Sudan University of Science and Technology

College of Graduate Studies

A thesis submitted as a partial fulfillment to the admission of the degree of Master in Geographic Information Systems and Geodesy

Detection of Changes in Nubian Lake Using GIS and Remote Sensing

اكتشاف التغيرات في بحيرة النوبة باستخدام نظم المعلومات الجغرافية والاستشعار عن بعد

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ABSTRACT

The Nubian lake is one of the largest industrial lakes resulting from the establishment of High Dam in Egypt and is located in the Sudanese-Egyptian border. This research deals with the study of changes in Nubian Lake using Geographic Information System and remote sensing. The ArcGIS capabilities had been utilized. The Remote sensing technique had been applied to assess the change that occurred at the lake boundary. Moreover, the urban development and the increased in the agricultural area between 1985-2017. The curve of change of the lake boundaries had been prepared and analyzed to figure out the reasons for the increasing and decreasing in the lake boundaries and the lake areas had been obtained during the periods of study, also the residential and agricultural areas had been calculated during this period. A model had been designed to replicate the classification process and to use it to reduce the lost time in the single classification process and the necessary steps to find the lake boundary; this model can be used automatically in studies similar to this study. Finally the outcomes of this thesis indicate that there are changes in the shape of the lake weather it is increasing or decreasing, also the growth in the town had been extended; in addition to that there is no significant increase in the agricultural areas.

المستخلص

إن بحيرة النوبة هي من أكبر البحيرات الصناعية الناتجة عن إنشاء السد العالي في مصر وهي تقع في الحدود السودانية المصرية. يتناول هذا البحث دراسة التغيرات في بحيرة النوبة باستخدام نظم المعلومات الجغرافية والإستشعارعن بعد, و قد تم استخدام قدرات ArcGIS وتقنيات الإستشعار عن بعد لتقييم التغير الذي حدث في حدود البحيرة وأيضاً تمت متابعة التطور العمراني والزيادة في الرقعة الزراعية وذلك في الفتره مابين 1985م -2017م. وتم إعداد وتحليل منحنى التغير لحدود البحيرة لمعرفه أسباب الزيادة والنقصان في حدود البحيرة، وتم الحصول علي مساحات البحيرة خلال الفترة الزمنية لمنطقة الدراسة كما تم حساب مساحة المناطق السكنية والزراعية خلال هذه الفترة. وقد صُمم نموذج ليقوم بتكرار عملية التصنيف واستخدامه لتقليل الوقت الضائع في عملية التصنيف المنفرد وما يلزمه من خطوات لإيجاد حدود البحيرة، هذا النموذج يمكن استخدامه تلقائياً في دراسات مماثلة لهذه الدراسة. واخيراً تشير نتائج هذا البحث إلى أن هنالك تغيرات في شكل البحيرة سواء كانت زيادة أو نقصان, كما زاد النمو في المدينة إضافة إلى ذلك عدم وجود زيادة ملحوظة في الرقعة الزراعية.

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Lina M. Abdelrahman

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AHDL	Aswan High Dam Level
AHD	Aswan High Dam
AOI	Area of Interest
GIS	Geographic Information Systems
LN	Lake Nubia
USGS	United States Geological Survey
WGS	World Geodetic System

CHAPTER ONE
INTRODUCTION

1.1 General Overview:

The Aswan High Dam started impounding in 1964 and was officially inaugurated in 1970. Its construction resulted in the creation of the longest manmade lake in the world (El-Shabrawy 2009).

The reservoir extends about 500 km upstream from the Aswan High Dam between the latitudes 23° 58' and 20° 27' N, and between longitudes 30° 35' and 33° 15' E. The current length of the submerged area is about 500 km, of which 350 km are within the Egyptian territory and is known as Lake Nasser. The 150 km stretch which lies in the northern part of Sudan is known as Lake Nubia. Lake Nubia is the investigated area of this study (Elshemy & Meon 2011).

Regarding Irrigated Agriculture Area there is two issues are involved; the first relates to the extent to which land reclaimed is actually irrigated. The other is the role of High Dam-supplied flows in the shift throughout Egypt from basin to recurrent irrigation. Complemented by more recent sources (Aali 2003).

The natural Nile cycle of flow and sediment discharge has been disrupted by human intervention, including closure of the Aswan High Dam; this intervention has resulted in a series of responses that now threaten the northern Nile delta. Erosion, salinization and pollution are inducing a marked decline in agricultural productivity and loss of land and coastal lagoons at a time when the population is expanding exponentially (Aali 2003).

1.2 Problem Statements:

1.2.1 Egyptian and Sudanese Nubia before the High Dam

In both Egypt and the Sudan, Nubians lived between the first and fifth cataracts in portions of the Nile Valley where flood water and other types of irrigation were largely restricted to a narrow border of alluvial deposits continually at risk from desert encroachment. The densest rural population lived in the southern most portion of Nubia in the Dongola region where there were more extensive flood plains. Concentrating on eight villages that had been carefully selected to reflect labor migration rates for absentee adult males that ranged between 50 and 100 percent (Aali 2003).

1.2.2 Egyptian and Sudanese Nubia after the High Dam

After and through Dam construction and starting of storage in lake of dam; because of lake flooding in maximum level issue of resettlement had been appeared.

1.2.2.1 Resettlement Impacts:

Split between Egypt and the Sudan, 100,000 to 120,000 Nubians required resettlement. Each population requested resettlement as a unit so as to maintain their cultural integrity. The majority of those in Egypt were resettled three to ten kilometers from the Nile near Kom Ombo 45 kilometers downstream from Aswan. There planners reclaimed older Nile alluvia to establish New Nubia in a curved 60 kilometers long and on average 3 kilometers wide. Housing and facilities were built for 47 village units whose relationship to each other approximated that in Old Nubia. To support the population, reclamation began on 21,000 feddans (18,000 feddans were eventually reclaimed) that would be irrigated by three main canals into which water would be pumped from the Nile (Aali 2003).

The resettles new neighbors would be Saiydis as well as Nubians who had resettled in the area following the construction and subsequent heightening's of the original Aswan Dam. Though the first ten years were very difficult, with a high death rate among children and the elderly during year one.

Unlike the situation in Egypt, 50,000 to 70,000 Sudanese Nubians were moved approximately 700 kilometers south to the semi-arid Butana plain near the town of Khashm el-Girba several hundred kilometers up the Atbara River from its junction with the Nile (Aali 2003).

1.2.2.2 Negative Impacts of Aswan High Dam:

In the 1970s, the Aswan High Dam became a global symbol of environmental and social problems caused by large-scale development projects. The AHD impacts touch upon a wide spectrum of life aspects, including a change in water quality, as the maximum water release through the AHD is about a quarter of the former flood and is practically silt-free. Bed and bank erosion occurred in the downstream reaches of the Nile, caused by a change in river water levels and flow velocities, and the promontories of the delta started to erode instead of progressing into the sea. (El-Shabrawy 2009)

1.3 Previous Studies:

- A research was conducted in Nubian Lake which is within the study area and the following was included in the research (El Gammal et al. 2010):

The purpose of this study is to determine the locations and causes of changes in water level (from level 160 to 183 m) in Lake Nasser by taking into consideration the surrounding geomorphic, structural, climatic and geologic features. Water infiltration in the dry valley (wadi) deposits debouching in the lake tributaries and water seepage through the floor of the lake will be investigated by comparing various thematic maps, including physiographic, rock properties and structural maps.

The Methodology of research was conducted two types of data with their respective methods of interpretation are used to investigate change detection in the surface of the lake. The first type includes the consideration of data collected by the Ministry of Irrigation and Agriculture of Egypt and the second type includes the use of remote sensing techniques on images taken at various dates.

Result of this research was decided that causes of the changes that happen in its water level, which varies from 160 to 183 m above sea level, should be carefully studied. To have a reasonable understanding of these processes, the influence of the physical features of the surroundings of the lake on the distribution of the flood water should be accessed. According to the degree of fluctuation of the level of flood water over the lake, extensive granite and sandstone outcrops, climate, topography and sand movements strongly influence the shape of Lake Nasser and its geomorphological evolution through time. These parameters also should have a great influence on the future development of the lake.

- Another research was conducted in Nubian lake within our study area (Elsahabi & Negm 2017):

The purpose of this study is to apply a 3D bed surface model strong enough to capture the large bed topography heterogeneity of the lake, conduct sensitivity analysis to increase confidence in the model results, and provide an engineering application of this model to aid in the management of this lake.

To achieve the objective of this study, the following tasks were performed:

1) Extraction of water surface areas using unsupervised classification this technique was performed to obtain the water body class of AHDL, because it is considered the best technique for water texture recognition the shape of the lake surface was formed by using the extracted lake boundaries obtained from the satellite images. Then, a group of scattering points (x, y, z) using the WGS84, UTM Z36N as a defined projected coordinate system were formed.
2) Spatial interpolation process in order to generate continuous areas necessary for research and knowledge of the bottom of LN, it was necessary to approximate values in areas that were not sampled directly
3) Generation of the 3D bed surfaces profiles, which allows for the extraction of valuable information.
4) Map of changes derivation; derived by overlaying the two created bed surfaces using (cut / fill) tool in ArcGIS Software, represents the changes (sediment / erosion) zones. This map was generated in order to quantify the amounts of sediment and erosion in the study area.
5) Sediment distribution and delta formation map; derived by subtracting the two created bed surfaces using the raster calculator tool in ArcGIS Software

Result of this research was the changes in bed levels between the two predicted bed surfaces, shown in (Figure 1-1 Map of changes) were generalized by three broad change categories, namely, no change, sedimentation and erosion. No change means the levels that have the same values in the old and new bed surface. Sedimentation means the old bed surface levels that were increased in the new bed surface and erosion means the old bed surface levels that were decreased in the new bed surface, according to, sedimentation distribution and delta formation map that was produced from a subtracting process between the bed surfaces of years 1964 and 2012. It is obvious that there was a variation in sedimentation thickness till the year 2012 along the study area, the maximum depth of sediments through this period was estimated to be about 53m.

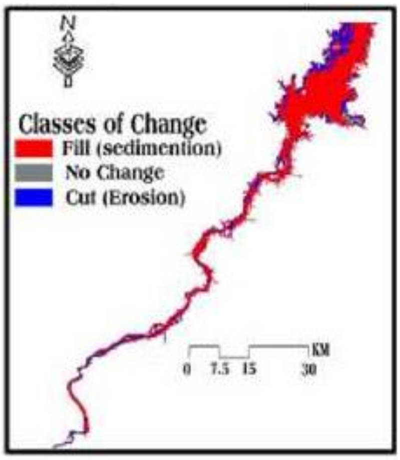

Figure 1- 1 Map of changes

1.4 Thesis Objectives:

This thesis aim to:

1- Change detection of Nubian Lake in different years.
2- Study of erosion and decompostion of Nubian Lake using GIS and RS.
3- Historical study of urban development

1.5 Thesis layout:

This thesis consists of five chapters, Chapter one contains an introduction. Chapter two explains the principles of remote sensing and GIS. Chapter three illustrate the Methodology, steps of historical study of lake Nubian and settlements, agricultural area developed. Chapter four present results and analysis finally, conclusion and recommendations state in Chapter five.

