Sudan University of Science & Technology

College of graduate Studies

Effects of Sand Encroachment on Omdurman Locality Using Remote Sensing (1987 – 2013)

تأثير زحف الرمال علي محليه أمدرمان باستخدام الاستشعار عن بعد (1987-2013)

A dissertation Submitted as a partial fulfillment to the Degree of Master of Science in Geodesy and GIS

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الآيـــة

قال تعالى:

﴿ قُلْ لَوْ كَانَ الْبَحْرُ مِدَادًا لِكَلِمَاتِ رَبِّي لَنَفِدَ الْبَحْرُ قَبْلَ أَنْ تَنْفَدَ كَلِمَاتُ رَبِّي وَلَوْ جِئْنَا بِمِثْلِهِ مَدَدًا ﴾

((صدق الله العظيم))

سورة الكهف

الأية (109)

Dedication

This dissertation is dedicated to my father's soul, i pray that this research be his ongoing charity.

To whom i grew up with her advocacies, my mother.

To my brothers who have supported me, and to my friends.

Abstract

Sand encroachment is one of the main problems threatening the agricultural production in some parts of Sudan, particularly in Omdurman locality. As the accumulations of sand dunes move, they bury villages, roads, oases, crops,market gardens, irrigation channels and dams, thus causing major material and socioeconomic damage .The integration of remote sensing and geographic information system (GIS) prove to be reliable tools to monitor the sand encroachment processes. It can be seen, frorm this disertation, that there is a decrease in sand encroachmen .This is drawn from the fact that urban development and areas covered by vegitation increased within the specified time span (1987 to 2013).

التجريده

زحف الرمال هي واحدة من المشاكل الرئيسية التي تهدد الإنتاج الزراعي في بعض مناطق السودان ، خاصة في محليات أم درمان . تراكمات الكثبان الرملية المتحركه ، و دفن القرى والطرق و الواحات والمحاصيل، الحدائق، السوق ، وقنوات الري والسدود ، مما تسبب في المواد الرئيسية الاجتماعية والاقتصادية . والتكامل بين الاستشعار عن بعد و نظم المعلومات الجغرافية اثبت أنه يمكن التعامل للحصول على أدوات مراقبة لعمليات زحف الرمال. وجد أن الرمال نقصت بديل النمو العمراني وزيادة رقعة الارضي الزراعيه خلال الفترة الزمنية المحددة (1987 – 2013 م).

Acknowledgement

I would like to express my thanks to all my friends and colleagues who have given me much help full advice and engorgement during this study.

I thanks very much my supervisor

Dr. Ahmed Mohammed Ibrahim.

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Abbreviation:

CCB	Central Census Bereu
CCD	Charge Coupled Devices
CERL	Construction Engineering Research Laboratories
EME	Electro Magnetic Energy
ERTS	Earth Resources Technology Satellites
ESRI	Environmental Systems Research Institute
ETM+	Electro Thematic Mapper plus
FAO	Food and Agriculture Organization
FICC	Federal Interagency Coordinating Committee
GIS	Geographic Information Systems
GRASS	Geographic Resources Analysis Support System
HRMSI	High Resolution Multispectral Stereo Imager
HRV	High Resolution Visible
ID	Identity
IRS	Indian Remote Sensing
ISRO	Space Research Organization
LISS	Linear Image Self Scanning
LISS-3	Linear Imaging Self Scanning Camera-3
LULC	Land Use/Land Cover Classification
MR	Microwave Region
MSS	Multi Spectral Scanners
NCFR	National Center For Research
OIR	Optical Infrared Region
OLI	Operational Land Imager
OMS	Optical Mechanical Scanner
PC	Personal Computer
RS	Remote Sensing
SLC	Scan Line Corrector
TIN	Triangular Irregular Networks
TM	Thematic Mapper
USA	United States America

Chapter One

Introduction

1.1 Introduction:

Sudan is a source, path and drainage basin for the Nile (Hamad and El-Battahani, 2005). Usually natural rivers are exposed to morphological changes due to a lot of factors, which could be internal or external ones. One of the external factors is the sand encroachment. Sand encroachment is a problem that relates directly to the requirements and life basin downstream countries, Sudan and Egypt. The moving of sand of different sizes, fine and medium ,occupies vast areas of the banks of River Nile . North of latitude 13° N, the Nile and its branches, the White and Blue , are greatly influenced by sand encroachment. The affected areas along the Nile and its tributaries , the Blue and White Niles, are the northern parts of Gezira State, the northern parts of the White Nile State and then very large areas within the River Nile State.Sand dunes threaten to bury human settlements, roads, farms, water and other resources. They have a fragile environment where instability with a series of changes in the structure and dynamics, lead to a system which is not in equilibrium with its surroundings within an arid and hyper- arid climate changes characterized by an increase of evaporation and long periods of dryness, very low rainfall and vegetation.

The phenomenon of morphological changes manifested in river meandering, sediment deposition, bed aggradations and bank erosion , including sand encroachment , have been noticed since the sixties, while yearly expanding in a slow process. The wind blown sand and its consequent creep towgrds the river channel have contributed to a large extent to gradual morphological changes. These morphological changes will have a serious impact on the region of the River Nile system, particularly Sudan and Egypt. An example is the adverse impacts on the economic and agricultural activities, a matter that was quite felt in the day- to-day lives of the people in these areas . The use of remote sensing and Geographic Information Systems (GIS) techniques over the past several decades, as a tool to study dynamic features, such as sand dunes, has given the researchers a synoptic view of the entire field as well as its sources. In addition, the ability to examine changes over time allows for the extrapolation of current climate regimes and the monitoring of marginal areas susceptible to future desertification

(Ramsey, 2003). One location of wind deposition, directly along the course of the River Nile is in north-central Sudan. Here, in the region of omdurman, understanding the dunes movement is vital for mitigating the potential sand threat to the River Nile.

1.2 Objective of The Dissertation:

This study is to estimate sand dunes movement, or encroachment, in Omdurman Locality .

1.3 Methodology:

The main source of information to assess the status of sand encroachment in the study area is based on remote sensing data analysis and interpretation. Geographic Information Systems (GIS) techniques is to be performed on Operational Land Imager (OLI) 2013,Enhanced Thematic Mapper plus (ETM+) 2000 and Thematic Mapper (TM) 1987, to identify and map five main units (classes).These are: water (The River Nile) , buildings , mountains , agricultur areas and the rest is the sand. The north eastern part of the study area, which is a hilly region without sand dunes, was omitted from the present study and added as a sixth class.

From this interpretation, it is possible to state that the sand moved from the northern and eastern parts of the study area towards the river nile and Kanner areas. Sand movement is affected by the dominant direction of the prevailing wind (northeasterly wind in winter). The results from Operational Land Imager (OLI) 2013 showed that the sand dunes cover about (25%) of the total area. While in Thematic Mapper plus (ETM+) 2000 and Thematic Mapper (TM) 1987 it is found that the sand covers an area of about (33% and 27 %) respectively. Form this study it can be seen that there is no increase in sand encroachment .This is draun form that urban development and areas covered by vegetation increased with in the specified time span (1987 and 2013).

1.4 Dissertation Layout:

This dissertation falls in seven Chapters including this introductey Chapter .Chapter two contains a literature review showing the past studies concering sand encroachment morements . Chapter three contain abreif portrayal of remote sensing. Geographic

Informatio Systems (GIS) is discused in Chapter four. Chapter five contaions the mothodolgy used and finally, Chapter six Results & Discussions and Chapter seven contains the conclusions and recommendations for future work.

Chapter Two

Sand Encroachment

2.1 Meaning of Sand Encroachment:

The term sand encroachment is meant to be the situation when grains of sand are carried by the wind and collected on the coast, along watercourses and on cultivated or uncultivated lands.

2.2 Literature Review

Sand encroachment is one of the main problems threatening the agricultural production in some parts of Sudan . As the accumulations of sand dunes move, they bury villages, roads, oases, crops,market gardens, irrigation channels and dams, thus causing major material and socioeconomic damage. Desertification control programmes must then be implemented in order to counter this very serious situation. In central Sudan, desert encroachment is a creeping phenomenon. It can not monitored if it fluctuates in intensity with the expansion/retraction of the Sahara that has been most recently claimed to occur (Nawal et al, undated). There are few fragmented studies which showed that the desert is expanding from the north of Sudan at an alarming rate threatening the livelihoods and affect vast areas. Baumer and Tahara,1979 reported that desertification in Sudan is spreading like cancer including the adjacent low rainfall savanna, and that it was quite clear that desert encroachment in the Sudan was mainly a man-made phenomenon caused by misuse of land. There, as elsewhere, vegetation zones have been shifting southward as a result 15 of overgrazing, wood cutting and accelerated soil erosion Eckholm,1977. According to Ibrahim ,1979 supported by the heir of satellite photographs, desert expansion proceed by forming new marginal islands around villages of settled cultivators in the Sahelian zone of Sudan. Lamprey, 1975 compared his map on desert boundary in 1975 with a vegetation map of Sudan by Harrison and Jackson, 1958. Lamprey based his map on a combination of reconnaissance flights and ground based surveys from a car. He concluded that the Sahara desert had advanced 90-100km between 1958 and 1975. Dixey and Aubert (1962) estimated the advance of sand dunes encroachment in some agricultural land in Sudan at a rate of 1to 3 meters per year. Awouda, (1985) quoted decarp (1976) estimated the Sudan desert movement to be at a rate of 5 to 6 kms per year, threatening all Nile irrigation schemes in northern and central Sudan, e.g. (Rahad, Suki and Gezira). Salih (1996) stated that sand moves from north to south at an alarming rate, and under those conditions 13 Sudanese states out of 26 at that time and before the independence of sounthen Sudan were affected by land degradation. He reported that sand and sand dunes in the area between latitudes 10^{o} N and 18^{o} N had originated from the weathering products of the Basement complex Nubian sandstone, together with the alluvial deposits. Doka and Hamid (2006) stated that many cultivated areas in Sudan, both irrigated and rain fed, had been subject to desert encroachment, mainly by wind erosion and related sand invasion.

