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Monitoring Desertification in Badra Area Eastern Iraq by Using Landsat Image Data

A THESIS SUBMITED TO THE COLLEGE OF SCIENCE UNIVERSITY OF BAGHDAD, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN GEOLOGY (REMOTE SENSING)

By
Ammar Abd Jasim AL-a'araage

B. Sc. in Geology, Baghdad University, 1999

Supervised
By
Dr. Wiled Abdul-Majeed Ahmad

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Examining committee decision

We the examining committee certify that after reading thesis entitled (Monitoring **Desertification in Badra Area Eastern Iraq by Using Landsat Image Data)** and examining the student **(Ammar Aba Jasim Al-Aaraage)** in its contact, we think in our opinion it is adequate with standing as a thesis for the Degree of Master of philosophy in Geology (Remote Sensing).

Chairman
Signature:
Name: **Mazin Y. Tamar-Agha**
Title: Professor
Address: Department of geology
University of Baghdad
Date: / /2012

Member
Signature: A.S.M
Name: **A. S. Mahdi**
Title: Assistant Professor
Address: College of Science
University of Baghdad
Date: / /2012

Khalid
Member
Signature:
Name: **Khalid I. Hassou**
Title: Senior Scientific Researcher
Address: The Ministry of Science and Technology
Date: / /2012

Advisor
Signature:
Name: **Wiled A. Ahmad**
Title: Assistant Professor
Address: College of Science
University of Baghdad
Date: / / 2012

Approved by the University Committee on Graduate Student:

Signature
Name: **Dr. Saleh Mahdi Ali**
Title: Professor
Address: Dean of the College of Science
University of Baghdad
Date: / /2012

SUPERVISORS CERTIFICATE

The Preparation of this thesis entitled

"Using Landsat Image Data in Monitoring Desertification in Badra Area Eastern Iraq"

By Ammar Abd Jasim, was made under my supervision at the College of Science, University of Baghdad-Iraq in partial fulfillment of the requirement for the degree of Master of Geology Geology (Remote Sensing).

Supervisor Walid A. Ahmad
Signature:
Name: Dr. Waleed Abdul-Majeed AL-Kaessi
Title: Assistant Professor
Address of: University of Baghdad / College Science
Date: / /2012

Approved by the Head of the Department of Geology

Signature: Ahmed Sh. Al-Bann
Name: Dr. Ahmad Shehab Al-Banna
Title: Professor
Occupation: Head of Department of Earth science / University of Baghdad / College Science
Date: / /2012

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AMMAR
2012

بسم الله الرحمن الرحيم

ظهر الفساد في البر والبحر

بما كسبت ايدي الناس

ليذيقهم بعض الذي عملوا

لعلهم يرجعون

صدق ألله العظيم

الروم (41)

DEDICATION

TO

MY PARENTS, MY WIFE

AND

CHILDREN

ABSTRACT

One of the most important recent issues facing Iraq as well as the world is the threat of continued land degradation and desertification, as a result of climatic factors and human activities. Remote sensing and satellites imageries play a major role in developing a global and local operational capability for monitoring land degradation and desertification processes in dry and semi-arid lands.

The study area is situated at Badra city Wasit Governorate, in the east part of Iraq, 180 km southeast of Baghdad. Its area is approximately 3500 square kilometers. Remote sensing and digital image analysis are applied to monitor desertification processes in the area for the period from 1976 to 2007. Four Landsat images covering the study area for the years MSS 1976, TM1990, TM2000 and ETM+2007 scenes, in addition to the ancillary data (such as topographic maps and climate data) have been used. Field observations are used to evaluate the potential of using remote sensing analysis in desertification processes monitoring.

The Normalized Difference Vegetation Index(NDVI), Salinity Index (SI), and Water Body Index (WI) , are used to identify the vegetation cover, water and saline land cover, and its changes which have taken place over the periods from 1976 to 2007. Two methods for changes detection are used in this study. Firstly, direct detection of change in indices images between different years analyses by use of visual interpretation in addition to statistical analysis. Secondly, change detection analysis by use Normalized Difference Vegetation Index (NDVI) is applied to determine and analyzes the vegetation cover changes over the four periods. Supervised classification is used for land use land cover (LULC) classification, five main land use land cover classified map are prepared (vegetation, water, wetland, Saline land and bare land).

The results of The Normalized Difference Vegetation Index(NDVI), Salinity Index (SI), and Water Body Index (WI) show the changes rate of desertification process and land degradation during the periods 1976 and 1990 , to be positive, while the rate of change for the period 1990 to 2000 and 2000 to 2007 are negative. The period 1976 and 2007 represent heavy damage and threats of desertification process, while 1990 shows positive statues and re-growth period. The change detection analysis by use Normalized Difference Vegetation Index (NDVI) shows the central part of the study area to be classified as severe of desertification and the other part is subjected to desertified. The results LULC classification show the bare land area is the largest land use and land cover classes in the study area which cover more 93% of the study area, and there are limited amount of water and vegetation land in the study area compared with its total size.

AOI	Area of interest
ASTER	Advanced Space borne Thermal Emission and Reflection Radiometer
AVHRR	Advanced Very High Resolution Radiometer
CCRS	Canada Center for Remote Sensing
CIR	Color infrared
CVA	Change vector analysis
ERDAS	Earth resources data analysis system
ETM	Enhance thematic mapper
ESRI	Environmental system research institute
GIS	Geographic information system
LULC	Land use and land cover
MSS	Multispectral Scanner
MODIS	Moderate Resolution Imaging Spectroradiometer
NDVI	Normalize differentiation vegetation index
NASA	National aeronautics and space administration
SAR	Synthetic aperture radar
SPOT	Satellite Pour Observation Terre
SRTM	Shuttle radar topography mission
SST	Sea-surface temperature
TM	Thematic Mapper
UTM	Universal transverse macerator

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CHAPTER ONE

INTRODUCTION

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INTRODUCTION

1.1 Overview

Some researchers consider desertification to be a process of change, while others view it as the end result of a process of change. This distinction represents one of the main points of disagreements concerning the concept of desertification. When it is considered to be a process, desertification has generally been viewed as a series of incremental changes in biological productivity in arid, semi-arid, and subhumid ecosystems, When considered as an end result, desertification refers to the prevalence of desert-like conditions in areas once green.

Although dozens of definitions exist, one point on which they all agree is that desertification is to be viewed as an environmentally adverse occurrence. Glantz and Orlovsky 1983 reviewed various definitions focusing on the form of change: desertification considered to be a deterioration of ecosystems (e.g. Reining,1981) , the destruction of biological potential (e.g. UNCOD, 1978), a reduction of productivity(e.g. Kassas, 1977), a decay of a productive system (e.g. Hare, 1976), an alteration in biomass(e.g. UN Secretariat, 1977), an intensification of desert conditions (e.g. Meckelein, 1980), or an impoverishment of ecosystems (e.g. Dregne, 1976). Some other definitions focus on what is changed in the soil; (e.g. salinization), vegetation (e.g. reduced density of biomass), water (e.g. Waterlogging), or air (e.g. increased albedo).

There is no consensus regarding the areas where desertification can take place. Many researchers identify arid, semi-arid , and subhumid areas as places where desertification can occur or where the risks of desertification are highest. Others refer to the extension, encroachment, or spread of desert characteristics into non-desert regions. With respect to the factor of time, some definitions refer to desertification as a permanent process. Others imply that desertification may be reversible, because the term “irreversible” is generally used in reference to situations in which the costs of reclamation are greater than the return to be expected from a known form of land use.

The mentioned above review of definitions shows that defining desertification conveys some impression of the difficulties involved in arriving at a definition of desertification. The following discussion examines some aspects that should be taken into consideration in suggesting a definition of desertification in arid and semi-arid areas. While distinguishing between desertification and land degradation is still difficult, it is made easier by the following criteria (Nasr, 1999) :

- Pure desert must be considered dry-lands with no plants and organic matter in the soil. Thus, pure desert areas should not be considered desertified.
- It is necessary to distinguish between desiccation (long-term drought) and desertification. The term drought is used to refer to an inter-annual fluctuation in precipitation in which there is a relative lack of rainfall for a period of one to four years, whereas desiccation is used to denote a protracted drought that has continued for a decade or more and may be considered a kind of climate change.
- It is also necessary to distinguish between desertification and land degradation. Land degradation refers to a decline in the long-term productive potential of soil (Lal,1994; UNEP, 1982; UNCED, 1992).
- Net degradation occurs whenever degradation processes significantly exceed nature’s restorative capacity. One obvious indicator of land degradation is a continuous decline in soil productivity (production per unit land), but a decline in one year followed by increase in the next is not indicative of land degradation.

