FEDERAL UNIVERSITY OYE-EKITI, EKITI

GEOSPATIAL ASSESSMENTS OF HYDROLOGICAL IMPACTS OF FLOOD OCCURRENCES IN ADO-EKITI AND ENVIRONS

PRESENTED BY: OREOLUWA PETER TEMITOPE

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CERTIFICATION

This is to certify that this project was carried out by **OREOLUWA, PETER TEMITOPE** with matriculation number, **WMA/13/1035**, a student of the Department of Water Resources Management and Agro-Meteorology, Federal University Oye, Oye-Ekiti, Ekiti State, Nigeria.

______________________ 22/03/19

Oreoluwa, P. T **Date**

(Project Student)

______________________ 22/03/2019

Mrs. T.E, Babalola **Date**

(Project supervisor)

______________________ 22/03/2019

Prof. A.Olufayo **Date**

(Head of Department)

DEDICATION

This project is dedicated to God Almighty, the one who made it possible for the completion of this work.

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I can't but thank my family for their fervent prayers and support most especially my parents Mr. and Mrs. Oreoluwa and my siblings I appreciate you all. God bless you.

ABSTRACT

Flood risk assessment is an important component of risk management. This study aims to generate a GIS-based flood risk map that can facilitate proper planning of mitigation measures against future floods occurrences. This study uses GIS technique and remotely sensed data to assess the extent of urbanization in land use, and vegetation changes in Ado-Ekiti metropolis between 1986 and 2017. Digital Elevation Models (DEM), settlement maps and satellite imageries to assess the susceptibility of the infrastructures located within the study area (Ado – Ekiti). Spatial analysis are used over Ado local government area with a view to making suggestions for future flood disaster and risk mitigation, generate map that provides useful spatial information of land use changes, population distribution and rainfall variability within flood vulnerable areas. The result shows that the NORMALIZED DIFFERENCE VEGETATION INDEX were generated for the years 1986, 2003 and 2017 to assess the changing patterns of vegetation in response to flooding in Ado-Ekiti metropolis. The NDVI for year 1986 shows that the vegetation was very healthy, recording high value of 0.35. The NDVI value obtained for year 2003 however decreased as compared to that of 1986 with a high value of 0.143accross the Ado-Ekiti metropolis. The vegetation pattern continued to change with a fairly lower value in 2018 with a low value of -0.007, depicting the extent of vegetation loss over the area. The significance of the normalized difference vegetation index values, which is a decreasing trend indicates increase in population that reduces natural vegetation, changing land use pattern (construction, anthropogenic) and significantly increased Flooding Drainage channels map generated indicated that stream channels and their characteristics (i.e. area and slope) affect the extent and frequency of runoff thus determine the likelihood of flooding within the study area.

Overall study therefore reveals that flood severity is rated very highly in the core Ado-Ekiti city centre, and that flooding in the town can be attributed to both physical and humanly activities.

While factors, such as rainfall intensity and duration, cannot be controlled, early warning of flooding based on climatic variability will help people in flood prone areas to prepare ahead of time.

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CHAPTER ONE

1.0 Introduction

Flooding is an exceptionally high level of water rising to submerge an area of land which is normally dry (Adebayo, 1987; Ayoade, 1988; Oriola, 2000; Adebayo and Jegede 2010; Arohunsoro, 2011). This definition applies generally to any type of flooding. However, flooding in river is a situation whereby water carried in a channel is in excess of the hydraulic capacity of the river such that it causes spilling of water on to the adjacent areas of the river. Flooding is a geophysical process which follows the occurrence of floods in any part of a geographical space. Floods and wet mass movements have globally the largest share in natural disaster occurrence: 49% between 2000 and 2008, of which floods alone represent 44%. In 2012, hydrological events caused 52% of total disaster victims, and were responsible for 42% of the total reported number of people killed and 16% of total damages (Below *et al.* 2009; Guha-Sapir *et al.* 2013). On a global scale, floods caused by heavy rain have a high frequency (Townsend and Walsh 1998; Dutta *et al.* 2000; Dolcine *et al.* 2001; Sheng *et al.* 2001; Bryant and Rainey 2002; Hudson and Colditz 2003; Knebl *et al.* 2005).

River flooding constitutes serious environmental problems in cities in Nigeria. Most major rivers are flooded annually particular during the peak of the rainy season when storms generate flows in excess of the river channel capacity. Notable river flooding in Nigerian urban centres include those of Asa in Ilorin city (Jimoh, 1997), Ala in Akure, Ondo State (Okokò and Olujimi, 2002), streams in Ado-Ekiti (Adebayo, 1987; Ebisemiju, 1993a) and River Ogunpa in Ibadan (Akintola, 1981). Other researches on flooding in Nigerian cities also include the works of Rasid (1982) in Benin City, Babatolu (2000) and Oriola (2000) in Ondo city in Ondo State.

Flooding of rivers is more regularly experienced in the Southern littoral region of the country because of the intensive equatorial rainfall and their proximity to the incursion of the sea waves and tides. In Northern dichotomy, flash flooding of rivers exhibits peculiarity due to the erratic nature of the rainfall regime. The onset of the rainy season is usually marked with torrential rain causing instantaneous/disastrous flooding. The South Western bloc of the country is exposed to more regular flooding of the major rivers and the water courses within the major cities and other human agglomerations. The more regular humid nature of the region predisposes it towards more perennial flooding. No matter the perspective from which factors generating flooding in the country is viewed, the fact remains that flooding annually takes its toll in Nigeria and the current episode of climate change across the globe may likely push the country to a greater degree of vulnerability to the phenomenon

1.1 Justification of Study

The National Emergency Management Agency (NEMA) is saddled with the task of formulating policies, assessment of natural and man-made disasters, provision of mitigating measures for disaster related activities, coordinating plans and programmes for offering relief to victims of such disasters (Adeoye et al., 2009). Assessment of floods will require knowledge of flood risk areas in order to develop prevention as well as mitigation measures. Flood risk maps are very essential tools in the identification of flood vulnerable areas (Jeb and Aggarwal, 2008). Geographic Information Systems (GIS) have been used in developing flood risk maps that show vulnerability to flooding in different places around the world. In developed countries, production of flood risk maps has become important criteria for carrying out some major development interventions (EC, 2007). However, Nigeria is still lacking in the effective use of scientific methods such as GIS to tackle such environmental issues. Although, flood risk maps have been produce for some major urban cities of the country, the existing ones, either considered very few factors that contribute to flooding or are obsolete. Owing to the need for flooding prevention in the Ado-Ekiti metropolis, there is therefore the need to produce flood vulnerability map considering multiple factors responsible.

1.2 Aim and Objectives

1.2.1 Aim

The aim of the study is to generate a GIS-based flood risk map that can facilitate proper planning of mitigation measures against future floods occurrences.

1.2.2 Objectives

The objectives of the study are to:

i. use GIS technique and remotely sensed data to assess the extent of urbanization in land use, and vegetation changes in Ado-Ekiti metropolis between 1986 and 2017;

ii. use Digital Elevation Models (DEM), settlement maps and satellite imageries to assess the susceptibility of the infrastructures located within the study area;

iii. carry out the spatial analysis of the study area with a view to making suggestions for future flood disaster and risk mitigation in the study area;

iv. Generate maps that provide useful spatial information of land use changes, population distribution and rainfall variability within flood vulnerable areas.

CHAPTER 2

2.0 Literature Review

The establishment of Ado-Ekiti as the headquarters of Ekiti Division in 1953 marked the beginning of rapid urbanization and increased spatial expansion of the settlement. However, between 1976 and 1986 serious flooding had begun to take its toll in the town. The hazards caused by the flooding ranged from destruction of household properties in various parts of the town to sinking and collapse of the building. Over the decade in reference losses incurred as a result of flooding in the town was estimated at about N2.5 milli on naira in the Nigeria context (Adebayo 1987; Ebisemiju, 1993a). According to Ebisemiju (1993a), about 95% of the losses were incurred by residents along River Ajilosun.

Since the year 2002, flooding has become an annual experience in Ado-Ekiti, following the creation of Ekiti State in 1996, particularly along the watersheds of the rivers traversing the city terrains. This impact of flood can be addressed geo-spatially with the use of remote sensing and GIS technology a lot can be achieved through this modern technological advancement.

The absence of reliable information and sound assessment methods on geospatial assessments of hydrological impacts of flood occurrences studies can have the most profound consequences on impact of flood and for the identification of likely extent of occurrence. Data for these purposes could be acquired using both ground based and remote sensing methods. Ground based methods of data acquisition include field observations, collection of *in-situ* data and measurements and land surveying activities, whereas remote sensing methods are based on the use of image data acquired by sensors of different types such as aerial camera, scanner or radar.

2.1 Historical Episodes of Flooding in Ado-Ekiti

The establishment of Ado-Ekiti as the headquarters of Ekiti Division in 1953 marked the beginning of rapid urbanization and increased spatial expansion of the settlement. However, between 1976 and 1986 serious flooding had begun to take its toll in the town. The hazards caused by the flooding ranged from destruction of household properties in various parts of the town to sinking and collapse of the building . Over the decade in reference losses incurred as a result of flooding in the town was estimated at about N2.5 million naira in the Nigeria context (Adebayo 1987; Ebisemiju, 1993a). According to Ebisemiju (1993a), about 95% of the losses were incurred by residents along River Ajilosun .