CHAPTER TWO

GIS, REOMATE SENCEING AND LANDSAT IMAGES

This chapter explain the GIS software(overview- Definitions- Development of Geographic information systems), remote sensing componant and the tools that had been used in this thesis.

2.1 GIS Overview

The appearance of geographic information systems (GIS) in the mid1960s reflects the progress in computer technology and the influence of quantitative revolution in geography. GIS has evolved dramatically from a tool of automated mapping and data management in the early days into a capable spatial data-handling and analysis technology and, more recently, into geographic information science (GISc). The commercial success since the early 1980s has gained GIS an increasingly wider application

GIS have become an increasingly important means for understanding and dealing with the pressing problems of water and related resources management in our world. GIS concepts and technologies help us collect and organize the data about such problems and understand their spatial relationships. GIS analysis capabilities provide ways for modeling and synthesizing information that contribute to supporting decisions for resource management across a wide range of scales, from local to global. A GIS also provides a means for visualizing resource characteristics, thereby enhancing understanding in support of decision making.(Weng 2010)

2.1.1. Definitions

Various definitions have been offered that reinforce the major dimensions of GIS. Several of these definitions are listed below. Elements of a GIS include the data and information technology (i.e., computers, software and networks) to support it. Spatial data include any data that have a geographic location. This “toolbox” definition focuses on the hardware and software components of a GIS. In its totality, a GIS can be viewed as a data-management system that permits access to and manipulation of spatial data and visual portrayal of data and analysis results. There are also the human and organizational aspects. For example, standards must be agreed upon to facilitate database integrity and sharing across the organization. There are also the people with GIS expertise who understand and can carry out the procedures and build and maintain the GIS. Finally, there is the organizational setting the technical, political, and financial operating environments created by the interaction among stakeholders in which the GIS is to function.(Weng 2010)

- GIS is a computerized system that is used to capture, store, retrieve, analyze and display spatial data.
- GIS is "an information system that is designed to work with data referenced by spatial or geographical coordinates".

2.1.2. Development of Geographic information systems

The development of GIS has relied on innovations made in many disciplines: geography, civil engineering, photogrammetry, remote sensing, surveying, geodesy, statistics, computer science, operations research, demography and many other branches of engineering and the natural and social sciences. Indeed, an outstanding characteristic of GIS is its interdisciplinary character in its development as a collection of tools as well as the wide variety of applications. GIS cartographic concepts originated with the maps created by early explorers and have been extended by modern geographers to portray locations on and characteristics of the Earth. Engineering measurement theories and practices of surveyors and geodesists provided the means to describe property boundaries and locate Earth features accurately. Civil engineers have migrated to digital formats for land-development plans, including parcel boundaries as well as elements for water and sewer pipes, roads and streets, and other infrastructure. Satellite and airborne remote sensing technologies have advanced to become a primary data source for high resolution mapping of land characteristics; these apply for base mapping, in real time and for assessing changes over time.

A GIS is sometimes distinguished from other computer-based systems that use geo-referenced information. What makes a GIS different is that it provides a more comprehensive environment for data integration and analysis. While these other

systems can generate computer-stored maps, and perhaps can make database retrievals, the GIS integrates data for multiple themes, provides tools for
Analysis across themes (e.g., overlay) and can be integrated with other analysis routines to obtain a modeling and decision support system. Another way that GIS is often distinguished from the companion technologies is that it has served an important role as an integrating technology. Rather than being completely new, GIS has evolved by linking a number of separate technologies into a single coordinated information system. However, distinctions between the various types of GISs.(Weng 2010)

2.2 Remote Sensing Overview:

2.2.1. Concept of Remote Sensing

Remote sensing refers to the activities of recording, observing, and perceiving (sensing) objects or events in far-away (remote) places. In remote sensing, the sensors are not in direct contact with the objects or events being observed. Electromagnetic radiation normally is used as the information carrier in remote sensing. The output of a remote sensing system is usually an image representing the scene being observed. A further step of image analysis and interpretation is required to extract useful information from the image. In a more restricted sense, remote sensing refers to the science and technology of acquiring information about the earth's surface (i.e., land and ocean) and atmosphere using sensors onboard airborne (e.g., aircraft or balloons) or space borne (e.g., satellites and space shuttles) platforms.(Weng 2010)
Depending on the scope, remote sensing may be broken down into:

(1) satellite remote sensing (when satellite platforms are used)

(2) photography and photogrammetry (when photographs are used to capture visible light)

(3) thermal remote sensing (when the thermal infrared portion of the spectrum is used)

(4) radar remote sensing (when microwave wavelengths are used)

(5) LiDAR remote sensing (when laser pulses are transmitted toward the ground and the distance between the sensor and the ground is measured based on the return time of each pulse).

2.2.2. Components of Remote Sensing

The base, on which remote sensors are placed to acquire information about the Earth's surface, is called platform. Platforms can be stationary like a tripod (for field observation) and stationary balloons or mobile like aircrafts and spacecrafts. The types of platforms depend upon the needs as well as constraints of the observation mission.

There are three main types of platforms, namely 1) Ground borne, 2) Air borne and 3)Space borne.

i. Ground borne platforms:

These platforms are used on the surface of the Earth. Cherry arm configuration of Remote Sensing van and tripod are the two commonly used ground borne platforms. They have the capability of viewing the object from different angles and are mainly used for collecting the ground truth or for laboratory simulation studies.(Weng 2010)

ii. Air borne Platforms:

These platforms are placed within the atmosphere of the Earth and can be further classified into balloons and aircrafts.

a. Balloons: Balloons as platforms are not very expensive like aircrafts. They have a great variety of shapes, sizes and performance capabilities. The balloons have low acceleration, require no power and exhibit low vibrations Balloons.

b. Aircrafts: Aircrafts are commonly used as remote-sensing for obtaining Aerial Photographs.

The advantages of using aircrafts as remote sensing platform are : high resolution of data recorded, possibility of carrying large pay loads, capability of imaging large area economically, accessibility of remote areas, convenience of selecting different scales, adequate control at all time etc. However, due to limitations of operating altitudes and range, the aircraft finds its greatest applications in local or regional programme rather than measurements on global scale. Besides all these, aircrafts have been playing an important role in the development of space borne remote sensing

iii. Space borne platforms:

Platforms in space, i.e. satellites are not affected by the earth's atmosphere. These platforms move freely in their orbits around the earth. The entire earth or any part of the earth can be covered at specified intervals. The coverage mainly depends on the orbit of the satellite. It is through these space borne platforms, we get enormous amount of remote sensing data and as a result Remote Sensing has gained international popularity. According to the orbital mode, there are two types of satellites – Geostationary or Earth synchronous and sun-synchronous.(Weng 2010)

2.2.3. Image Classification

Image classification uses spectral information represented by digital numbers in one or more spectral bands and attempts to classify each individual pixel based on the spectral information. The objective is to assign all pixels in the image to particular classes or themes (e.g., water, forest, residential, commercial, etc.) and to generate a thematic "map." It is important to differentiate between information classes and spectral classes. The former refers to the categories of interest that the analyst is actually trying to identify from the imagery, and the latter refers to the groups of pixels that are uniform with respect to their brightness values in the different spectral channels of the data. Generally, there are two approaches to image classification: supervised and unsupervised classification.

In a supervised classification, the analyst identifies in the imagery homogeneous representative samples of different cover types (i.e., information classes) of interest to be used as training areas. Each pixel in the imagery then would be compared spectrally with the training samples to determine to which information class they should belong.

In an unsupervised classification, spectral classes are first grouped based solely on digital numbers in the imagery, which then are matched by the analyst to information classes. (Weng 2010)

2.2.3.1.The following Tools had been used in this research: -

1- **Unsupervised classification tool: -**

- This tool combines the functionalities of the ISO Cluster and Maximum Likelihood Classification tools. It outputs a classified raster. It optionally outputs a signature file.
- The resulting signature file from this tool can be used as the input for another classification tool, such as Maximum Likelihood Classification, for greater control over the classification parameters.
- The minimum valid value for the number of classes is two. There is no maximum number of clusters. In general, more clusters require more iteration.
- To provide the sufficient statistics necessary to generate a signature file for a future classification, each cluster should contain enough cells to accurately represent the cluster. The value entered for the minimum class size should be approximately 10 times larger than the number of layers in the input raster bands.
- The value entered for the sample interval indicates one cell out of every n-by-n block of cells is used in the cluster calculations.(Verbyla 2002)

2- **Dissolve tool :-**

Dissolve can create very large features in the output feature class. This is especially true when there is a small number of unique values in the Dissolve Field(s) or when dissolving all features into a single feature. Very large features may cause processing or display problems and/or have poor performance when drawn on a map or when edited. Problems may also occur if the dissolve output created a feature at the maximum size on one machine, and then this output was moved to a machine with less available memory.(Verbyla 2002)

2.2.4. LAND SAT Overview:

For the last three decades, Landsat spacecraft have collected specialized digital photographs of the Earth's continents and coastal regions. Scientists and researchers use these images to evaluate dynamic changes in our environment, both natural phenomena and changes caused by human activities.

Originally known as Earth Resources Technology Satellite Program, the Landsat Program was inspired by photographs of Earth taken by Apollo Moon missions in the 1960's. While weather satellites were already monitoring Earth's atmosphere, they were not designed to collect terrain data. The express intent of the Landsat Program was to use orbiting spacecraft to study and monitor the earth's landmasses.

The Landsat Program came to fruition when Landsat-1, the first unmanned satellite specifically dedicated to multispectral remote sensing, was launched on July 23, 1972. Landsat-1, a joint effort between NASA and the USGS, was the 1st in a series of 7 (to date) earth-observing satellites providing continuous coverage of most of the Earth's surface. Today, 2 of these satellites are still in operation, Landsat-5 and Landsat-7.

Landsat-1 outlived its design life by five years, operating until January 1978. This exceeded all expectations, as did the quality, and impact of the data collected, 300,000 images of the earth's surface. Landsat-2 and Landsat-3 were both still considered experimental projects when launched in 1975 and 1978 respectively. However, in 1979, due to the program's technical and scientific success, Operational status was declared, and operational responsibility was moved from NASA to NOAA.

Landsat-4 and Landsat-5 was identical spacecraft, both built at the same time, but were launched separately, in 1982 and 1984.

Landsat-6 was launched by EOSAT in 1993, but the satellite failed to achieve orbit. With Landsat’s 4 and 5 both beyond their design lives, the loss of Landsat-6, and the Landsat-7 program being so young, it seemed that a data gap was inevitable. However, Landsat-5 continued to operate well beyond its designed life.

Launched on April 15, 1999, Landsat-7 was designed for a 705 km, Earth mapping orbit with a repeat cycle of 16 days. Its payload is the Enhanced Thematic Mapper

Plus (ETM+), a single nadir-pointing instrument which provides for an eight-band multispectral scanning radiometer capable of providing high-resolution image information of the Earth's surface. Designed to collect, filter and detect radiation from the Earth in a swath 185 km wide as it passes overhead, the ETM+ produces approximately 3.8 gigabits of data for each scene.