There is still a good deal of confusion regarding the definition, diagnosis, and measurement of desertification. The following definition of desertification was agreed to be the world's leaders at the 1992 Earth Summit and adopted by the United Nations Convention to Combat Desertification (UNCCD): "Land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities (UNCCD,1999). This definition is now widely regarded to be the authoritative definition of desertification.

The definition proposed by the UN Convention on Desertification (UNCOD), desertification is considered the result of a series of natural and anthropogenic processes, leading to gradual environmental degradation or loss of the land's biological or economic productivity (UNEP, 1994). Since UNCOD held in 1977 desertification has variously been viewed as one of the most pressing environmental issues affecting human kind (UNEP, 1987).

The increasing rate of desertification on a global scale is one of the most pressing concerns among environmental scientists and laymen since it implies a clear manifestation of climatic change processes and human interaction on the environment (Collado et al., 2002). By the UNEP classification system, 41% of the Earth's land area is hyper-arid , arid , semi-arid or dry sub-humid (UNEP, 1992). UNEP estimated that 69% of the drylands, excluding the hyper-arid deserts, were already moderately to severely degraded by 1992 (Dregne et al., 1991).From about 900 million inhabitants of drylands 135 million are considered at risk of collapse of their traditional land use systems and episodic mass starvation continues to be a problem in Africa (Lean, 1998).

Several geostationary and polar-orbiting satellites (e.g., METEOSAT/GOES , NOAA-AVHRR, LANDSAT , SPOT-HRV and - VEGETATION, IKONOS) are available which operate in the reflective and emissive domain and offer considerable potential, besides airborne systems for individual surveys on local to regional scale . The various data sources available through remote sensing offer the possibility of gaining environmental data over both large areas and relatively long-time periods. Remote sensing systems, and in particular Earth observation satellites, provide significant contributions to desertification assessment and monitoring, particularly by providing methodological pathways for scaling up the results of field investigations and by supplying the spatial information needed for regional scale analysis of the relationships between climate change, land degradation and desertification processes

1.2 The aim of study

This study is dealing with assessment of desertification problem. It will concentrate on analyzing the desertification levels in the study area and effective of desertification in this area and impacts on the live. The aims of this study are as follows:

-To illustrate how satellite remote sensing data (Landsat MSS, TM and ETM+) can be used to study and monitor desertification.

-To quantify and analyze the extent of the area affected by desertification in the study area.

-To illustrate several concepts to studying desertification phenomena in arid environments using computer aided analyses and software (ERDS 9.2 and GIS 9.3).

-To develop a decision tool to evaluate the degree of desertification in study area and combat it.

1.3 Problems and Indicators Related to Processes of Desertification

Problems posed by land degradation processes can hardly be generalized across landuse zones. Land degradation problems differ in range-land, rainfed, and irrigated areas. According to UNEP, the main desertification problems in range-land areas are: overgrazing, shrub clearing, soil erosion, and cultivation. In the desertification of rainfed areas, soil erosion is the principal problem. The main desertification problem in irrigated agriculture is salinization or alkalization (Nasr, 1999).

A- Overgrazing refers to the practice of allowing a much larger number of animals to graze at a location than it can actually support. This includes: (a) selecting inappropriate times for grazing, often too soon after the beginning of rainfall, (b) overstocking, (c) failing to actively seed, and (d) failing to adjust existing or traditional land-use and grazing rights. The main indicator of overgrazing is the (disappearance of range-lands) because animals usually eat the most palatable plants first and the least palatable ones last, thus selecting and ensuring the dominance of relatively unpalatable species.

B- Shrub clearing is caused by the practice of constantly using woody plants as a source of energy for human needs. A visible indicator of shrub clearing is the “disappearance of shrubs” in areas that can support woody vegetation.

C- Soil erosion results from the uprooting of shrubs, which leads to the destruction of the soil structure and thus to accelerated erosion of the soil by wind and water. Soil infiltration of rainwater decreases, and surface runoff increases. One clear indicator of soil erosion is the formation of drought watercourses in the depressions of Valleys.

D- Over-cultivation of food or field crops in areas that ought to have been used only for grazing over a long time of period. The soil structure is destroyed by ploughing , particularly in dry years, because the surface remains bare of vegetation. A clear indicator of rainfed cultivation in an area that should actually be used for grazing is the occurrence of (dust storms), which means a reduction of range-land at the cost of arable land.

E- Salinization is the main desertification problem in irrigated agriculture. Salinization involves a number of interrelated processes occurring in the soil, for example waterlogging, increasing salt content, and alkalinization, in which some nutrients can no longer be absorbed due to the increasing PH-value of the soil. This problem is caused by the overuse of water through unsuitable irrigation techniques, accompanied by inefficient drainage systems. This type of desertification is to be seen in some of the irrigated agriculture in Iraq.

1.4 Indicators of Desertification

According to Reining (1978) and Enne and Zucca (2000), the process of desertification manifests in many ways which could be used to assess the magnitude of degradation as also the vulnerability of an ecosystem to desertification. By indicator is meant something that provides information about the condition being investigated (FAO/UNEP, 1984).

The indicators may be grouped into the following (Reining, 1978):

I- Physical Indicators:

- Aridification
- Degree of salinity and alkalinity
- Groundwater table and its quality
- Depth of soil above root-inhibiting layers
- Presence of crust
- Amount of organic matter in soil

- Changes in water flow and sediment run-off
- Water and wind erosion affected areas
- Relative reflectance of land/Surface albedo

II- Biological/Agricultural Indicators

- Change in perennial plant cover (during the dry season)
- Above ground biomass of vegetation
- Yield of crops
- Distribution and frequency of key plant species
- Population of domestic animals
- Animal herd composition

III- Social Indicators

- Land use pattern (e.g. Pastoralism; Mining; Firewood)
- Settlement Pattern (e.g. new settlement; Expansion of settlement; Sedentarisation).
- Human biological parameters (e.g. Population number; Measures of nutritional status)
- Social process parameters (e.g. Conflict; Migration; Marginalization).

❖ **Indicators used in this study:**

1. Aridification.
2. Degree of salinity.
3. Changes in water surface.
4. Change in plant cover.
5. Relative reflectance of land/Surface albedo.

1.5 Monitoring Indicators of Desertification Processes by means of Satellite Systems

Efforts to monitor, desertification have always been subject to the criticism as there is a big discrepancy between the time frame of human monitoring activities and the time frame of desertification processes. What we have to study is not the changes that take place in a single year, but the changes that occur during a long time-series. Due to the lack of data and information on the real magnitude of desertification and its changes over time. It has been expedient to carry out this study with the aid of satellites in view of their multispectral properties , which enable them to use thermal imaging techniques to represent vegetation cover.

1.5.1 Resolution of Existing Satellites

The first satellite to be launched successfully was the Soviet SPUTNIK, which went into orbit in 1957. Today, almost 10,000 satellites are being used to serve the earth and/or study the environment. The spatial resolution of satellites ranges from high-resolutions capable of imaging objects only 0.5 meters in size to low resolutions covering tens of kilometers. The temporal resolution ranges between geo-stationary satellites and those that cover a certain strip of area every 10-16 days. The spectral resolution ranges between long-wave infrared (IR) and ultra-shortwave (UV).

1.5.2 Advantages of Satellites for Data Collection

In regard to the collection of Desertification data, satellite remote sensing systems have the advantages that they can provide both regional and global data, use their unique sensing capabilities to monitor changes ranging in duration from half an hour to many years, and process the data collected for the purposes of comparison.

1.5.3The Most Well-Known Satellites

The most well-known satellites are : (a) the LANDSAT-TM series, which incorporate a thematic mapper (TM) and multi-spectral scanner (MS), and work at scales from 1:50,000 to 1:1,000,000, (b) the weather satellite METEOSAT, and (c) NOAA satellites, which provide an overall views of the earth through images made in the red (-R) and near-infrared (NIR) ranges, i.e. in the range of thermal radiation. In 1985, the FAO of the United Nations commissioned the establishment of a Global Information and Early Warning System (GIEWS) for natural disasters such as droughts, floods and earthquakes, and later formed FAO's Rome-based Remote Sensing Unit (FAO RSU).

1.6 Desertification as a Global Problem

The livelihoods of more than 1.2 billion people are at risk and over135 million may be in danger of being driven from their land as a consequence of desertification. Desertification is land degradation in arid, semi-arid and sub-humid areas and damages today over 30% of the total land area of the world. (Common Information Space of the UN Organizations in Bonn).