2.3 Wind Erosion and Sand encorochment:

The main causes of wind erosion are:

- Violent wind blowing over a large area
- Stunted or sparse vegetation
- A degraded soil that is mobile, bare and dry.

2.3.1 Violence of wind

The first factor affecting the displacement of soil particles is the direction, speed and duration of the wind. When a wind blows predominantly from one direction, it is known as a prevailing wind. Wind speed is zero at ground level, but increases in force the higher it is from the surface of the ground. Its speed increaes as the logarithm of height (Figure 2.1). A wind cannot lift sand particles off the ground until its speed, at 30 cm above ground level, measured with an anemometer, is at least 6 meters per second. Wind speed is an essential factor, for it determines the force of sand removal. The greater the speed is, the greater the carrying capacity will be The second factor is the size and density of sand particles. Particles with a diameter of about (1 μm) are the first to be removed, whereas a violent wind is needed to remove larger particles.

Figure (2. 1): Wind speed as function of altitude (Height) (Henin et al, 1960)

2.3.2 General Mechanisms Involved:

Particles in movement are the site of various interactions, the main ones being the avalanche effect, sorting and corrosion. The avalanche effect is the result of saltation. As the grains of sand fall back, they cause the displacement of a larger quantity of particles, so that the more intense the saltation process caused by the wind, the greater the number of particles set in motion, until a maximum or saturation point is reached, where the quantity lost is equal to the quantity gained at any given moment. The distance needed to reach this saturation point will depend on the sensitivity of a soil to erosion on a very fragile soil, it can occur over a distance of about 50 meters, whereas it will require more than 1 000 meters on a really cohesive soil.

The sorting mechanism concerns the wind's displacement of the finest and lightest particles, leaving behind the larger particles. This process gradually impoverishes the soil, since the organic matter made up of small light elements is the first to be removed.

Corrosion is the mechanical attack on the surface as the sand-laden wind blows over it. In arid regions, it is the aggravating cause of soil erosion and is seen in parallel streaks or the polishing of rocks. The united Nations Food and Agriculture Organization(FAO),(2010). The various ways in which ,sand particiles are carried by the wind are shown in Figure (2.2).

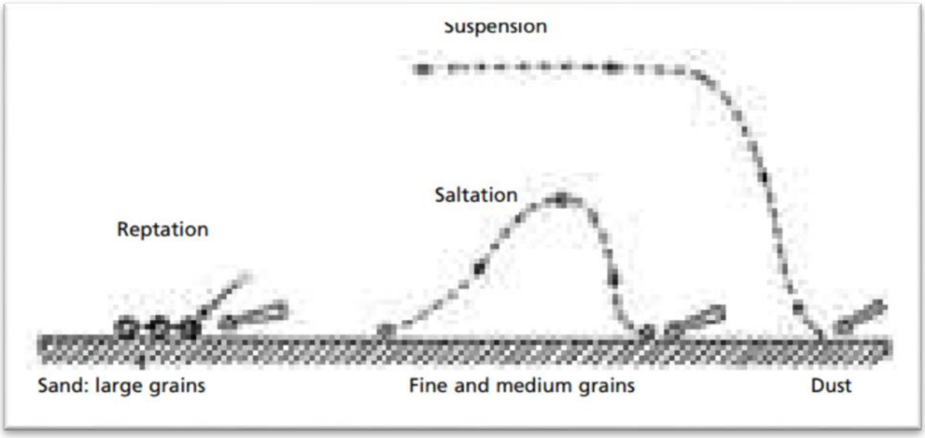


Figure (2. 2): Ways in which particles are carried by the wind (Lemoine,1996)

2.3.3 State of Vegetation:

Vegetation preserves the cohesion of the surface layer of soil, retains particles, resists the avalanche effect and is the best protection against the negative effects of wind. This is why wind erosion is such a threat in arid and semi-arid regions where natural vegetation; whether woodland, bushland or grassland is sparse, stunted or nonexisting and where rainfall is low and irregular. Moreover, unsustainable harvesting of such slow-growing stands leads to rapid degradation of the soil, which lacks protection and is therefore subject to the action of the wind.

2.3.4 Nature and State of Soil:

Wind erosion is the result of the wind attacking the soil. Such erosion takes place if the soil has the following characteristics:

- Mobile, dry and finely crushed (coarse, texured and rich in fine sand poor in clay and organic matter).
- A uniform surface with no natural or artificial obstacles.
- Sparse or non- existence of plant cover.

Soil that has been dried out over a long period is found especially in arid and semiarid zones. The soil’s susceptibility to erosion can be exacerbated by poor farming practices (clearing of large areas), poor pastoral practices (overgrazing, with loosening and powdering of the soil) and unsustainable harvesting of forests, all of which make it extremely vulnerable to the action of the wind (FAO,2010).

2.3.5 Effects of Wind on Vegetation :

The wind has both mechanical and physiological effects on vegetation.

2.3.5.1 Mechanical Effects:

The soil particles that are carried off collide with stalks and leaves with a force that abrades their tissue. In the zones from which the particles are carried off, roots are uncovered and the vegetation risks being uprooted, while in zones where the particles are deposited the vegetation is steadily buried.

2.3.5.2 Physiological Effects:

The wind increases evaporation and dries out plants, mainly in the dry season. The air's evaporating power is proportional to the square root of the wind speed. Moreover, the soil's water retention capacity is reduced, leading to water. stress. The surrounding or moving mass of dry air, tends to absorb humidity and exacerbate the water deficit and this deficit is the main foctor determining local vegetation, in as much as the latter has to adapt to the severe shortage of water **.**

2.3.6 Wind-Borne Accumulations:

When the wind grows lighter, it loses its capacity to carry sand particles, which are then dropped. Forms of sandy accumulation vary widely, depending on landform, the nature of the soil on which they encroach, the presence or lack of vegetation, and the size of the grains of sand. The results of these accumlations are: Wind veils, Nebka dunes and Barchans.

2.3.6.1 Wind Veils:

Sand particles are carried over hard, flat and uniform surfaces, forming sandy veils of varying thicknesses, which constitute a constant threat to villages, roads, railways and irrigation channels. This type of wind accumulation is the source of the surface sand encroachment found almost everywhere in the country, which becomes particularly serious following clearing, forest fires and overgrazing.

2.3.6.2 Nebka Dunes:

These accumulations are caused by the presence of rocks, plant or other obstacles in the path of moving sand particles. There are two types of nebka: sand arrow nebkas, which are small ovoid dunes (50 centimeters in height, 150 centimeters in length and 40 centimeters in breadth) lying in the direction of the prevailing wind; and bushy nebkas, similar to sand arrow nebkas, but capable of reaching a height of 2 meters and a length of 3 to 4 meters (Figure 2.3).

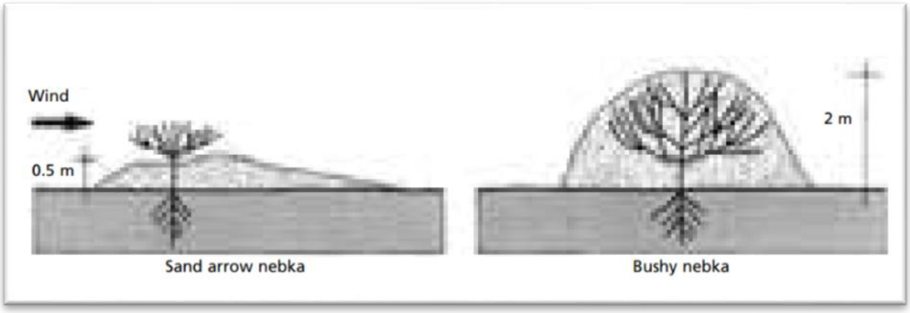


Figure (2. 3): Forms of Nbkas (FAO,1988)

2.3.6.3 Barchans:

These are huge crescent-shaped dunes convex to the wind (Figure 2.4).

