mapping of flood vulnerability and landuse/landcover change in Gwagwalada town; this remain a vital tool to meet up with data / information supply for urban planning and decision making that would reduce urban flooding.

1.3 ASSUMPTION

1. All elevation within the range of 178.0m to 186.33m above sea level are Floodable.
2. All the buildings within this elevation range are vulnerable to flood.
3. All the buildings within the floodplains are also increasing flood.

1.4 AIM AND OBJECTIVES

The aim of the study is to assess the vulnerability of Gwagwalada town to flooding using remote sensing techniques. The above aim would be achieved through the following objectives:-

1- Mapping of Quickbird and Ikonos imagery of the study area.

2- Generation of DEM from topographic sheets of the study area (Kuje sheets 2007 NW1c and 207 NW1f).

3- Map out the risk area and the sensitivity to the severity of the flood.

1.5 JUSTIFICATION

Mapping of urban area constitutes an integral component of the process of environmental resource management. Maps are essential for planning, evaluation and monitoring of environmental resources, and landuse management, particularly if digitally integrated into a geographic information system as an information base.

Gwagwalada town occupies an area of 68.75 square kilometer and it is located in Gwagwalada Area Council of the Federal Capital Territory. This area has over the years witnessed frequent flooding episodes especially that of year 2003 and 2006 where lives and properties worth millions of Naira was lost (The Sun online, 2009) .This has necessitated this research, which leads to the development of a thorough and efficient mechanism of mapping both flood hazard vulnerability and the changes in buildup area over time as planners and decision makers require such data/information for effective planning purposes to prevent, mitigate floods towards sustainable growth and development of the floodplains and basins in Gwagwalada town. Also the need to constantly monitor and map changes that has occurred in the floodplain built-up area is crucial for the design and maintenance of urban storm water drainage network, for storm water removal to cope with flood hazard occasions.

The choice of Remote Sensing Technique as a tool for problem solving in this research is because it provides the fastest means of generating diverse information on the semi urban landscape and equally has the advantage of being used to identify changes in a dynamic semi urban environment of this nature. Based on the observations made on the field, most of the areas lack proper landuse planning and the rate of development and urbanization within Gwagwalada town is on the increase. Studies of this nature at this point in time has become necessary to provide the necessary caution, warning and information for decision making and planning purposes.

1.6 SCOPE AND LIMITATION

This research effort is restricted to Gwagwalada town. The study utilized Quickbird 2003 and Ikonos 2006 remotely sensed data and two topographic maps of the study area at a scale of 1:10000 for buildup change detection and to generate a digital elevation model which enabled the delineation of the study area into three flood hazard vulnerability levels. I utilized the above mentioned data because these were the only data that were readily available to the researcher as at the time of the research. The research would be restricted to the mapping of both flood vulnerability levels (using elevation range) and changes in the buildup area between 1981, 2003 and 2006 in the study area.

The limitation of the study is lack of finance to purchase recent satellite imageries of year 1991, 2007, 2008 and 2009.Hence, the researcher could not utilize any of these satellite imageries in carrying out this research.

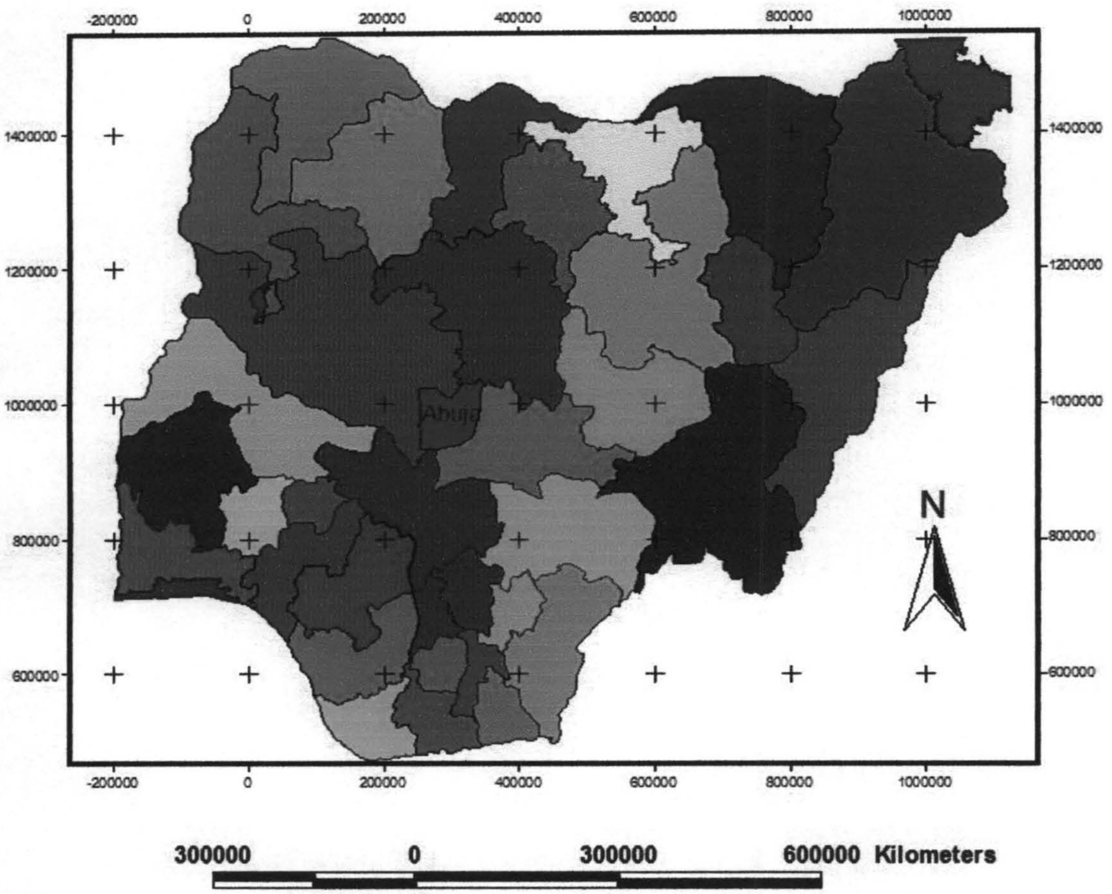
1.7 BASELINE CONDITION OF THE STUDY AREA

1.7.1 LOCATION AND SIZE

The need for immediate development of Gwagwalada town in the year 1980 was due to the decision of the Federal Government to allow willing indigenes of the Federal Capital Territory (FCT) to remain within the FCT. Gwagwalada town was to serve as the Administrative Headquarters of the territory for the distribution of services, facilities and amenities to the inhabitants (Gwagwalada Master Plan, 1980).

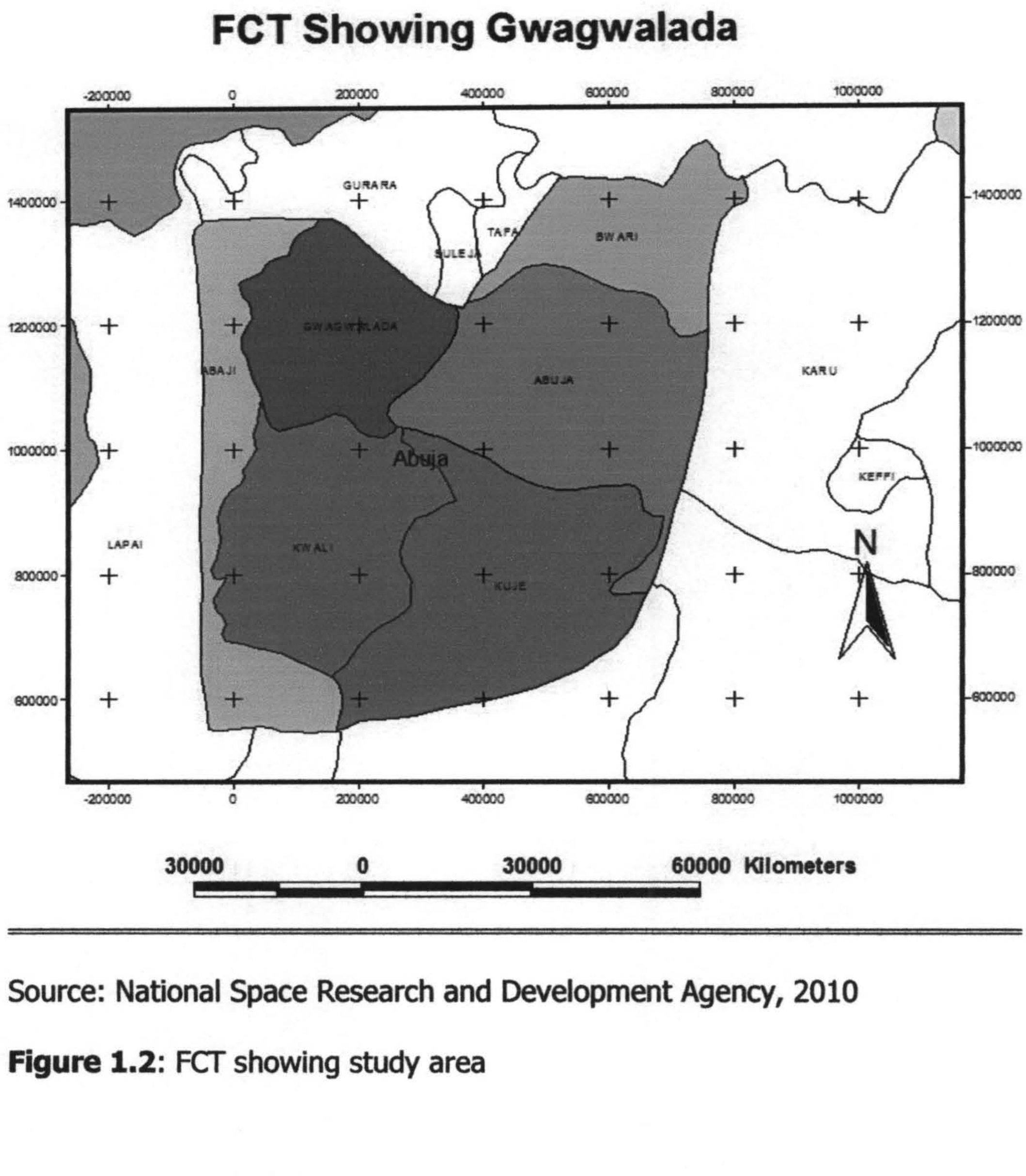
Gwagwalada town is located about 40 Kilometers away from the Federal Capital City and it is centrally located within the FCT. Gwagwalada town is located between latitude $8^0 55'$N and $9^0 00'$N and longitude $7^0 00'$E and $7^0 05'$E (Figure 1.1). Gwagwalada Area Council where Gwagwalada town is located is bounded by Kuje Area Council to the East, Abaji Area Council to the West, Kwali Area Council to the South, Abuja Municipal to the North East and Suleja Local Government of Niger State to the North (Balogun, 2001).

Map of Nigeria Showing Abuja



Source: National Space Research and Development Agency, 2010

Figure.1.1: Nigeria showing Abuja



Source: National Space Research and Development Agency, 2010

Figure 1.2: FCT showing study area

The study area has a total landmass of about 68.75km2 and with the rapid rate of urbanization; developmental processes are now taking place even outside the semi urban area boundary. The study area is dissected horizontally into two parts by the River Usuma and vertically by the Lokoja – Kaduna express road. To the West of the study area lays the Gurara River, while the Abuja hills lie to the North. Gwagwalada semi urban area constitute areas like Phase 1, Phase 2, Phase 3, Kontagora Estate, Hajj camp which constitute the well planned area within the town. Other parts include New Kurunku, Dagiri, Ungwan-Dodo, and Ungwan Shanu, these constitutes the less or unplanned area of the town (Balogun, 2001).

1.7.2 **CLIMATE**

Due to the location of the study area in the middle belt of Nigeria, the activities of the tropical Maritime Air Mass from April to October and the tropical continental Air mass which also predominate the area between November and March also have serious influence on the climatic condition of the area. The climate of Gwagwalada town just like most climate in the tropics have a number of climatic elements in common, most especially the wet and dry season's characteristics.