Desertification is both a local as well as a global challenge. It has underlying causes in poverty affecting millions of local communities and populations. Its manifestations on the other hand go beyond national boundaries, affecting regional and international waters, global biodiversity and climate change. for this reason effective combat against desertification must involve all concerned stakeholders at national, sub-regional , regional and global levels; it must involve the states, private sector, civil society and the communities themselves; and it must be an integral part of the overall strategy for sustainable human development.

Desertification constitutes one of the global international environmental problems the world is facing. It has been recognized as a problem of significant importance since the early1970 but the international community has never given it its full attention and commitment. In particular, adequate financial resources have not been forthcoming, partly because the impacts of desertification in any given region don't spill over to other regions. The international community has addressed the threat of desertification through a convention negotiated at the level of the United Nations. It constitutes a significant effort to mainstream desertification but remains peripheral instrument with rather weak commitments.

Desertification constitutes one of the global problems whose its global importance has been recognized by the international community. This importance is clearly visible in the massive endorsement that states have given to the United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification.

Desertification is a problem that affects over all the most of regions of the world in developed and developing countries but Africa and Asia, the continents with the largest number of least developed countries, is the regions that suffers most from desertification. Desertification is perceived differently from other global environmental problems such as climate change mitigation or biodiversity management. This is due in part to the fact that the negative impacts of desertification are confined to a given region and do not affect directly all countries. It is nevertheless slowly being recognized that land degradation in drylands is, for instance, a significant vector of biodiversity loss.

Desertification is even more closely associated with the development process insofar as it impacts on peoples livelihoods much more directly than other environmental problems. In particular, there are close links between desertification and food production. Given that the satisfaction of basic food needs for an increasing world population constitutes one of the central challenges of environmental management in the coming years, the loss of productive land is of major concern in a world where hundreds of millions of individuals already go hungry today.

An exact assessment of the extent of desertification remains elusive both because of the difficulties involved in measuring it and because of the different definitions used over time. However, it is estimated that about 40% of the total land area of the world or 6.1 billion hectares is dryland and that 15% of these drylands (1 billion hectares) are hyper-arid deserts. The greatest impact of desertification is in the African continent where dryland, including hyper-arid deserts, comprise about two-thirds of the continent. It is significant that the 5.1 billion hectares drylands that are not hyper-arid deserts support about a fifth of the world population.(Figure 2.1)

The Arab states , by virtue of its geographical location, one of the most arid regions with fragile ecosystems, where climate plays an important role in the composition. However, the negative effects of this phenomenon are becoming more widespread at a rapid rate due to the high temperature resulting from global warming. Desertification and sweep the Arab territories at a time when the high proportion of agricultural and livestock production to meet population growth and rising standard of living is very urgently needed. It also estimates that the United Nations Environment value lost productivity each year in developing countries due to desertification 16 $ billion.

It should be noted when you look at the evolution and spread of desertification is that many of these desertified land threatened by desertification or located throughout the Arab world. Recalling some of the figures that about

18% of agricultural land or arable become a reality under the influence of desertification. In Sudan, for example but not limited to, advancing front line of desertification rate of 90 to 100 km per year, and 1% of irrigated land in Iraq become salt land per year or become as desertified land. In Syria, the convergence rate of saline land 50% of agricultural land. (http://www.dwworld.de/dw/article/0,,1571216,00.html).

Recognizing that the face of desertification is a global responsibility, the United Nations drafted a treaty to combat the spread of desertification. This treaty became valid on December 26 / December 1996, when ratified by at the time, 60 countries, bringing the number later to more than that. It is worth mentioning here is that this Treaty intended to compel the States concerned to perform actions on the ground to combat desertification and protect the environment and natural resources.

In order to monitor the implementation of these measures held the competent UN Committee monitoring the application of this Treaty meeting periodically. In addition, the phenomenon of desertification has started to take an important place on the agenda of concerns of the United Nations, which has allocated the 2006 World Year of combating desertification.

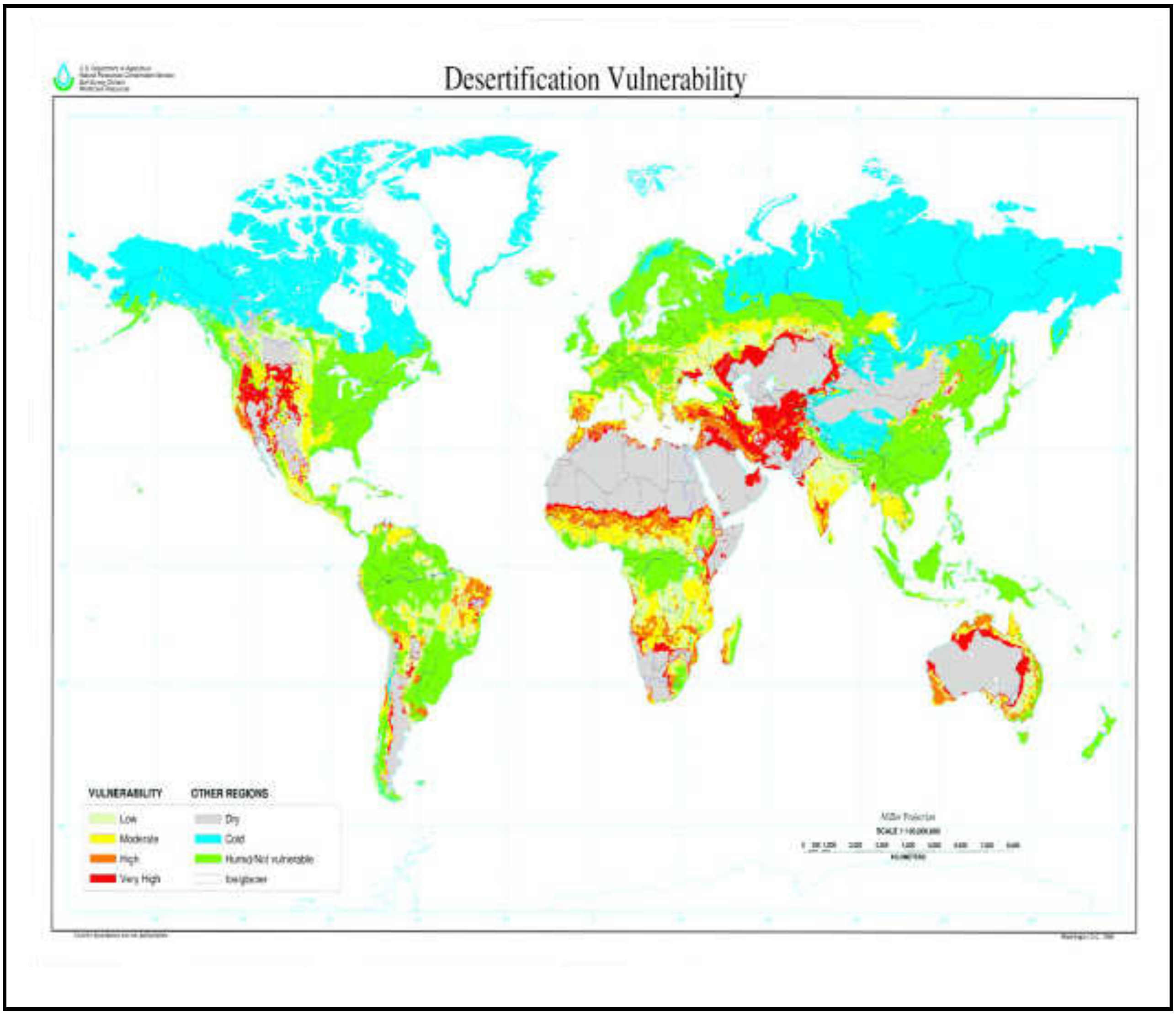


Figure 1.1: The Desertification Vulnerability map is based on a reclassification of the global soil climate map and global soil map, and the source of map from http://soils.usda.gov/use/worldsoils/mapindex/desert-map.zip ,1998.

1.7 The desertification in Iraq

Iraq faces the biggest environmental problem in its history which is the massive desertification which puts the food security at risk. Many natural and human factors meet in causing desertification, and have the results of environmental, economic, social and cultural consequences most notably the loss of productive land and the movement of sand dunes and blowing sand and severe dust storms and the resulting increase in air pollution. Since 1981, this percentage is mainly due to military operations, which destroyed both the soil and plants and have had negative consequences on the environment (Website of Syrian Geographical Society. http://www.geosyr.com/vb/t446.html). It is known that 90% of the area of Iraq is located within the area of dry and semi-dry climate, where the rate of drought as least coefficient is fixed at about 20 degrees, and temperatures rise in summer to the extent of 52 C° with a high rate of evaporation of up to 2000-3000 mm especially in the Mesopotamian plain and the number of sunny days at the rate of up to 260 sunny days. And the prevailing winds in Iraq is the northwesterly winds which are hot and dry and spreading dust in summer. The estimates of specialists are that more than four million acres of dunes moving in the central and southern Iraq, causing the landfill of strategic projects, such as roads , railways , irrigation and drainage and agricultural land, and cause the dunes moving to raise the dust storms that threaten human health.