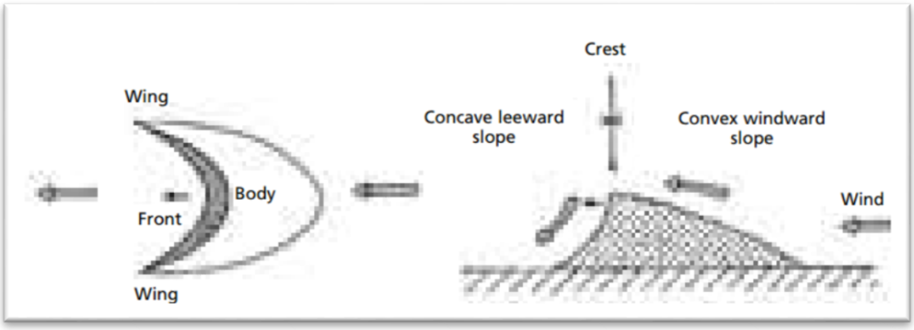
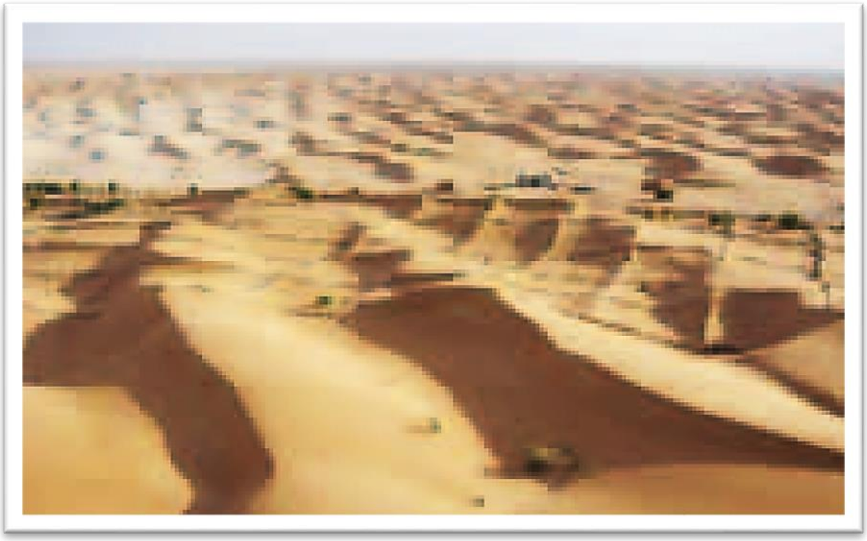


Figure (2. 4): Barchans (Rochelte,1989)

There are several stages in their formation: they start as sandy shields, then turn into barchanic shields, then barchanic dihedrons, and finally full-scale barchans. These stages are shown in Figue (2.5) a,b as samples Barchans tend not to remain isolated, but can join up and form complexeranging from train-like successions of barchans to area dunemas

Plant (2. 1) a: Isolated barchan (hadid,1989)



Plant (2. 2) b: Barchanic field or collection of barchans (hadid,1989)

Chapter Three

Remote Sensing

3.1 Definitions:

Remote Sensing (RS) has many definitions Sabins and Floyd (1986) defined Remote Sensing as " collecting and interpreting information about a target, without being in physical contact with the object ".

According to Nassri (1999) (RS) is defined as " the acquisition of information about an object from a distance without being physically in contact to it, by detecting and measuring changes in the reflected electromagnetic energy ".

The definition given by Jensen (2000) is " the art and science of obtaining information about an object without being in direct physical contact with the object ". Perhaps, the most applicable and used definition is the one given by Nassri (1999) .

3.2 Principles of Remote Sensing:

Detection and discrimination of objects or surface features means detecting and recording of radiant energy reflected or emitted by objects or surface material. Different objects return different amounts and kinds of energy in different bands of the electromagnetic spectrum incident upon it. This unique property depends on the material properties.

3.3 Stages in Remote Sensing

Any Electro Magnetic Energy (EME), is it seif-emitted or emitted (rodiated) fram the sean , undergoes the following stages :

1. Transmission of energy from the source to the surface of the earth, as well as absorption and scattering
2. Interaction of EMR with the earth's surface: reflection and emission

3. Transmission of energy from the surface to the remote sensor
4. Sensor data output.
5. Data transmission, processing and analysis.

Figure (3.1) below shows these stages, inclnding the emission source.

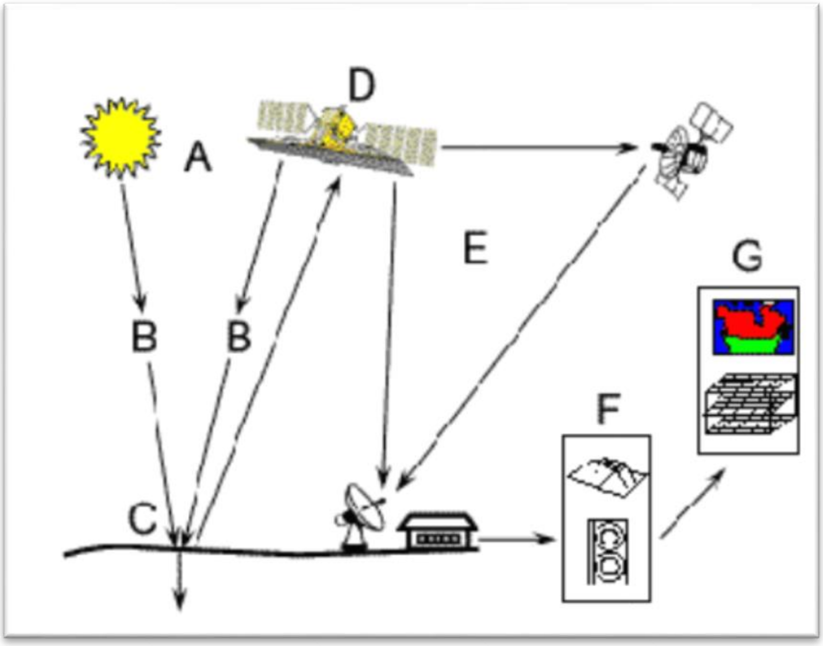


Figure (3. 1): Stages in Remote Sensing (CCRS/CCT, 1999)

Energy Source or Illumination (A)

The first requirement for remote sensing is to have an energy source, which illuminates or provides electromagnetic energy to the target of interest.

Radiation and the Atmosphere (B)

As the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

Interaction With the Target (C)

Once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation .

Recording of Energy by the Sensor (D)

After the energy has been scattered by, or emitted from the target, a sensor (remote - not in contact with the target) is required to collect and record the electromagnetic radiation.

Transmission, Reception, and Processing (E)

The energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data is processed.

Interpretation and Analysis (F)

The processed image is interpreted**,** visually and/or digitally or electronically, to extract information about the target, which was illuminated.

Application (G)

The final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

3.4 Remote Sensing Sensors:

A sensor is a device that gathers energy (EMR or other), converts it into a signal and presents it in a simple and understandable form suitable for obtaining information about the target under investigation. These may be active or passive depending on the source of energy:

Sensors used for remote sensing can be broadly classified as those operating in Optical Infrared Region (OIR) and those operating in the Microwave Region (MR). OIR and MR sensors can further be subdivided into passive and active.

3.4.1 Active Sensors

These sensors use their own source of energy. Earth surface is illuminated through energy emitted by its own source part of its reflected energy by the surface ,in the direction of the sensor, is received to gather the information.

3.4.2 Passive Sensors:

This type of sensors receive solar electromagnetic energy reflected from the surface or energy emitted by the surface itself. These sensors do not have their own source of energy and cannot be used at night times, except the thermal sensor, Optilcal Mechanical Scanner (OMS), Thematic Mapper (TM), High Resolution Visible (HRV), Linear Image Self Scanning (LISS) and Linear Imaging Self Scanning Camera-3 (LISS-3) Sensors .When they are active, or passive, could either be imaging sensors, like a camera , or Sensors which acquire images of the area and non-imaging types like non-scanning radiometers or atmospheric sounders

3.5 Multi Spectral Scanners (MSS):

There are many Types of MSS Scanners these are**:** Optical Mechanical Scanner, Thematic Mapper, High Resolution Visible Linear Image Self Scanning Camera and Linear Imaging Self Scanning Camera .

3.5.1 Optical Mechanical Scanners (OMS):

These of scanners are found onboard Landsat series of satellites of United States America (USA) ; having bands , L1, L2,L3, L4 & L5 and provide line scan type imagery using an oscillating mirror to continuously scan the earth surface perpendicular to the spacecraft velocity**.** Six lines are scanned simultaneously in each of the four spectral bands for each mirror sweep. Spacecraft motion provides the along-track progression of the scan lines. Radiation is sensed simultaneously by an array of six detectors each of four spectral bands from 0.5 to 1.1 micrometers. The detectors' outputs are sampled, encoded and formatted into a continuous digital data.