Recent data extrapolated from adjacent weather stations as well as weather station within the study area revealed that long term mean temperature in the study area ranges from 30^0C – 37.0^0C yearly and mean total annual rainfall of approximately 1.650mm per annum (Balogun,2001). Gwagwalada town usually records its highest temperature during the dry season of the year due to the general cloudless of the period. The maximum temperature occurs in the month of March with temperature rate of 34^0C and the minimum temperature occur in the month of January and December during the harmattan wind with temperature as low as 27^0C (Balogun, 2001).

Rainfall In the fringes of the town place a vital role with respect to agricultural activities since agriculture within the study area is highly dependent on rainfall. The major cause of rainfall in the area is convectional rising of air containing water vapor, with the combination of other factors (Balogun, 2001).

About 60% of the annual rains fall during the months of July to September and it is during this period that floods occur within the unplanned area of the study area, most especially the area lying around the floodplain of River Usuma that traverse Gwagwalada tow. This factor was actually considered in the initial stage of the planning of the town for the disposal of storms water.

Another crucial climatic characteristic of this area is the frequent occurrence of squall lines heralded by thunder storms, lightening, strong winds and rainfall of high intensity. This climatic phenomenon often causes serious damage to buildings when they occur or when they lead to the occurrence of flood disaster.

The study area records relative humidity of about 25% in the dry season of the year, 50% at the inception of the rainy season. The high relative humidity in Gwagwalada town occurs during the rainy season, and this gives the area a heat trap effect which makes it uncomfortably hot (Balogun, 2001).

1.7.3 **GEOLOGY AND RELIEF**

Generally, two broad geological regions with each one having similar structural and lithological characteristics are recognized within the FCT (Balogun, 2001). Virtually all the area is predominantly underlain by Pre-Cambrian magnetite gneisses, granites and schist of the crystalline basement complex. The schist belt outcrops exist along the South Western merges of the area. This schist belt is the only area that is not satisfactory area for foundations of heavy buildings. The remaining part of the study area is quite reliable for heavy structures as well as free from geological hazards. Quaternary alluvium deposits are found within the River Usuma channel and this is a source of fine sand which is used for constructional activities.

The Elevation within the Gwagwalada town ranges between 213.3 meters to the North and 142.2 meters to the Southern part. The slopes within the study area are generally long and gentle in nature which ranges from up to 4%.

The area lies within the largest of the plains in the FCT with an area extent of 1,818 square kilometers. It is an undulating area that is dissected by streams with channels that are sometimes barely distinct. The study area is bounded to the North-East by the Suleja Hills to the South by Ungwan – Karu Hills (Balogun, 2001).

1.7.4 **HYDROLOGY**

The two largest rivers in the FCT are River Usuma and River Gurara, which both constitute major elements of influence of the physical landscape. The former is being managed to the advantage of the FCT through the construction of Lower Usuma Dam. River Usuma empty into Gurara River which in turn also empties into River Niger (Balogun, 2001).

Gwagwalada town is drained by River Usuma which is an important tributary of River Gurara and is the largest river and major river within the study area. The River Usuma around Gwagwalada town is quite shallow at almost all times of the year except during the rainy season within the month of July to September. The water quality of this river around the study area is highly polluted because of the high iron and ammonia content as well as heavy metals due to several domestic, cottage industrial activities and farming activities upstream (Balogun,2001).

The Iku River which takes its source from the Abuja hills is another significant river which influence is felt downstream. Another smaller river which is significant to this study area is the Wuye River and it is to the east of the town because of the use of the water for irrigation. Due to the nature of the terrain and human activities in these study area flash floods is a characteristic of all streams and rivers in the study area particularly during the rainy season. Due to continuous impact of man to this hydrological system of which the study area falls, flooding becomes a major environmental hazard threatening the area and its danger and threat is increasing every year (Balogun, 2001).

1.7.5 **SOIL AND VEGETATION**

The soils in Gwagwalada town show a high level of variability. Alluvial soils are commonly found in the valleys of the main river (River Usuma) and other streams within the study area; These soils cover very small part of the study area and the water table around the places where this type of soils is prominent is usually very high. It has well decomposed organic matter content in the surface layer, and its texture become heavier with depth, as the weathered parent material is approached. The materials are poorly sorted because of their alluvial origin. The color of this soil type change from grey to darker, with depth. This is usually caused by the poor nature of drainage and the high level of organic matter content that exist on the surface layer (Balogun, 2001).

The soils of Gwagwalada town outside the river bank are luvisols. These soils are products of soil materials transported from the hills and are generally the local soils developed on the foot-plains located within the Iku-Gurara plain where Gwagwalada town is located. The soil is associated with the interfluves which are part of the landscape that are continually being eroded by the streams and by sheet-wash from the hills (Balogun, 2001).

The soils that border the alluvial valley bottom most especially of the River Usuma have a tick cover of sand-wash materials. The characteristics of the soil shows that they all have palest colors and the textural character of the soil takes common pattern of loamy sand top soil and sand clay B horizon. Due to the nature of the soils they are either loose or they have weak structures. These soils are very vulnerable to erosion due to their nature.

The FCT as a whole is located within the northern boundary of the Guinea Savannah (Balogun, 2001). Rainforest and riparian vegetation are the two types of vegetation found within the FCT and they all occupy 21% of its total land cover. According to Balogun (2001), Gwagwalada vegetation types is that of shrub savanna and this vegetation type also covers other areas which include, Iku-Gurara plains, Usuma valley, Cibiri, Gwako and also between Gwagwalada and Tunga-Aguma.

The vegetation is made up of species of plants such as Danulio Oliver, *Albizia Zygia*, Shea butter tree *Butrospermum paradoxium* and African Locust bean, *parkia clapper oniana, Terminatia pilisotigma, Amona, Nauclea and Bombax contrahan constitute* are the shrubs found within the area (Balogun,2001).

This vegetation is of importance to the inhabitants of Gwagwalada town as well as inhabitants living at the fringe. Over the years the impact of man has been felt on the vegetation due to the continuous expansion of the urban area as well as the high demand and rapid rate of fuel wood harvest and other constructional activities taken place.

1.7.6 POPULATION AND HUMAN ACTIVITIES

The population of the study area is heterogeneous in nature comprising of the original inhabitants of the town (the Bassa people), the Gwari, Tiv, Yoruba, Hausa, Igbo. The Hausas are also highly concentrated around Ungwan Shanu and Kasuwan Dare parts of the town.

Gwagwalada town has a population of about 23,114 people and is the largest satellite town and the third largest urban centre in the FCT (1991 National population Census; Balogun, 2001). Gwagwalada is two-in-one towns, consisting of the traditional old town which is highly unplanned with basically the indigenous people inhabiting this area. Such areas are Ungwan Shanu, Ungwan Bassa, Ungwan Gwari, Ungwan-Dodo and Katunku. With the rush of people into the town, presently these areas where the indigenous inhabitants earlier dominate are now mixed up with various tribes. The planned area of the urban area constitutes Phase 1, Phase 2, Phase 3, Hajj Camp, FCDA staff housing estate, and the University area.

The indigenous people of the study area are mostly farmers, who are engaged in crop production as a means of livelihood. They cultivate different types of crops within the rainy season. Types of crops cultivated are highly chosen based on the nature of climate and soil conditions. The crops' production normally takes place at the fringe of the town and the crops produced include millet, sorghum, maize, rice, yam, potatoes, cocoyam, melon, garden egg and vegetables. The productions of most of these crops are highly determined by availability of storage facilities.

The inhabitants are also involved in irrigational agriculture around the River Usuma at the downstream and upstream on the river bans; though most agricultural activities take place during the raining season with only minute number of the population participating in dry season irrigational agriculture. Based on this, substantial number of the population suffers from seasonal unemployment, mostly among the indigenes that highly rely on agriculture as a source of livelihood.

The indigenous people as well as Hausa dwellers of the town are also engaged in the domestication of animals such as goats, chickens, cows and dogs and few numbers are employed in the Local Area Council, the University and other institutions within the town. Despite the fact that the indigenes engage in diverse economic activities, crop production remains the most pronounced economic activity of the indigenes of the town, while settlers are more into social services and other business oriented activities.

1.7.7 **INFRASTRUCTURAL FACILITIES**

Gwagwalada town is a nodal town within the national, regional and local road networks, as the famous Kaduna – Lokoja road (A2) road passes through the town. The town has a road linking it to Kuje in the east and the boarder town of Izom to the north. In the planned area of the town, the streets are highly organized, with exception of the unplanned area of the town. The planned area is divided into five districts which are Phase 1, Phase 3, Phase 3, and FCDA Staff Housing Estate.

Like the city of Abuja, each of Phase one, two and three are organized into neighborhoods and they are served by arterial collector and local roads (Balogun, 2001). Other developmental infrastructures found within the study area include potable water, electricity and periodic market with decayed facilities. Three levels of health facilities exist within the town which is grouped as primary, secondary, and tertiary level. The height of the health facilities made available in this town is the University of Abuja teaching Hospital formally Gwagwalada Specialist Hospital. Primary schools are highly concentrated and a number of government and private secondary schools, are concentrated within the town. The most important of these educational institutions is the University of Abuja due to its centrality and location in the FCT.

1.7.8 **ECONOMIC ACTIVITIES**

According to Balogun (2001), apart from the agricultural activities the town has a strong economic base mostly related informal sector. There are so many informal activities which include motor vehicle mechanics, tailoring, wristwatch repairs, electronics repairs, vulcanizing, motorcycling transport, photography, electricity works, cement block making, furniture making. Other economic activities involve the selling of manufactured goods such as textile, and provisions, and there can be in itinerant hawking, petty trading and shop keeping. Exchange of goods within the market is dominated by market women who are the main distributor of agricultural produce.

These activities are very important backbones of the economy of the town because of the contribution to the production economy and this constitute a high percentage of the town income and more so this sector provides employment to large a number of people who are not educated

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 OPERATIONAL DEFINITION

2.1.1 DRAINAGE BASIN

A drainage basin is an area drained by a river system and can also be referred to as watershed or catchments (Wikipedia, 2006). Oyegoke and Efeadi (2007), referred to a drainage basin as a tract of land where water from rain or snowmelt drains downhill into a body of water. The constituent body of water as well as the land surfaces from which water drains into those channels still forms part of the drainage basin. The drainage basin acts like a funnel, collecting all the water within the area covered by the basin and channeling it into a water way.

Drainage basin is the entire area providing run-off and sustaining part or all of the stream flow of the main stream and its tributaries. The function of the drainage basin and its significance is hinted in the synonyms which have gradually been adopted including drainage area, catchments area especially employed in river control engineering, and watershed, utilized especially in water supply engineering (Gregory and Walling, 1973).

For a given stream, it is a tract of land drained of both surface run-off and groundwater discharge which is significantly different from a watershed which is the area that supplies run-off to a stream or river (Oyegoke and Ifeadi, 2007). An urban drainage basin is a catchment that has experienced urbanization and increase in population growth.

The importance of drainage basin abounds and range from geopolitical boundaries to even resource management. In hydrology, the drainage basin is a logical unit of focus for studying the movement of water within the hydrological cycle because the majority of water that discharges from the basin outlet originated as precipitation falling on the basin. Drainage basins are important elements to consider also in ecology. As water flows over the ground and along rivers, it can pick up nutrients, sediments and pollutant. These get transported towards the outlet of the basin and can affect the ecological processes along the way as well as in the recurring water body (Gregory and Walling, 1973).

2.1.2 FLOOD

A flood is an overflow or accumulation of an expanse of water that submerges land. Flooding may result from the volume of water within a body of water, such as a river or lake, which overflows or breaks levies, with the result that some of the water escapes its normal boundaries. Floods can also occur in rivers, when the strength of the river is so high it flows out of the river channel, particularly at bends or meanders and causes damage to homes and businesses along such rivers (Wikipedia, 2009)

Flooding is a natural consequence of global/local weather conditions and human activities. Floods occur within few hours of heavy rainfall or after a dam collapse or sudden release of water from dams or large reservoirs. Floods also occur due to blocked drainages after heavy down pour (Oriola, 1994).

A flood is said to occur when there is an unusual high stage of a river due to run off from precipitation in quantities too large to be confined in the normal water surface elevations of the streams or rivers (Mayhem, 1997).