Landsat-7 imagery is used extensively in many diverse applications in such areas as agriculture, forestry, geography, geology, global change research, mapping, oceanography, resource management, and water quality. The most common use of Landsat data in popular culture is seen when the largest parts of the earth surface are displayed on web mapping services like Google Maps/Google Earth,

On July 1, 2001, the U.S. Government accepted operational responsibility for Landsat’s 4 and 5 back from Space Imaging (formerly EOSAT). Space Imaging also relinquished their commercial right to Landsat data, enabling the USGS to sell all Landsat 4 and Landsat 5 data in accordance with the USGS pricing policy

Landsat-7 data products are available from the USGS Center for Earth Resources Observation and Science (EROS). These products are distributed at COFUR prices or "the Cost of Fulfilling User Requests". This is a significant price reduction from commercial data sales, allowing renewed use of Landsat data in academic institutions for scientific research. This has stimulated the use of multispectral imagery in a variety of applications, fostering new uses not only for Landsat data but for other remote sensing data as well. As of June 4, 2007, the USGS has been releasing selected Landsat 7 image data of the United States through the Web. These data are of high quality with limited cloud cover.

The next-generation Landsat, known as LDCM (Landsat Data Continuity Mission, is expected to be launched in the summer of 2011. The USGS will be responsible for the mission operations, along with collecting, archiving, processing and distributing the data to the U.S. Government and other users (Council 2013). As seen in the graphic below (Figure 2- 1 Landsat Development)

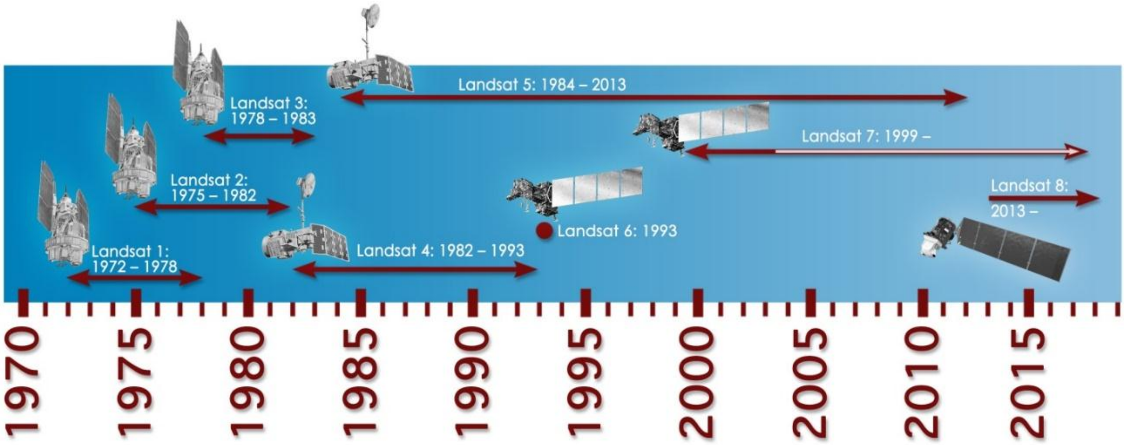

Figure 2- 1 Landsat Development

2.2.5. Characteristics of the Landsat System

Landsat satellites image the Earth's surface along the satellite's ground track in a 185-kilometer-wide (115-mile-wide) swath as the satellite moves in a descending orbit (moving from north to south) over the sunlit side of the Earth. Landsat 7 and Landsat 8 orbit the Earth at 705 kilometers (438 miles) altitude. They each make a complete orbit every 99 minutes, complete about 14 full orbits each day, and cross every point on Earth once every 16 days. Although each satellite has a 16-day full-Earth-coverage cycle, their orbits are offset to allow 8-day repeat coverage of any Landsat scene area on the globe. Landsat 4 and 5 also followed this orbit. Landsat 1, 2, and 3 orbited at an altitude of 920 kilometers (572 miles), circling the Earth every 103 minutes yielding repeat coverage every 18 days. The primary sensor onboard Landsat 1, 2, and 3 was the Multispectral Scanner (MSS), with an image resolution of approximately 80 meters in four spectral bands ranging from the visible green to the near-infrared (IR) wavelengths (table 2). The improved Thematic Mapper (TM) sensors onboard Landsat 4 and 5 were designed with several additional bands in the shortwave infrared (SWIR) part of the spectrum; improved spatial resolution of 30 meters for the visible, near-IR, and SWIR bands; and the addition of a 120-meter thermal-IR band. Landsat 7 carries the Enhanced Thematic Mapper Plus (ETM+), with 30-meter visible, near-IR, and SWIR bands, a 60-meter thermal band, and a 15-meter panchromatic band(U.S. Geological Survey (USGS) 2012)

CHAPTER THREE

METHODOLOGY

This chapter explains the Methodology, steps of comparison the change of NUBAIN Lake in different years and the urban development in the study area,

3.1. Study area: -

The study area consists of Northern state near Sudanese –Egyptian boundaries (Nubian Lake). The study area lay between latitudes (21°13'42"N-21°25'36"N) and Longitudes (31°28'10"E-30°59'36"E) (Figure 3- 1 Study area).

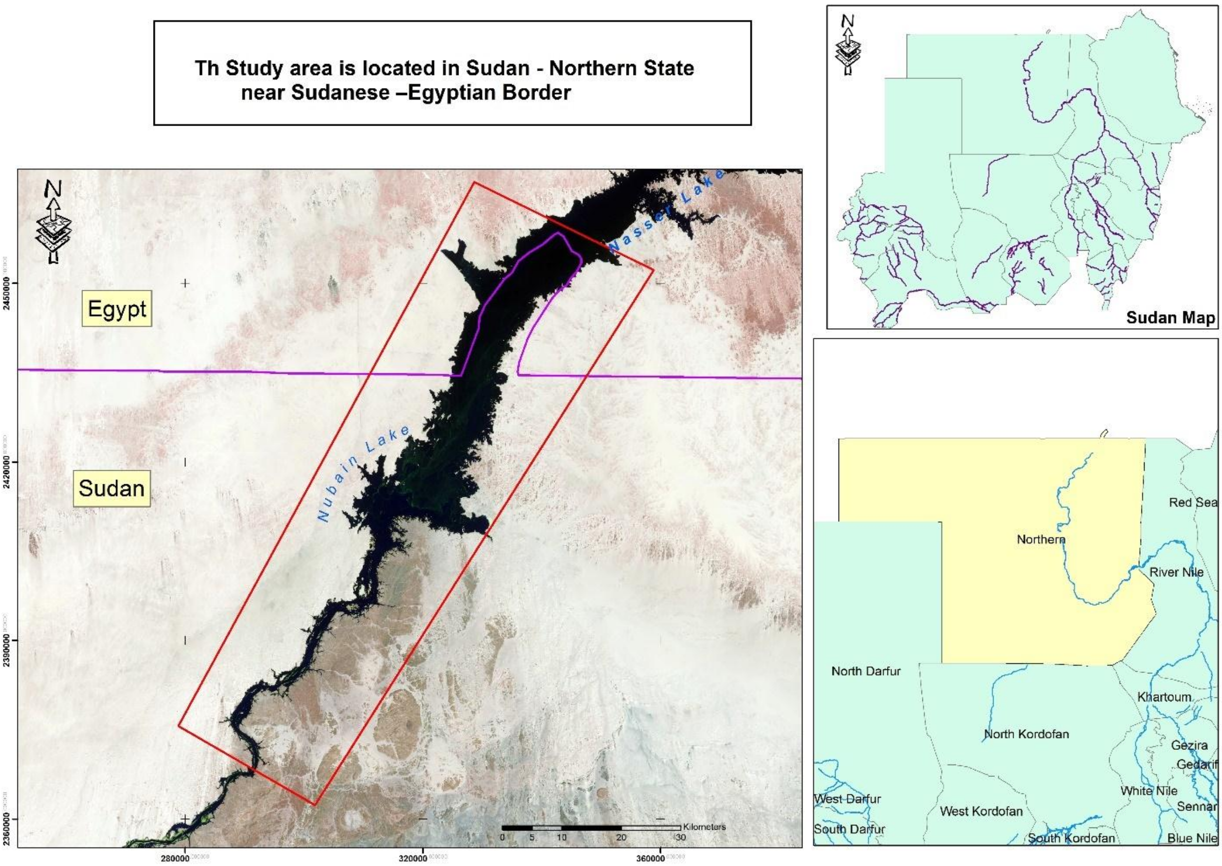

Figure 3- 1 Study area

3.2. Work PLAN: -

The research had been carried out in two main steps; namely change detection of Nubian lake and urban development.

1. change detection Nubian lake:

- Downloading Satellite images
- Selecting targeting images (dry season – wet season)
- Preparing area of interest (AOI)
- Unsupervised classification
- Convert raster to polygon
- Dissolve features
- Selecting lake class
- Comparison between different years

2. Urban development:

- Use Google earth.
- Extract boundaries of town, roads and agriculture areas.
- Comparison between different years.

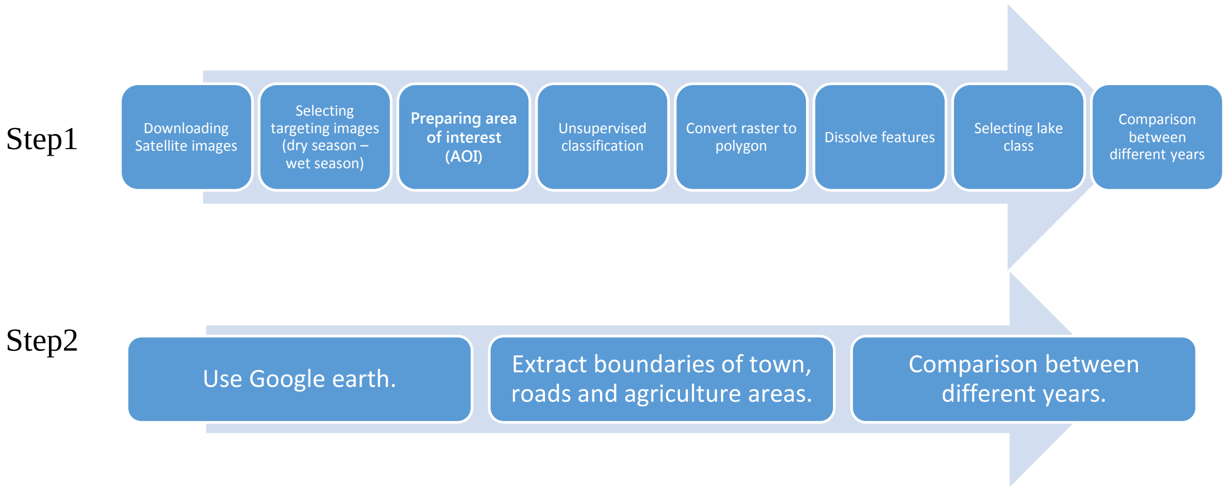

Figure 3- 2 Work Plan

3.3. Sources of the data: -

1- Satellite Image (175/45): -

- Date of data: May. 2015 and Feb. 2016
- Resolution: 30*30 m
- Datum: WGS84
- Projection: UTM, Zone 36N.

www.earthexplorer.com

Data (32 years between 1985-2017) from Landsat (L8 OLI/TIRS), Landsat (L7 ETM+SLC-on (1999-2003) and Landsat (L4-5 TM) satellites had been used for the study. To estimate the changes of the Nubian Lake, the following image had been downloaded as shown in (Table 3-1 Satellite Image).