Since the year 2002, flooding has become an annual experience in Ado-Ekiti, following the creation of Ekiti State in 1996, particularly along the watersheds of the rivers traversing the city terrains. But of particular significance is the notoriety of the flooding of River Ajilosun drainage basin. A commercial motorcycle operator was lost to the floods of Thursday, 21st September. Several houses were submerged at Olorunda/Olorunsogo Streets of the River Ofin drainage basin during the prolonged rains of October 2009. The floods of the year also led to the collapse of the popular Ajilosun bridge resulting in traffic diversion and delays. The flood water also swept away vegetable and maize farms in the downstream reaches of River Ajilosun. Many roads in the city were also rendered impassable because flood-erosion created deep – pot holes and craters on them.

On Sunday October 23rd, 2010, a six year old girl drowned in a ditch behind Mountain of Fire and Miracles Church of Adeparusi Off Opopogbooro during an early morning down pour which lasted for almost 4 hours (0630HRS – 1000 HRS GMT). The State Emergency Management

Agency (SEMA) is institutionally concerned with coordinating of relief activities for the victims of natural disaster such as flooding. In 2005/2006, victims of flooding were given bags of rice and bundles of zinc roofing sheets.

Given the extent of damage caused by flooding in Ado- Ekiti, and particularly in River Ajilosun drainage basin, there is the danger of becoming myopic about the potentially hazardous situation of flooding in River Ajilosun drainage basin if sustainable control measures are not putting in place. At present, hazards are confined to built up areas which border the main stream channel and stream valley.

We must recollect that flooding in Ibadan started gradually on a mild note (Akintola, 1966), but today it has assumed catastrophic dimensions in the city (Obateru, 1978). Consequent upon the foregoing highlights, flooding in Ado-Ekiti requires proper attention. This is in a bid to forestall its incident from reaching a national disaster level like Ogunpa floods of 31st August, 1980 at Ibadan (Olaniran, 1983) and the widespread flooding in the city on Friday 26th August, 2011. The risk of these occurrences can be evaluated using Geo-spatial tools and analysis

2.2 Remote Sensing

The satellite remote sensing is a timely technological development in view of serious pressures on our natural habitat (Roy & Ravan, 1994). It is used to interpret the images or numerical values obtained from a distance in order to acquire meaningful information of particular features on earth (Janssen and Bakker, 2001; Mertes,2002). For the last couple of decades, the application of remote sensing is not only revolutionized the way data have been collected but also significantly improved the quality and accessibility of important spatial information for conservation and management of natural resources (Bedru, 2006). The parallel advance in the reliability of GIS has permitted the interpretation of large quantity of data generated through remote sensing to address different environmental problems (Menon and Bawa, 1997; Bedru, 2006). GIS are increasingly being used in business because they are powerful tools that can be used to unleash the wealth of information that is locked up in the data that describes location (e.g., addresses, zip codes, counties, latitude and longitude). GIS is a decision support tool that allows a user to bring together spatial data (e.g., maps) and databases containing attribute and other types of data (e.g., images or graphs). A key feature of GIS which distinguishes it from other information systems is that the spatial relationship between objects can be integrated into analyses. This provides users the opportunity to realize greater benefits from their data because most data include a significant geographic component. Despite these facts and the large size of the GIS market ($3.5 billion in 1992; plus its prospects for significant future growth (25%-33% through the 1990's), little attention has been paid to the technology by business school researchers in general, and by information systems researchers in particular. More than a decade ago business school scholars had recognized the promise and importance of mapping as a tool for visualization. More recently, GIS vendors such as MapInfo, Strategic Mapping, Inc., and the Environmental Systems Research Institute @SRI) have all partnered with mainstream business software vendors such as Microsoft, Oracle, and others to bring their GIS products to the business community. Nevertheless, to date, few information systems researchers have chosen to examine this technology. As a result, researchers from other academic disciplines such as geography and computer science have performed the bulk of the GIS research. As GIS becomes more pronounced as a decision support tool for business and management, information systems researchers need to become more involved in examining GIS.

2.2.1 Active and Passive Remote Sensing

Remote sensing uses devices known as sensors that can measure and record the electromagnetic energy. Active sensors such as radar and laser have their own source of energy and can emit a controlled beam of energy to the surface and can measure the amount of reflected energy. These sensors are used to measure the time delay between emission and return and can determine the location, height, speed and direction of an object under investigation. As active sensors can emit their own controlled signals, they can be operated both day and night, regardless of the energy available from external sources. Passive sensors, on the contrary, can only work using the natural sources of energy. As a result, most passive sensors use the sun as a source of energy and can only work during day time. However, passive sensors that measure the longer wavelengths related to the earth's temperature do not depend on the external source of illumination and can be operated at any time (Woldai, 2001).

2.2.2 Image Data Characterization

Remote sensor data are more than a picture, and they are measurements of emitted or reflected electromagnetic energy. Image data are stored in a regular grid format with rows and columns in which a single picture element represents a 'pixel'. As the intensity and wavelengths of reflected and emitted electromagnetic radiation are a function of a particular surface on the earth, each surface is characterized by its own 'spectral signature' that can be mapped using remote sensing (Janssen and Bakker, 2001; Mironga , 2004; Jensen, 2005).

Information from remote sensing images can be interpreted by visual image interpretation and by the ability of individual to relate colours and patterns to the real world features. The image is then to be visualized on a screen or in hard copy and is used to interpret the colours and patterns on the picture. In digital image classification, the operator instructs the computer to perform the interpretation (Janssen and Bakker, 2001).

2.2.3 Limitations of Remote Sensing

Despite its invaluable applications in different areas of interest, the use of remote sensing technology in monitoring and managing habitats and ecosystems is likely to face some practical drawbacks. These include practical limitations, which are usually inherent in the technology itself such as the limited ability of light to penetrate through water and atmosphere. The second limitation of remote sensing is the difficulties in assessing suitability in certain sensors. For example, remote sensing tends to provide geomorphological rather than ecological information on reef structures. This is because of the limited spectral and spatial resolution of the sensors caused by the presence of various external barriers like turbidity and water depth. Besides, a more pronounced limitation of remote sensing is the problem of cloud cover that significantly reduces the number of suitable images to be available at all seasons (Mironga, 2004).

Over the past three to four decades, there has been an explosive increase in the use of remotely sensed data for various types of resource, environmental, and urban studies. The evolving capability of geographic information systems (GIS) makes it possible for computer systems to handle geospatial data in a more efficient and effective way.

GIS as a modeling tool needs to integrate remote sensing data with other types of geospatial data. This is particularly true when considering that cartographic data produced in GIS are usually static in nature, with most being collected on a single occasion and then archived. Remotely sensed data can be used to correct, update, and maintain GIS databases.

It is still true that GIS is a predominantly data-handling technology, whereas remote sensing is primarily a data-collection technology. Many tasks that are quite difficult to do in remote sensing image processing systems are relatively easy in a GIS, and vice versa. In a word, the need for the combined use of remotely sensed data and GIS data and for the joint use of remote sensing (including digital image processing) and GIS functionalities for managing, analysing, and displaying such data leads to their integration.

2.2.4 Geographic Information Systems

A logical starting point for discussing GIS is to define the term. It should be recognized that GIS is more than a tool for map preparation or for generating presentation graphics. For example, several spread sheet packages now include GIS functionality that allows users to prepare map displays. Although such capabilities are useful for creating presentation graphics and similar displays, this represents only a few of the capabilities that full-function GIS possess. Thus, GIS should be viewed as much more than a simple mapping tool. Although several definitions for GIS have been advanced, we prefer the following:

'A geographic information system (GIS) is a computer based information system that provides tools to collect, integrate, manage, analyse, model, and display data that is referenced to an accurate cartographic representation of objects in space." (Memecke, B.E., et al.,1995).

Given this definition, it should also be recognized that GIS possess several characteristics that distinguish them from other information systems. First, GIS are designed to support the production of maps. Several methods are available for map making. These include digitizing paper maps, generating maps from aerial photographs or satellite imagery, and collecting map coordinates using surveying techniques or global positioning systems (GPS). Such techniques are either labour intensive or require specialized training and equipment. Thus, in many ways data acquisition can potentially be one of the more difficult and costly issues in implementing a GIS.

Second, GIS are spatial database management tools. In other words, they can be used to collect and manage spatially-defined data. The process of data management begins with defining a link between map data and attribute data. The term geocoding describes the process of linking attribute data with the spatial coordinates on a map. For example, if a user needed to place the locations of her customers' stores on a map, she could geocode each Customer's address against coordinates on the map to define points that would be used to represent the location of each customer. The geocoding process creates fields in the attribute database for the longitude (location X-value) and latitude (location Y-value) of each address. The resulting link generates a geographic database which is a synergistic combination of the two data sets (i.e., the map data and the attribute data). For most applications, this database provides the user with significantly more information than each data set would provide if used separately.