Flood is a water related disaster and the most devastating natural phenomena that affects and disrupts the wellbeing of a society, especially that of poor people due to the limitation of their resources (Prathumchai, 2008).

Various definitions have been used in defining floods (large rainfall surpluses) over a region depending on the purpose in view. This simple Parameter, rainfall, can reflect many aspects of flood, is used partially in all definitions of flood. Meteorological flood can be defined as a situation over a region where that rainfall is mostly higher than the climatological mean value because the natural vegetation and economic activities of the region have been adjusted to the long term average of that region (Parthasarathy et al. 1987).Therefore, the conditions which lead to flood occur when the rainfall amount over a particular region is more than a certain amount, normal for that region (Friedman, 1957).

The United Nations Commission for Human settlements (UNCHS-HABITAT) (1981) defines Hazard, vulnerability, risk in the following ways:-

(a) Hazard-Is the probability that in a given period and a given area, an extreme potentially damaging natural phenomena occurs that induce air, earth movements, which affect a given zone. The magnitude of the phenomena, the probability of its occurrence and extent of its impact can vary, in some cases, be determined.

(b) Vulnerability-of any physical, structural or socio economic element to a natural hazard is its probability of being damaged, destroyed, or lost. Vulnerability is not static but must be considered as a dynamic process, integrating changes and developments that alter and affect the probability of loss and damage of all exposed elements.

(c) Risk- is related directly to the concept of disaster, given that it induces total losses and damages that can be suffered after a natural hazard: death and injured people, damage to property and interruption of activities. Risk implies a future potential condition, a function of magnitude of the natural hazard and of the vulnerability of all exposed elements in a determined moment.

2.1.3 LANDUSE / LANDCOVER

Land-use and Land-cover are two different concepts. Land cover emphasizes on land's "natural properties" and it is the synthetic reflection of various elements in the global surface (Ndabula, 2006).

Land-use emphasizes more on land's "social properties' and it is the output of the activities of man. Thus, land-use is a process of turning natural ecosystem into social ecosystem and the process is a complicated procedure by the synthetic effect from nature, economy and society (Yang, 2002).

Land-use land-cover being a new concept emerging with the remote sensory technology has become a crucial item of basic task in identification and monitoring of urban environment. This is possible with the more thorough development of remote sensing classification technique. Land-use land-cover is continuously changing both under the influence of man and nature resulting on various impacts on the ecosystem (Rajan et al, 1997a).

Urban drainage basin is constantly and rapidly changing due to various human development activities and natural conditions. Therefore the management of urban drainage basins involves procedures of monitoring and modeling which require reliable information base and robust analytical techniques. Conventional surveying and mapping methods cannot deliver the necessary information in a timely and cost effective manner (Ndabula, 2006). Given its cost effective and technological soundness remote sensing is increasingly being used to develop useful sources of information and to support decision making in connection with a wide array of urban applications (Celine and Vicente, 1998; Yu Cheng-Ming 2003; Lo and Yang, 2003).

2.2 DRAINAGE BASIN/WATERSHED LANDUSE LANDCOVER CHANGE RELATIONSHIP

Land-use land-cover change in a drainage basin has a strong relationship (direct or indirect) with land degradation processes. Landuse/landcover changes in a human dominated ecosystem also affect geographical and social processes leading to land degradation (Medis and Wadigamangawa, 1996; Gupta and Srivastava, 2004).

Land use land cover change have impact on the entire ecosystem, this is because land surface has a considerable control on planets energy balance, biogeochemical and hydrologic cycles, which in turn influence the climate and other systems that do shape the earth (Ndabula, 2006).

There is a well established tendency for water run-off to increase with land degradation (Gupta and Srivastava; Symeonankis et al 2003; US CCSP, 2004; Celine and Vicente, 1998). Over grazing for example leads to trampling and compaction of the soil which reduces the infiltration and thus, increases the amount of rainfall water that is generated as run off. Deforestation also leads to increased over land flow since it removes the vegetation cover which probably affects rates of runoff more than any other single factor. Results of researches carried out on the effects of urbanization on drainage basins (Neller, 1988; Noorazuan 2005; Bowling et al, 2006; Rao et al, 2006) shows that Land use land cover change in urban drainage basins adversely affects these drainage basins ecosystem, causing them to be one of the most dynamic systems. Urban stream channels are very unstable, exhibiting extensive deposition of sand bars, expansion of floodplains, reduced channel capacities to regulate stream flow, increased run-off/stream flow. There is the development of an erosive regime, with scour holes, down cutting bank erosion and channel migration.

Robert et al, (2007) suggest that there is a relationship between urban drainage basin Land-use Land-cover patterns and surface water quality. The result from multiple regression analysis conducted indicates that water quality degradation is associated with basin wide upland land-uses.

To control land degradation, there is therefore the need for assessment of changes that do take place in land-use land-cover from time to time. The dynamic nature of the urban catchments, foster rapid Land-use Land-cover Change and land degradation. The use of remotely sensed data to monitor the status of the dynamic change of Land-use Land-cover has become the most rapid, effectual and credible method to study urban catchment's environmental degradation (Ndabula, 2006).

A systematic understanding of changes in Land-use/Land-cover is critical to the understanding of the ecosystem functioning and services and human welfare (Ramsey, 2001). Determining the effects of land-use/land-cover change on the urban catchments system depends on an understanding of past land-use practice, current land-use/land-cover as affected by human institutions, population size and distribution, economic development, technological and other factors (US CCSP, 2004).

2.3 REMOTE SENSING/ GIS MAPPING AND MANAGEMENT OF DRAINAGE BASIN/WATERSHED

Remote sensing and geographic information system have become increasingly important in hydrology and hydrological mapping. However, the current use of remote sensing information in the fields of planning, design and operation of water resources systems still falls below its potential (Schuttz, 1997). Geographic information system technologies are relatively new and still near the lower end of the growth curve in terms of applications (Good Child, 1996).

Remote Sensing and Geographic information system techniques have a wide range of applications in drainage basin studies such as drainage basin delineation and determining of form variable such as Area, length, perimeter shape, relief, delineating drainage network and analyzing network variables such as channel frequency, length, drainage density, stream order, drainage pattern and network changes (Goodchild, 1996). The understanding of these is crucial to understanding the basin hydrologic variables.

The applications of remote Sensing / GIS cover the wider field of Landuse/Landcover Changes, mapping of surface imperviousness, whose relationship with hydrological variables cannot be over emphasized. The development of DEM has made floodplain analysis more significant. The recent advancements in the application of Remote Sensing / GIS in storm water management e.g. run-off estimation, hydrographs studies, storm water modeling simulation and predictions are particularly important in flood risk management (Zandbergen, 1998).

2.4 REVIEW OF RELATED LITERATURES

2.4.1 INTRODUCTION

Flooding in urban/semi urban drainage basins is controlled by the interplay of a wide range of hydrologic, hydraulic and hydrometeorological processes. From the hydrometeorological perspective, the distribution of extreme rainfall rates at short time scales and small spatial scales is of fundamental importance for urban flood response. The hydrologic response of urban drainage basins is complicated by (a) The alterations to the drainage network, especially through the storm drain system of an urban drainage basin and (b) alterations to the infiltration properties of a basin through detention basins and impervious cover. The hydraulic properties of urban stream channels are profoundly influenced by bridges, culverts, channel stabilization project, detention basins and channels reach. Hydraulic properties of an urban stream channel are also altered by the river itself as it adapts to the challenging hydraulic response of a drainage basin (Smith et al, 2003).

2.4.2 REVIEW OF RELATED LITERATURES ON REMOTE SENSING/GIS APPLICATION TO DRAINAGE BASIN/WATERSED MANAGEMENT

Shakirudeen (2004) in his study on Urban Land-use Change and the flooding patterns in Ashimowu watershed in Lagos, Nigeria combined Remote Sensing, hydrology, Geographic Information System (GIS) and digitally generated urban land surface modeling to investigate the urban flood problem in Lagos. His findings revealed total catchment's area is 13.46km^2, seven (7) major land-use/land-cover classes. The built up area within the Ashimowu watershed progressively increased from about 166.88 hectares (12.40%) in 1965 to 1231.00 hectares (91.46%) in 2003 at an average rate of 28.0032 hectares per annum indicating extensive human activities. These development activities in turn, have resulted in massive wetland losses and increases impervious surfaces throughout the watershed. Land-use change has a direct impact on the infiltration process. Rainfall/runoff relationship within the watershed showed continuous increase in peak flow and area inundated as urban impervious increases. Most primary drains are left to carry more storm water than they were designed to handle. In fact many drains are capable of carrying less than 50% of the volume, during heavy rains. Also there is a strong linear relationship between flood generation form rainstorms and urban land use within the watershed.

George et al (2007) reported the findings of their study of urban development and its environmental impact on the Tampa Bay Watershed of West Central Florida. They used Landsat imagery to determine spatial and temporal changes as well as the development density of urban land-use and analyzed the impervious surface distribution, while population distribution and density were extracted from 2000 Census data. They also analyzed non-point source pollution for measuring water quality for the sub drainage basin. They used regression analysis to establish the relationship between 2002 urban land-use, population distribution and their environmental influences. The results suggested that strong association existed between most pollutant loadings and the extent of impervious surface within each sub-drainage basin in 2002, while population density exhibited apparent correlation with loading rates of several pollutants.

Yang et al (2003), studied urban land-cover change detection through sub-pixel imperviousness mapping using remote sensed data in western Georgia. In their methodology, they developed a sub-pixel impervious change Detection (SICD) approach to detect urban land-cover change using landsat and high-resolution imagery. They used two temporal data, 1993 and 2001 using a regression tree algorithm. The spatial patterns of the predicted percent imperviousness were categorized into three (3) main groups thus: (i) Low – Medium impervious are areas of residential use around the rural-urban fringe, (ii) Medium – high impervious are areas of the urban center and the immediate surroundings of the Atlanta Metropolitan area and (iii) high impervious areas as centers where most of the urban sprawl and suburbanization took place. Though commission error were observed in some areas where bare ground was mapped as medium-high impervious surface, due to its spectral confusion with built-up. The use of the sub-pixel change detection approach is an improvement in accuracy over others such as the post classification (map-to-map comparison) which gives little information on the intensity of change between one identified land-use/land-cover class and another and which involves intensive manual interpretation and relies heavily on the skills of the interpreter. The spectral based (image - image) method of change detection though provide quantitative information on spectral change over time. However, interpretation of spectral difference images in terms of land-use/land-cover change is not always straight forward, besides in urban studies using remotely sensed data assumed homogeneity within a single pixel, resulting in no quantitative changes at sub-pixel level while in actual situation most landsat parcels in urban Areas are mixed and composed of several land-use/land-cover types hence ignoring the sub-pixel variations can lead to biased estimate in urban change analysis.

Neller (1988) published his study on comparison of channel erosion in small urban and rural catchments in Armidele, New South Wales. He used erosion pins which he monitored for eighteen months and observed that urban channel bank erosion was found to be 3-6 times greater than that of a nearby rural channel and the rate of knick point retreat was 2-4 times greater. The increase in urban channel bank erosion was the product of change in runoff conditions associated with urban development. The measurement of both channel and catchment's characteristic for both urban and rural channels showed similarities in Drainage basin area, mean catchment's slope, stream channel slope, main channel length, but a wide difference in area of imperviousness being 13.6% in the urban channel and 1.40% in the rural channel catchments. Despite the similarity in total rainfall recorded between the catchments over the eighteen months, the study confirmed in its results that;

i. total runoff from the urban catchments was 7 – 8 times grater than from the rural (231, 391m^3 compared to 29, 845m^3);

ii. there was 3 – 7 times as many runoff events in the urban catchments (92 compared to 25);

iii. on average, peak storm runoff was 3-5 times larger in the urban catchments (167151[1] compared to 4715[1]) and

iv. The average time to produce runoff from a given rainfall event was reduced in the urban catchments by 63% (i.e. 1 – 5 hrs compared to 4 – 1 hrs).