Iraq’s arable land suffers from severe degradation due to poor administration and the inadequacy of the techniques used as well as practices. Erroneous and / or harsh natural conditions cause the rise in saline land, particularly alkaline salt (50%), land with high salinity is 4% of the total arable land compared to 26% of the land is saline. This confirms Iraq has a serious environmental problem of desertification. The roots of this problem is exacerbated after 1990, when the amount of land affected by salinity increased to 3.1% and the significant deterioration which happened in the vegetation, let alone increase in areas covered by mobile sand dunes (0.6%), was a result of land degradation and wind and water erosion (38%), and the military operations of the wars fought by Iraq. The estimated statistics of the Ministry of Environment in 2007 that the proportions of land affected by the forms of desertification are high and varies according to its causes. Some sources confirm that the case indicates that the reality is worse than the declared figures, but the absence of exact data and mechanisms for monitoring and measurement deepen the environmental situation in general and desertification in particular (Ministry of Planning in Iraq / National Development Plan for the years 2010 – 2014).

Examples of desertified areas in Iraq, the province of Babylon are in the area of the (Shomali area / Midhtahia area), in the province of Salahalddin (Tikrit and Baiji area), in Diwaniyah province in (Afak area), and (Anbar province) most of the territory of Al-Anbar province is desert due to the degradation of vegetation due to lack of rainfall and overgrazing and logging, in the province of Theiqar in southern Batha area center of Nasiriya province to Basra province. In Basra province, the degradation of vegetation cover due to overgrazing and logging, and some of the sand dunes, and this applies to the Wasit province also, in Ninawa province, Al-hadar area and Alsakhna area and Abu adal, in the province of Karbala, most of desertified land is in the province Alkrt area , Ean -Altamr area and Razaza area with areas of 26 km^2, in the province of Muthanna, 2800 acres land desertified, in the AL-Kadar area, which are a desert area exposed to soil erosion and the sand is mobile and fixed because of the lack of green belts (Environmental Statistics Report for the year 2006, the Ministry of Planning, Baghdad, 2007)

Therefore the problem of desertification is the biggest environmental problem facing Iraq today, ministries government a should work to combat desertification through the study of the problem and develop serious solutions and benefit from the experiences of other countries that have suffered from such problem , and must also work to increase the green cover by increasing the cultivated areas and the adoption of modern irrigation methods such as drip irrigation or using sprinklers for rationing water lost as a result of irrigation by the old ways that are still based in Iraq that no longer served the needs agricultural and lead to waste in the water that suffer from squeeze due to lack of water resources of Iraq.

❖ The most important causes of desertification in Iraq

There are many reasons that helped the spread of desertification in Iraq. The most important of those reasons are:

1- Climate change: the most important of which is global warming, which poses a threat to all life on earth such as natural disasters, devastating floods, Hurricane, and the other threatens of drought and desertification in many areas, including Iraq. It is well known that a temperature in Iraq rises to the fifties in summer which increase the percentage of evaporation. Low rainfall, where no more than average rainfall 40 days per year in the south and 70 days per year in the north (http://www.aljazeera.net/NR/exeres/2765CBCE-F093-4F21-8337-D3A328 C0B880.htm).

2- Drought, which is due largely to two things, first the lack of rain especially in last years since 1991. Rain has a significant impact on the occurrence of drought and desertification and thus dust storms. The second reason for the drought is the lack of the waters of the Tigris and Euphrates, which had a negative impact on agriculture, and these two reasons in the basis for the spread of desertification. Experts in the eighties had expected that the drought will happen to the Second Decade of the third millennium after 2010, but drought previously expect due to lack of rainfall and low water of the Tigris and the Euphrates in Iraq.

3-Increase in dust storms in Iraq due to a lack of vegetation and lack of rain, and the other reason is the overgrazing of the shepherds. There are areas where the plant must reach to a certain stage of growth or a certain height to suit the grazing. There is another reason to repeat the sand storm is the deforestation and cutting of trees continued.

4- Migration of farmers from their farms because of lack of water and irrigation projects, the lack of modern methods of agricultural development and the lack of support and government assistance. All these reasons have helped the absence of the right opportunities for agriculture and the spread of desertification and the elimination of vegetation cover in Iraq.

5-Salinization of land in Iraq is the phenomenon of degradation or desertification of land in the Mesopotamian Plain as a result of the accumulation of dissolved salts such as chlorides and sodium sulfate, calcium and magnesium (which move from their different formation sources by different factors of transport under the natural conditions prevailing, dry climate and topographical conditions and hydrological soil in addition to the activities of man such as agriculture and irrigation).This accumulation of salts in soils reaches to the maximum extent in the surface layer of the soils and the roots, causing damage of plant that lead ultimately to its death, which leads to the emergence of other types of desertification of the land as a result of loss of vegetable cover. In Iraq, the problem of salinity and soil salinity is the greatest of the major problems that hinder the development of agriculture at the present time, especially in central and southern Iraq.

1.8 Climate and Desertification

Determining the contribution of climate variability to desertification is a complex matter, and it is virtually impossible to separate the impacts of drought and desertification, because these processes often work together (Nicholson et al., 1998, Hulme, 2001). Current ideas about the linkages between climate and desertification fall into two broad categories: internal feedback mechanisms and global circulation changes related to patterns of sea-surface temperature (SST).

Desertification is of particular interest to climatologists in their attempts to understand climate variation and change on both short and long time scales (Hare, 1976). Therefor some researchers consider climate to be the major contributor to desertification processes, with human factors playing a relatively minor supporting role. Other researchers reverse the significance of these two factors. For example, (Le Houerou, 1959) concluded that its edges the Sahara is mainly made by man, climate being only a supporting factor (Rapp, 1974, p.32). A third group blames climate and man more or less equally. For example, (Grove, 1973) has noted that (desertification or desert encroachment can result from a change in climate or from human action and it is often difficult to distinguish between the two). Each of these views can be shown to be valid, at least at the local level, and on a case-by-case basis.

Climate change refers to the view that the statistics that represent the average state of the weather for a relatively longer period of time are changing, and that desertification is primarily a result of such natural shifts in climate regimes. Drought episodes have also been cited as a major cause of desertification, since during such extended dry spells desertification becomes relatively more severe, widespread, and visible, and its rate of occurrence increases sharply. As the probability of droughts increases as one moves from the humid to the more arid regions, so does the proneness to desertification. Land forms, soils, and vegetation are often transformed during such extended drought periods.

The relationship between climate change and desertification is a correlation relationship, as the climate change impact on desertification as well as the desertification impact on climate change. The effect of global climate change on desertification is complex and not sufficiently understood. Climate change may adversely affect biodiversity and exacerbate desertification due to increase in evapotranspiration and a likely decrease in rainfall in drylands (although it may increase globally). However , since carbon dioxide is also a major resource for plant productivity, water use efficiency will significantly improve for some dryland species that can favorably respond to its increase. These contrasting responses of different dryland plants to the increasing carbon dioxide and temperatures may lead to changes in species composition and abundances. Therefore, although climate change may increase aridity and desertification risk in many areas (medium certainty) , the consequent effects on services driven by biodiversity loss and , hence , on desertification are difficult to predict.. While Desertification affects global climate change through soil and vegetation losses. Dryland soils contain over a quarter of all of the organic carbon stores in the world as well as nearly all the inorganic carbon. Unimpeded desertification may release a major fraction of this carbon to the global atmosphere, with significant feedback consequences to the global climate system. It is estimated that 300 million tons of carbon are lost to the atmosphere from drylands as a result of desertification each year (about 4% of the total global emissions from all sources combined). (http://www.greenfacts.org/en/desertification/index.htm). Figure 1.2 shows the relationship between desertification and climate change and biodiversity loss.