Table 3-1 Satellite Image

Year	1	2	3	4	5	6	7	8	9	10	11	12
1985												
1987												
1988												
1990												
1992												
1994												
1995												
1998												
1999												
2000												
2002												
2003												
2006												
2009												
2013												
2014												
2015												
2016												
2017												

The highlight box refer to image that had been downloaded from internet sources

2- Shape file of administrative: -

- Date of data: April. 2017
- Datum: WGS84

www.Diva-GIS.com

3.4. Data Processing: -

3.4.1 Selecting targeting images (dry season – wet season)

Eight images had been choosen from the previous table (Table 3-1 Satellite Image) with yearly gap and the same month of each year had been selected if it available, to get the chanages in the Lake over the years.

Time gap had been choosen in dry, wet season for dam programe operation where dam gate had been closed during the dry season to store the water and reopened at the wet season to pass the sediment.

Table 3-2 Selected Satellite Image

Category	Images
Dry Season	March 1985 March 1988 May 1998 March 2003 March 2006 March 2009 March 2014 March 2017
Wet Season	October 1987 October 1990 October 1998 July 2003 October 2013 October 2016

3.4.2 Preparing area of interest (AOI)

By create Polygon around Nubian lake in Sudan boundary AOI had been shown (Figure 3-1 Study area)

3.4.3 Unsupervised classification

The goal of classification is to assign each cell in the study area to a known class (supervised classification) or to a cluster (unsupervised classification), to achieve class of water bodies the unsupervised classification had been conducted .

3.4.4 Convert raster to polygon

By conducting all previous class in the last step the conversion tool had been used to convert a raster dataset to polygon, each group of contiguous cells with the same values had been converted.

Figure 3- 3 Image before conversion

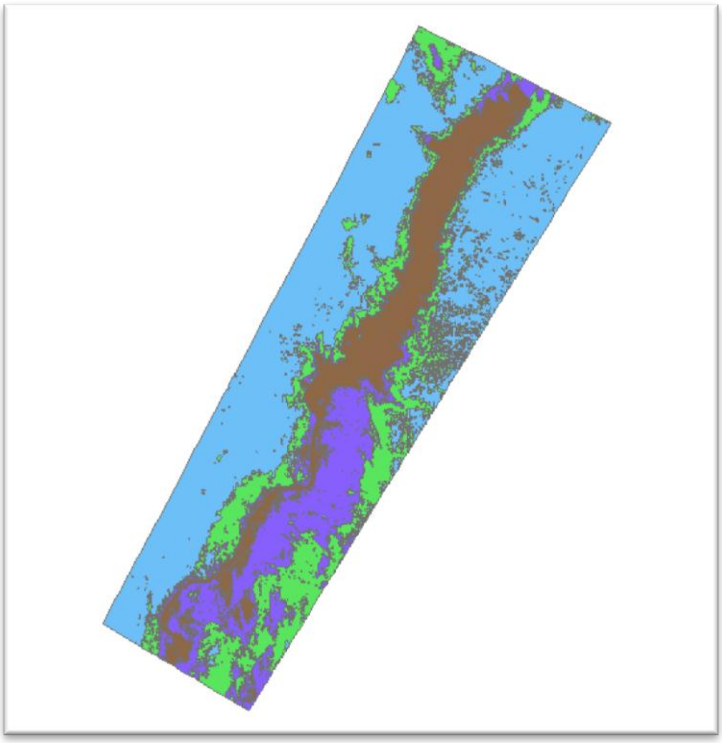

Figure 3- 4 Image after Conversion

3.4.5 Dissolve features

Dissolve tool had been used to Aggregates features based on specified attributes.

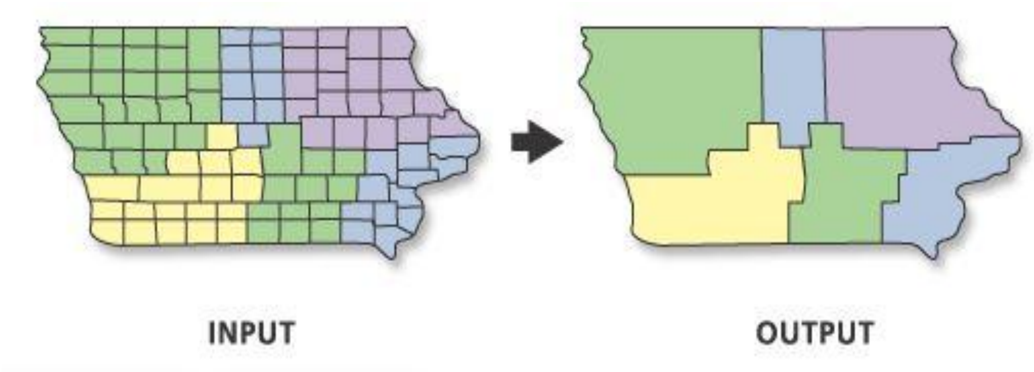

Figure 3- 5 Dissolve features

3.4.6 Selecting lake class

All the records in a table that term lake shape had been selected and converted to new shapefile.

3.4.7 Comparison between different years

The boundaries of the lake had been compared during the years previously selected and their area had been calculated to detect the changes in the area of lake, with the year that followed.

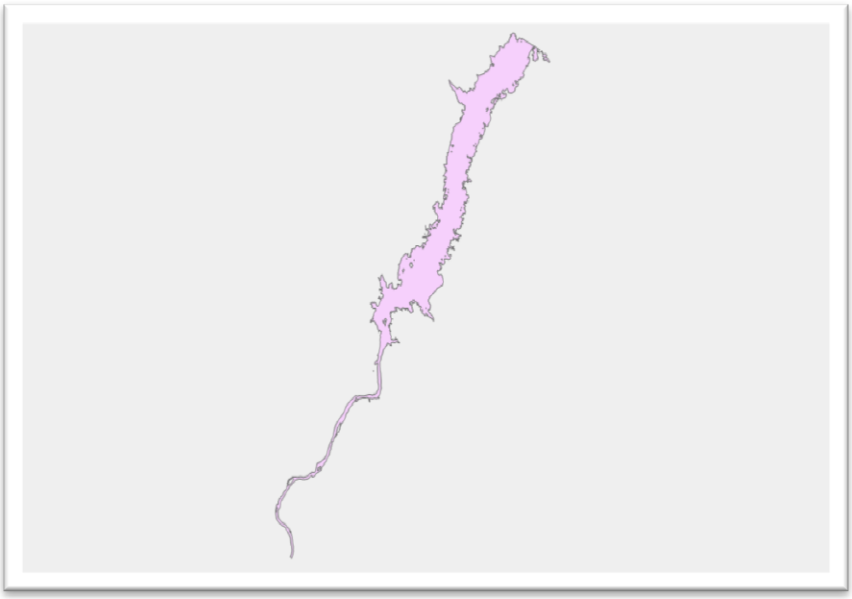

Figure 3- 6 Image 1985

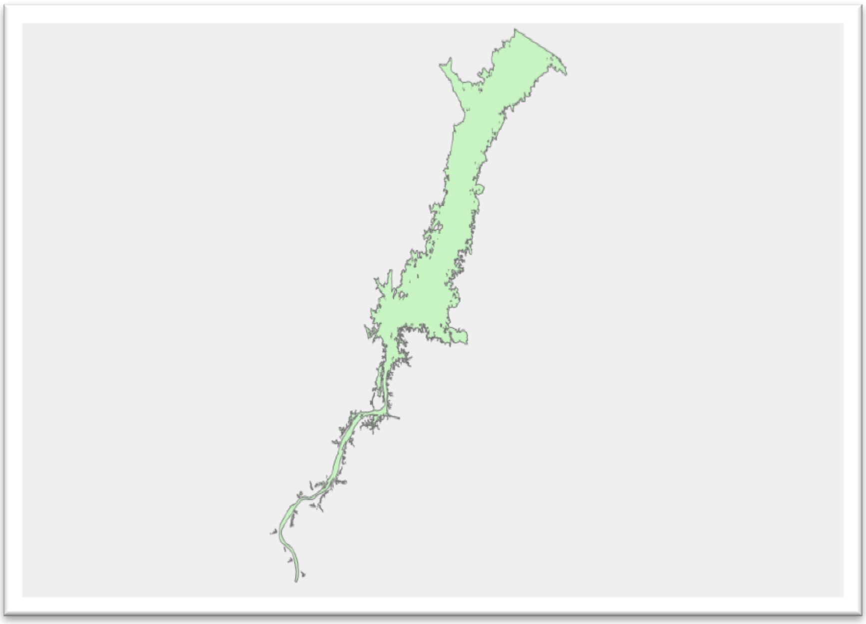

Figure 3- 7 Image 2017

3.4.8 Use Google earth (image from google earth)

The images had been chosen for the years (2002,2006,2010,2012,2014 and 2016) from Google Earth to recognized the residential areas and agricultural land.

3.4.9 Extract boundaries of town and agriculture areas

The town borders and agricultural areas had been digital numbered during different years.

3.4.10 Comparison between different years

The borders of town and their area of growth had been compared during different years.

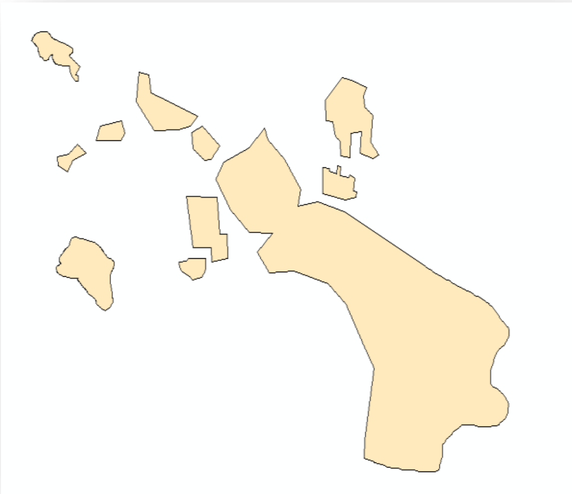

Figure 3- 8 Built up area 2002

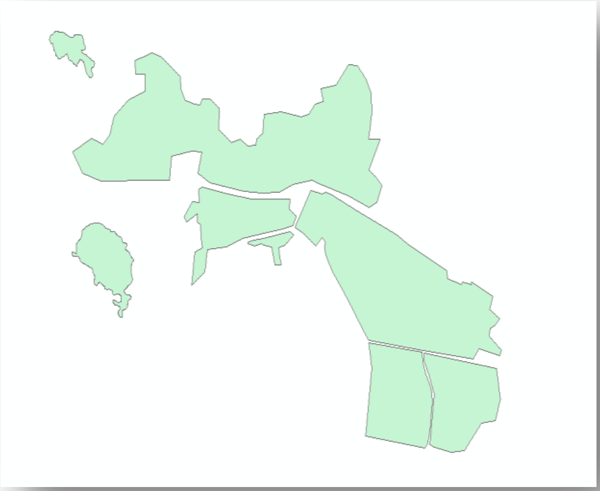

Figure 3- 9 Built up area 2016

As well as the borders of agricultural projects and the emergence of any agricultural land during different years and also follow-up the growth of infrastructure in and compared over the selected years.