Noorazuan et al (2005), in their study applied GIS in evaluating land-use/land-cover change and its impact on hydrological regime in Langat River Basin in Kuala Lumpur, Malaysia. It is one of the most rapid semi-urban basins that are experiencing unprecedented land-use/land-cover changes due to the onslaught of development. This study made use of the digitally GIS-based landuse maps of 1984, 1990, 1995 and 1997 to study the landscape patterns, while spatial statistics were carried out using GIS ArcView 3.2a with patch analysis extension and SPSS 11.0. The historical mean hourly and daily stream flow data from the department of irrigation and Drainage (D.D)

Okoduwa (1999) applied Geographic Information System (GIS) in the prediction of urban flooding in Benin City, Nigeria. This was achieved by creating a digital database of selected variables such as landuse, landcover and soil strength. The software used was ArcView 3.1 and the overlay techniques in GIS were used for analysis. The result of the analysis showed high flood prone areas, medium flood prone areas and low flood prone areas. In carry out the overlay operation, he first carried out the land use and the reclassified Digital Elevation Model (DEM). The land use map and the relief map were overlaid using the union function with the geo-processing hazard contained in the Arc View. The union function was used to create new theme by overlaying two polygons of the input theme; that is the land use theme and the relief theme, were split at the intersection. The dissolved function contained in the geo-processing wizard was used to enhance the merging of the feature of the two themes which generated a theme called land Relief Map. The land relief map was then overlaid on the soil strength, and high intensity of land use as well as areas with low relief, are areas that are prone to high flooding, while areas with high soils strength, low intensity of land use, as well as with high relief area prone to low flooding. Also areas with medium soil strength, medium intensity of land use as well as areas with medium relief area prone to medium flooding. Having overlaid land relief map on the soil strength map, the overlay gave a map (Benin City), showing areas that are prone to high flooding, and areas prone to medium flooding and areas that are prone to low flooding respectively.

Okoduwa (1999) also reported that in Thailand flood forecasts were prepared for the Huai nam chum catchments of Pa Sak watershed, Phetchabun province, using a hydraulic model and a GIS. The objective was to test what extent the integration of a hydraulic model and a GIS can contribute to the quantitative assessment of effects of the upstream land use changes on downstream flood pattern. The HEC/hydraulic Model and ILWIS (GIS) were used. The results of the simulation were able to show the effect of the land use changes on flood levels downstream.

The result of the study further showed that a hydraulic model like HEC – I makes it possible to predict the effects of upstream land use changes on down stream level. In this research, GIS appeared to be an efficient tool for the preparation of part of the input data required by such a model but it was not possible to link GIS and the HEC – I directly. It could not be confirmed whether the use of a GIS would be an advantage when other hydraulic model are used.

Georgakos et al (1997) undertook an estimation of flash flood potential for large areas in United States of America. A methodology for determining the potential for flash floods in small basins within large geographical area was presented. Geographical Information System (GIS) technology was used to assimilate digital spatial data, remotely sensed data with physically based hydrological – hydraulic models catchments response. The methodology used digital terrain elevation data, digital river reach data, and the US Geological Survey land use and Land cover data to produce estimates of the effective rainfall volume of a certain duration required to produce flooding in small streams. This flood potential index is called Threshold runoff. For operational application, soil water accounting models were used to yield estimates of effective precipitation over areas of $1000km^2$. Maps of flash flood potential could then be constructed using remotely sensed and on-site data.

Kafle et al (2007) carried out a study on flood hazard mapping and risk assessment in the flood plain of Bagmati River in Nepal. The main objective of the study is to integrate flood simulation model, remotely sensed data with topographic and socio-economic data in a GIS environment for flood risk mapping in the flood plain of Bagmati River in Nepal. A hydraulic model was used to simulate flood flows through the river and its flood plain for discharges corresponding to various returns periods. The main spilling sections along the river and inundation area extent as well as flood depths in the river and plain were conducted. Water surface profiles, along the river reach under study, for floods of various return periods were computed with sub critical simulation. These profiles were exported to GIS and processed to generate water surface Triangular Irregular Network (TIN).There was an intersection of the terrain TIN and water surface TIN. The flood hazard factors for each Village Development Committees (VDCs) were generated based on the total inundation area and inundation area having a flood depth of greater than 1m. The Digital Elevation Model (DEM) of the study area was prepared using contour map (1:25,000) and random spot heights. The terrain and river geometry were extracted from the DEM. The flood plain visualization was carried out using one-dimensional hydraulic model HEC-RAS. HEC-Georas, an Arc View extension, was used as the interface between HEC-RAS and GIS. For a 50year flood, an area of 360km^2 of the 87 VDCs was estimated to be affected by flood with 183km^2 having a flood depth of greater than 1m. Nearly 45% of the total area of the flood affected VDCs were found to be inundated. The model results were verified by making a field visit and collecting data on flood depths corresponding to the peak flood of year 2004 that had a magnitude close to that of a 50yer flood. Vulnerability was assessed based on the economic importance of land type being inundated ad population density. Flood risk factor for each VDC was determined using the flood hazard and vulnerability factors based on matrix multiplication method. Finally a flood risk map was developed.17 VDCs were found to be under high risk category, 19 VDCs under medium risk category and 51 VDCs under low risk category respectively. The right bank of the river between 10km and 30km was identified as the main spilling reach. This study could be useful for reducing flood damages and planning mitigation measures. The limitation in the study as regards the use of remotely sensed imagery for flood depth estimation as observed by (Islam et al 2001; Islam et al 2002; Townsend et al 1998; Wadye et al 1993) In Kafle et al (2007) is that flood depth is considered as the most important indicator of the intensity of flood hazard. However, estimation of flood depth from remotely sensed imagery is a very difficult task and alternatively, water-surface TIN and terrain TIN were intersected to estimate the flood depth.

Lal et al (2006) in their study of the assessment of flood vulnerability and Mitigation planning in Munshiganj District of Bangladesh using Remote Sensing and GIS created a flood vulnerability map of Munshiganj district using satellite and GIS techniques and a hydrological model output (Mike - 11). Landsat TM data was used to generate a landcover, while JERS – SAR and RADASAT data were combined to map the flooded area in a normal flood event. An attempt was made to combine two sensor data as a way of practical usage of satellite data during a rainy season when it is impossible to acquire optical sensor data. ADEOS AVNIR, JERS, SAR along with RADASAT was used for interpretation of the flooded and non flooded areas. Simple threshold classification technique and visual interpretation were used in the interpretation of both optical and SAR images. Field verification was used to further clarify in flooded and non flooded areas where there was ambiguity in interpreting satellite data. Also, the optical images helped in identifying water features that are not affected by rainfall. Further, flood map and SRTM image were calculated for averaging the normal flood boundary. It was identified at the altitude of 7meters then built flood depth using Cut/Fill technique to subtract elevation at flood boundary maximum height. Finally, inside flood depth classification was completed.

In terms of flood extent and depth, it was found that about 2.61% of the total area of the district falls under high vulnerability, 45.31% under medium vulnerability, 13.96% under low vulnerability and the rest 38.12% is not vulnerable to flood. Landsat TM data was used to generate a landuse map and combining this landuse with population data, a population distribution map was produced according to land use types. Subsequently, this population distribution map was compared with flooded area for creating a map indicating the population at risk in a flood event. Attempt was made to identify shelters during a flood based on information such as existing schools/ hospitals location, topography and accessibility. Prioritization of shelters was carried out based on population at risk during a flood event. Finally, a flood mitigation plan for Mushiganj district based on shelter and evacuation was proposed considering selected shelter's capacities and accessibility.

Chandra et al (2005) conducted a study which pertains to analysis of Air borne synthetic Aperture Radar (ASAR) images in mapping the flood inundation and causative factors of flood in the lower reaches of Baghmati river basin, Bihar, India for the period July to October 2004. Flood impact assessment was done using temporal ASAR images (C-band) acquired during three periods corresponding to pre-flood (10 June, 2004), during flood (22 July, 2004) and post – flood (10 October, 2004). The landuse/land cover map of the study area was generated using LISS III (December, 2002). These imageries were geometrically corrected using SOI topographic sheets. SOI maps and collateral data were used for identifying different terrain features on the image. A Digital Elevation model of the area was developed. Satellite images were then co-registered and processed using ERDAS IMAGINE digital image processing software ver.8.7. The impact of the flood on landuse of the study area was assessed by integrating the flood inundation layers with the landuse/landcover layer in the GIS environment. The result shows that 62%

of the agricultural area was inundated. Flood water drained faster in the left bank, where as it was slow in the right bank. The DEM of the area shows that the flood prone right bank of the Baghmati River is a topographic low sandwiched between Kosi and Burhi Gandak highs (Mega fans). The Baghmati River flows at high elevation than the right bank area. Low width to depth high salse ratios indicate vulnerability for flooding due to low carrying capacity and avulsion. Over bank flow is observed to initiate from the reactivation of under fit channels and tributaries. The low topography, low carrying capacity and avulsive behavior of the river are attributed here in to frequent and prolonged flooding of the right bank. In this particular case, the earthwork along the river course also is found to impede the recession of flood water.

CHAPTER THREE

MATERIALS AND METHODS

3.1 INTRODUCTION

This chapter describes the various Data, materials, instruments/software and methods that were used in carrying out this research. Among the issues treated are materials used and their sources, techniques of data collection, planning and design of field surveys, analysis of data /images and the generation of Digital elevation model.

3.2 MATERIALS

The data utilized in carrying out this research work were collected from secondary sources and manipulated to produce required data. Verification of manipulated data was carried out through conducting ground truth exercise using handheld GARMIN XL GPS.

3.2.1 TYPES OF MATERIALS/DATA USED

Data used in this research include:

(i) Two large scale topographic maps covering the study area at a scale of 1:10,000.These were obtained from the Federal Capital Development Authority. The topographic maps used include Kuje sheet 207NW1c and Kuje sheet 207NW1f.The contour interval on these topographic maps is 2.5metres.The grid intervals for these topographic maps are 500metres and the sheet sizes are 3"45N and 2"30E.The topographic map ground coverage is 7000metres by 4600metres approximately.

These topographic maps were compiled and produced by Akinsehinde Lekanu and CO. Lagos in 1981 from Aerial photographs taken by Kenting Africa in 1976.

(ii) Quickbird satellite image of 2003 with spatial resolution of 60cm and Ikonos satellite image of 2006 with spatial resolution of 1metre were obtained from Abuja Geographic information system in January 2009.

3.3 PLANNING AND DESIGN OF FIELD SURVEYS

Field survey entails going to the field to pick GPS ground control points and to do ground verification. These points were picked as major roads, T junctions, public schools, open lands. The reason why the researcher chooses these points and not others is because in the process of verification these points would be visible and easily read on the secondary data used for this research. From field work conducted 32 GPS ground control points were picked for ground verification.

3.3.1 FIELD MAPPING

The GPS was initialized or set up to UTM, Minna datum 32 and to true bearing. The GPS was allowed to capture at least ten satellite signals with expected position error (EPE) not greater than 10 inches to give 3D accurate reading. GPS coordinate values of X and Y were read and recorded for each identified features.

3.4 GIS TECHNIQUES OF DATA COLLECTION AND ANALYSIS

Kuje topographic map sheets 207NW1c and 207NW1f of 1981 and satellite imageries of Ikonos 2006 and Quickbird 2003 were all scanned and inputted into GIS environment. Onscreen digitization was done using ILWIS 3.1 Academic software. Images were exported into ArcView 3.2a environment for further GIS operations.

3.4.1 GEO – REFERENCING:

In order to start extracting features attempt was made to digitally register the satellite imageries and topographic maps to conform to a unified coordinate system. Hence, the following procedure was adopted:

(I) Scan the analog topographic maps (Kuje sheet 207 NW1c and 207 WN1f) and satellite imageries (Ikonos 2006 and Quickbird 2003) using the Ao scanner. The scanned data was imported into ILWIS 3.1 Academic environment by going to file on the ILWIS window, then import via geogateway .Four ground control points were obtained using GARMIN XL GPS to cross check the existing coordinates of the topographic map which was then used to georeference the map and the satellite imageries. (ii) From the main window in ILWIS 3.2 Academic, the file menu was open to click on map reference.

(iii) Map reference- coordinate system dialog box appears. The selection of coordinate system I used was done here (using the create button and choose for either metric coordinate or geographic coordinates).In this study I utilized the geographic coordinates.