Once these databases are defined, GIS can be used to query data based on spatial criteria, based on criteria derived from the attribute data, or based on some combination of these data. Spatial queries can be used to answer questions such as "where is this house?' or "what is located at this intersection "'. Although queries such as this may be possible with attribute data alone; GIS provides an integrated environment for performing these queries. Furthermore, GIS can be used to perform queries with concepts such as "next to," "contained within," and other spatially-referenced questions that often cannot be asked using other database management systems. (Berry, J.K. 1993)

For example, while GIS and other types of database systems both offer tools that allow users to perform queries based on attribute data such as an address or a zip code, GIS incorporate tools that allow users to query data by pointing to objects, by defining polygons, or by selecting records within a given distance from a location.

A third category of GIS capabilities is the display of spatial data. In other words, maps can be portrayed using a GIS. In addition, more than one set of data can be displayed and viewed simultaneously. This capability is available because data sets are represented as unique layers. Each layer is similar to an individual user view (or table) in a database. Layers can be laid one on top of another, thus creating one or more new layers (or user views) which

Contain images showing how data are related. For example, a common application for layering is to display a map showing both sales territories and the locations of Prospective customers. These two distinct data sets would be stored in a GIS as two separate layers; however, these layers can be simultaneously displayed on the same map so that the user can see where the sales territories are relative to the prospective customers. This display capability is important because it allows a user to visualize the data and thereby identity patterns or relationships that might not otherwise be obvious.

Spatial analysis represents a fourth capability of GIS. Spatial analysis is similar to the decision modeling Capabilities of decision support systems (DSS) which allow DSS to be used to perform sophisticated what if analyses. GIS can be used to perform "what if" analysis that incorporate spatial data. In other words, GIS supports queries such as what number of people will drive by our service station if we locate it at the corner of Charles Street and Fire Tower Road or what number of people per day will see an advertisement if the billboard is placed at 1401 Maple Drive? Statistical tools and data manipulation functions that can be used to implement models and transform data are generally available to make such analyses. Furthermore, a variety of add-in spatial models have been developed and can be used for common business problems such as those related to transportation and logistics (e.g., truck routing), marketing analysis (e.g., proximity modeling), and environmental management and remediation (e.g., modeling the impact of clear-cutting on erosion rates). Fundamentally, one of the key value-adding capabilities of GIS is for visualizing the variables in these models. In summary, GIS is a powerful decision support tool because it allows users to not only manage attribute data, but also to capture, manage, and incorporate spatial data in their analyses. Because of these capabilities as well as other industry trends (e.g., decreased computing costs, increased data availability), the GIS market has experienced rapid growth in the past few years, although government still represents the largest segment of the GIS-user community, much of this recent growth can be attributed to widespread diffusion of GIS into the business community. To define how GIS can be and is being used in business, the following section presents a framework for understanding GIS functionality in the context of business.

2.2.5 GIS applications

Most organizations use information systems for one or more of the following core applications: transaction, processing, operations, inventory management, planning and decision making, and internal management and control. GIS can be used for these and other applications because they possess functionalities that are common to other types of information systems. However, GIS also possess unique functionalities that distinguish them from other information systems. For instance, (Mennecke, B.E et al, 1995) proposed a framework which defines the relationships between GIS functionalities and the application areas for which GIS can be used by businesses. This framework is useful to identify how GIS can be used and defining research opportunities. The framework specifies four core GIS functions: spatial visualization, database management, decision modeling, and design and planning. Spatial imaging refers to the fundamental GIS capability of representing data and Information within a spatially defined coordinate system (e.g., a map). The database management function represents the capability of GIS to store, manipulate, and provide access to data. The decision modeling function represents the GIS capability to provide analytical tools that can be used to support decision making. Finally, the design and planning function represents those GIS tools that can be used to create, design, and plan. In addition to the core GIS functions, the model also represents several specific GIS applications toward which these GIS functions can be applied. These applications include surveying and mapping, facility management, market analysis, transportation, logistics, strategic planning, decision making, design and engineering. Each of these application areas utilizes, to one degree or another, each of the core GIS functions. However, each application also relies to a greater degree on one or more of the core GIS functions; thus, each application is shown proximate to the core function(s) that is (are) most important for that application.

Surveying and mapping is commonly called automated mapping (AM) and represents one of the first GIS applications. (Coppock, J.T. L Rhind, D.W. 1991). AM is an important business application because it allows organizations to generate spatial data in house. In addition, remote sensing and GPS can be used to more accurately generate maps because the paper map is removed as the data source (Goodchild, M.F. 1992). In spite of this, map acquisition can be one of the most problematic areas in GIS usage. For instance, costs for data can exceed twenty percent of the cost of a GIS implementation and data accuracy can be a significant problem. Errors can arise for several reasons including problems associated with defining positional accuracy (i.e., is the object where the map says it is?), attribute accuracy (i.e., is the object defined and classified correctly?), and completeness (i.e., are all of the relevant objects shown?) (Chrisman, N.R.1991). Additionally, definitional problems can complicate data collection because the classification of an object can depend both on the user's purpose for the map (i.e., what objects are to be coded?) and interpretive issues (e.g., is this a tree or a bush?) (Goodchild, M.F.1992). .An organization's ability to produce maps can also be constrained because many business personnel do not have the cartographic training that is needed to generate maps.

A second GIS business application is in facilities management (FM). GIS are useful for FM applications because they provide managers with tools to support real-time monitoring of facilities and resources. This becomes all the more important for organizations that are undergoing restructuring or for organizations that have resources that are geographically distributed. The key functions of GIS used in FM are the spatial visualization and database management functions. In other words, most FM applications use historical or transaction (real-time) data to manage or monitor facilities. They also rely heavily on the imaging capabilities of GIS to represent the spatial arrangement of data elements. The (Automated Mapping)AM function of GIS are often combined with FM functions to provide organizations with a system for generating, managing, and utilizing maps and other spatial data (i.e., AM/FM Systems).

The third GIS application is market analysis. The primary function of market analysis is to understand the customer. (Francese, P., & Piirto, R. 1990). GIS is a powerful market analysis tool because it provides a platform for representing the spatial relationship between the components of the market; that is, the customers, suppliers, and competitors. The key GIS functions used for market analysis are the database management and decision modeling functions. In other words, most market analysis applications use historical or transaction (real-time) data in combination with decision modelling and support tools to analyse the organization's marketing environment.

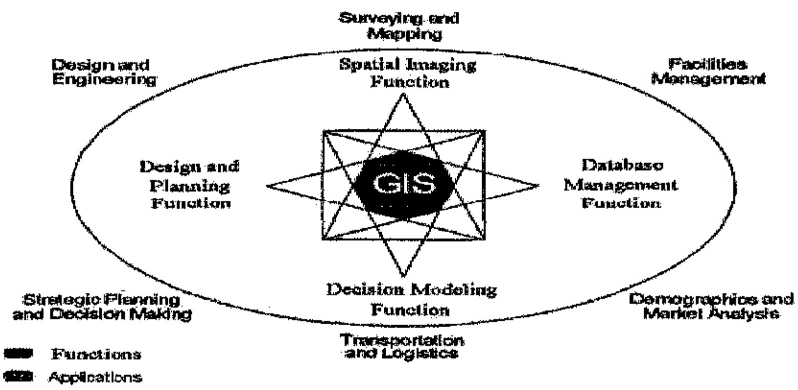


Figure 1
GIS Functions and Applications
(from Mennecke, Dangermond, Santoro, Darling, & Crossland, 1995)

The fourth GIS application area is in logistics and transportation problems. GIS is useful for logistical problems because these problems almost always involve spatial data. In this context, GIS can be used both as a platform for performing decision modeling and also for displaying the results of analyses (Grabowski, M., & Sanbom, S. 1992). A number of specific GIS applications in this area including vehicle routing, dispatch, production control, inventory management, and navigation (White, M. 1991).

The heart of transportation and logistical GIS is the decision modeling function (Choy, M., et al, 1994). Algorithms such as transportation network models, facility layout models, proximity models, adjacency models, and material flow models are used with these systems.

The fifth GIS application area is in strategic decision making, much of what managers do in business relates to planning and making decisions (Simon, H.A. 1960, 1976). Strategic decision making often involves decisions that are broad in scope, unstructured, and focused on long time frames. Information systems designed for strategic decision making generally provide access to data, analytic and modeling tools, and communication support. Unfortunately, these information systems often inadequately represent spatial data and information (Densham, P.J. 1991). The term spatial decision support system (SDSS) has been advanced to describe systems that incorporate GIS capabilities along with the analytical modeling tools found in DSS (Densham, P.J. 1991; Cooke, D.F. 1992, Crossland, M.D 1995). SDSS support the input and output of spatial data, they allow the representation of complex spatial structures, and they include analytical tools for spatial, geographical, and statistical analyses (Densham, P.J. 1991). Both the decision modeling and the design and planning functions are important for strategic decision making. However, of the six applications for GIS, this is the least well developed (Cowen, D.J. 62 Shirley, W.L. 1991, Goodchild, M.F. (1992). This is partially due to the fact that strategic decision making often involves long-term time frames and most GIS do not provide sophisticated scheduling, planning, or analysis tools that could be used to support these applications (Cowen, D.J. 62 Shirley, W.L. 1991; Maguire, D.J. 1991). Furthermore, methods for representing temporal attributes in spatial data are still poorly developed.