3.5.2 Thematic Mapper (TM):

This type of scanners is used in Landsat series satellites; namely Landsat’s 4 and 5 which have onboard a new payload called "Thematic Mapper" with 7 spectral bands and ground resolution of 30 meters. This is in addition to the MSS payload, which is identical to those carried onboard Landsat’s 1 and 2 and replaces Red Blue Violet (R BV) payload. The Thematic Mapper (TM) is also an Optical Mechanical Scanner (OMS), similar to Multi Spectral Scanner (MSS); however, being a second-generation line-scanning sensor, it ensures better performance characteristics in terms of:

(i) Improved pointing accuracy and stability ,
(ii) high resolution ,
(iii) new and more number of spectral bands,
(iv) 16 days repetitive coverage ,
(v) high scanning efficiency using bi-directional scanning ,and increased quantization levels.

For achieving the bi-directional scanning, a Scan Line Corrector (SLC) is introduced between the telescope and focal plane. The (SLC) ensures parallel lines of scanning in the forward and reverse directions.

3.5.3 High Resolution Visible (HRV) Image:

The French SPOT-1 spacecraft carries two nominally identical the HRV images, which can be operated independently or in various coupled modes. In contrast to the oscillating mirror design used in the Landsat imaging system, High Resolution Visible (HRV) cameras use Charge Coupled Devices (CCD) array as the sensing element for the first time in space environment. Each of the two cameras can be operated in either multispectral (20 meter resolution) mode or panchromatic (10 meter resolution) mode. The swath covered is 60 Kilometers ; and the cameras can be offseted up to 27 degrees on either side of nadir. Thus any point within a width of 950 kilometers, centered on the satellite track, can be observed by a programmed camera control. SPOT-1 has a stereo coverage capability in orbit with tiltable cameras, which again provide stereo image pairs almost similar to areail photograhs of a metric camera.

3.5.4 Linear Image Self Scanning (LISS) Camera:

The Indian Remote Sensing (IRS) is fully designed and fabricated by the Indian Space Research Organization (ISRO) .The first version was launched on March 17th, 1988 by a Russian launcher. It has four spectral bands in the ranges of 0.45 to 0.86 μm 0.45 to 0.53 μm 0.45 to 0.59 μm, 0.62 to 0.68 μm and 0.77 to 0.86 μm in the visible and near infrared range with two different spatial resolutions of 72.5 meters . and 36.25 meters from an open LISS-1 camera and two LISS-2 cameras respectively. It provides a repetitive coverage every 22 days. Like all other LANDSAT/ SPOT missions which are designed for global coverage, IRS is also in sun synchronous, polar orbit at about 900 kilometer altitude and, like spot, covers a width of 148 kilometers on ground. It uses linear array detectors Charge Coupled Devices.

3.5.5 Linear Imaging Self Scanning Camera-3 (LISS-3):

This camera is configured to provide imageries in three visible bands as well as in short-wave infrared band. The resolution and swath for visible bands are 23.5 meter and 142 kilometers, respectively. The detector is a 6000 element detectors the CCD based on a linear array with a pixel dimensions of 10μm by 7 μm. The detector is placed at the focus of a refractive type optical system consisting of eight lens elements, which provide a focal length of 360 mm. The processing of the analogue output video signal is similar to that of PAN chromatic Camera (PAN). For this camera, a 7-bit digitization is used which gives an intensity variation of 128 levels.

4.6 Remote Sensing Satellites:

There is a number of remote sensing satellites used for various, wide range applications These are:

1. LAND SAT Series
2. MODIS, ASTER
3. SPOT Series
4. IRS series
5. IKONOS
6. LIDAR
7. RADAR

8. SRTM .

The most important and mostly used is the LANSAT servies of satellites , and, them fore, a rief accoeat about theses satellites is givew in the comning section.

NASA, with the co-operation of the U.S. Department of Interior, began a conceptual study of the feasibility of a series of Earth Resources Technology Satellites (ERTS). ERTS-1 was launched on July 23, 1972. It is the first unmanned satellite specifically designed to acquire data about earth resources on a systematic, repetitive, medium resolution, multispectral basis. It was primarily designed as an experimental system to test the feasibility of collecting earth resources data from unmanned satellites. Just prior to the launch of ERTS-2 on January 22nd 1975, NASA officially renamed the ERTS programme as "LANDSAT" programme. All subsequent satellites in the series carried the Landsat designation. So far, five Landsat satellites have been launched successfully; there have been three different types of sensors included in various combinations on these missions. There are Multispectral Scanner Systems (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM). After more than two decades of success, the LANDSAT program realized its first unsuccessful mission with the launch failure of Landsat-6 on October 5, 1993. The sensor included on-board was the Enhanced Thematic Mapper (ETM). To provide continuity with Landsat -4 and -5 the ETM incorporated the same seven spectral bands and the same spatial resolutions as the TM. The ETM's major improvement over the TM was the addition of an eighth panchromatic band operating in 0.50 to 0.90 μm ranges and a spatial resolution of 15 meter. Landsat-7 includes two sensors: the Enhanced Thematic Mapper plus (ETM+) and the High Resolution Multispectral Stereo Imager (HRMSI).

Chapter Four

Geographic Information Systems (GIS)

4.1 Definitions:

(GIS) can be defined as: a computer tool for capturing, storing, querying, analyzing and displaying spatial data from the real world for a particular set of purposes.

There are many other definitions for GIS depending on its components and functions. The United States (U.S) Federal Interagency Coordinating Committee (FICC, 1988) definition stated that “a GIS is a system of computer hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modularity and display of spatially referenced data for solving complex planning and management problems” .Shoba and Ra sappan (2013) say “ GIS has capability of efficient storage, retrieval, integration, manipulation, updating, managing, changing exchanging, combining, analyzing, and presenting geographical and non-geographical information” (Christopher 1988) .

4.2 Overview:

Geographic information systems are an important product of the revolution of information technology, which allow the use and analysis of spatial information in conjunction with connected socio-economic information, and therefore it's an ideal basis for the planning and management of information related to various aspects of life. GIS technology can be used for scientific investigations, resources, management, asset management, environmental impact assessment, urban planning, cartography, criminology, history, sales, marketing, logistics... etc. Its applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations.

4.3 Components of GIS

Actually, the power and comprehensiveness of GIS stems from the strength of its components. Mainly it has five components; hardware, software, data, people, and procedures.

4.3.1 Hardware

GIS needs many types of hardware to satisfy some of its main functions such as data collection, storage, manipulation, and presentation. The heart of GIS is the computer which can be a Personal Computer (PC) or a workstation depending on the volume of data gathered for a given GIS project and the organization of such data. The input and output units are mainly the keyboard and the mouse for , input a monitor for the output . Many types of devices are attached to the computer as input devices such as scanners, cameras, digitizers, and many others. Also printers and plotters of different sizes are attached to the computer as output devices. Network hardwares, such as modems, cables, hubs, bridges and other network devices, are utilized in GIS to share data, software, and hardware.

4.3.2 Software

Several comprehensive software systems are developed and fully support GIS applications. GIS has benefited greatly from the rapid, continuous developments in software systems. Many organizations and companies, concerned with GIS had developed softwares to satisfy different functions of GIS such as those developed by the Environmental Systems Research Institute (ESRI) Arc view, Arc info and ArcGis. Arc GIS is composed of many modules such as Arc Map, Arc Catalogue, Arc Toolbox, Arc Reader, Arc Globe, and Arc Scene. These modules are functioning in an integrating manner for capturing, managing, manipulating, displaying, and analyzing spatial data. There are many other GIS softwares such as IDRISI which had been developed by the Graduate School of Geography at Clark University, Geographic Resources Analysis Support System (GRASS) which had been developed by United States (U.S) Army Construction Engineering Research Laboratories (USA CERL), and Intergraph's Modular GIS Environment (MGE) in addition to many other functional systems.

4.3.3 Data

The efficiency of any GIS scheme depends on the quantity and the quality of data. The expected results of analysis are affected directly by the availability, accessibility, reliability, validity, integrity, and completeness of data (Carver, 1998). Data must be classified in several classes and all data of a particular level of classification, such as roads or vegetation type are grouped into layers or coverage. Layers can be combined in various ways to create new layers that are functions of individual ones. It should be borne in mind that data collection and processing is the most expensive part of GIS and constitute the major expenditure in any GIS project. There are two main types of GIS data, namely, spatial (geographical) data and non-spatial or (attributes) data.

4.3.3.1 Spatial Data:

Spatial data describes the absolute, or relative, locations of geographic features. It is the graphical representation of the geographic locations in a digital form, and it can be classified into two basic data models: raster data model and vector data model. Raster data model known, also, as a grid model is a mathematical model. It is a set of grid of uniform regular cells, where the cell is called pixel. It refers to a picture element, usually rectangular or square, but it may be triangular or hexagonal. The main sources of raster data models are satellite imageries, aerial photographs and a digital image scan of existing maps. Vector data model is a representation of geographical phenomena in terms of the spatial components; consisting of points, lines, areas, surfaces and volumes. Each layer in the vector data model must be composed of only one component. The point is an object of zero dimensions called node or vertex; line is the link between two points which has one dimension called a link or an arc, while an area has two dimensions and composed of at least two arcs called a polygon or face. The geometrical relationships and connections between objects are controlled by topology that is independent of their coordinates. A topology model is based on mathematical graph theory that deals with the geometrical properties and employs nodes and links.