(iv) Based on the map reference-Digitizer control points dialog box from ILWIS 3.1 Academic ,the following procedures was adopted:-

- Clicked the reference point in the map with the digitizer cursor for points 1 to 4 respectively.
- Input the corresponding map coordinates for these points (1 to 4) above as read from the analog map.
- The feed back (sigma) value for different X and different Y was checked. For a good map reference, the figure should be in the range of 0-1.However, for this work, the value of 0.51 sigma was recorded signifying a good value.

3.4.2 **SUBSETTING:**

Coordinates of the study area were picked from the topographic maps of the study area and verified on the field using GPS and registered to create a box which defined the subset made up of the study area on the satellite images and topographic maps using ArcView 3.2a software.

3.4.3 **IMAGE INTERPRETATION**

Supervised classification was used. All classification results were delineated as polygons using on screen digitization with the aid of ArcView 3.2a software. Results of digitization were edited using ArcGIS Software. Layers were topologies and saved as themes or convergence used in maps composition.

3.4.4 CONTOUR DIGITIZATION AND DTM CREATION

Using the boundaries of subset of River Usuma Drainage basin which falls on Gwagwalada semi urban area, two topographic maps of Kuje 1981 with scale of 1:10,000 was used to digitize contours as source of spot heights or Z values. ILWIS 3.1 Academic software was used for the digitization of the topographic map. Onscreen digitization was employed in the digitization of the topographic maps as digitized contours generated were interpolated to create the DTM used for this research. Onscreen digitization as used in this work involves editing a segment or point map while an existing map is displayed as a background in a map window. By using the mouse, user directly digitize elements of interest on the background map. The procedures in digitizing are as follows: -

(a) With the digitizer, user then adds points continuously along the feature (in this exercise contour) which becomes a series of (segments, lines or arc). Errors were taken care of because it was possible for the user to delete points or segments, rename points or segments, move points and at the same time enter the attributes at ease within the data base.

(b) Next is to create a segment map by selecting the "create segment map" dialog box "coordinate system Tie points" was used. The above mentioned steps were employed in the digitizing of contour lines from existing topographic maps of the study area.

(c) Having completed the line feature extraction (contours) the digitized contours was then exported to ArcView 3.2a environment for further analysis such as the generation of DTM and relevant analysis such as Hill shading, elevation range among others. To generate a DTM the procedure below was observed:-

(d) Having exported the digitized contour to Arcview 3.2a environment, the surface menu was clicked while selecting the "create TIN" from feature, then the height and mass point was selected and all other default accepted. Then the interpolation eventually took place to visualize DTM.

(f) Elevation range, hill shading were executed following procedure (d) above.

3.5 DELINEATION OF FLOOD PLAIN

The flood plain was delineated and flood vulnerability levels for the study area were determined. The study area was categorized into highly vulnerable, less vulnerable and areas free from flood. Primary data (history/location data, hydrologic and hydraulic data) and secondary data (elevation data) could be used for the delineation and categorization above. In this research, elevation data was used in the delineation and categorization of flood vulnerability levels, because as observed by Sarma et al. (2005) the spatial data stored in digital data base such as DTM/DEM can be used to predict the future flood events. Another reason why the researcher resorted to the use of elevation data was because the data were the only readily available data to the researcher as at the time of conducting this research.This was done by digitizing along areas of spread using the elevation range as follows (a) 178.0m to 183.833m above sea level as areas highly vulnerable to flood hazard (b) 183.833m to 186.33m above sea level as areas less vulnerable to flood and (c) 186.33m to 201.33m above sea level as areas free from flood.

Having digitized the vulnerability levels along their respective contours of elevation range using the draw line tool as contained in the ArcView 3.2a software (by drawing a continuous series of point along the elevation range) effort was made to label them accordingly as expressed in a, b and c above.

3.6 OVERLAY OF SEGMENT MAP OF VULNERABILITY LEVELS ON UNCLASSIFIED IKONOS 2006 IMAGERY

The segment map produced showing areas under different vulnerability levels to flood in the study area was overlaid on the unclassified satellite image (Ikonos 2006) of the study area in order to generate two new maps that shows the areas under the three different vulnerability levels in the study area. The new maps were labeled accordingly.

CHAPTER FOUR

RESULTS

4.1 DIGITIZED CONTOURS

Fig.4.1 is a digitized contour of the study area. This shows the general elevation of the study area to be undulating in nature. The digitized contours were interpolated to create a digital elevation model of the study area.

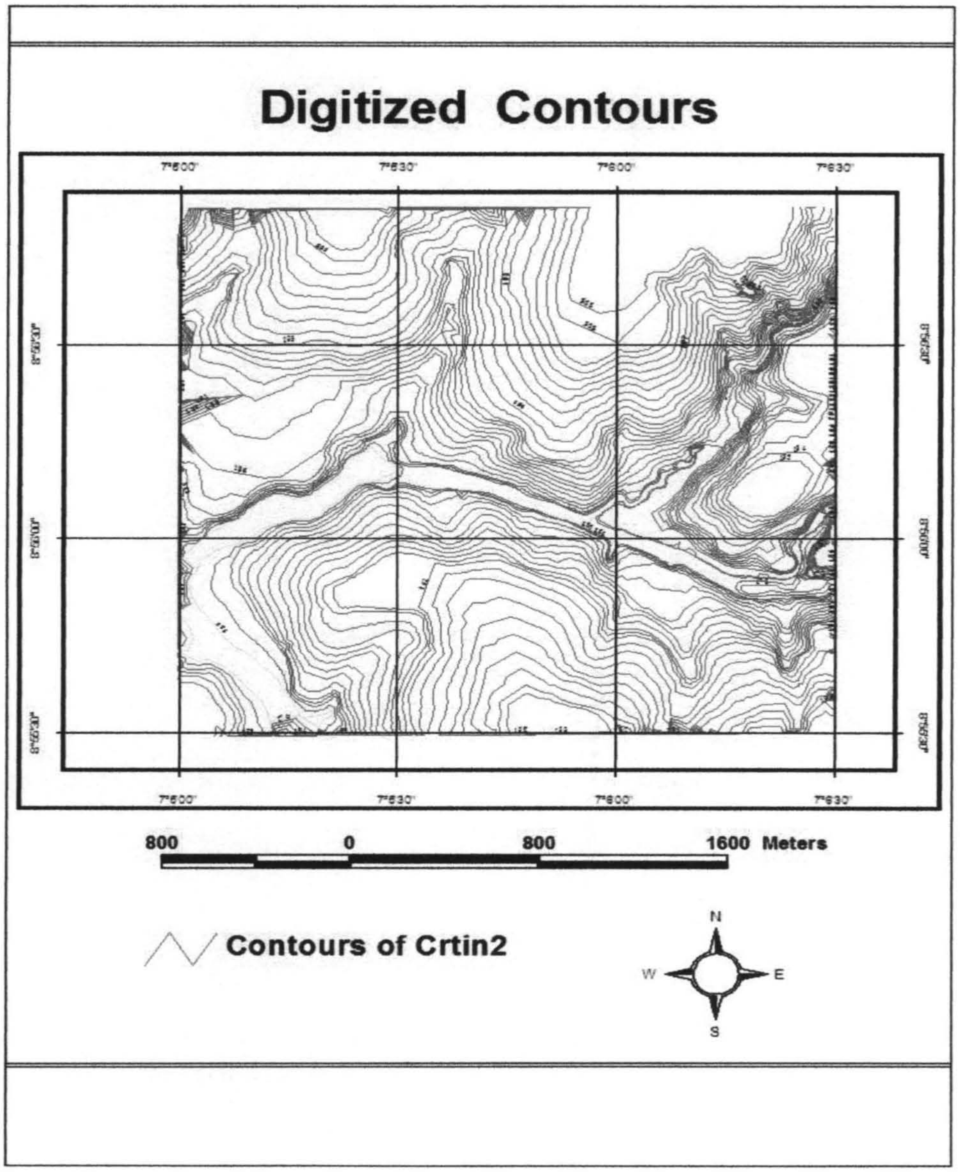


Fig. 4.1: Digitized Contour

4.2 OVERLAY OF CONTOURS ON DEM

Present mapping programs are rarely implemented with only planimetric considerations. The digital elevation model (DEM) of the study area was overlaid by digitized contours of the study area (figure 4.2). This highlights the topography of the study area (distribution of river, highland, lowland in the study area).

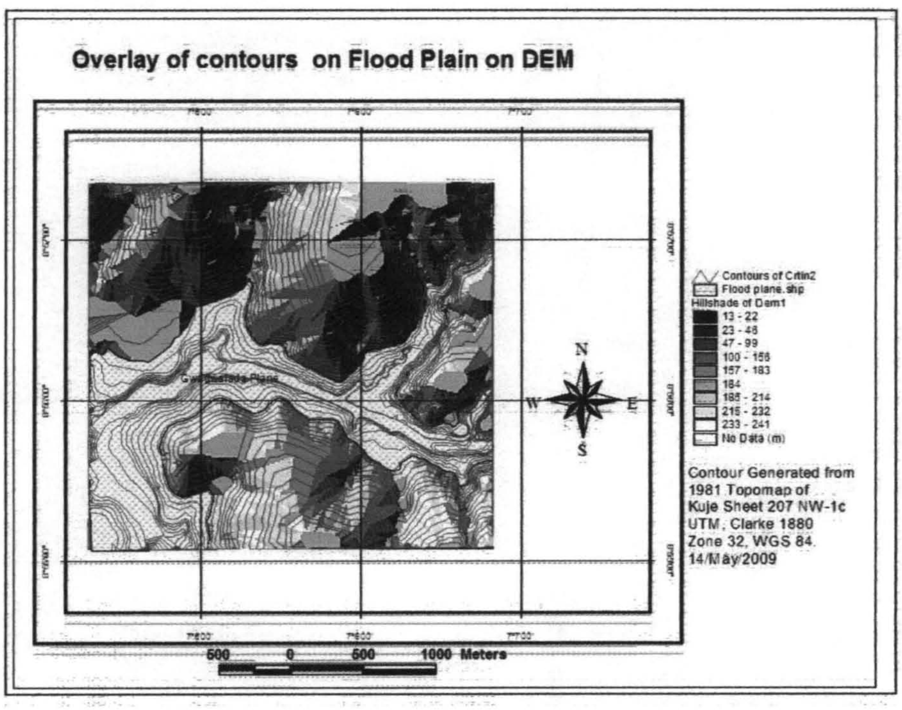


Fig. 4.2: Overlay of contours on DEM

4.3 GWAGWALADA ELEVATION RANGE

Gwagwalada elevation range (figure 4.3) shows elevation data of the study area belonging to the same general category defined by an upper and lower limit. The lowest elevation in the study area is found around River Usuma with an elevation of 177.8m above sea level. The highest elevation is found at 205m above sea level in the northern part of the study area.

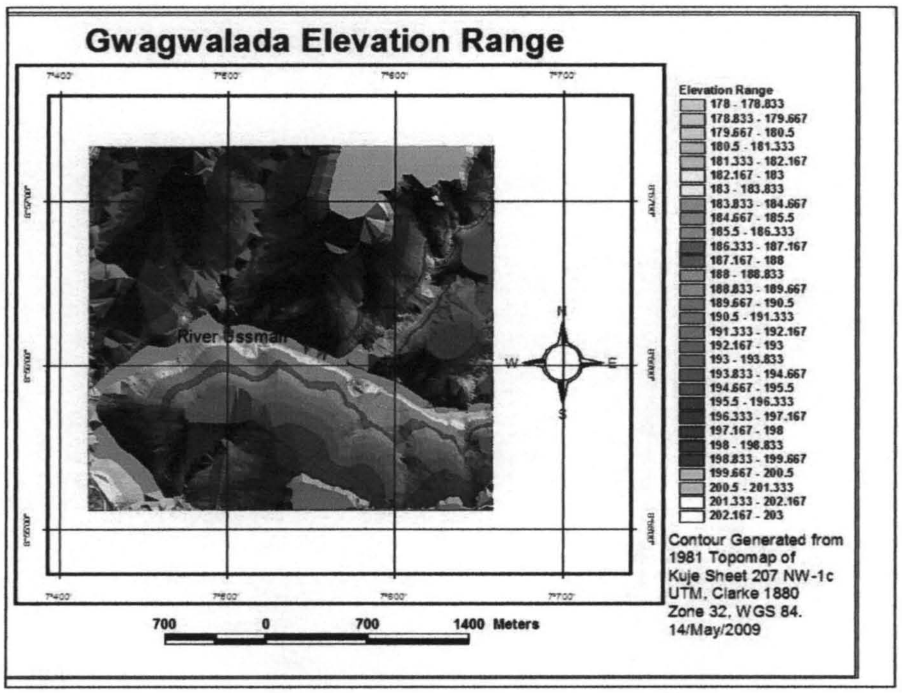


Figure4.3: Gwagwalada Elevation Range

4.4 RIVER USUMA OVERLAID ON DEM

The study area is drained by River Usuma which is an important tributary of River Gurara and it is the largest river and major river within the study area.