The sixth GIS application area is design and planning. Various information systems have been used for engineering, drafting, and design tasks. For example, computer aided design (CAD) systems are routinely used to develop and archive architectural and other designs. GIS can be used to design plans, layouts, and maps in similar ways to CAD systems. GIS and CAD do differ from one another, however, in that CAD systems have rudimentary links to databases, they deal with relatively small quantities of data, they often do not allow users to assign symbology automatically based .on user defined criteria, and they have limited analytical capabilities (Castner, H.W. & Robinson, A.H. (1969). In spite of this, GIS are quite similar to CAD technologies and are, in a sense, descended from these systems (Maguire, D.J. 1991). GIS applications for design and engineering make use of both the imaging and the planning functions of GIS and are used in landscape engineering, environmental restoration, commercial and residential construction and development, and a host of other design and planning activities.

As this review has shown, GIS represents a powerful and versatile tool. The tremendous growth in the GIS market and its potential for future diffusion into the business community highlights the importance of this technology. To date, however, little research has been conducted on GIS by information systems researchers.

2.2.6 Managing and Using GIS

The model of GIS applications proposed by Mennecke et al (Mennecke, B.E, et al 1995). Suggests four core GIS functions: spatial imaging, database management, decision modeling, and design and planning. Each of these functions suggests four areas in which research on the use of GIS should focus: human factors, GIS technology, decision making and collaboration, and planning systems. Each of these will be discussed below.

2.2.7 GIS and Human Factors.

Because GIS is a technology that supports the manipulation and analysis of spatial data, the display characteristics and tools associated with the user interface are critical in the use and management of GIS. Consequently there is a great need for on-going research in human factors issues associated with using GIS. There is a rich literature on human factors that can be applied to GIS. Early research about human factors in geographic data analysis studied how humans perceive and mentally process data on maps. Therefore, much of the early research dealt with colours, patterns and representations of various cartographic features (Castner, H.W. & Robinson, A.H. 1969). For example, Bertin (Bertin, J. 1983) proposed taxonomy of graphical representations of data that may be useful for GIS human factors research (Crossland, M.D. 1992). Bertin's research described the efficiency of human processing associated with over 100 types of graphical displays of tabular information. Many of the graphical constructions described by Bertin were maps and map derivatives. Additionally, early research in information systems which focused on the user interface and graphical displays of early information systems may also be useful for GIS research (Benbasat, I, et al 1986).

With the broad scope of applications that GIS may be used for, it is also important to consider task characteristics when studying human factors in GIS. In particular, task characteristics such as task structure, information symmetry, and complexity should be clearly defined in this research (Simon, H.A. (1960, Mennecke, B.E., & Wheeler, B.C. 1993). In addition, individual cognitive characteristics of subjects in these types of studies should also be considered. For example, (Crossland et al 1993). considered spatial cognition and need for cognition as they relate to decision-making performance in spatial problem solving. In addition, Mark (Mark, D.M. 1993) has described human spatial cognition as an important factor in the use of GIS software.

Future research is needed to understand how these factors interact and effect how users perceive spatial data and how this relates to decision making effectiveness. In addition, future research is needed to better understand how GIS can be integrated with other information systems and how the user interface of these systems can be adapted and improved for use by users unfamiliar with GIS or with cartographic principles (Raper, J.F. 1991).

2.2.8 Data Management and GIS Technology.

Considerable attention has been paid to the technological issues in developing and using GIS. Important issues that need additional research attention include database design (Healey, R.G. 1991), data acquisition, data communication, 3-D data visualization, and multimedia systems. The spatial data on which GIS are built are much more complicated than the textual/attribute data that database software has traditionally been called on to manage (Gatrell, A.C. 1991). This has led to considerable interest in research on database design for GIS (Healey, R.G. 1991). Topics that need to be researched include query language design, database model selection, error detection and quality control, the use of knowledge-based and object-oriented databases, and distributed database designs (Healey, R.G., Maguire, D.J.; Rhind, D.W., et al 1991).

For instance, Aangeenbrug (Aangeenbrug, R.T. 1991) notes that object-oriented databases have constraints when applied to spatial data because it is not always clear how to define spatial objects. In addition, distributed systems such as those implemented in navigation and IVHS present special problems related to concurrency control, data distribution and data communications (Choy, M., et al 1994). Considerable research has been conducted recently in the area of visualization both for geographic data and for other forms of spatial images (e.g., medical imaging, entertainment, chemical engineering). Nevertheless, additional research is needed in this area (Raper, J.F. 62 & Kelk, B. 1991). For instance, consideration needs to be given to the representation of the output of 3-D objects on 2-D media such as paper and video displays (Goodchild, M.F. 1992). Applications for GIS in multimedia systems, including their integration into executive information systems (EIS) and decision support systems (DSS), also need to be examined (Laurini, R., & Thompson, D. 1992). In particular, both Antenucci, and colleagues (Antenucci, J.C., et al 1991) and Rhind et al. suggest that GIS functionality will likely become encompassed into other information systems (e.g., the recent addition of GIS display tools into commercial spread sheet products represent an example of this phenomenon). Thus, information systems researchers should understand these trends and set about to examine their impacts on organizations and users.

2.2.9 Decision Making and Collaboration.

Often GIS are used only as a tool to query a database or as a vehicle for displaying maps and spatial imagery. In this context, GIS represents an important enhancement to traditional database management systems and presentation graphics tools because it provides the decision maker with a powerful way to organize, retrieve, and display data based on its spatial characteristics.

However, as noted above, GIS can also be employed as a tool to support more sophisticated manipulations and analyses of data. For instance, most current GIS incorporate transformational and statistical functions and thus can be used to manipulate data and develop analyses and projections. Even though GIS provide researchers with capabilities that are not present in other information systems, little has been done to examine the efficacy and efficiency of GIS functionality in supporting decision making. One of the few reported studies of GIS supported decision making did find that GIS enables the decision maker to answer certain kinds of questions more quickly and more accurately compared to decision makers using paper maps(Crossland, M.D. 1992). Nevertheless, more needs to be done to precisely evaluate whether and how various GIS functions, tools, and displays influence decision quality, user satisfaction, and other variables related to decision making. For instance, more research is needed to examine the impacts of varying display characteristics, data representations, and map projections on decision making.

In addition, research is also needed to examine the use and value of various spatial analysis tools in decision making (Openshaw, S. 1991). Finally, research should examine and identify those types of data and problem situations where GIS is an appropriate decision making tool as well as those situations where other types of tools might be more appropriate.

Remote sensing relies on the measurement of electromagnetic energy reflected or emitted by the earth's surface (Janssen, 2001; Woldai, 2001). Electromagnetic energy, which propagates through space in the form of waves, is characterized by electrical and magnetic fields that are perpendicular to each other (Woldai, 2001).

All matters with a certain temperature radiate electromagnetic waves of various wavelengths. The total range of wavelengths is commonly referred to as the electromagnetic spectrum, which extends from gamma rays to radiowaves. Remote sensing operates in several regions of the electromagnetic spectrum. The ultraviolet portion of the spectrum has the shortest wavelengths, while thermal and microwave regions are longer wavelengths that the remote sensing is practically operating. When electromagnetic radiation falls upon a surface, some of the energy is absorbed, some is transmitted through the surface and the rest is reflected. Surfaces of the earth also naturally emit radiation mostly in the form of heat (infrared radiation) and the reflected and emitted radiations are recorded on photographic film or a digital sensor (Mironga, 2004)

Thermal infrared of the electromagnetic radiation gives information about surface temperature that can be related to various features of the earth such as the mineral composition of rocks or the conditions of vegetation cover. Microwaves can provide information on surface roughness and the properties of the earth's surface such as water contents. The visible region of the spectrum, which is commonly known as light is the only portion of the spectrum that is associated with the concept of colours. Blue, green and red spectra are known as primary colours of the visible spectrum (Woldai, 2001).

CHAPTER 3

3.0 materials and method

3.0.1 Study area

Ado Ekiti, the capital city of Ekiti State lies between the boundaries latitude $7^{0}37'15.996''$N and longitude $5^{0}13'17.0004''$E. of the Greenwich Meridian. It is bounded in the north by Ido-Osi and Oye local government areas, in the west by Ijero and Ekiti south west, Ikere and Emure-Ise-Orun local government areas (Omotoyinbo, 1994).

The relief of Ado-Ekiti is relatively low with isolated hills and inselbergs that are dome-shaped. At the base of these rocks are boulders littering all over the place (Ayoade, 1982). The major river draining the area is Ireje River which flows south-east, it is associated with simple form of minor tributaries. Ireje River is seasonal with characteristic reduction in volume or total dry up in case of extreme drought. Ado-Ekiti has a planimetric area of about 84km2 (Ebisemyu, 1989).

The climate of the area is determined by the interaction between the dominant. Tropical maritime and Tropical continental air masses. Rainy season spans late March to November, although there may be false start of rains in February. Mean monthly rainfall totals is heaviest in June and September which coincides with the double maxima occurring after the passage of the overhead sun. Annual rainfall totals vary between 1200mm and 1400mm. Rainfall is characteristically highly intensive with 75% of the rainfall type exhibiting medium to high intensity (Adebayo, 1993). Relative humidity is never less than 80% in the rainy season while in the dry season it can be as low as 30%. Temperature distribution in the area follows closely the rainfall patterns.