4.3.3.2 Attributes

Attributes are non-graphic data that describe properties of the geographic features or elements represented on the map. Attributes are stored in a table in a manner that each record or row in the table corresponds to a given geographic object on the map, whereas each property is stored in a column or a field. Each object must have an Identity (ID) or access key. The number of columns representing the properties is not limited, but is optionally selected due to the available attributes. The number of columns may be extended by joining several tables automatically using a common field. The first line or row in the attributes table contains the name of the field which must not exceed ten characters. The data of each field must be of the same type of characters and the type can be short integer, long integer, float, double, text and date.

4.3.4 People

Different levels of people from different disciplines are involved to establish a GIS project or organization. People involved in a GIS team depend on the capacity of the organization and the nature of the GIS project. AGIS team may include GIS experts, who advise and solve problems for end users, cartographers, system analysts, computer specialists and people specialized in the field of the project in question e.g. geologists, agriculturists, engineers . A GIS team also include end users, who seek problem solutions and see final products only in the form of maps and reports,and GIS operators of low levels of experience who understand the functions of specific systems so as to manipulate data and data compilers, who understand the data but not the system.

4.3.5 Procedures

Procedures include how the data will be retrieved, input into the system, stored, managed, transformed, analyzed, and finally presented in a final output. The procedures are the steps taken to answer the questions needed to be resolved. The ability of a GIS to perform spatial analysis and answer these questions is what differentiates this type of system from any other information systems. The transformation processes include such tasks as adjusting the coordinate systems, setting a projection, correcting any digitized errors in a data set, and converting data from vector to raster or raster to vector (Carver, 1998).

4.4 Functionalities of GIS:

Most GIS packages provide functions and tools to enable the execution of different operations necessary for a given GIS project. There are main five functions as shown with their relationships in Figure (4.1) below

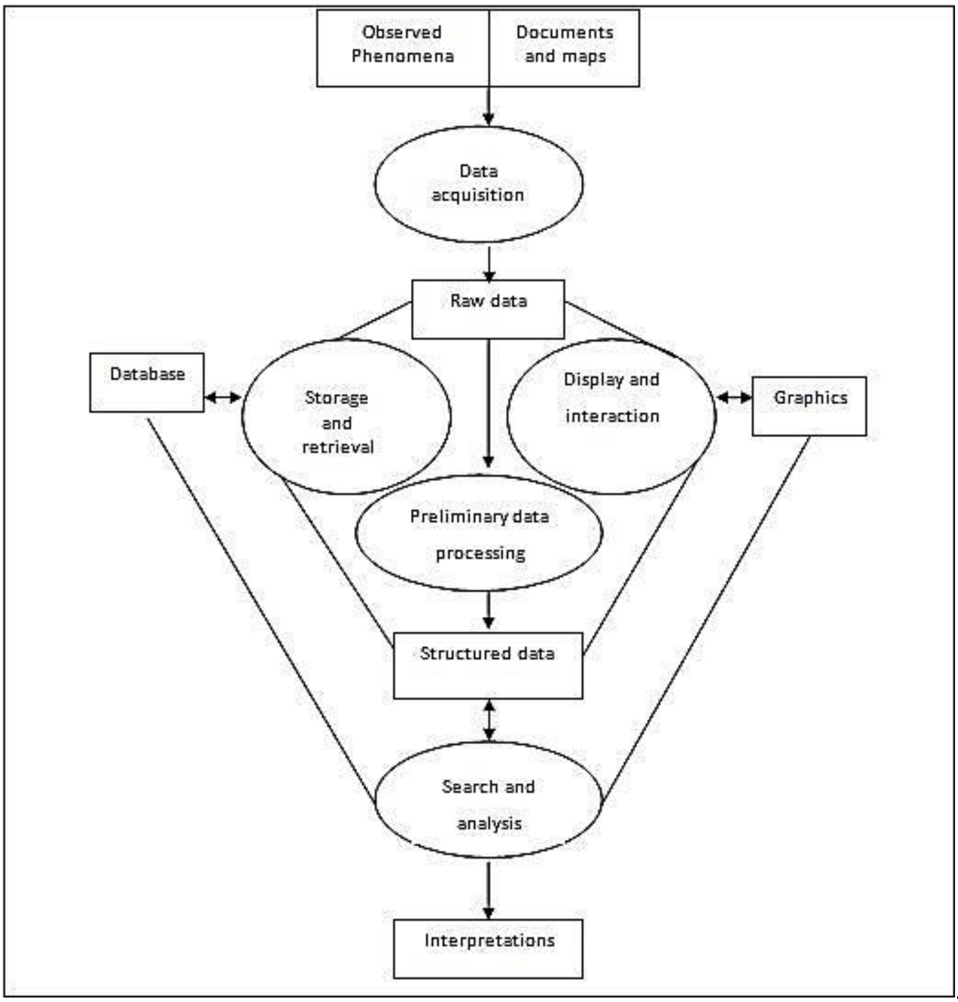


Figure (4. 1): Relationship between GIS functions (Christopher, 1988)

4.4.1 Data Acquisition

All data needed for a GIS project must be transformed from their original source form to the digital form to satisfy the basic requirements of GIS. Data can be obtained from primary data acquisition techniques such as direct ground survey techniques, whether in a digital form or in a hard copy form. Data in hard copy maps, which are secondary data acquisition sources, are transformed to the digital form by digitization or scanning and the resulting format depends on the employed technique. Satellite imageries and aerial photographs are important source of spatial data which can be obtained directly in digital form or scanned from hard copies. Aerial photographs provide spatial data of high accuracy which is suitable for creation and updating of large scale topographic maps while the accuracy of the spatial data obtained from remote sensing depends mainly on the ground resolution. Data acquisition is a critical, time consuming and expensive stage in many geographical information tasks.

4.4.2 Preliminary Data Processing

Preliminary data processing includes creating topologically structured data, classification of remotely sensed data, change of structure of data, coordinate systems and map projections transformation and conversion from raster to vector or vice versa according to the type of analysis tools. The required conversion to a raster data model from a vector data model can be done straight forward by rasterization algorithms while factorization of raster data is more complicated. Data of unknown coordinate systems can be forced by rubber sheet transformation to fit into known coordinate systems data of the same location. Data processing involves the creation of surface models by interpolation techniques to generate contour maps, Triangular Irregular Networks (TIN) or any other relief representation method. Acquiring data from different sources may cause the problem of using two or more classification or coding referring to the same phenomenon. Re-coding must be applied to solve this problem by reclassification to combine several classes to form a generalized less-detailed class.

4.4.3 Data Storage and Retrieval:

The manner by which the data is stored depends on the data model. The storage of vector data model consists of the spatial data or the map and the attribute tables, where every record in the attributes table corresponds to a spatial object or a feature in the map and the fields of the table are the attributes of these spatial objects. Each spatial object must have a unique identifier or access key to link the spatial object to its attributes in the table. The raster data is saved in the computer memory in the form of two-dimensional arrays in which, the coordinates of grid cells, or pixels, are implicit within the row and column ordering of the matrix. The property of this type of storage from a retrieval point of view, that each element can be referred to or addressed directly in terms of the row number and the column number.

4.4.4 Spatial Search and Analysis:

The objective of any GIS project is to use the stored data to make decisions and to solve problems in a particular application. GIS utilizes many functions to carry out searches and analysis to satisfy these objectives, which can be summarized in the following two sections.

4.4.4.1 Containment Search within a Spatial Region:

This is a straight forward spatial analysis to find features or part of features that lie within a given region of space. A rectangular window can be defined to find spatial objects that lie within it.

4.4.4.2 Proximal Search:

There are many types of proximal search. One of them may be regarded as an extension of the spatial containment search, where a zone of specified distance from a particular object is defined. This object can be point, line or area and this zone is called buffer in the case of vector model and spread in raster based systems.

4.4.4.3 Phenomenon Based Search and Overlay Processing:

This type of search may be based on a single phenomenon irrespective of other phenomena or a search for regions that are defined by combinations of phenomena.

4.5 Interpolation and Surface Modeling:

Interpolation functions are performed in sample points taken in a regular distance interval forming a regular grid. The values of the known sample points are used to estimate the unknown values by carrying out an analysis of the correlation function between the sample values and the distance.

4.5.1 Best Path Analysis and Routing:

Network data models, or raster data models, are used to find the best route in terms of cost, length or other criteria. Network data models are used to select a path from already existing paths such as roads and rivers while raster data models are used when the problem is to find a path across terrains that may not have any predefined path.