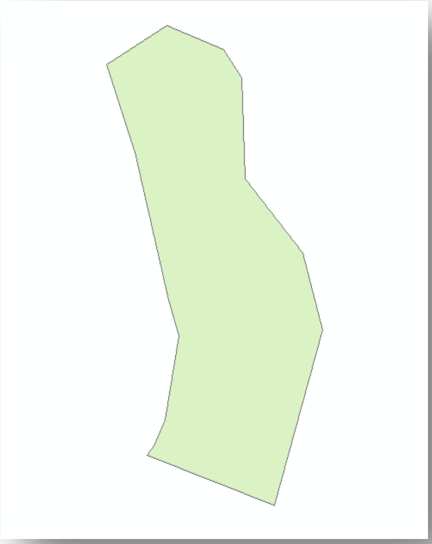

Figure 3- 10 Agricultural area 2002

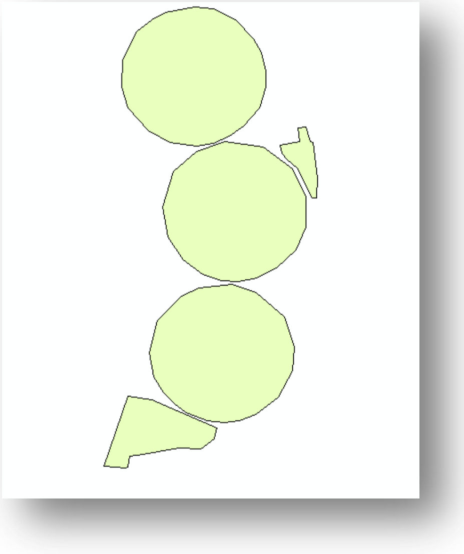

Figure 3- 11 Agricultural area 2016

3.4.11 Model builder:

By using model builder “Model Builder is very useful for constructing and executing simple workflows, it also provides advanced methods for extending ArcGIS functionality by allowing you to create and share your models as tool” the following Model had been built to assemble all the previous procedures.

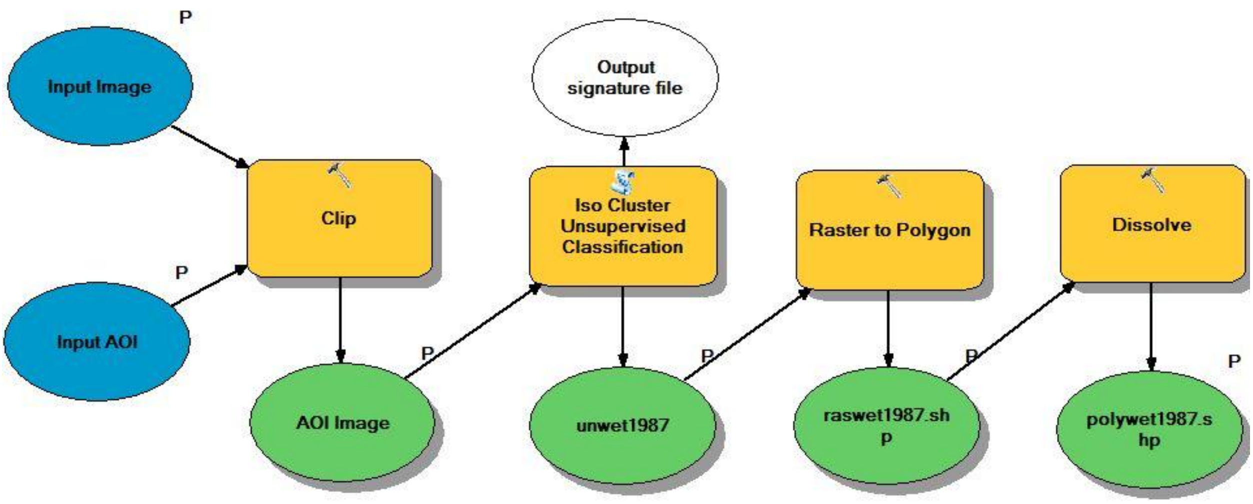

Figure 3- 12 Classification model

The following chart elaborates the steps of methodology (Figure 3-13 Flow chart of the Methodology).

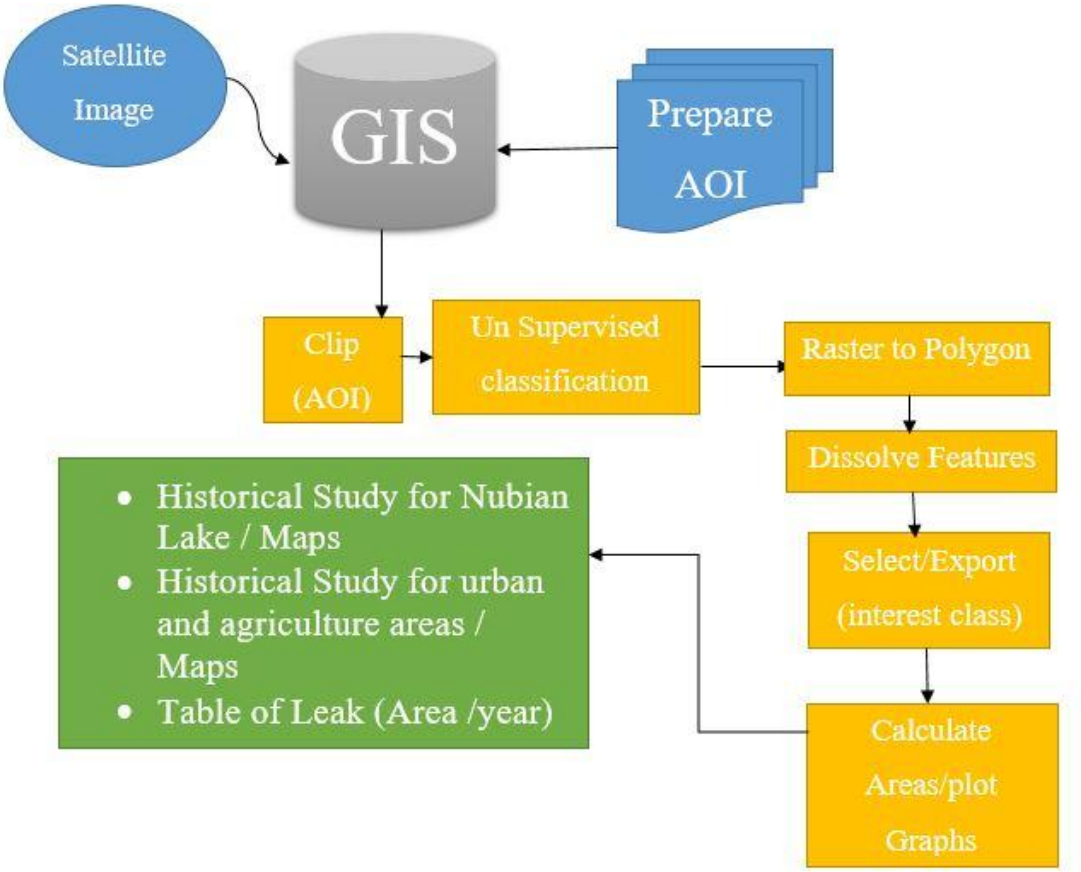

Figure 3- 13 Flowchart of the Methodology

CHAPTER FOUR

RESULTS AND ANALYSIS

This chapter presents results of data processing and analysis of the previous chapter and explanations of these results obtained.

The analysis steps as shown in the flow chart (Figure 3- 13 Flowchart of the Methodology) had been applied and the following results had been obtained:

- The areas of the lake had been computed and the difference over the years in the dry season up to Sudan- Egypt boundaries, as shown in the tables below.

Table 4-1 The areas of the lake -Dry Season

Year	Area (Km^2)
1985	424.774
1988	354.486
1998	354.486
2003	604.081
2006	592.599
2009	706.160
2014	660.342
2017	672.873

Table 4-2 The difference of areas of the lake

Period	Diff
1985 - 2017	248.099
1985 - 2009	281.386
1985 - 1998	-70.288

- The flow chart below explain the changes in the area of the lake over the years as shown in the previous table (Table 4-1 The areas of the lake -Dry Season)

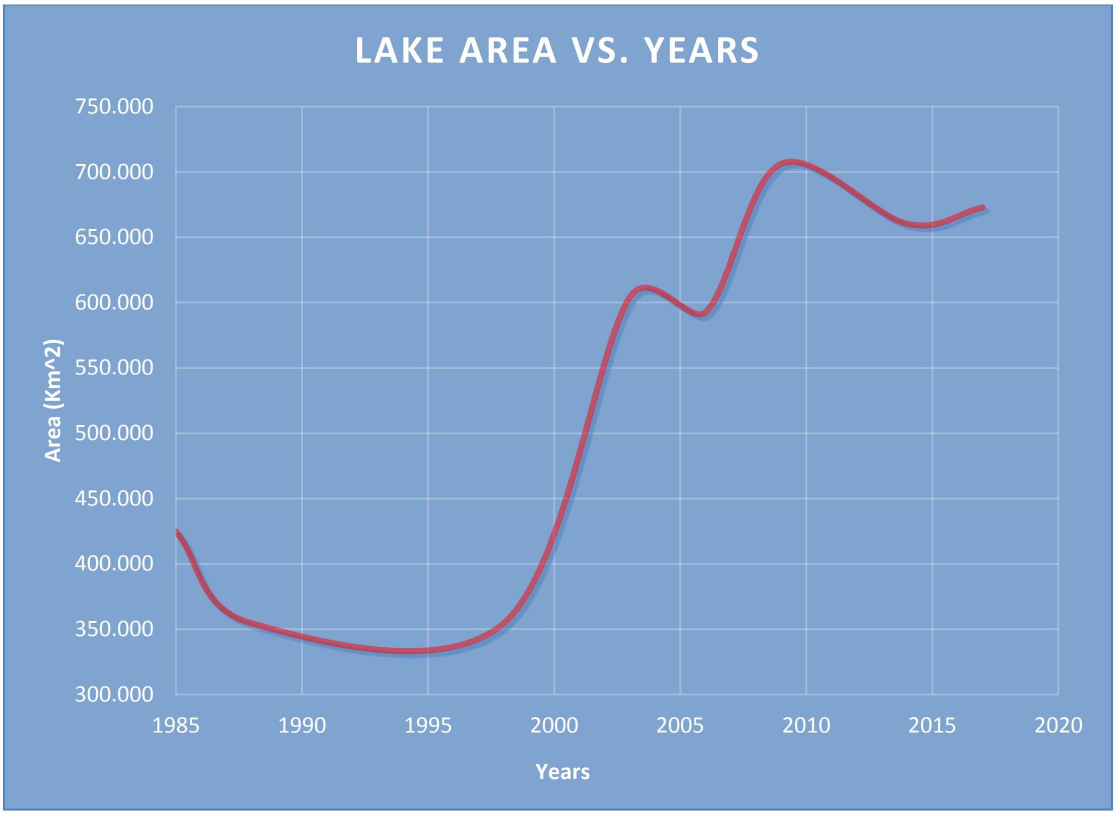

Figure 4- 1 The areas of the lake -Dry Season

- Changes of lake area in period 1985-2017:
- The boundaries of the lake had been conducted over the years to figure out the difference and the change in the lake.
- As it was noted from the table (Table 4-2 The difference of areas of the lake) that the period between 1985-2017 the area of the lake had been increased by 248.099, as for the period between 1985-2009 the area of the lake had been increased by 281.386, with regard to the period between 1985-1998 the area of the lake had been decreased by 70.288 , as shown in the figures below:

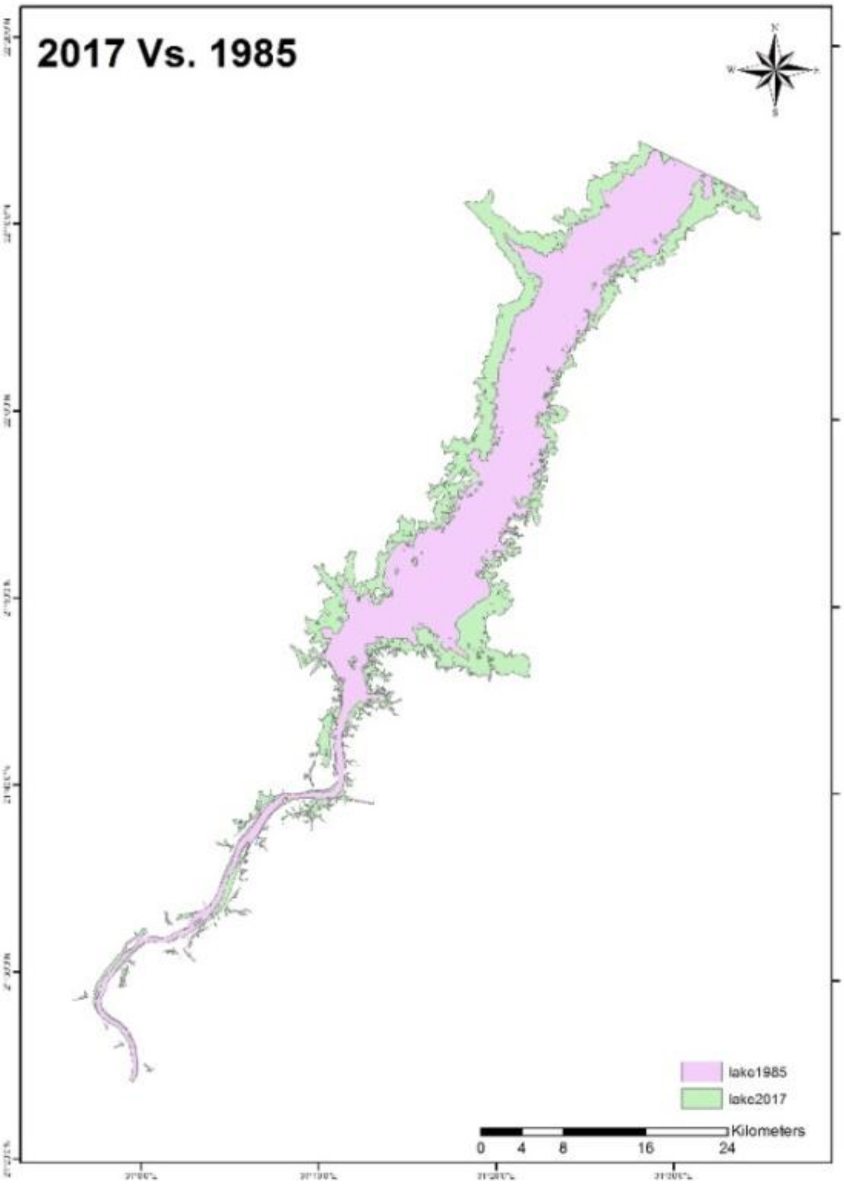

Figure 4- 2 Comparison between 1985-2017

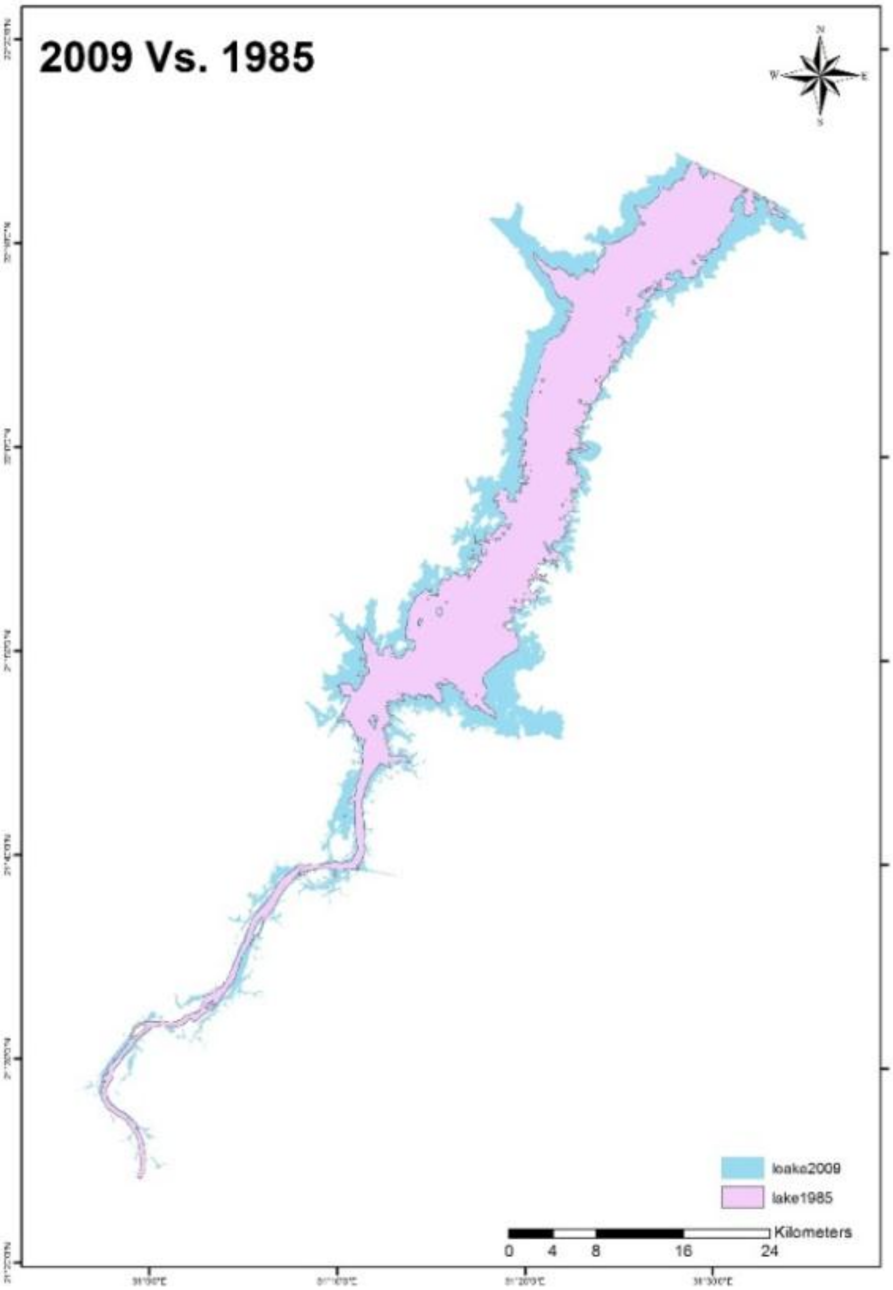

Figure 4- 3 Comparison between 1985-2009

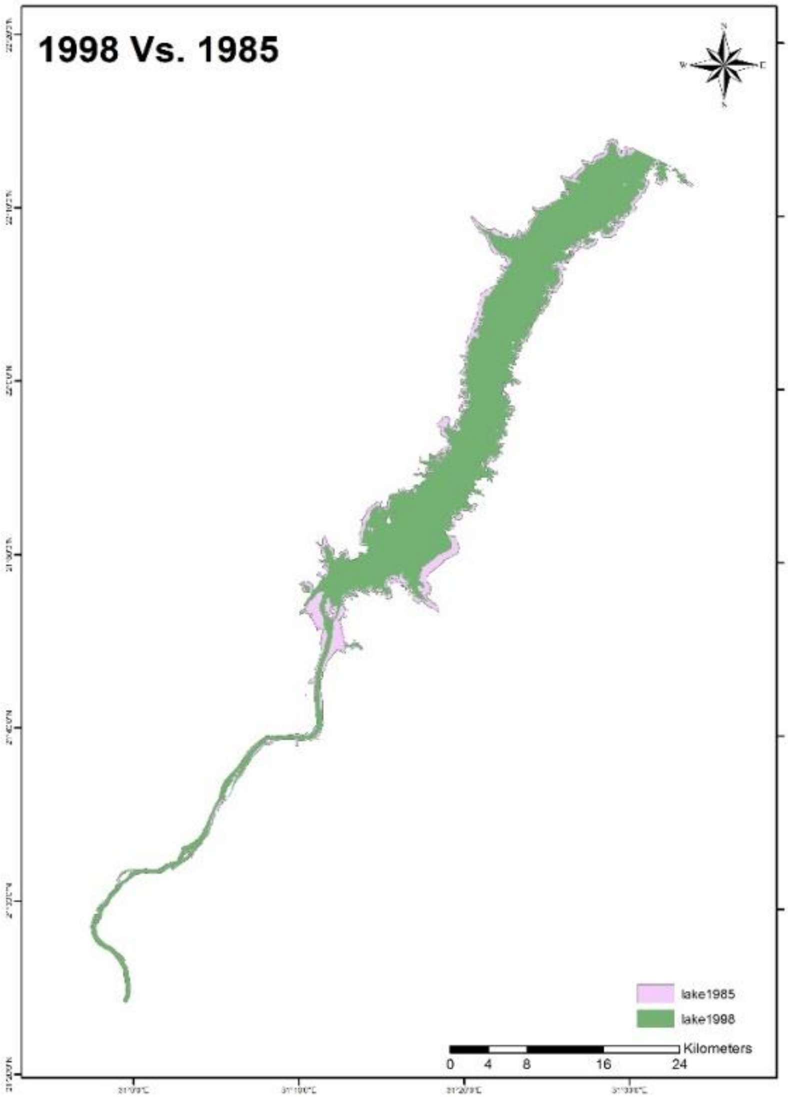

Figure 4- 4 Comparison between 1985-2017

- As shown in the table (Table 4-2 The difference of areas of the lake) above, there was an increase and decrease in the water level for many reasons and it depend on the purpose of the storage and uses of the lake in dry and wet seasons, also the operation of the dam.
- In some cases there is a flood which leads to sedimentation of the deposit, and this indicates to an increase in the area of the lake.
- The area of the lake decreases during the discharge of water from dam operation.

- The areas of the lake had been computed and the difference over the years in the wet season, as shown in the tables below.