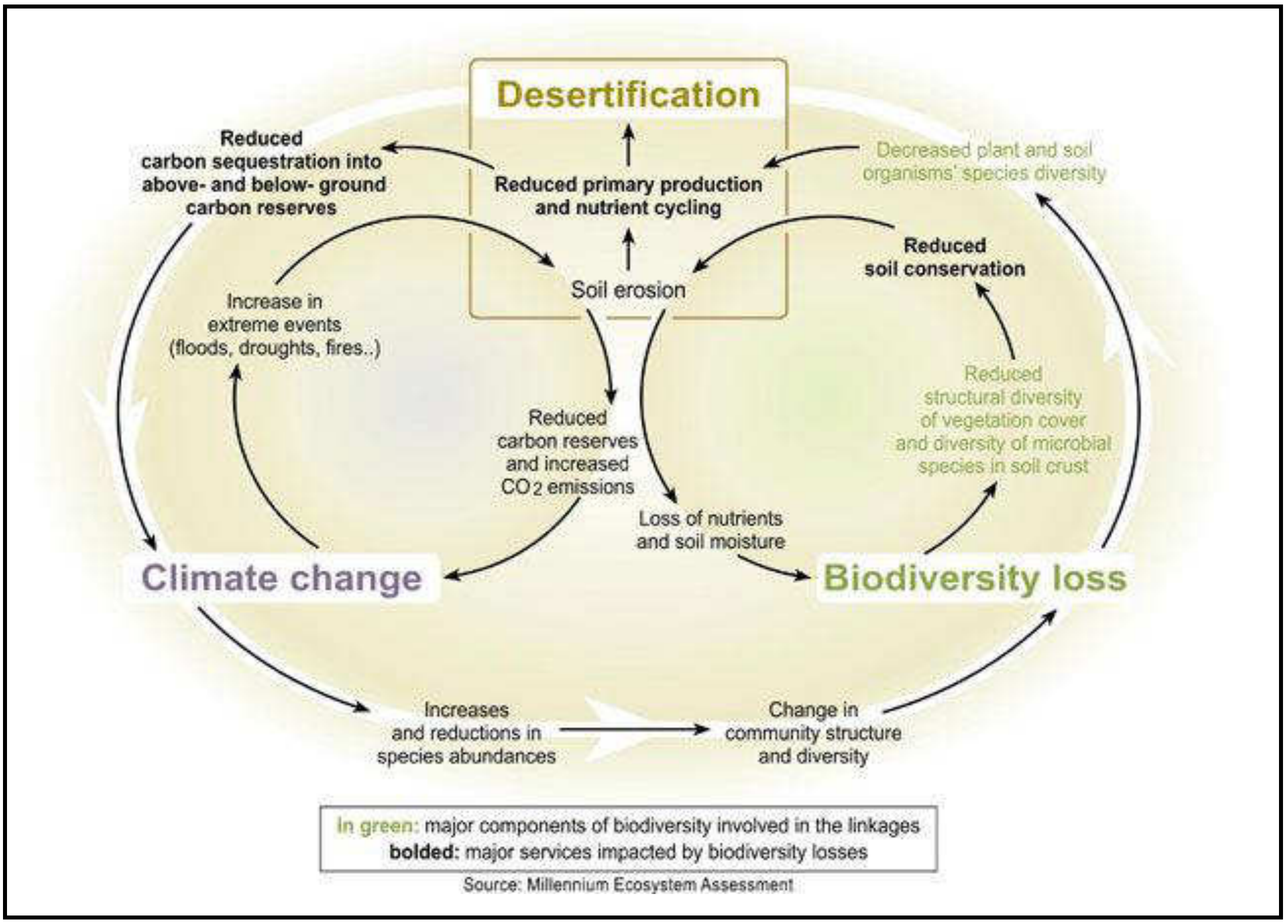


Figure 1.2: Linkages and Feedback among Desertification, Global Climate Change, and Biodiversity Loss (Source: MA Desertification Synthesis Report (2005), p.17

In this figure: The major components of biodiversity loss (in green) directly affect major dryland services (in bold). The inner loops connect desertification to biodiversity loss and climate change through soil erosion. The outer loop interrelates biodiversity loss and climate change. On the top section of the outer loop, reduced primary production and microbial activity reduce carbon sequestration and contribute to global warming. On the bottom section of the outer loop, global warming increases evapotranspiration ,thus adversely affecting biodiversity; changes in community structure and diversity are also expected because different species will react differently to the elevated (CO_2) concentrations.

1.9 Previous Studies

There are many studies and literatures investigate desertification in arid and semi-arid region in Iraq and around the world, and here under some of them:

1.9.1 Some of local previous studies:

- Hassan (1984), based on the visual interpretation of Landsat satellite images (MSS and TM) extracted appropriate and useful information concerning the desertification phenomena in central part of Iraq and draw map showing the changes that took place in the study area during the period 1972-1984.
- Shaker (1985), in her thesis used aerial photographs scale 1: 35000 supported by field work to study desertification in central and southern part of Iraq especially the effect of sand dune movement and shifting .
- Hassan (1988), used digital image processing analysis and visual interpretation of Landsat images to study the desertification process especially for sand dunes movement.
- Hassan (1992), used Landsat TM image s for 1988 and 1990 to monitor and estimate the sand dunes movement in the Al-Masab Al-Aam and the third river area.
- Abdul-Qadir, 2002, in her thesis, digital satellite remote sensing data has been processed and manipulated in computerized GIS manner to build-up digital information database in order to support a suggested methodology, which is developed to detect the groundwater effective zones in the overall northern western desert and selected area Kassra-Habbaria.
- Fadhil , 2004, used two Landsat TM and ETM+ imageries to assess the extent of land degradation in the upper Mesopotamian plain of

Iraq during the period 1990 to 2000. The indices used in this research are NDVI, NDWT, Tasseled Cap, and a new index that is the Normalized Differential Sand Dune Index (NDSDI).

- Benni (2009),made an assessment of desertification phenomena by using remote sensing and GIS techniques . The Indices NDVI, SMA , EMI , and classification of land cover for the Landsat imagery of MSS, TM and ETM+ for the periods 1972, 1990 and 2000, were used . The statistical analysis of the classified images indicates that sand fraction increased from 1972 to 1990 and from 1990 to 2000, the vegetation cover shows very significant decrease of vegetation from 1972 to 1990 and from 1990 to 2000.

1.9.2 Some of regional previous studies:

- Dregne (1986), described many aspects that causing desertification in the arid regions of the world. He mentioned that deterioration in soil and plant cover has adversely affected nearly 50 percent of the land areas as the result of human mismanagement of cultivated and rang lands.
- Saha, Kudrat , and Bhan ,(1990) used digital classification of TM data in mapping salt affected and surface waterlogged lands in India , and found that these salt _ effected and waterlogged areas could be effectively delineated , mapped and digitally classified with an accuracy of about 96% using bands 3,4,5 , and 7.
- Shosheng and Kutiel (1994), investigated the advantages of remote sensing techniques in relation with field surveys in providing a regional description of vegetation cover and Monitoring Temporal Vegetation Cover Changes.
- Harahsheh and Tateishi, 2001, studied desertification processes, causes and indicators occurring in West Asia, and desertification mapping, assessment and monitoring using remote sensing and GIS TechniquesEmam et al, 2003, they evaluate three indicators to study the risk of desertification in Varamin

Plain (central of Iran) by using a geographic information system (GIS). These indicators are to include soil, groundwater and Landuse.

- Emam (2003), evaluated three indicators to study the risk of desertification in Varamin Plain (central of Iran) by using a geographic information system (GIS). These indicators are to include soil, groundwater and Landuse.
- Panah and Ehsani (2004) have studied land cover changes due to human activities using the application of remotely sensed data based on visual and digital procedures, various changes are identified during 23 years for three times, using digital images of MSS (1977), TM (1988), and ETM+ (2000). The obtained results have shown that during 23 years, drastic changes occurred in relation with desertification and 68%of the occurred changes are in between 1985-2000.
- Shilong (2005), in his study used NDVI time series data sets from 1982 to 1999 and climatic variables as indicated decline in desertification in China during two decades, the NDVI data set provides spatially continuous information on vegetation coverage , and has been used in combination with climate data to obtain spatially continuous boundaries.
- Zubair (2006), in his thesis investigated the use of GIS and remote sensing in mapping land use land cover in Ilorin between 1972 and 2001 to detect the changes that has taken place in this status between these periods.
- Khiry (2007), in her thesis spatial data and multitemporal analysis of remote sensing data (years 1976, 1988 and 2003) were used to study the phenomena of desertification processes in North Kordofan State (Sudan), SMA technique was adopted to map and analyses the desertification processes using the above mentioned data combinations of multispectral mixture analysis of Landsat imagery and field observations for dynamics of desertification in the study area.

CHAPTER TWO

DESCRIPTION OF STUDY AREA

CHAPTER TOW

DESCRIPTION OF STUDY AREA

2.1 Location of the study area

The area of study is situated in Badra city, Wasit Governorate, in the east of Iraq, 180 km southeast of Baghdad. It is bounded from the east by Iraqi-Iranian border and from the northwest by Diyala province border. The area of the study is more than 3500 Km^2, Figure 2.1.