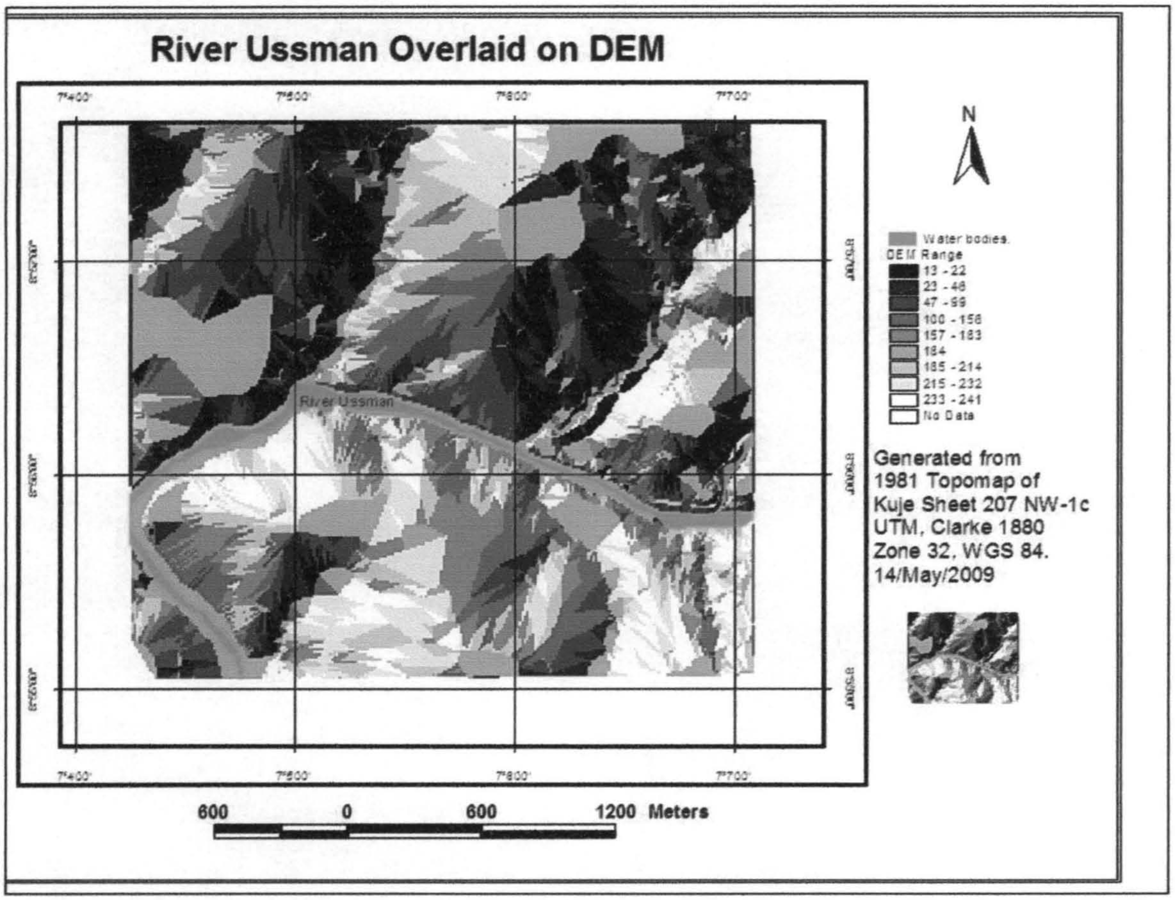


Fig. 4.4: River Usuma overlaid on DEM of study area

4.5 FLOOD VULNERABILITY COMPUTATION

Based on the DEM/elevation range generated, the study area was categorized in to three flood hazard vulnerability levels which include highly vulnerable, less vulnerable and areas free from flood.

Table 4.1: Vulnerability level computation

Vulnerability level	Area Extent (km^2)	Percentage of Area (%)
Highly vulnerable to flood	11.6	16.9
Less vulnerable to flood	09.	1.3
Free from flood	56.25	81

Source: Author's field work, 2009

4.6 OVERLAY OF SEGMENT MAP OF VULNERABILITY LEVELS ON UNCLASSIFIED IKONOS 2006 IMAGERY

Figures 4.5 highlights the different areas in the study where the three flood vulnerability levels are found. The different flood vulnerability levels are separated by imaginary lines.

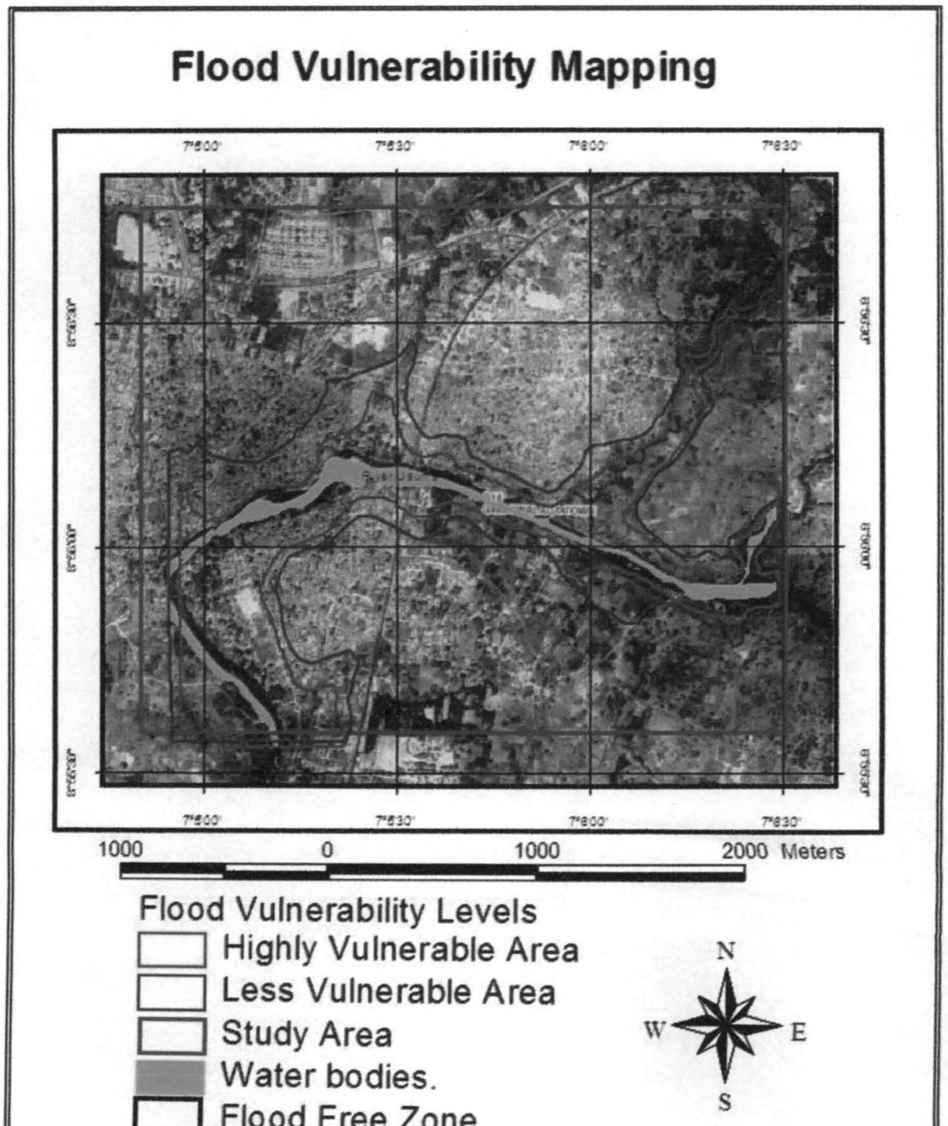


Fig. 4.5: Flood vulnerability map

4.6 OVERLAY OF SEGMENT MAP OF VULNERABILITY LEVELS ON UNCLASSIFIED IKONOS 2006 IMAGERY

Figures 4.5 highlights the different areas in the study where the three flood vulnerability levels are found. The different flood vulnerability levels are separated by imaginary lines.

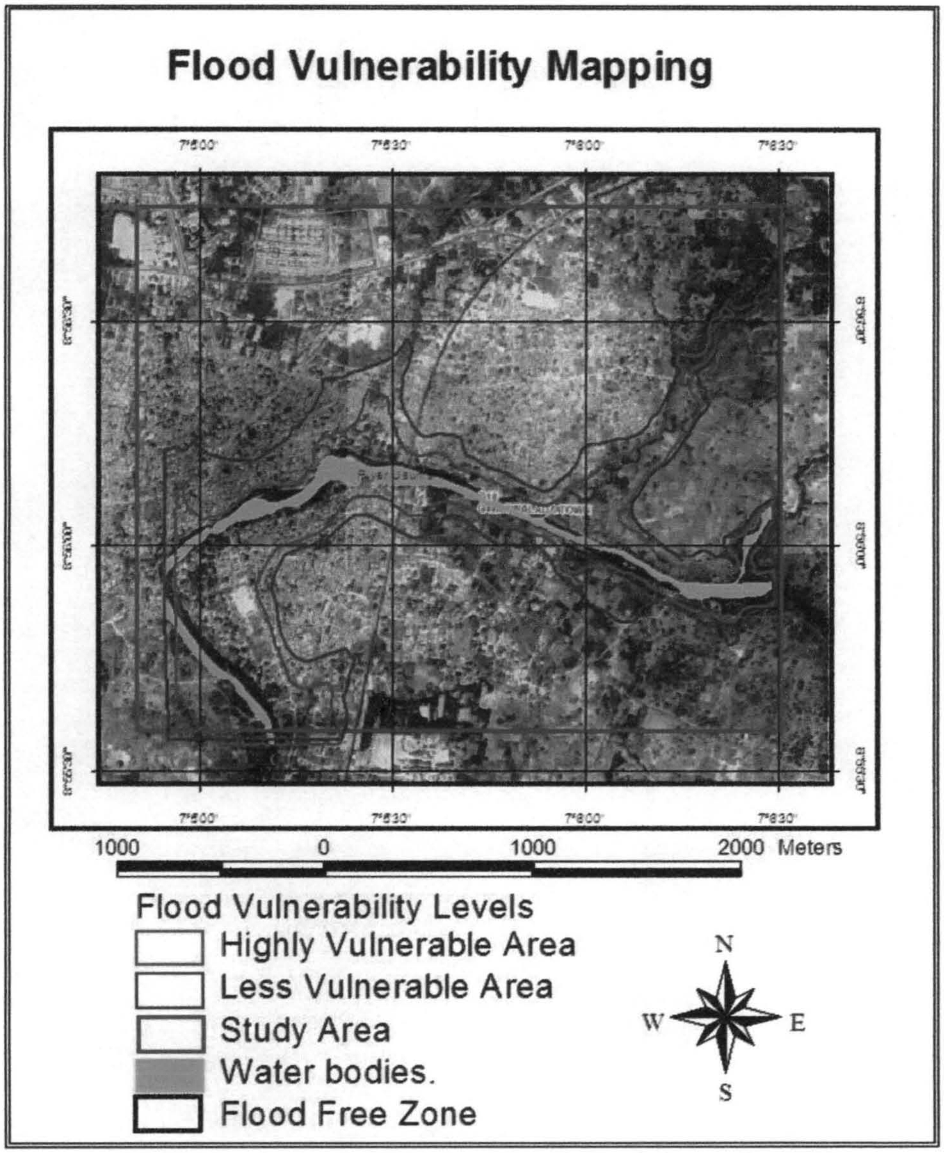


Fig. 4.5: Flood vulnerability map

4.7 1981 GWAGWALADA BUILDUP AREA

The buildup area in 1981 was occupying 0.33 square kilometers (0.50% of the study area).