4.5.2 Spatial Interaction Modeling:

Spatial interaction modeling is used for identifying optimal locations of facilities that satisfy particular requirements or criterion.

4.5.3 Correlations:

GIS analysis is useful to integrate information within spatial region to search for links between events. This type of analysis can be applied to find factors that cause a certain phenomenon for example to find correlation between environmental factors and diseases.

4.5.4 Map Algebra with Gridded Data:

GIS analysis is useful to integrate information within a spatial region to search for links between events.

Chapter Five

Practical Work

5.1 Study Area and Methodology:

The locality of Omdurman lies between longitudes (31° 37′ ,32° 36′) East and between latitudes (15°11′ 30″, 16° 39′ 30″) North is bounded by the western banks of River Nile and the White Nile on the east, the locality of Kararey on the north, the locality of Omdbada on the north – west and Northern Kordofan state On the south west. (Eiman A. Mohammed1, Hanan M. Alawad1, Khalid (January 30, 2015), Urban expansion and population growth in Omdurman city)

5.1.1 Study Area

Sudan _ Khartoum State _ Omdurman as in Figure (5.1)

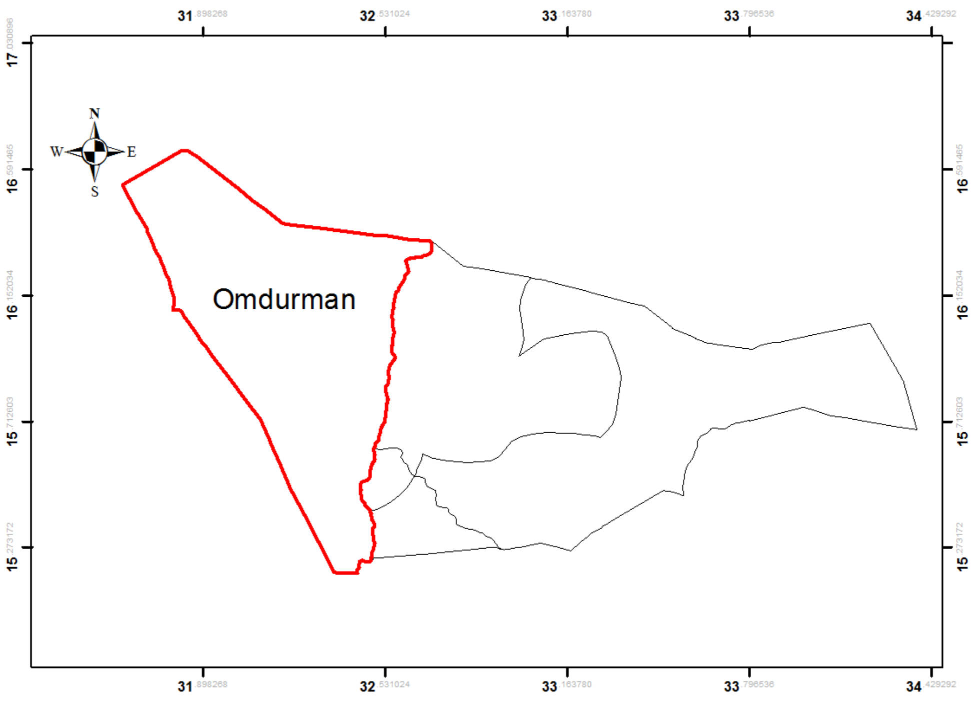


Figure (5. 1): Study Area

5.1.2 Administrative Units:

The locality of Omdurman is branched into eleven administrative units These are: Wadnoobawi, Hai-Alaraab , Almoaraddaa, Central Market , The Great Market, The Public Market, Abuangaa, Industries, Alfitiahaab, Abu-saeed and Alreef Aljanoobi .

5.1.3 Surface Topography:

The surface of the locality is characterized by genetly rolling terrain and the end of the water discharge is generally the River Nile. Omdurman takes this charaterized terrain surface and the land tend to rise from the north west where the highest peak is kararey and ELmurkhiat mountains.There are some velleys at the feet of these mountions which collect rian water during the season of automn from the plane and flat surface area within the locality and discharge considerable volumes of water into Abu-Arga and shambat which ,in turn , discharge these volumes of water into the River Nile sea Figure (5.2).

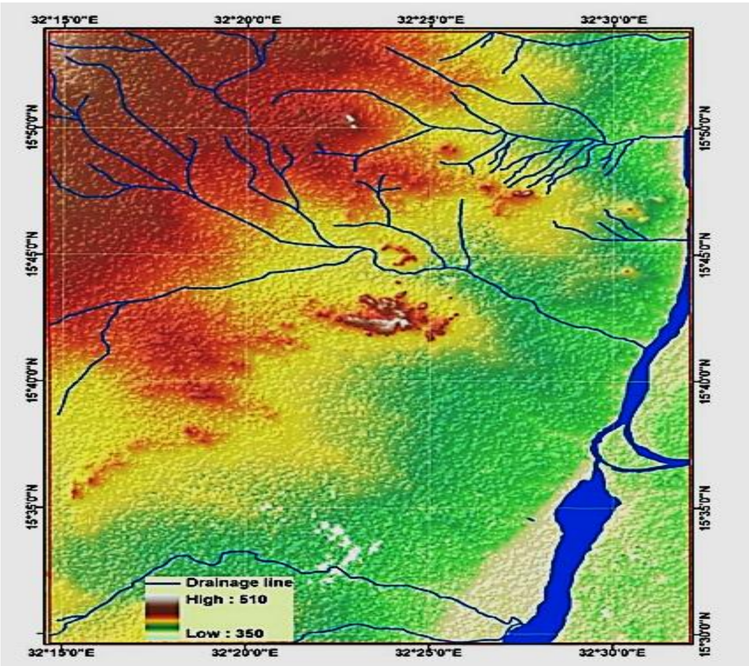


Figure (5. 2): Natural Drainage System of Omdurman Locality .

5.1.4 Geology

There are many geological formations within the locality the main ones are briefly discussed in the comming sections.

5.1.4.1 Basic Rocks:

Basic rocks are found in the northern and western areas and include Alnaess, Granite and Schist that dare beyond primary ancient granite rock formations which formed the water falls.

5.1.4.2 Nubian Grits Formation:

Nubian Grits Formation covers a large part of the area of Omdurman It may began forming at the beginning of the second geological erra ; because of vertical movements. Horizontal matrix layers with a slight slope above the basalt rosks, consisting of aL basalt, which ranges in thickness of the rosk from a few meters to more than 500 meters.

5.1.4.3 The Mud Flats Formation:

The mud flats formation, which is found near the River Nile, formed from the muds carried out by floods and sediment originating from the Blue Nile. This is the share of arable land Omdurman and that there is on the banks of the Nile form the western unity of the northern and southern countryside, where all the grown vegetables and fruits are marketed in the national capital markets.

5.1.4.4 Modern Sedimentary Formation:

This is formed form gravel and washed sand that are found in the northern part of the locality.

5.1.5 Soil:

The importance of soil stems from its influence on the installed chemical and mechanical composites. It furnishes the most appropriate different themes for different types of activities as they come in the introduction of the natural resources which contribute to national economy Because of its importance for economic production

, the soil formation in Omdurman is the modern sedimentary formation which is subject to inundation by floods of the River Nile and change sector sediments . This sediment is found in lands located right next to the Nile on its western side Also , shallow deposits soil in the present age of gravel , and sandstones far away from the river Nile and no part of them is found in the western and southern regions in the semi- desert areas dry soil (the organic material is dried) is found in parts of the western boundary of the locality .

5.1.6 Vegetation:

Building on division of Sudan into regions , vegetation located at Omdurman Locality can be referred to regional scope of the desert and semi-desert area coverd by vegetation is approximately 70% of the total area covered by plants leaving 30% of the area to be covered by plants which consist mainly of sial , sidr , tondob, shade and , decoration trees .