The following UTM Projection bound the area:

A- Left X: 33^0 05^- Y: 45^0 50^-

B- Right X: 32^0 98^- Y: 46^0 27^-

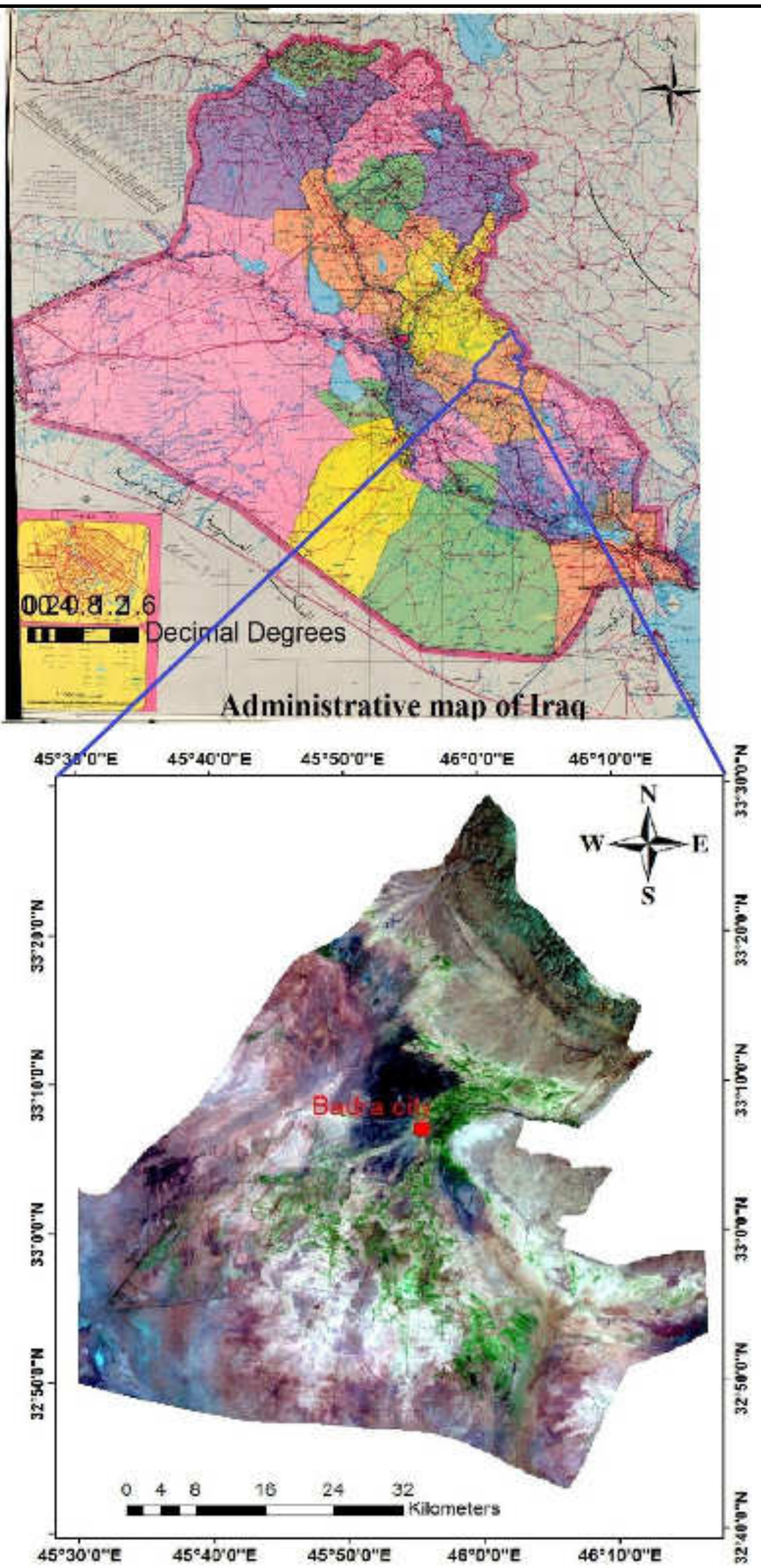
C- Upper X: 33^0 49^- Y:45^0 01^-

D- Lower X: 33^0 71^- Y: 46^0 10^-

Projection: UTM, Zone 38, Spheroid Name: WGS 84.

2.2 Historical introduction about Badra city

Badra is located about 70 km east north of Al Kut city in Wasit Governorate. It neighbors, in its eastern borders, the Republic of Iran, and represents the only contact of Wasit Governorate with the neighboring country. It is more than 3500 km^2 in area. Badra is known as border town in addition to the presence of orchards and gravel quarries. Two districts are connected with Badra which are Jassan and Zorbatiyah.



Satellite image of the study area

Figure 2.1: Location of the study area

When the Mesopotamian civilization was in its first boom, the town (AL-Deer) was located close to the borders of Iran and its name means (in Akkadian language) the fortress town or fortified place, and that where the name Badra come from.

Badra village arose on the ruins of (Al-Deer) and was a manifestation of its regeneration, the name of Badra is derived from the Aramaic word Badraya , composed of (Bait), and (deer) the old name, as with Biskaya and Basmaya and other cities' names that were inhabited by the Arameans, or that were known in their travels and contacts, and then they added the word Bait on these names. Also, name of Badra mentioned in some Arab references as the Badraya and this name has mentioned in Aramaic books as (BaitDraya) and it means those who strew agricultural crops and it's a name of one of the tribes as mentioned in historical references.

Al-Deer site was known and constant since the earliest times so that the world map have been developed in Babylon nearly four thousand years on a slab of clay, which is the oldest map in history that identified the site of (Al-Deer) in an area south of the city of Assyria in the north-east of the swamps. This map represents the entire world in that age and consists of a circle surrounded by (the heavenly sea) and inside, Babylonia and Assyria were instilled. The southern part may inundate by a swamp connected with the sea. At the present time, the mentioned map preserved in the British Museum's treasury.

Generally, Badra city rises on the ruins of old Badraya which has played an important role since the first ages of human civilization, and still contains the ruins of the old city (Al-Aakr hill) near the present Badra which is a wide hill with a height to 20 m and a length of about 500 meter, which is an important archaeological site in Iraq as well as the Badraya mentioned with an old town away from about 100 km called Biskaya, therefor it is named Badraya and Biskaya. Badra became important during the Ottoman rule, where the center of the brigade is called its name and the city of Kut was one of their districts. Badra is famous for its dates and orchards y that surround the town. The climate in Badra is nice due to proximity to the mountains of Bashtkoh, but the water is bad and unpalatable.

Of the most important areas that belong to Badra is Jassan located 15 km southwest of Badra. Jassan is one of the old areas of the Brigade to Kut, but the date of its establishment is not known exactly and it has been mentioned in events of 828 AH ,1425 AD. Also Zorbatiyah area, which belongs to the region of Badra, is located 18 km to the north-east. The town features are the beautiful and pleasant climate. The origin of the word Zorbatiyah meaning (pot of gold), a metaphor for the fertile soil and the large number of its resources (http://members.chello.se/kut/under1.htm).

2.3 Geology the study area

The area of study (Badra – Jassan area) is part of the Foothill Zone and Mesopotamian Zone within twisted and region unstable from Iraq (unstable shelf), Which is characterized by a broad concave and convex folds affected by the movements builds mountains, which began in the Cretaceous and peaked in the early Pliocene age (Buday and Jassim, 1987).

Geological formations exposed in some parts of the study area, range in age from lower Miocene to Holocene. There are geological formations belonging to the era of lower Miocene exposed along the northeastern border of the study area series of Southern Hamrin mountain),While covering the Quaternary deposits (Pleistocene and Holocene) central and southern Iraq (Hassan, Part 1.1977) .

2.3.1 Stratigraphy

In general, the (Upper Miocene-Pliocene) cycle is represented by sediments laid down during the paroxysmal phases of the orogenic uplift of the epigeosynclinal and (later on) epiplatform mountain belts of Iraq (Buday, 1980).The cycle is characterized by the progressive change from the marine sedimentation into the lacustrineand fluviatile one. This change was simultaneously accompanied by the gradational coarsening of the clastics laid down during the cycle (Buday, 1980)

The main source area of the clastics was the rising mountain in the northeast of Iraq (Buday, 1980), and in the southwest the uplifted Stable Shelf was the source of the terrigenous clastics deposited to the northeast of the Euphrates Boundary Fault (Dibdibba Formation)(Upper Miocene-Pliocene), (Jassim et al; in Jassim and Goff, 2006).

- **Stratigraphic Succession**

The stratigraphic succession of the study area consists of the following formations: The Euphrates Formation (L.Miocene),The Fatha Formation (M.Miocene) ,The Anjana Formation (U.Miocene) ,The Muqdadiyah Formation (Pliocene), in addition to Quaternary sediments. Some of these formations deposited in shallow marine environment and some are deposited in a continental environment (Figure 2.2).