Ado Ekiti is the trade Centre for a farming region where yams, cassava, grain and tobacco are grown. Cotton is also grown for weaving

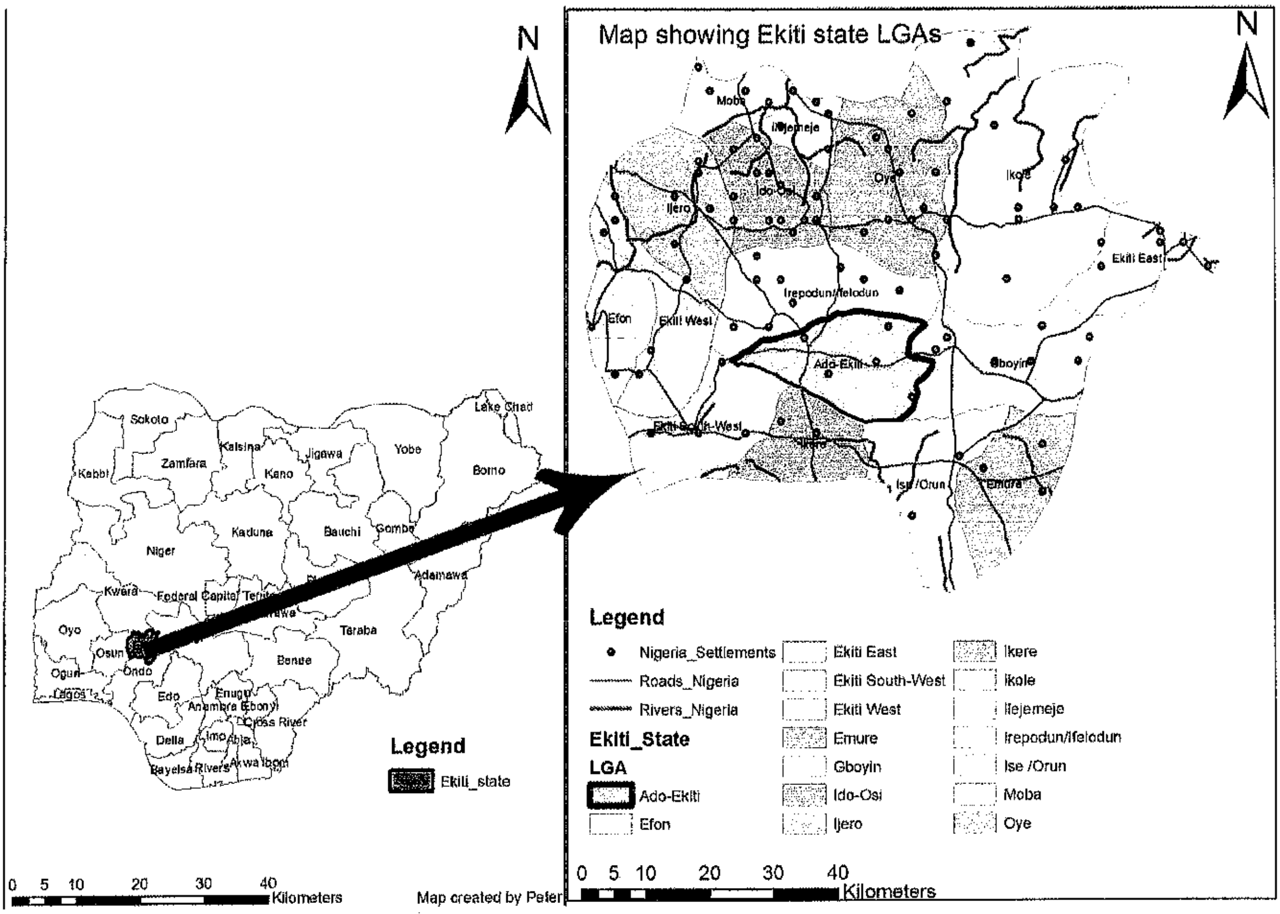


FIG.3.0 SHOWING EKITI-STATE, ADO-EKITI LOCAL GOVERNMENT RIVER/STREAMS

3.1 Data and

3.2 Data Sources

This section highlights the various types of data sets with their respective sources employed in achieving the objectives of this study.

3.2.1 Rainfall Data and Sources

The CHIRPS(Climate Hazards Group Infrared Precipitation with Station data) data alongside NIMET rainfall data were used for this research, to assess the rainfall variability over various locations within the study area, for the period of 1986-2017.The monthly rainfall data obtained from the ground-observed stations of the Nigeria Meteorological Agency (NIMET) stations at Ikere provided sparsely populated records in terms of frequency, magnitude and insufficient spatial coverage of rainfall over the study. Therefore, this research has searched for other alternative data sources of estimated meteorological data. The CHIRPS, a remotely-sensed data source was used to provide the rainfall and runoff datasets at 13km spatial distance from within the study area. Such comprehensive rainfall data could help in evaluating the repeatability of rainstorms over the study area.

3.2.2 SRTM 30m DEM

The shuttle Radar Topography Mission (SRTM) 30m DEM of the study area was obtained from United States Geological Survey/National Aeronautics and Space Administration/Shuttle Radar Topography Mission (USGS/NASA SRTM). This data was already in decimal degrees with datum WGS84. The data was downloaded from the (Data source: Earth explorer website).

3.2.3 Landsat Data

In this study the Landsat imagery was used for the urbanization assessment of the study area, providing the Land use changes within the period of study. The spatial resolution of Landsat imagery is adequate for river morphological analysis particularly, to identify and monitor the dynamics of river systems, migration of the confluence, movement of river channels, and eroded and deposited riverbanks (Priestnall and Aplin, 2006). The Landsat time series satellite images from the Landsat 5, Landsat 7 and Landsat 8 were acquired for the years 1986, 2001 and 2017 respectively. These were all obtained online from the data archive of Global Land Cover Facility (GLCF) under the United States Geological Survey (USGS). The images acquired for the use of this study are all cloud free; these were modified and projected using Universal Transverse Mercator UTM 31. WGS 1984 Coordinate system.

3.2.4 Vector Data

The study area boundary map was used to clip out area of interest from the satellite imageries. The local government boundary map and Nigerian Administrative map on the scale of 1:50,000 was obtained from National Space Research and Development Agency, Abuja (NASRDA)

3.3 Flow Chart

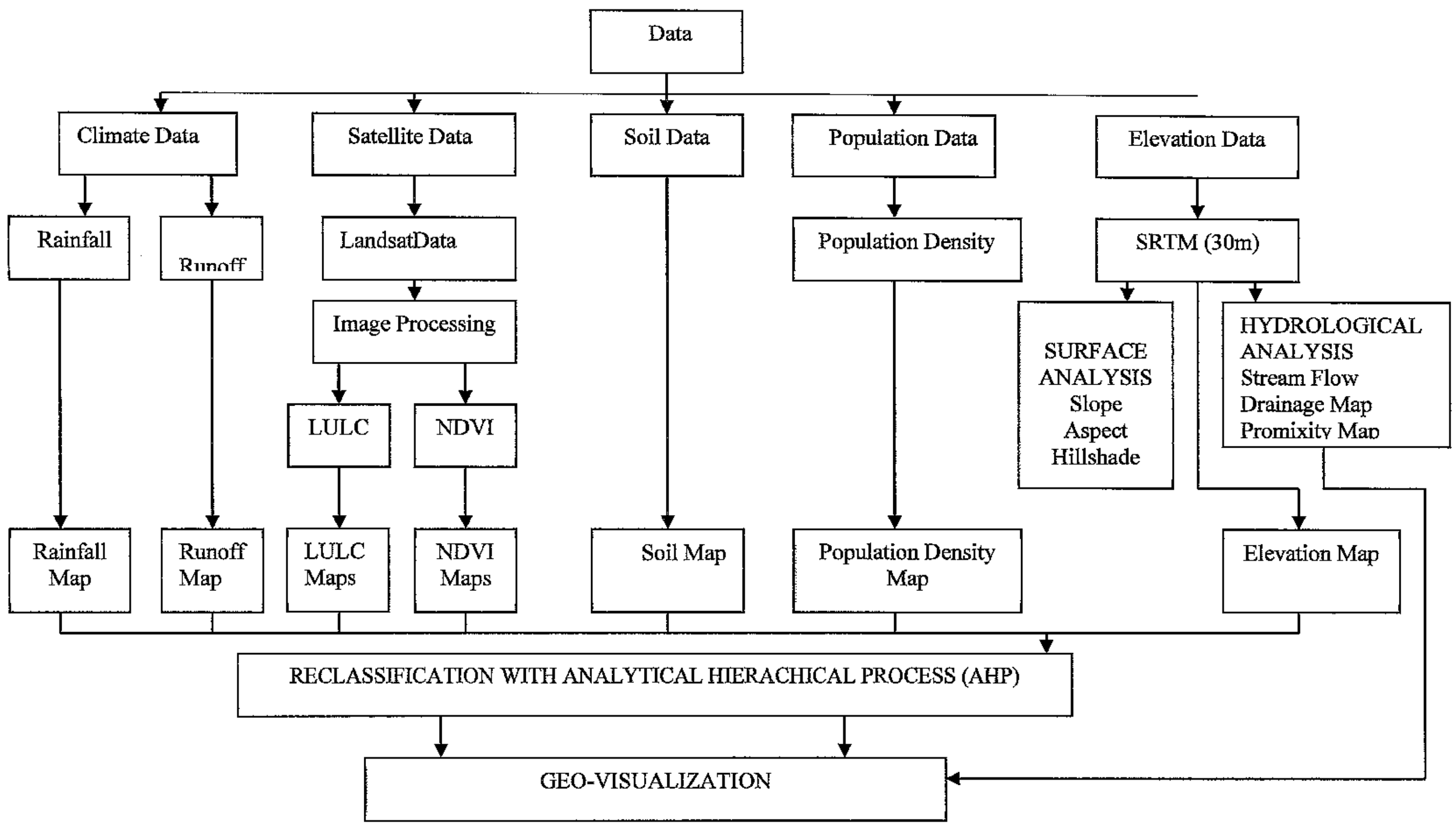


Figure.3.2 Flow Chart of the Methodology (Adopted from Akande *et al*, 2018)

3.4 Methods

The methods adopted to accomplish the main goal of this study are the normal step-by-step procedures for space-based hydrological land resources surveys as highlighted below.