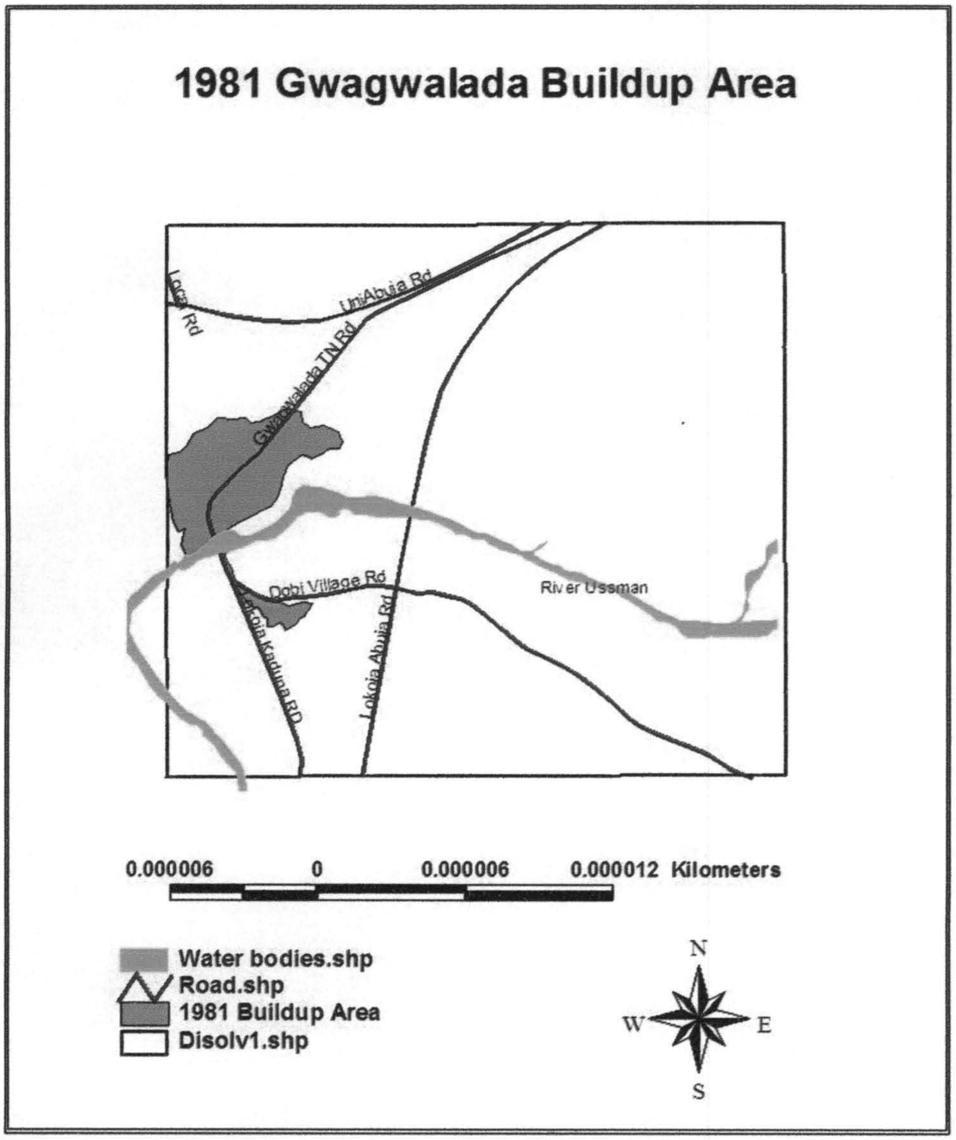


Fig. 4.6: 1981 Buildup areas

4.8 2003 GWAGWALADA BUILDUP AREA

The buildup area in Gwagwalada town in 2003 was occupying 9.9 kilometer square (17.46% of the study area)

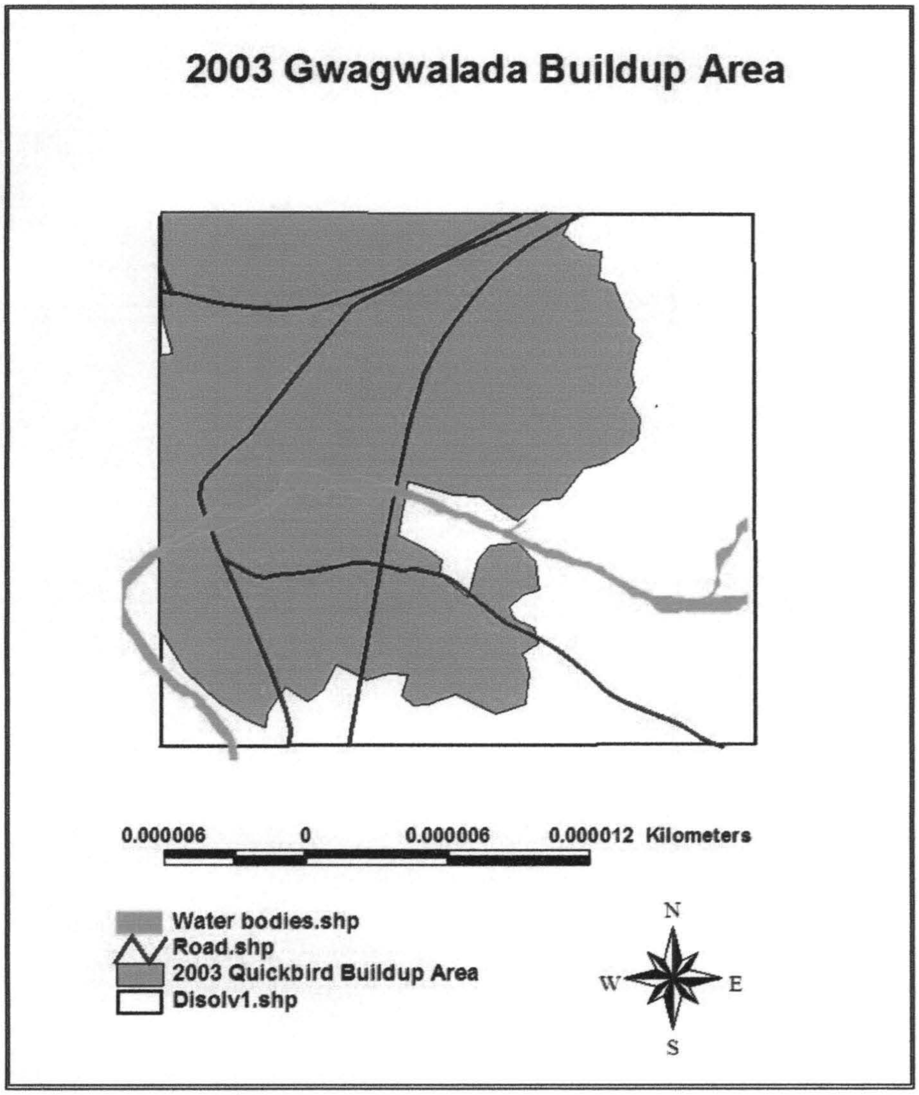


Fig. 4.7: 2003 Buildup areas

4.9 MAP AND GRAPHICAL VISUALIZATION OF BUILDUP AREA

Figure 4.11 is a representation of areas covered by buildup in Gwagwalada town between 1981 to 2006. There is an increase in the buildup area over time indicating extensive human activities.

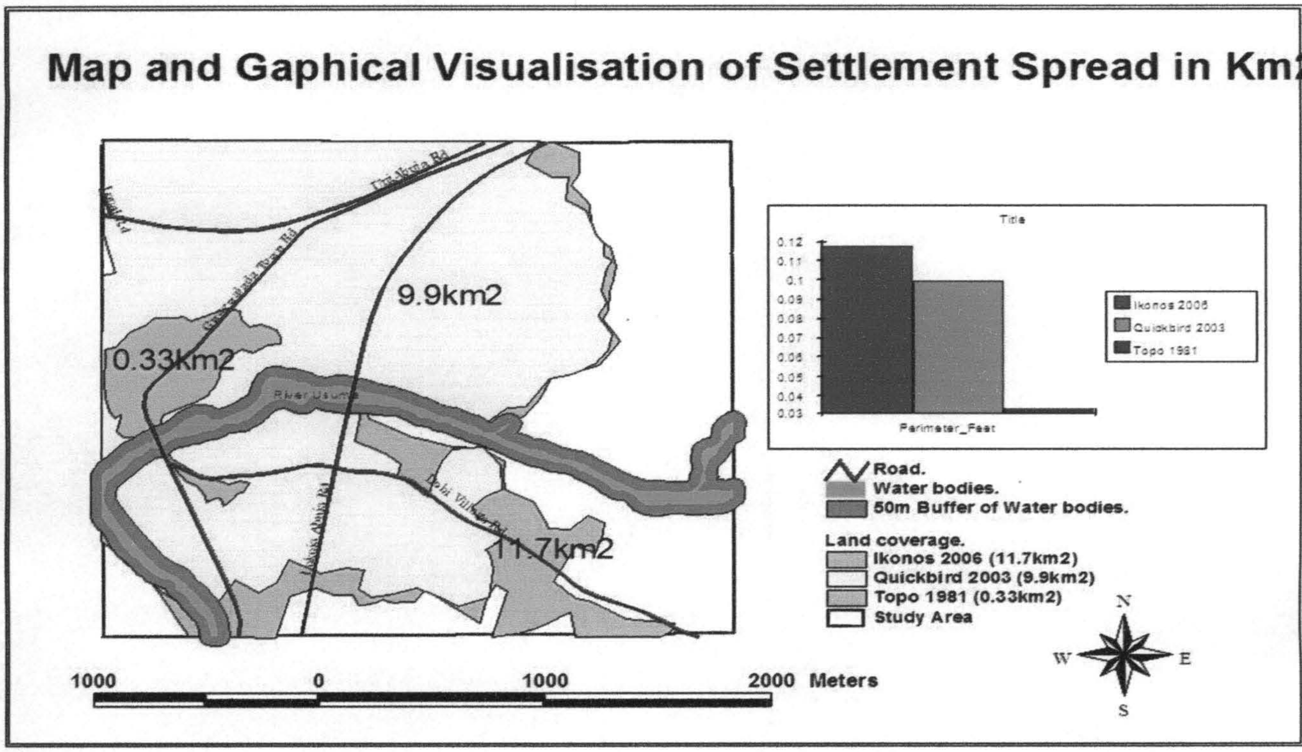


Fig. 4.8: Map and Graphical Visualization of buildup area between 1981to 2006

CHAPTER FIVE

DISCUSSION, SUMMARY, CONCLUSON AND RECOMMENDATIONS

5.1 DISCUSSION OF RESULTS

5.1.1 DIGITAL ELEVATION MODEL PRODUCED FROM DIGITIZED CONTOURS

The DEM clearly shows that the topography of Gwagwalada town is undulating .The lowest elevation is found around River Usuma with an elevation of 177.6m above sea level in the south eastern part of the study area. The elevation of the town rises gradually up the northern part of the study area with the highest elevation at 205m above sea level as shown in figure 4.2 and 4.3.The elevation of the town also rises southwards away from the banks of River Usuma to about 202.6m Above Sea Level at the extreme southern part of the study area.

5.1.2 AREAS VULNERABLE TO FLOOD ON DEM AND IMAGERIES.

Based on the DEM/elevation range generated, Gwagwalada town was categorized in to three flood vulnerability levels which include highly vulnerable, less vulnerable and areas free from flood. The area with the highest flood vulnerability level occupies an area of 11.60km^2 (16.90% of the study area), the less vulnerable area occupies an area of 0.9km^2 (1.31% of the area) and the area free from flood occupies an area of 56.25km2 (81.81% of the study area) table 4.1. Areas lying along the banks of River Usuma are highly vulnerable to flooding and this area is predominantly occupied by buildup which signifies extensive human activities. Generally speaking, majority of the floodplains and areas free from flood are occupied by buildup and the vulnerability to flood in the study area most importantly decreases northwards away from the banks of river Usuma.