A-The Euphrates Formation (L.Miocene)

The formation is exposed in a relatively limited area at northeastern border of the study area, The Euphrates Formation consists of limestone and dolomite having fine to medium crystallization grains with the content of Pseudo Oolitic. The exposed part of the formations contains conglomerate and conglomeratic limestone. The presence of conglomerate caused by the impact of orogenic phase during the deposition in the Miocene. The thickness of the formation is about (50 m) and reflects deep marine deposition environment in its lower part and continental environment in the upper parts. Upper contact graded and conformable with the overlying Fatha formations, (S.E. Geological Survey and Mining, 1993).

B- Fatha Formation (M.Miocene)

The Fatha Formation exposed in parallel to extensions of Hamrin Mountain with direction northwest–southeast. The stratigraphic succession of Fatha Formation consists of two cycles, each cycle begin with sequence of layers of mudstone and Marl , thin layer of limestone and thick layers of gypsum. The layers of this formation have high dip toward south-west of the study area especially north of the Zorbatiyah area. The thickness of the Formation about 300 m and the environment of its deposited are Shallow marine environment within the semi-closed basins with high salinity, especially in the upper parts of the formations. The contact with the overlying Injana Formation represented by an unconformity surface consists of thick layers of sandstone, (Hassan, 1977).

C- Injana Formation (U.Miocene)

Injana Formation (Upper Miocene-Pliocene) represents the lower fine grained molasses sediments deposited at the beginning in marine and progressively in fluvio-lacustrine environment (Buday, 1980). The type section was measured near Injana area at Jabal Himreen, the thickness of the Formation in the type section is 620 m (AL-Rawi et al., 1992), and the age of the formation is Upper Miocene.

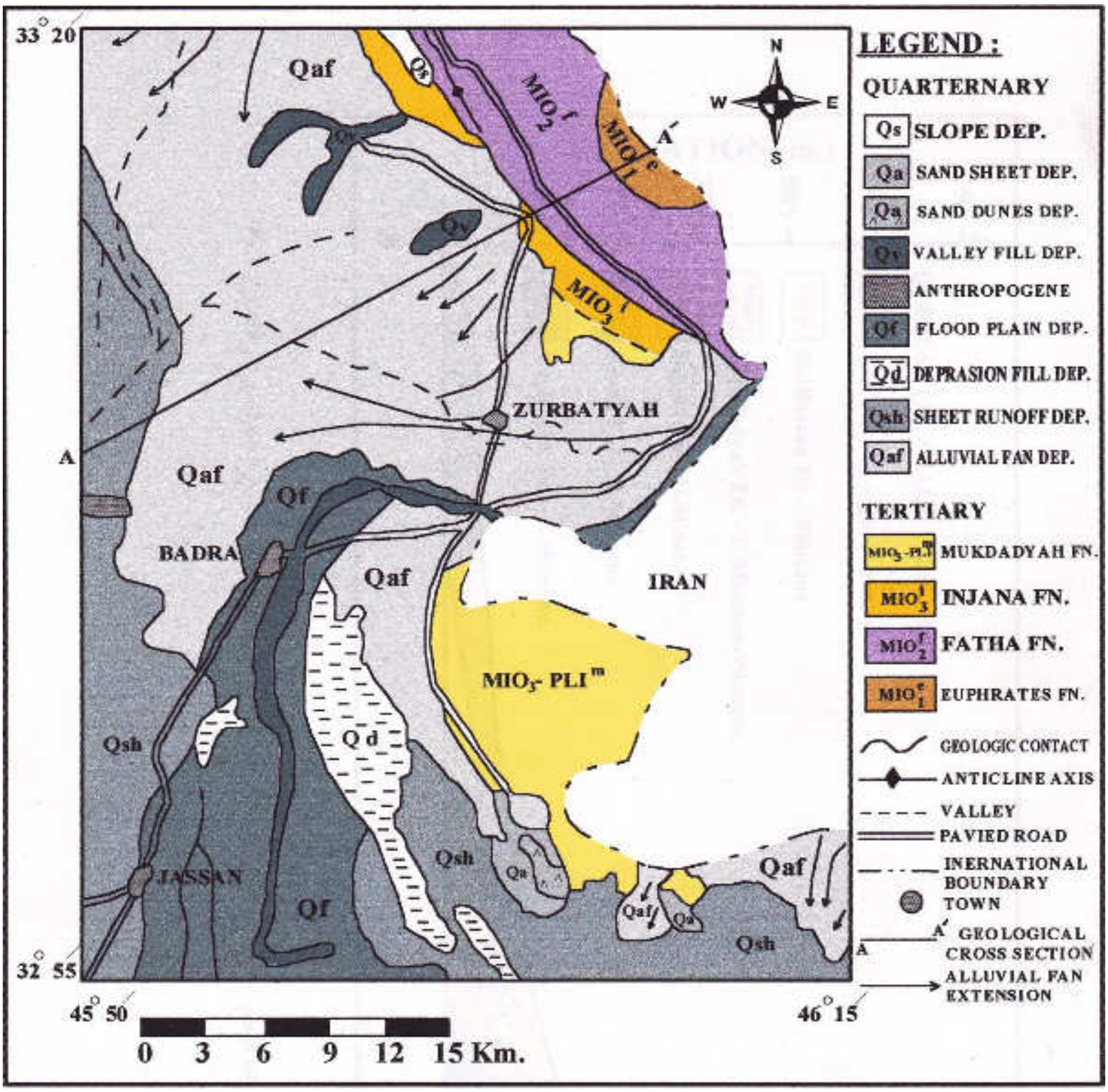


Figure 2.2: Geological map of the study area (State Company for Geological Survey and mining /1993).

The lithology of Injana Formation consists predominantly of alternating red, brown and gray marls, siltstone and sandstone with rarely fresh water limestone, seems of gypsum are also present. The sandstone is carbonate rich with a considerable amount of detrital carbonate fragments (Al-Rawi and Mohamed, 1987). In the studied area Injana Formation was found to extend over a wide area as an erosional surface and along the core of the anticline, such distribution may be due to differential weathering .The Formation is composed of several progressive cycles of sandstone, siltstone , and claystone with a predominant red coloring, Many veins of secondary gypsum were noticed within these units.

D- Muqdadiyah Formation (Pliocene)

The two Formations are daichronous and can be recognized throughout the Foothill and High Folded Zones .The name of the two formations were replaced by Al-Mukdadiya (Pliocene) and Bai-Hassan (Upper Miocene-Pliocene) (Al-Rawi et al., 1992).

The type section is measured near Al-Mukdadiya City in Diyala Governorate, the thickness of the Formation in the type section is (1411m) (Al-Rawi et al., 1992).While in the area under study the thickness of the Formation ranges between (20-75) meters. The Formation according to Basi and Jassim, (1974) comprises of fining upwards cycles of pebbly sandstone, sandstone and mudstone and it is believed to be deposited in a fluvial environment in a rapidly subsiding foredeep basin. Al-Mukdadiya Formation is composed principally of clasitcs, mainly pebbly sandstone, sandstone and red mudstone. The sandstone is often strongly cross bedded. The upper contact of Al-Mukdadiya Formation in the area under study is an erosional surface , with the Quaternary deposits lying over Al-Mukdadiya Formation as an angular unconformity surface.

E-The Quaternary Deposits

Quaternary deposits were deposited on a major regional unconformity surface following intense deformation along the collision cone between the Arabian and Iranian Plates (Jassim and Goff, 2006). The Quaternary deposits comprised of Pleistocene and Recent deposits (Holocene) these include alluvium deposits, which consist of mixture of gravel, sand, silt, clay, and conglomerates of post Pliocene deposits, they show no sign of bedding or stratification (Hamza et al., 1989).

The Quaternary deposits in the area under study consist of mixture of gravel, sand, silt and clay, those sediments lying over Al-Mukdadiya Formation as an angular unconformity , it extends along the south and southwest parts of the studied area.

2.3.2 Tectonic Setting

According to Buday (1980), Iraq lies on the border area between the two main Phanareozoic units of the Middle East i.e., Between the Arabian part of the African (Nubio-Arabian) Platform and the Asian branches of the Alpine Geosyncline. The present day configuration of the NE margin of the Arabian Plate is the result of continental collision.

At the end of Eocene the Neo-Tethys Ocean closed, the accretionary prism in the suture zone of the Neo-Tethys remained near sea level at this time. Shallow water carbonate deposition occurred on a broad platform extending from the NE part of the Arabian Plate (Euphrates and Jeribe Formations of Iraq) (Jassim and Goff, 2006).