5.1.7 Population:

The Population of the locality grew from about 726,827 in 2001 to 7830,479 in 2006 with an annual increase of 977% . This last figure of population increased to 8363,915 in 2008 with an annual increase of about 7% (Central Census Bereu (CCB), 2008). The built up area in the locality are approximately 5080401at Omdurman , about 150000 at ombedda and kararey about 750000 Table (5.1) and Figure (5.3) show the urban land and percentage of increase between 1987and 2013

Table (5. 1): Summary of the urban land area and percentage of increase between 1987 and 2013

Point	Year	Urban land (Km^2)	Increase %
1	1987	147.7954	-
2	2000	245.5256	66
3	2013	614.9032	150

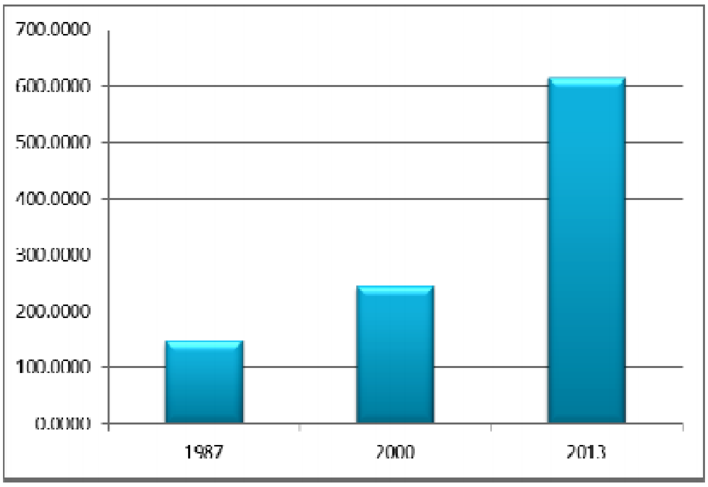


Figure (5. 3): The increase in urban land between 1987 and 2013

5.1.8 Agriculture:

The Agricultural (cultivated and non- cultivated) area is tolal one million fedans.in this area the registered part is almost 954000 fedans.The investered Existing projects within the registered area is dominenently in the east, west and northern parts of the locality covering 30% of the registered area . The most important firms and companies investing in these lands are:

1. Agricultural Production Improvement Company (space of 3,500 fadan).

2. Agricultural Production Developing Company (space of 4,500 fadan).

3. National Bank of Egypt (space of 500 fadan).

4. Sidonks (space of 400 fadan).

5. CTC (space of 400 fadan).

6. Amana Alroad Company (space of 3500 fadan).

7. Agricultural Improvement (space of 400 fadan).

8. Invested Project with an area ranging from small mulit-purpose (10 – 50

fadans), form a total of 2000 projects.

5.2. Data Source:

The study is based on multi-temporal Landsat imageries with path 173/row49 acquired in different dates spaning from 1987, as a bench mark, to 2013 comprising a total time space of 17 years The Landsat data were obtained from the National Center For Research (NCFR). Details of the satellite imageries together with the acquisition dates are provided in Table (5.2) . All of the datasets are orthorectified and registered to a common coordinate system, UTM zon 36N with WGS84 datum.

Table (5. 2): Details of the used Landsat imageries.

Point	Sensor type	Acquisition date	Spatial resolution
1	Landsat 5 TM	November 1987	30m
2	Landsat 7 ETM+	December 2000	30m
3	Landsat 8 OLI	December 2013	30m

5.3 Methodology:

The method used was designed to exploit the multi concept of modern space technologies such as remote sensing and geographical information system as described below: Multi temporal (multi data) analysis by which satellite data for 3 years was used to detect the change in the area through space and time. Landsat images acquired for this area are, TM Landsat (173/49) 1987, ETM+ Landsat7(173/49)2000,OLILandsat8(173/49)2013.

The layer stack was used to get the best bands or combination of bands to identifying the different features on the scene. Georeferencing was used to correct and adapt the image geometrically. Image to map rectification keyboard model through Erdas Imagine 8.5 was used to correct the other images.A subset to the study area was made from the main image, and the result was three sub images to the study area(1987,2000,and2013).

Unsupervised classification was used to distribute the study area into seven classes:

•TheRiverNile
•Agriculturalarea
•Rockland
•urban
•soil
•sand

Normalized Deference Vegetation Index (NDVI) was used based on visual and Digital interpretation. Areas and percentage of the areas affected by sand area in each year were calculated, and then post classification approach was adopted based on map calculation which was applied to determine the dynamic of change in sand encroachment. Geographical Information System (GIS) was used for data capture, input,manipulation,transformation,visualization,combination,analysis,andoutput.

Chapter Six

Results & Discussions

6.1 Results and Discussion:

The main source of information to assess the status of sand encroachment in the study area was based on remote sensing data analysis and interpretation. Supervised classification was performed on TM (1987) , ETM+ (2000) and OLI (2013), to identify and map six main classes shown in Figure (5.5,a,b and c):Thosses water (The River Nile) ,vegetation ,urban, rock ,soil and sand .

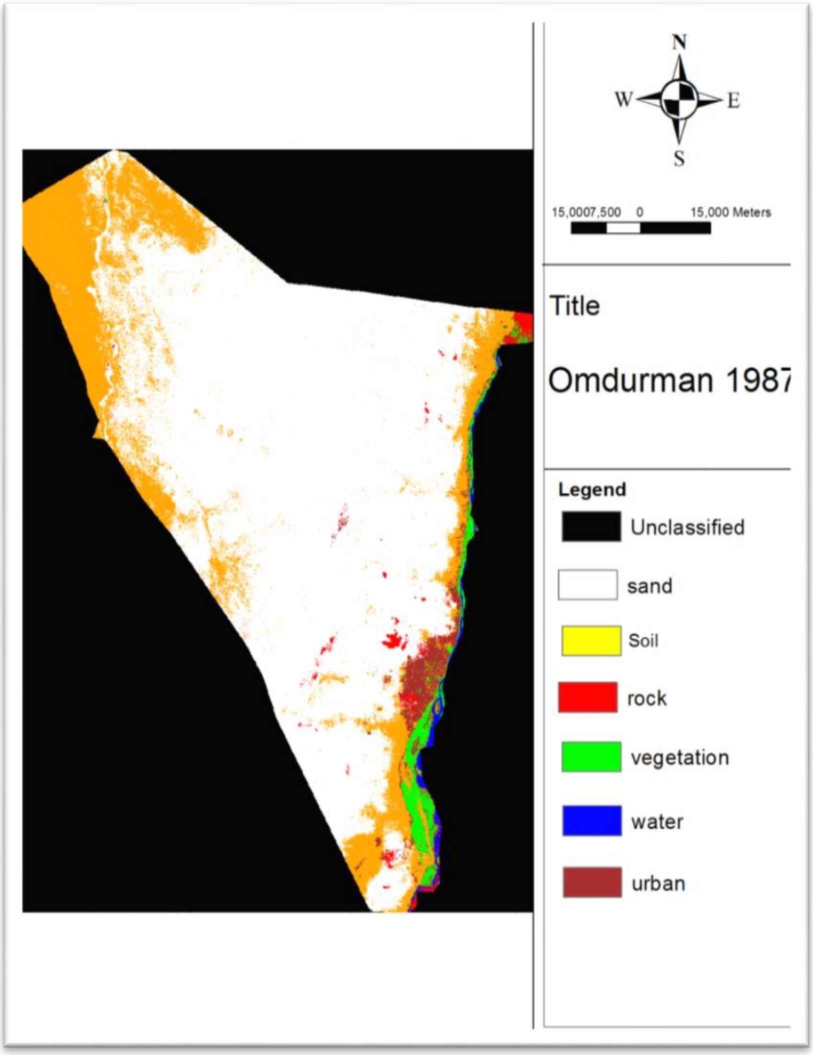


Figure (5. 4) a: Results of the application of supervised classification (Omdurman locality 1987) .

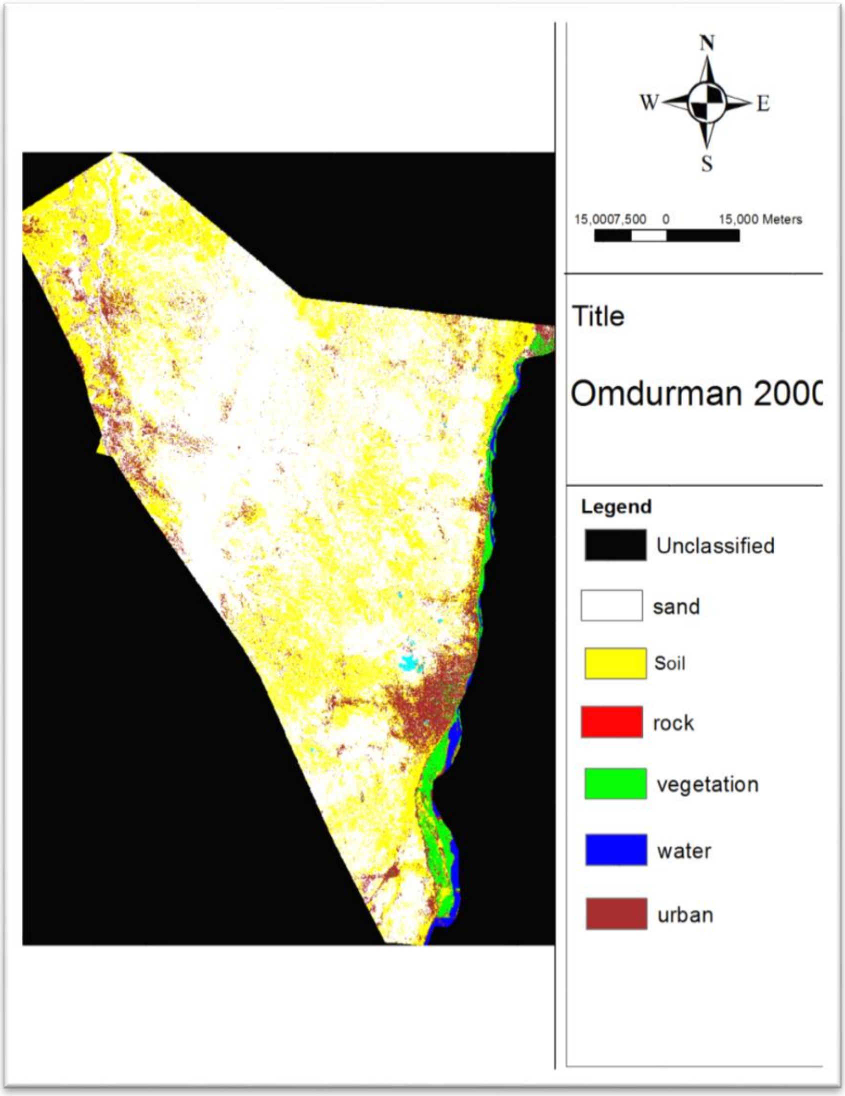


Figure (5.4) b: Results of the application of supervised classification (Omdurman locality 2000) .