Table 4-3 The areas of the lake – Wet Season

Year	Area (Km^2)
1987	446.922
1990	542.171
1998	822.224
2003	603.214
2013	683.128
2016	699.902

Table 4-4 The difference of areas of the lake

Period	Diff
1987-2016	252.979401
1987-2003	156.291957
1987-1998	375.301449

The flow chart below explain the changes in the area of the lake over the years as shown in the previous table (Table 4-3The areas of the lake – Wet Season)

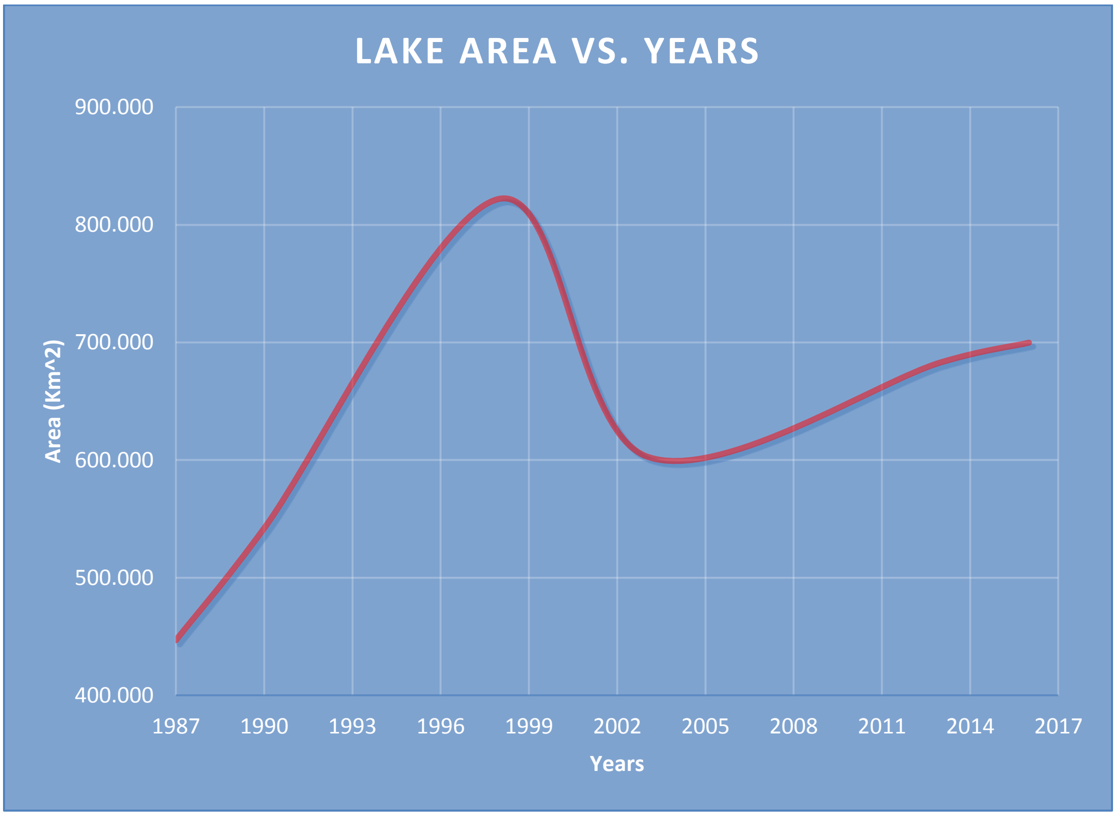

Figure 4- 5 The areas of the lake - Wet Season

- As it was noted from the table (Table 4-4The difference of areas of the lake) the period between 1987-2016 the area of the lake had been increased by 252.979401, as for the period between 1987-2003 the area of the lake had been increased by 156.291957, with regard to the period between 1987-1998 the area of the lake had been increased by 375.301449 , as shown in the figures below:

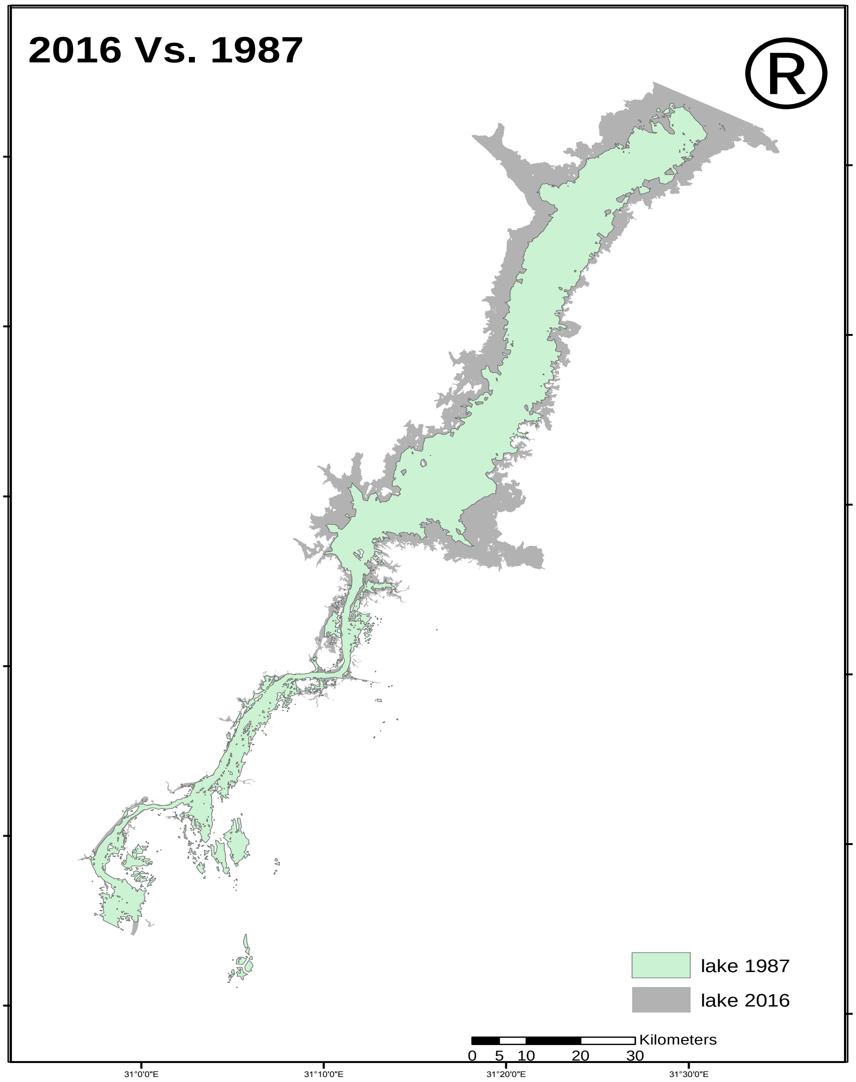

Figure 4- 6 Comparison between 1987-2016

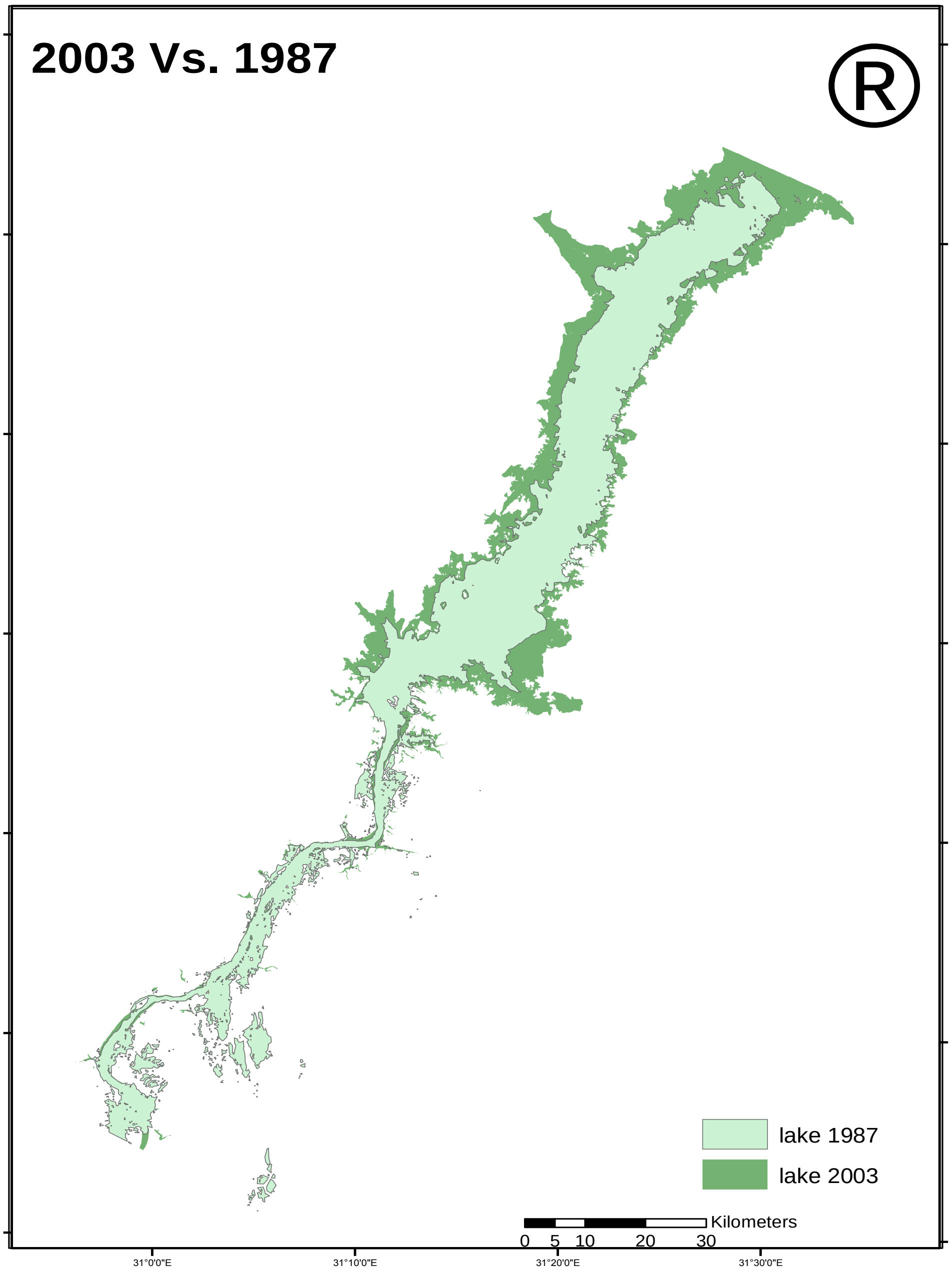

Figure 4- 7 Comparison between 1987-2003

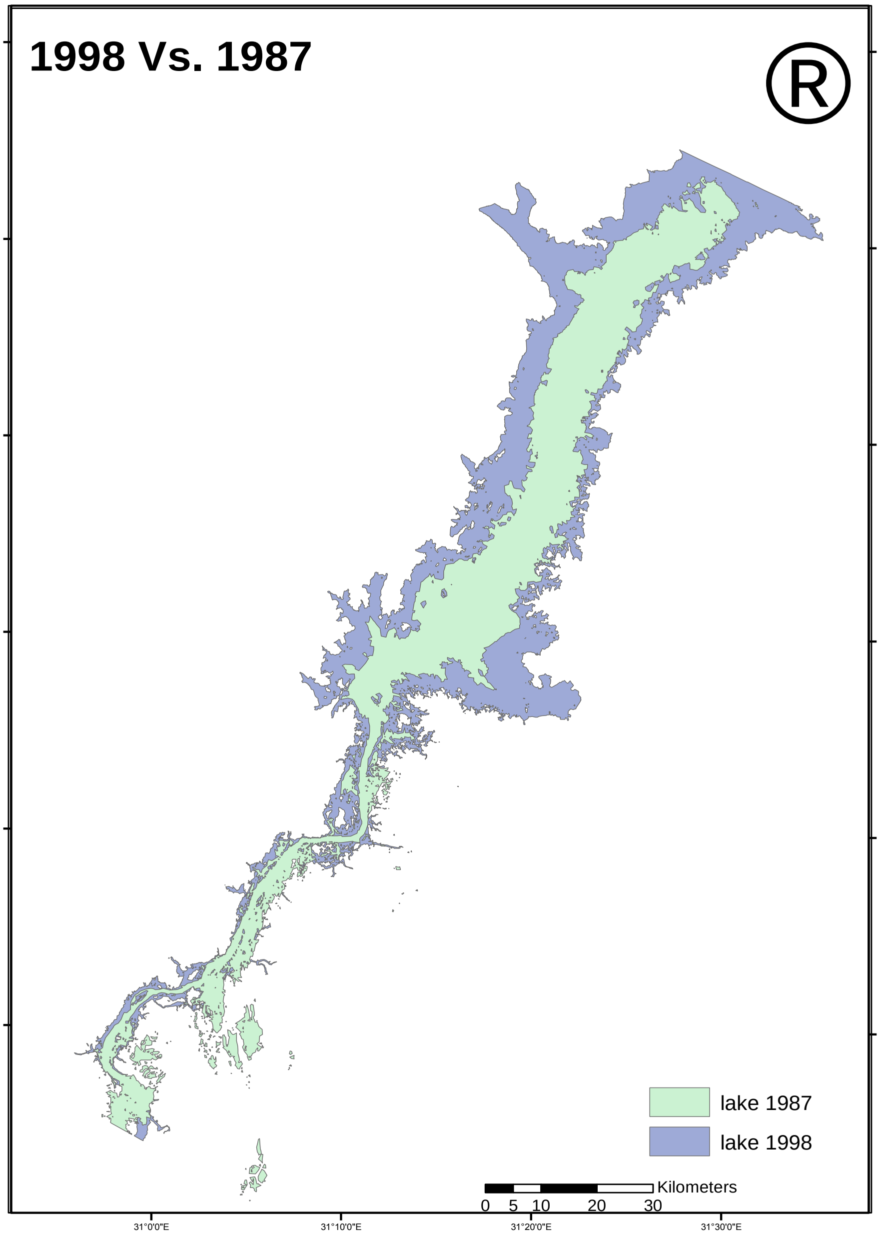

Figure 4- 8 Comparison between 1987-1998

After the boundaries of the lake had been extracted in both dry and wet seasons, there was an increase and decrease in water level, the outcome of this change is an increase in the residential areas as shown in figures (Figure 3- 8 Built up area 2002) and (Figure 3- 9 Built up area 2016) the following table explain the residential areas (Table 4-5 The residential areas)

Table 4-5 The residential areas

Year	Area (Km^2)
2002	8.650736
2006	8.631599
2010	9.920866
2012	10.886589
2014	10.886589
2016	11.654768

The flow chart below explain the residential areas over the years as shown in the previous table (Table 4-5The residential areas**)**

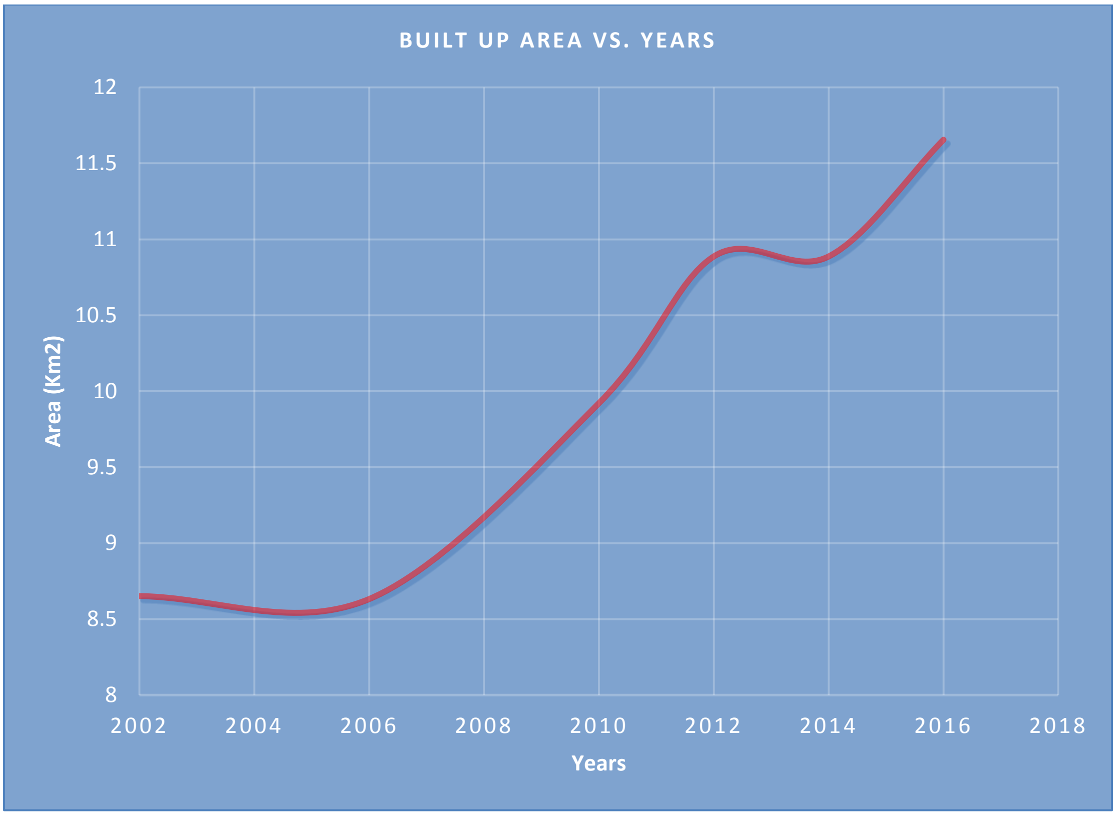

Figure 4- 9 The areas of built-up area

- Agriculture areas had been calculated in each of the years shown in the table below (Table 4-6 Agricultural areas) and it had been noted that the agriculture areas increased by a small amount, this indicates that the agriculture area is not growing.

Table 4-6 Agricultural areas

Year	Area (Km^2)
2002	2.171348
2006	2.115005
2010	2.094086
2012	2.616331
2014	2.322309
2016	2.84974

- The flow chart below explain the agricultural areas over the years as shown in the previous table (Table 4-6 Agricultural areas)

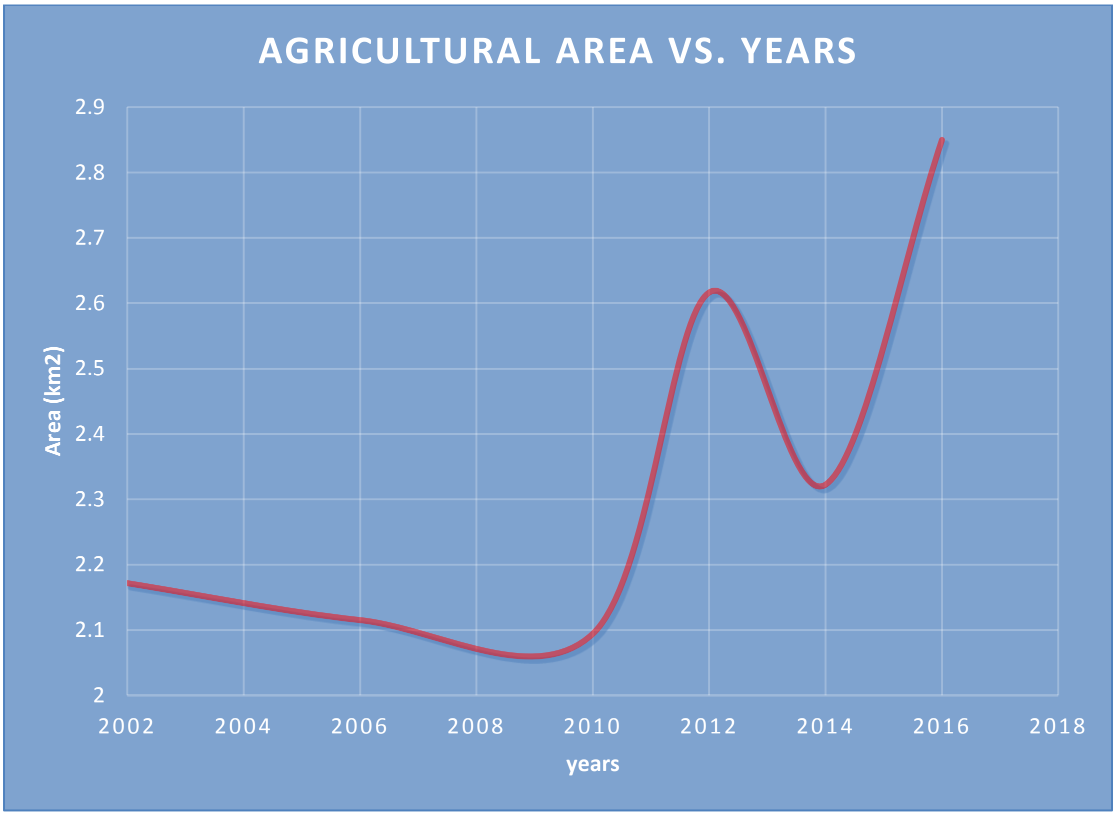

Figure 4- 10 The curve of agricultural areas

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This thesis presents and discusses the changes of Nubian lake within Sudanese boundaries using GIS/RS techniques. The shape of the lake surface boundaries had been extracted from the satellite images using unsupervised classification. On the other hand the results showed that the growth in the town had been increased. Moreover, irrigation system changed from canalization irrigation system to pivot irrigation system. From these results I had concluded the following:

- There is increasing in the residential areas.
- There is no significant increasing in the agricultural areas which means the sedimentation rate was low and doesn't allow for the increase in the agricultural areas.

5.2 Recommendations

Based on the study results, the recommendations for future research work are as follows:

- Use high resolution images to get better results.
- Use another method for the image analysis.

REFERENCES

Aali, S. El, 2003. The Aswan High Dam Case (Unpublished 2003 T.Scudder Manuscript) Section One: Saad el Aali – the Aswan High Dam. *Unpublished*, pp.1–36.

Council, N.R., 2013. *Landsat and beyond: sustaining and enhancing the Nation's land imaging program*,

Elsahabi, M. & Negm, A., 2017. Building 3D Profile for Lake Nubia, 〈Sudan〉 Using RS/GIS for Accurate Estimation of Sediment. *Procedia Engineering*, 181, pp.845–852.

El-Shabrawy, G., 2009. Lake Nasser - Nubia. *The Nile*, 89, pp.125–155.

Elshemy, M. & Meon, G., 2011. Climate Change Impacts on Water Quality Indices of the Southern Part of Aswan High Dam Reservoir, Lake Nubia. *Iwtc.Info*, (October).

El Gammal, E.A., Salem, S.M. & El Gammal, A.E.A., 2010. Change detection studies on the world's biggest artificial lake (Lake Nasser, Egypt). *Egyptian Journal of Remote Sensing and Space Science*, 13(2), pp.89–99.

U.S. Geological Survey (USGS), 2012. Landsat — A Global Land-Imaging Mission. *U.S. Geological Survey Fact Sheet 2012-3072*, (May), p.4.

Verbyla, D.L., 2002. *Practical GIS Analysis*,

Weng, Q., 2010. *Remote Sensing and GIS Integration*,