3.4.1 Pre-Fieldwork and Initial Preparation of Data Acquisition

Pre-field or initial indoor preparation included the assemblage and review of the relevant literature materials; visitation to a number of related establishments and organizations for the generation of attribute datasets. The Institutions and centres visited included the Federal University of Technology, Akure, Centre for Space Research and Applications (CESRA), Nigerian Meteorological Agency (NIMET), Nigeria and the National Bureau of Statistics (NBS).

During the pre-field work and initial preparation, the following actions were taken:

i. Assemblage of ancillary data on climate, soils, vegetation and land use.

ii. Acquisition of relevant maps including those of the topography, geology, geomorphology, drainage;

iii. Acquisition of space derived data of Landsat ETM, Google Earth and Shuttle Radar Topographic Mission;

iv. Acquisition and installation of appropriate software packages such as ILWIS 3.3, ERDAS Imagine 9.2, ArcGIS 9.2, Golden Surfer 9.0 and other support packages;

Interpretation of satellite imageries to generate land use map based on supervised classification system and from this a tentative legend of land use categories was composed. The systematic interpretation of satellite imagery involved several basic characteristics of features shown on an image. The exact characteristics useful for any specific task, and the manner, in which they are considered, depend on the field of application. The image signals of shape, tone, pattern, shadow, texture, topography, resolution, site and association were used as registered on the satellite products to delineate and map the land use features. Also, the processes of satellite image manipulation such as detection, recognition, identification, analysis, deduction, classification and idealization were equally used.

3.5 Satellite Image Processing

The satellite imageries downloaded have already been corrected from the manufacturer radiometrically and geometrically to raster image (Geotiff). The images coordinate system is in projection coordinate of the World Geodetic System 1984 (WGS 1984).Satellite images of Landsat MSS, TM, ETM and OLI for path 190 and row 55 which were acquired from the years 1986-2017 (with a map projection of UTM-Zone 31, spheroid and datum WGS-84) have been used for the landuse/land cover mapping and change detection processes. These images were stacked in the ERDAS IMAGINE 9.2 software and subset by the boundary of the area Catchment. The most common image processing function (digital image processing) in this study consists of eight steps: Pre-processing is done before the main data analysis and extraction of information. Preprocessing involves two major processes: geometric correction and radiometric correction or haze correction. Remote sensing imageries are inherently subjected to geometric distortions. These distortions may be due to the perspective of the sensor optics, the motion of the scanning system, the motion of the platform (the platform altitude, attitude and velocity), the terrain relief, or the curvature and rotation of the earth. Geometric corrections are done in order to compensate for these distortions so that the geometric representation of the imagery will be as close as possible to the real world. Many of these variations are systematic or predictable in nature and accurate modeling of the sensor and the platform motion and the geometric relationship of the platform with the earth can correct these distortions.

Pre-processing operations, sometimes referred to as image restoration and rectification, are intended to correct for sensor- and platform-specific radiometric and geometric distortions of data. Radiometric corrections may be necessary due to variations in scene illumination and viewing geometry, atmospheric conditions, and sensor noise and response. Each of these will vary depending on the specific sensor and platform used to acquire the data and the conditions during data acquisition. Also, it may be desirable to convert and/or calibrate the data to known (absolute) radiation or reflectance units in order to facilitate comparison between data.

3.5.1 Generation of Normalized Difference Vegetation Index (NDVI)

For the calculation of NDVI (Normalized Difference Vegetation Index), the digital data for the study area of at least one time was used. The NDVI image was then subjected to NDVI computation, using the formulae by Curran (1992).

$$\text{Normalized difference vegetation index} = \frac{NIR - Red}{NIR + Red} \qquad (3.1)$$

Where; NIR is the Near-InfraRed.

The principle behind the NDVI is that Channel 1 is in the red-light region of the electromagnetic spectrum where chlorophyll causes considerable absorption of incoming sunlight, whereas Channel 2 is in the near-infrared region of the spectrum where a plant's spongy mesophyll leaf structure creates considerable reflectance. This relatively simply algorithm produces output values in the range of -1.0 to 1.0.Increasing positive NDVI values, shown in increasing shades of green on the images, indicate increasing amounts of green vegetation. NDVI values near zero and decreasing negative values indicate non-vegetated features such as barren surfaces (rock and soil) and water, snow, ice, and clouds. A high positive correlation of NDVI with forest stand biomass indicates that NDVI could be directly used for biomass estimation under similar environmental conditions.

To measure and map the density of green vegetation across the basin, the researcher used satellite data with distinct wavelengths of visible and near-infrared sunlight that is absorbed and reflected by the plants. Calculating the ratio of the visible and near-infrared light reflected back up to the sensor yielded a number from minus one (-1) to plus one (+1). The result of this calculation is called the Normalized Difference Vegetation Index, or NDVI. An NDVI value of zero means no green vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves. The NDVI was computed by calculating the ratio of the VI (vegetation index.

3.5.2 Digital Terrain Model

The DEM image data were extracted and imported into the ArcGIS 10.3 where the elevation values were converted to points. The points were treated as spot heights which were then interpolated. Deterministic interpolation techniques were used to create surfaces from the measured points, based on the extent of similarity (Inverse Distance Weighted). The deterministic interpolation technique used was the local interpolator which calculated predictions from the measured points within neighborhoods', which have similar spatial areas within the larger study area. The DTM provided automatic layers for perspective viewing, slope analysis, terrain analysis, hydrograph analysis and flood simulation. It was further transformed into a 3D (Triangulated Irregular Network) perspective with the aid of hill shading.

3.5.3 Slope Map from DEM

The slopes help to identify the maximum rate of change in surface value over aspecific distance and they are expressed in degrees or percentage. In actualizing the slope map from the DEM required for the final thesis analysis, the spatial analyst tool in ArcMap 9.3 was used in the slope map calculation. Calculating slope is one function of many in spatial analyst tool and this function was used to derive the slope map from the DEM.

3.5.4 Reclassification of Slope Map

The slope map was reclassified into a relative friction cost of 10 classes in order to have a common value. The slope map classification was achieved using symbology under the diagram properties in the model. In the classified slope map,1 was used to represent good areas with low cost value to build a road while 10 represent bad, which is a high cost to build a road. The reclassification of the slope map will help in differentiating the different slopes between the different slope classes during criteria evaluation and as such provides a proximity surface on the best area to construct the road path.

3.5.5 Creation of Flood Maps and Determination of the Flood Risk

The flood maps of the study area were created separately using the DEMs and the land use/cover map derived from the satellite image. These were combined to create/generate the total flooded area. To determine the flood risk, a simple technique of Map Crossing in a GIS was used. The total areas of the land use classes were determined and then for each individual land use type.

Then the total land use map was crossed with the flood map. After which the following were calculated:

a) The percentage of the total area flooded.

b) The areas flooded by water for each land use class (e.g. Vegetation, Built-up, etc.)

3.6 Methods of Data Analysis

3.6.1 The Computer Software Used

Five different types of software were used for this project. These included

c) ILWIS – this was used for image sampling and image classifications of the Landsat MSS, TM and ETM+ imageries, and for accuracy assessment for the analysis.

d) ArcGIS – this was used for displaying and subsequent processing and enhancement of the image. It was also used for the masking of the area of interest, using both the administrative and local government maps.

e) ERDAS Imagine – This was used for the development of land use land cover classes and subsequently for change detection analysis of Landsat 8 imagery of the study area.