5.1.3 GWAGWALADA TOWN BUILDUP EXPANSION

The digital maps produced representing build up area (figure 4.6, 4.7, and 4.8) shows that within Gwagwalada town, the buildup area progressively increased from about 0.33 square kilometer (0.50% of the study area) in 1981 to 9.9 square kilometer (17.46%) in 2003 and 11.72 square kilometer (17.80%) in 2006 at an average rate of 0.435 square kilometer per annum from 1981 to 2003 and an average rate of 0.607 square kilometer from 2003 to 2006 indicating extensive human activities. The development have resulted in massive wetland, vegetation losses and increases impervious surfaces throughout the town. Shakirudeen (2004) in his research on Ashimowu watershed in Lagos observed that landuse landcover change in Nigerian towns has direct impact on the infiltration process and he also observed that there is a strong linear relationship between flood generation from rainstorm and urban landuse in Nigerian towns. This applies to Gwagwalada town.

The implication of increased buildup expansion on the floodplains and basins is that some inhabitants of Gwagwalada floodplains have become vulnerable to flood hazard as the study area has been experiencing frequent flooding prominent among which was that of 2003 and 2006 where property were destroyed and lives were lost. This confirms the works of Neller (1988), Shakirudeen (2004) , Noorazuan et al. (2005), Theodore (2006) among others which is supportive of the fact that development in watershed and floodplains adversely affect the ecosystems in these watershed and floodplains which causes the stream channels in such watershed and floodplains to be very unstable, exhibiting extensive deposition of sand bars, expansion of floodplains, reduced channel capacities to regulate stream flow and increased run-off / stream flow. In the long-run these urban dwellers are exposed to increasing flood risk and community vulnerability due to the fact that these settlements have encroached on the floodplain and equally because of changing landforms in the basin.

It is worthy of note from here that there are other major causes of floods in most urban centers of Nigeria, most especially in fast growing towns like Gwagwalada town, other than buildup encroachment on floodplains. As observed by Olusegun (2004a; 2004b) human population increase, landscaping in paved areas, stream and channel obstruction due to bad waste disposal habit and other human activities at floodplains are considered to be the major causes of floods in fast growing towns and this applies to Gwagwalada town.

5.2 SUMMARY

- Expansion has lead to increase buildup in floodplains.
- The buildups in floodplains have increased the frequency of flooding.
- The elevation clearly indicated areas vulnerable to flood as a dominant factor influencing flood.

5.3 CONCLUSION

The results obtained here are supportive of the conclusions that the rate of development in Gwagwalada town's floodplains is on the increase which has lead to haphazard urban extension and development trends, increase imperviousness, changes in the spatial watershed landuse patterns, increased buildup encroachment on the flood plain and extreme susceptibility to flood hazard, loss of productive agricultural lands and vegetation cover not minding the consequences of such development on the floodplain which results in the frequent flooding episodes witnessed in the study area. The buildups on the bank of river Usuma are highly vulnerable to flooding and the vulnerability of the town to flood decreases northwards away from the banks of river Usuma.

5.4 RECOMMENDATIONS

Based on the results and findings of this research, as well as the existing body of knowledge, the following recommendations are hereby offered:

1. Households residing on the banks of river Usuma should as a matter of urgency be relocated to areas not vulnerable to flood within the study area.

2. Also Federal Capital development Authority should ensure there is proper and efficient Land use planning and regulations in the study area.
3. Residents in the study area should desist from indiscriminate dumping of waste into drainage ways and gutters; household waste and sediments already in drainage ways and gutters should be removed immediately.
4. Stakeholders should embark on public campaigns/enlighten programs to educate residents on how human activities can add to flooding problems
5. Agencies saddled with the responsibility of managing disasters should be properly funded and a GIS data base of the study area and other flood pruned areas in the FCT created.

5.5 SUGGESTION FOR FURTHER STUDY

This research forms a basis for further research on flood vulnerability Assessment using remote sensing techniques as some other areas relevant to this research were not explored by the researcher.Hence,the following are suggestions for further study:

- Assessment of Landuse change and its impact on runoff and sediment yield.
- Assessment of the number of houses and people vulnerable to flood overlaid on flood vulnerability map.
- Flood vulnerability assessment using hydrologic and hydraulic models.

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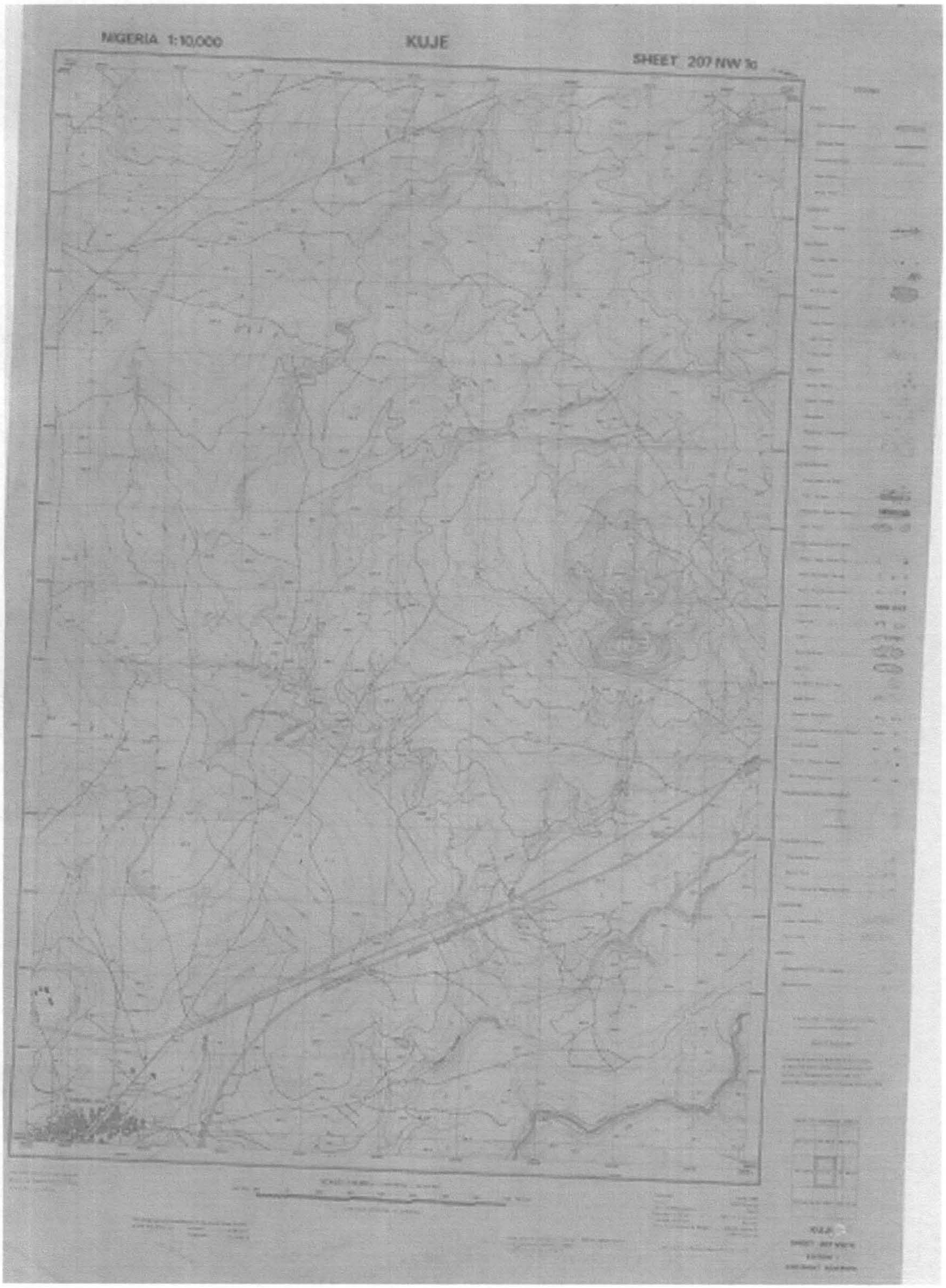
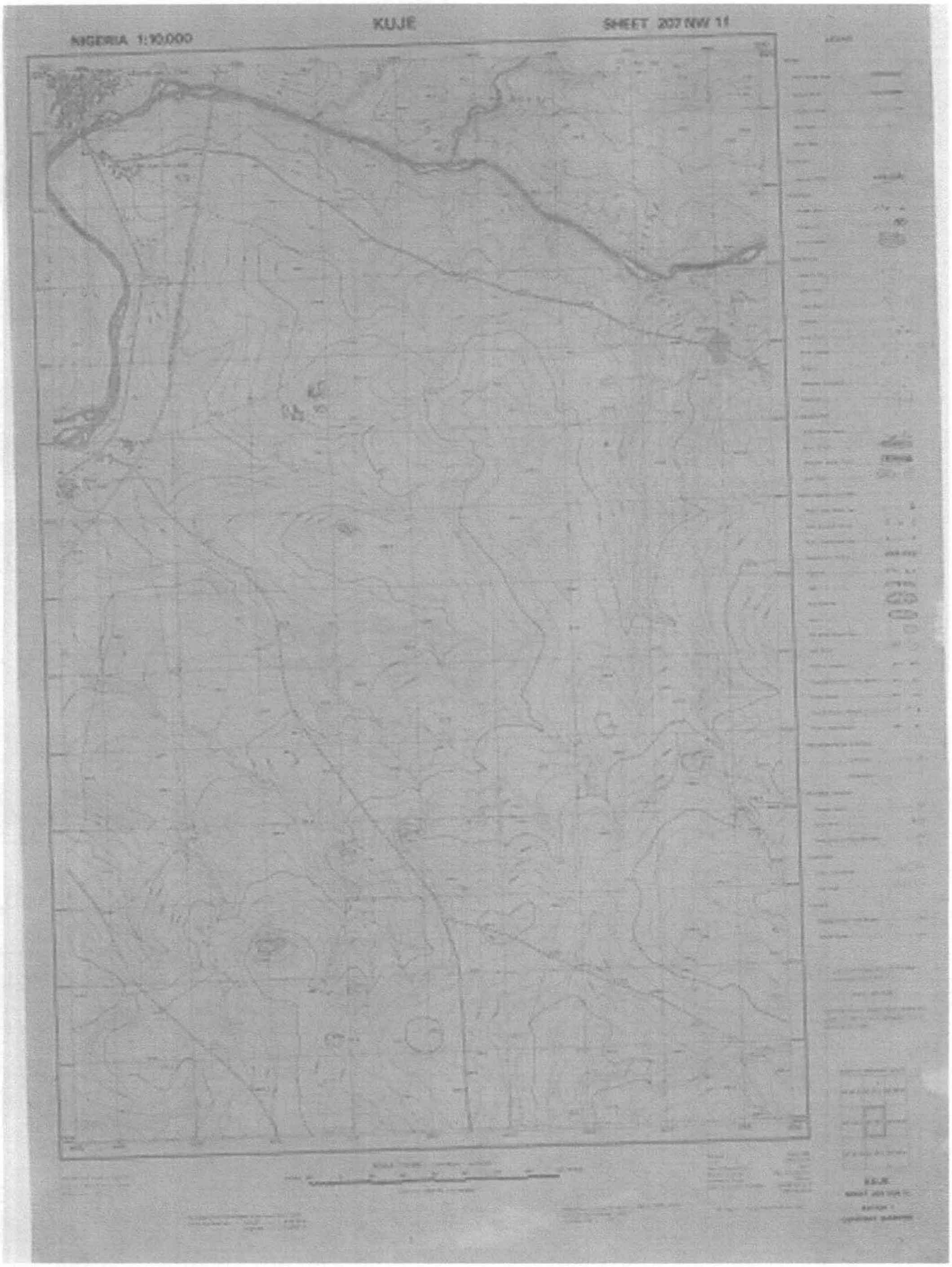
APPENDICES

Appendix 1: Topographic map of Kuje sheet 207 NW1c



Appendix 2: Topographic map of Kuje sheet 207 NW1f



Appendix 3: 2006 Ikonos Image of the Study Area

Appendix 4: 2003 Quickbird Image of the Study Area