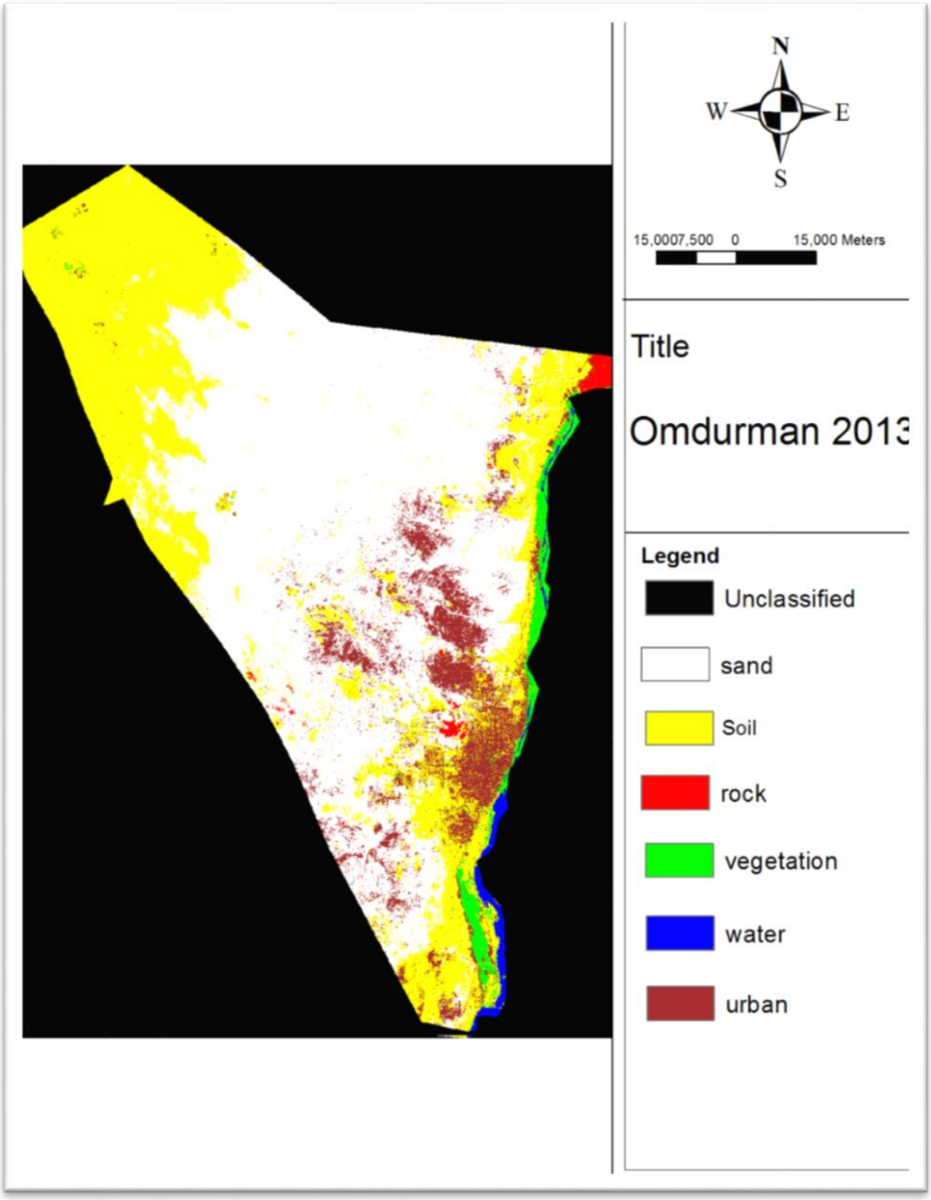


Figure (5.4) c: Results of the application of supervised classification (Omdurman locality 2013) .

Was omitted from the present study and added as a sixth class. From this interpretation, it is possible to state that the sand moved from the northern and eastern parts of the study area towards the Nile River In the year 1987, sand movement is affected by the dominant direction of the prevailing wind (northeasterly wind in winter). The supervised classification results for (TM) 1987 showed that The River Nile ,vegetation ,urban, rock ,soil and sand cover 0.3%, 0.8% ,0.9%, 0.5%, 8% and 32% of the total area, respectively. while(ETM+) and (OLI) the cover an area of (0.3% , 0.8% , 3% ,0.3% , 12% and 27%) and (0.4% , 0.9% ,5% ,0.3% ,14% and 25%), respectively (see Table, 5.3).

Table (5. 3): supervised classification for each Landsat image of the study area

Class	Area					
	1987		2000		2013	
	sq.km	Percentage	sq.km	Percentage	sq.km	Percentage
Unclassified	4116.89	56.3	4077.1	55.7	4017.2	54.9
Urban	68.3	0.93	223.1	3.01	346.7	4.73
Vegetation	61	0.83	57.1	0.8	64.8	0.89
Water	20.25	0.28	26.4	0.36	29.2	0.4
Rock	23.6	0.32	25.01	0.34	36.6	0.5
Soil	621.6	8.49	885.7	12	991.4	13.52
Sand	2388.5	32	2017.8	27	1838.9	25

The supervised classification results for TM 1987 and OLI 2013, showed that stabilized sand dunes cover 32%, 27% and 25% of the total area, respectively as shown in Table (5.4)

Table (5. 4): Percentage of decrease in the sand area between 1987, and 2013

Point	Year	Sand	Percentage
1	1987	2388.5	32
2	2000	2017.8	27
3	2013	1838.9	25

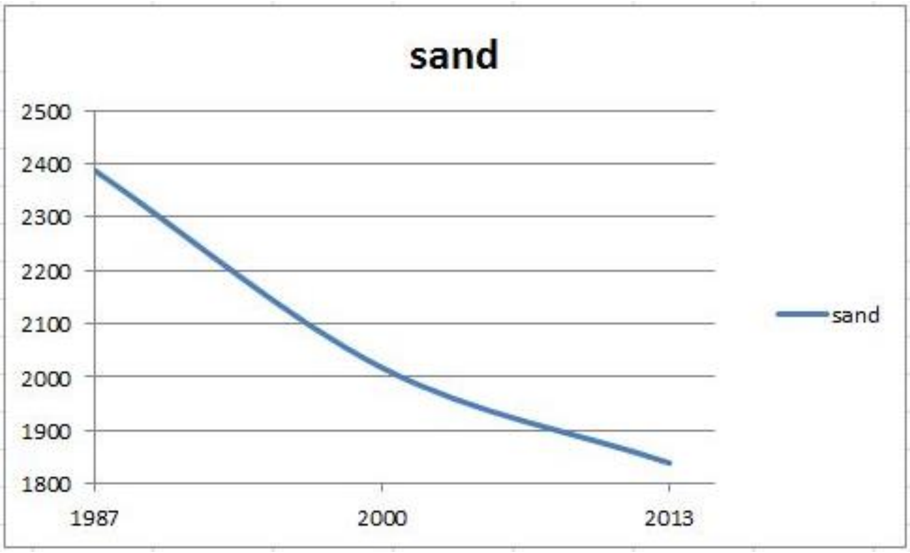


Figure (5. 5): The decrease in sand area between 1987 and 2013

Form Table (5.4) it can be seen that there is decrease in sand encroachment .This is drawn form that urban development and areas covered by vegetation increased with in the specified time span (1987 and 2013).

Chapter Seven

Conclusions and Recommendations

7.1 Conclusion:

1. The integration of Remote Sensing and (GIS) prove to be a reliable tool to monitor the sand encroachment processes.

2. Form Table (5.4) it can be seen that there is no increase in sand encroachment.but decrease This is drawn form that urban development and areas covered by vegetation increased with in the specified time span (1987 and 2013).

7.2 Recommendations:

1. Detailed studies should be carried out to cover different aspects of soil, vegetation cover, irrigation, etc. more deeply and to emphasize combating sand encroachment.
2. Use of the remote sensing and GIS integrated tools to measure chang and desertification in the aera.

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