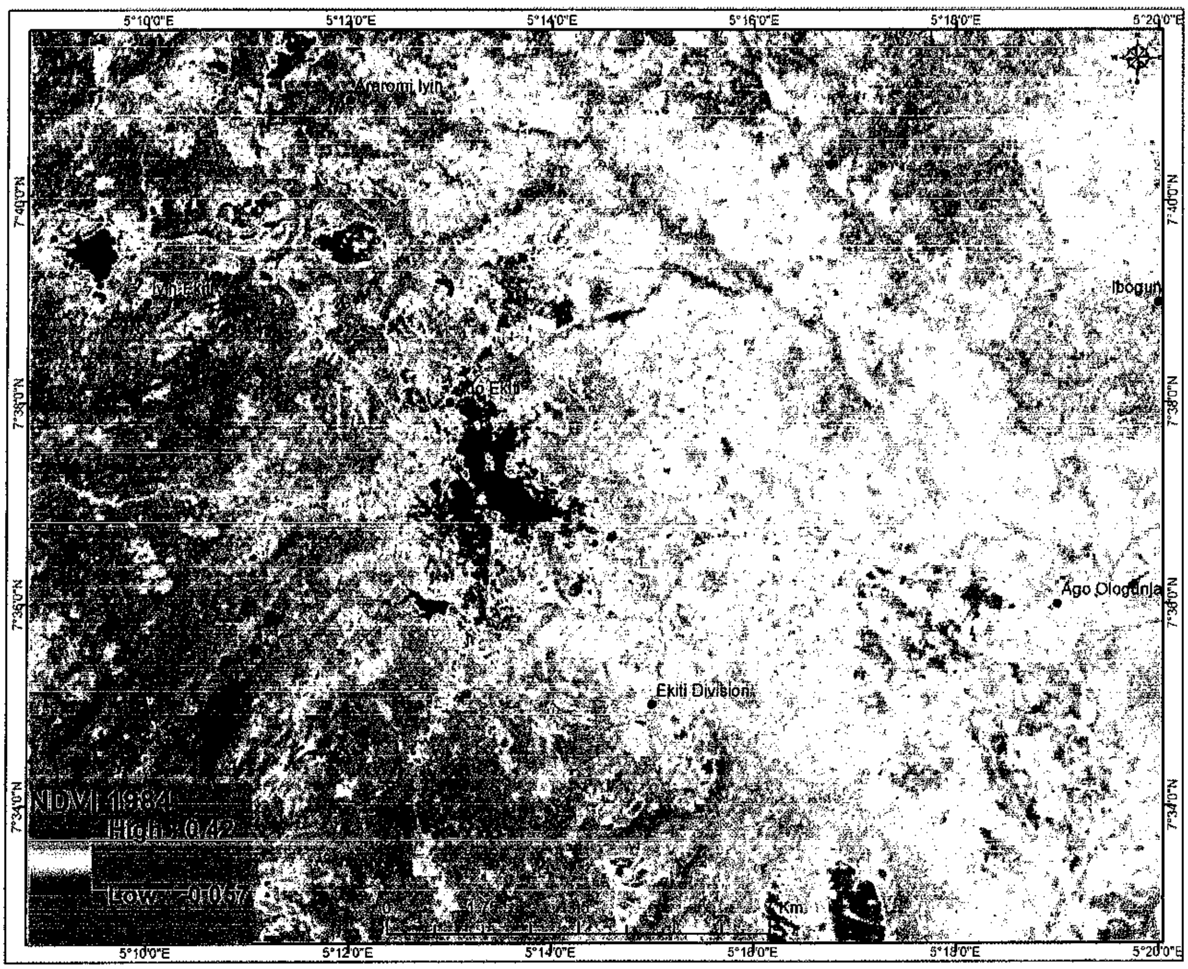
f) Ferret (NOAA) – This was used for data extraction and conversion from the Network common data format.

g) Microsoft Excel - This was used in producing the tables, bar graphs and histograms for the presentation of the research.

CHAPTER 4

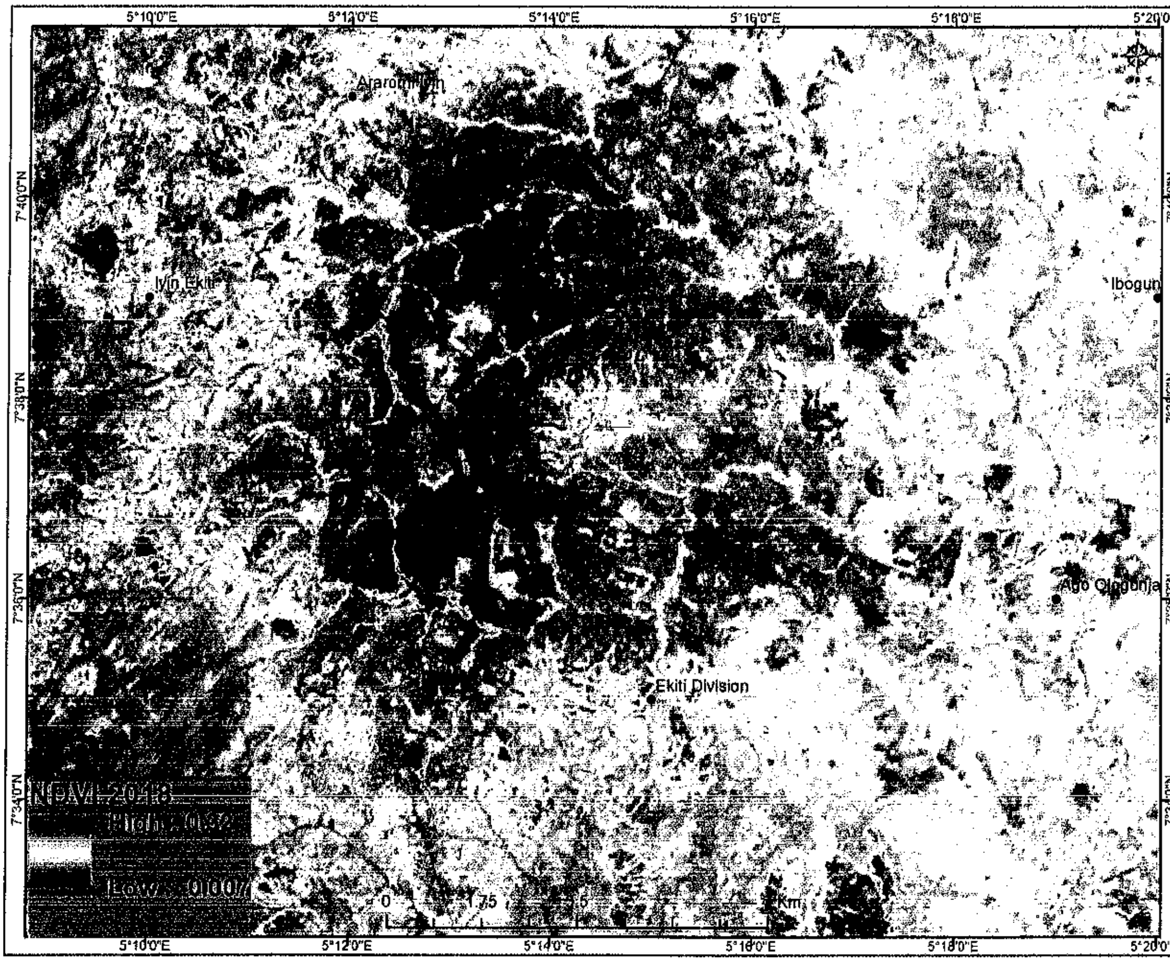
4.0 Results and Discussion

4.1 Ndvi Analysis result



NDVI Map of Ado-Ekiti and environs (1984)

NDVI Map of Ado-Ekiti and environs (2003)

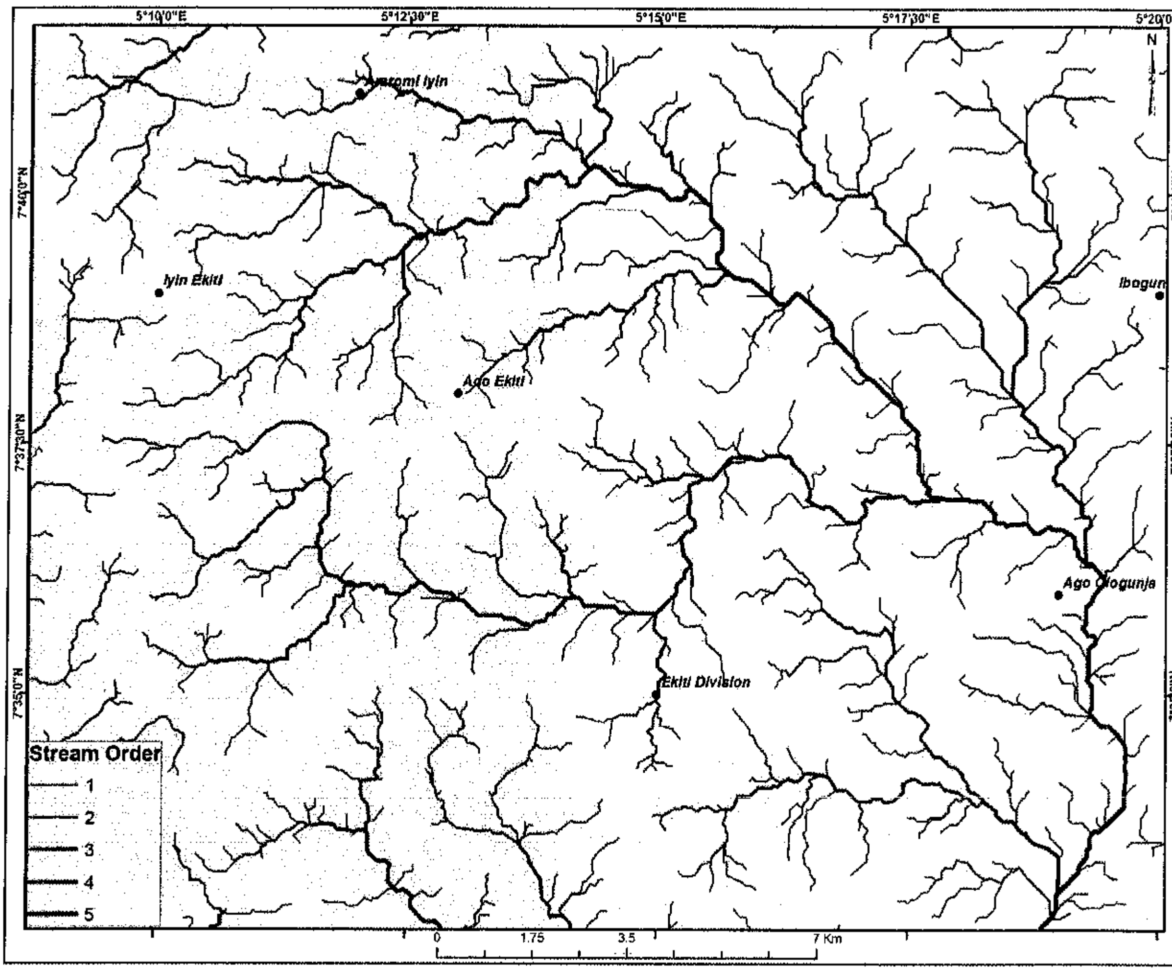


NDVI Map of Ado-Ekiti and environs (2018)

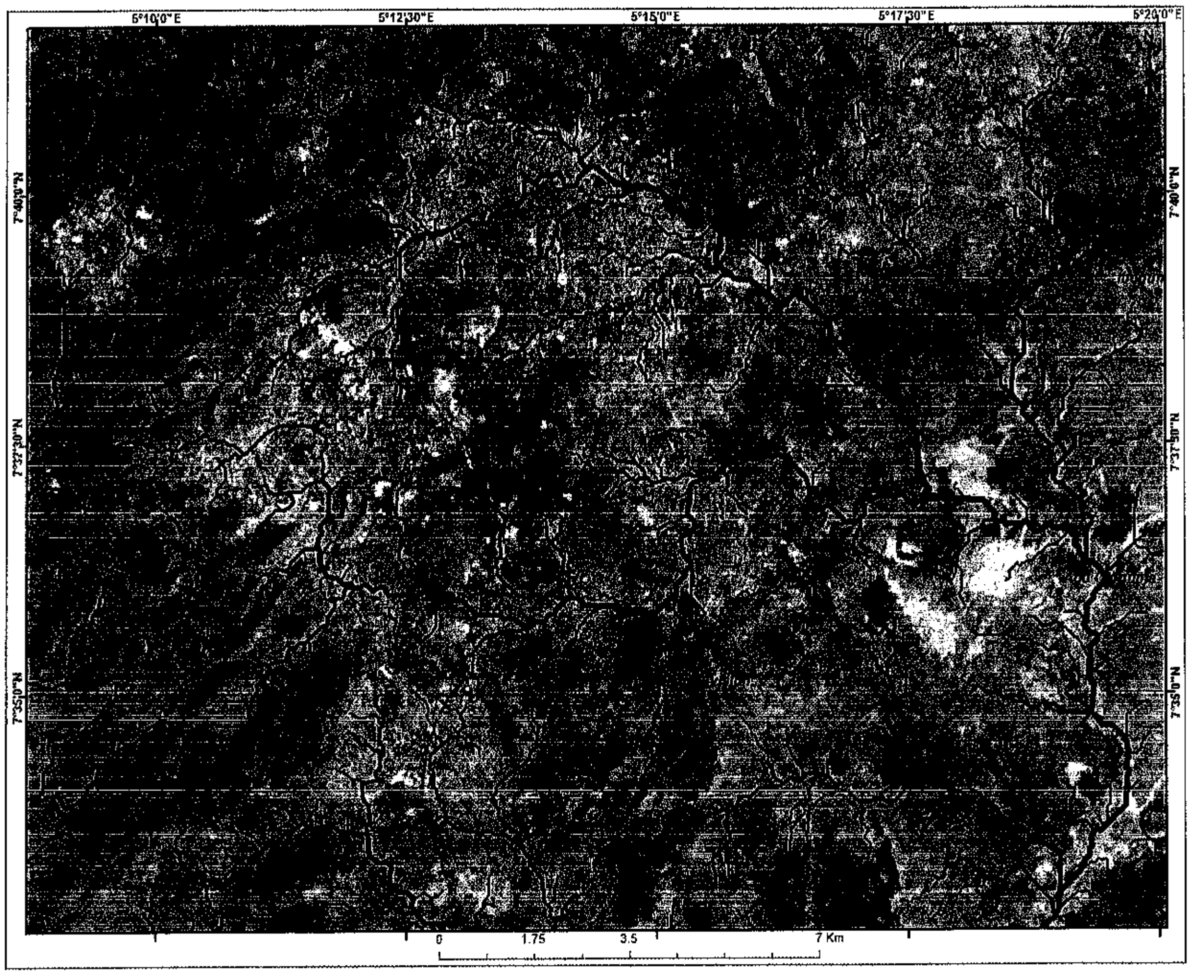
4.2 Discussion

Vegetation indices allow us to delineate the distribution of vegetation and soil based on the characteristic reflectance patterns of green vegetation. The NDVI is a simple numerical indicator that can be used to analyze the remote sensing measurements, from a remote platform and assess whether the target or object being observed contains live green vegetation or not (Meera, Parthiban, Nagaraj and Christy, 2015).

The NDVI was generated for the years 1986, 2003 and 2017 to assess the changing patterns of vegetation in response to flooding in Ado-Ekiti metropolis. The NDVI for year 1986 shows that the vegetation was very healthy, recording high value of 0.35. The NDVI value obtained for year 2003 however decreased as compared to that of 1986 with a high value of 0.143accross the AdoEkiti metropolis. The vegetation pattern continued to change with a fairly lower value in 2018 with a low value of -0.007, depicting the extent of vegetation loss over the area. This vegetation loss will therefore increase the possible chance of flood occurrences in the area.



Map of Stream flow network of Ado-Ekiti and environs (Author's research, 2018)



Landsat image overlay of stream flow network of Ado-Ekiti and environs

The diagram above showing the drainage channels across the study area were analysed using the SRTM (30m) data to delineate the possible river flow with their respective orders. This analysis was perform using the Spatial Analyst tool in ArcGIS and further analysis were performed to understand the flow of water on the surface of these basins and then creation of stream channels. The map is as shown in figure 4.6(a). The surface water on the landscape of the drainage flow across the stream channels and their characteristics (i.e area and slope) affect the extent and frequency of runoff thus determine the likelihood of flooding within the study area. The results obtained from the drainage delineation also showed that most of the river tributaries within the Ado-Ekiti metropolis flow in- and out of its boundary.

The proximity analysis map was derived from the created stream-flow network and the flood extent layer within the study area for worse case scenarios, were generated and overlayed on the Landsat OLI mage of 2018 composite image of the study area. The addition of the stream buffer zone and the reclassified slope steepness produced the different flood risk zones. The overlay of the settlements and Local Government Area layers distinguishes the different places in study areas within the risk zones, with a buffer of 50m.

CHAPTER 5

5.0 Conclusion

This study integrated acquired field data with remotely-sensed datasets, having verified the spatio-temporal characteristics of the datasets. The results obtained were discussed and presented in tables, graphs, charts and maps.

The geo-morphological features as well as the physical properties of the stream flow are shown to have contributed to the speed of run-off and amount of flooding experienced within the area. Such features include the slope, vegetation index, and the drainage density. As shown in the maps, areas with lower slope angles which are closer to stream networks would have the capacity of being flooded. The slope of the study area would affect both the speed of runoff and the rate of infiltration of water. The lower parts of the slope indicated low infiltration rate, leading to surface runoff, thus increasing the possibility chances of flooding occurrences. Thus, land use planners would want to develop infrastructures with this information at the back of their minds and ensure that such developments are either built on natural or artificially made higher grounds to avoid flooding.

The result from the stream flow analysis revealed the risk of flooding along the stream network. From the stream buffer analysis of 50m and it was observed that the round and broader steams would produce a higher surface runoff in the rainy season, thus leading to flood during heavy rainfall.

This study therefore reveals that flood severity is rated very highly in the core Ado-Ekiti city centre, and that flooding in the town can be attributed to both physical and humanly activities. While factors, such as rainfall intensity and duration, cannot be controlled, early warning of flooding based on climatic variability will help people in flood prone areas to prepare ahead of time.

5.1 Recommendation

Construction and improvement of drainage networks to effectively dispose flood water will go a long way in reducing the risks of flooding. Indiscriminate dumping of wastes in drainage and water channels prevents the disposal of flood water thereby leading to flooding of houses, schools, churches and markets. Lastly, public enlightenment and education can result in change of behavior toward environment abuses. There is an urgent need for a collaborative effort of both government and stakeholders to support town planning, engineering and other professional agencies to combat flooding in Nigeria to avoid its long-range consequences.

Physical planners and policy makers should know that natural disasters such floods have destructive power, could be very sudden, occasional and so on. These therefore are pointers to appropriate planning and forecast. For the region to achieve improvement in environmental management and accelerated development for sustainable growth and development, there must be redoubled effort to scale up flood control and management, climate change irrigation and adaptation initiatives. Environmental education is imperative and it is now a must. At every level of education; on radio, television, newspaper and magazines, and in every public forum, these must be stressed; and research and development efforts should not be relented either.

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