In Pliocene time further compression led to the progradation of huge alluvial fans into the Mesopotamian foreland basin (Al-Mukdadiya and Bai-Hassan Formations), (Jassim and Goff, 2006). The Himreen-Makhul Subzone is structurally deepest part of the Foothill Zone. The subzone was the depocenter of the Neogene's molasse but has been a subsiding unit throughout the Mesozoic and Tertiary (Jassim and Goff, 2006).The area under study according to Buday and Jassim (1987) lies in two zones, Mesopotamian Zone (Tigris Subzone), and Foothill Zone (Himreen-Makhul Subzone).

2.3.3 Hydrology of the study area

Galal Badra is the main river and the only source of surface water in the area, which is an extension within Iraqi territory of two tributaries (Canin Jam and Rod Kafi) in Iran. The area of the river basin of Galal Badra in Iran is about 1650 Km^2 and the river enters the Iraqi border in Sdrr Arafat area, where it leaves the first basin in Iran to enter the second basin in Iraq towards the eastern Zorbatiyah region. Galal Badra River slopes at a rate of 0.4), and is divided into several small channels irrigation towards the south-west, and these channels disappear as a result of lack of water discharged due to the high values of evaporation and infiltration (Hassan, 1977).

The catchment area of Galal Badra River inside the Iraqi territory is located to the north east of the study area and located along the southern part of Hamrin mountain range. The catchment area of the river inside the Iraqi territory is approximately 300 km^2.There are also a group of playa spread in the middle of the study area between the Badra area to the south towards the Hor Alshwooajh area, which represents the point of discharge for the Galal Badra river and seasonal valleys along the south east of study area (Ali, 2002).

The Quaternary deposits and Muqdadiya Formation are the main aquifers in the study area that extend over large areas covering most of the region. The thickness of these aquifers decrease between the center of the region and the edges where the thickness decreases towards the north east at the foothill area. lithology of these aquifers composed of layers of gravel and sand for the Quaternary deposits, sandstone and fine gravel for the Muqdadiya Formations . There are two levels of groundwater in the study area, the upper level represents open aquifers while the lower level represents the confined aquifers and the difference between them about 13 m (Ali, 2002).

There are a set of the springs spread along the foothill area (Hamrin mountain chain) due to the exposed mud layers which are covered by layers of gravel, sand or sandstone containing groundwater. Water of these springs flow towards the seasonal valleys which spread in the study area and most of them discharge in the Galal Badra river (S.E. Geological Survey and Mining 1993). Also, Alfhudyat springs that located in the center of the region and to the south-east of the Badra area, have been observed where its water flow toward the seasonal valleys, which pour into Galal Badra river.

2.4 Climate of the study area

Climate means the variation in the rates of climatic conditions over a long period, while the weather, reflects on the state of weather over a short period (day, for example). The elements of climate, is the most important effects on the environmental conditions in any area , which effects on vegetation , soil , geomorphic features, precipitation and water quantity and quality ,also its the cause of the substantive changes that take place within the local environment and its linked to activities of living organism.

Climate is classified depending on the climatic elements such as rainfall, temperature , humidity, winds to give or determine the features of each type of climatic elements. The area of study characterized by very hot summer and cold winter with limited rainfall, Therefore, the region is classified according to its climatic elements (ALI, B., M. ,2002) in the category of arid and/or semi-arid areas, as the average total annual rainfall up to 217mm less than 250 mm, while the rate of evaporation of about 261.73mm, these rates by using the weather Badra station records for the period from 1994 to 2007.

As to rainfall, there are two period, first, a wet period, which is characterized by the availability of rainfall with various rates, and the second is the dry period with no rain. Wet period extends from October to March, while the four remaining months represent the dry period (ALI, 2002)

The study area is affected by global climatic change, as indicated by increase of the temperature , evaporation , and decreasing rainfall, relative humidity from 1976-2007 and there is remarkable increase in the number regional dust storm that blowing in Iraq and Middle East region doubled during 2008 (AlKhafaji, 2009).

Two stations (Alhi and Badra) which record the climatic elements are used. These elements are such as rainfall, temperature (minimum and maximum), relative humidity , evaporation , wind speed and direction, and suspended dust, rising dust & dust storms for the years 1976- 2007 for Alhi stations and 1994-2007 for Badra station because it was established in 1994 , with some years or months of missing record. Table (2.1) and (2.2).

Table2.1: Mean annual and monthly of climate elements for the period (1994-2007), source (Iraqi meteorological organization, Badra Station).

	Mean Rain-fall mm.	**Mean Mini. Temp. C°**	**Mean Maxi. Temp. C°**	**Mean Temp C°**	**Mean Relative Humidity RH%**	**Mean Evapora-tion mm.**	**Mean Wind Speed**
JAN.	**49.86**	**6.2**	**16.1**	**11.0**	**76**	**62.6**	**2.4**
FAB.	**29.49**	**7.5**	**19.1**	**12.8**	**64**	**91.6**	**2.5**
MAR.	**29.14**	**11.4**	**24.2**	**17.4**	**51**	**172.5**	**3.1**
APR.	**14.66**	**17.2**	**30.7**	**24.4**	**44**	**244.32**	**3.5**
MAY.	**1.6**	**22.9**	**38.5**	**31.2**	**29**	**360.13**	**3.2**
JUN.	**0.7**	**26.3**	**43.5**	**35.2**	**23**	**466.0**	**3.9**
JUL.	**0.06**	**28.6**	**45.6**	**37.6**	**22**	**500.2**	**4.0**
AUG.	**0.0**	**27.7**	**45.0**	**37.2**	**22**	**472.3**	**3.7**
SEP.	**0.0**	**23.2**	**41.3**	**32.0**	**26**	**355.5**	**3.0**
OCT.	**16.77**	**19.2**	**35**	**26.4**	**35**	**232.8**	**2.3**
NOV.	**40.415**	**11.4**	**24.7**	**17.3**	**57**	**116.72**	**2.1**
DEC.	**35.14**	**7.1**	**17.9**	**11.8**	**70**	**66.01**	**2.1**
Mean annual	**18.15**	**17.4**	**31.8**	**24.5**	**43**	**261.73**	**3.0**
Total Mean	**217.8**						

Table 2.2: Mean annual and monthly of climate elements for the period (1976-2007), source (Iraqi meteorological organization, AL-Hai station).

	Mean Rain-fall mm.	Mean Mini. Temp. C°	Mean Maxi. Temp. C°	Mean Temp C°	Mean Relative Humidity RH%	Mean Evapora-tion mm.	Mean Wind Speed
JAN.	29.58	6.5	16.9	11.5	72.33	100.7	3.8
FAB.	19.22	8.2	19.8	13.9	63.16	125.6	4.4
MAR.	22.25	12.1	24.6	18.2	55.6	216.6	4.4
APR.	13.63	17.7	31.6	24.8	45.6	312.2	4.6
MAY.	5.35	23.5	38.4	31.2	32.8	452.2	4.7
JUN.	0.1	27.1	43.1	35.4	24.9	619.9	5.8
JUL.	0.0	29.0	45.0	37.4	23.8	708.0	6.1
AUG.	0.0	28.1	44.8	36.7	24.8	657.3	5.6
SEP.	0.5	24.8	42.0	33.2	27.9	508.8	4.7
OCT.	4.5	19.7	35.5	27.4	39.4	324.5	3.9
NOV.	22.2	12.7	25.8	18.8	55.6	174.3	4.0
DEC.	23.19	8.4	19.0	13.2	69.4	116.5	3.7
Mean annual	11.7	18.2	32.2	25.1	44.58	359.7	4.6
Total Mean	140.50						

The main climatic elements used in this study:

A-Rainfall

Badra Station has mean monthly rainfall range from Zero in summer months to (49.859 mm) in Jan. for the years 1994-2007 , the Alhi station mean monthly range from Zero June , July , Aug to 29.577 mm in Jan. for the years 1976-2007. The mean annual rainfall of the Badra station for the years 1994-2007 about 191.50 mm, while the means annual rainfall of the Alhi station for the years 1976-2007 is 131.60 mm (Figure 2.3).

The maximum annual rainfall of the Badra station for the years 1994-2007 is 303.2 mm in1994, while the minimum annual rainfall is 98.1 in 1995 . The maximum annual rainfall of the Alhi station for the years 1976-2007 is 233.4 mm in 1996, while the minimum annual rainfall is 66.5 in 2001. Figure (2.4) show location of study area in the Contour map of Mean annual rainfall in Iraq and Table (2.1), (2.2) show the Means monthly rainfall, Mean annual and Total mean in study area.

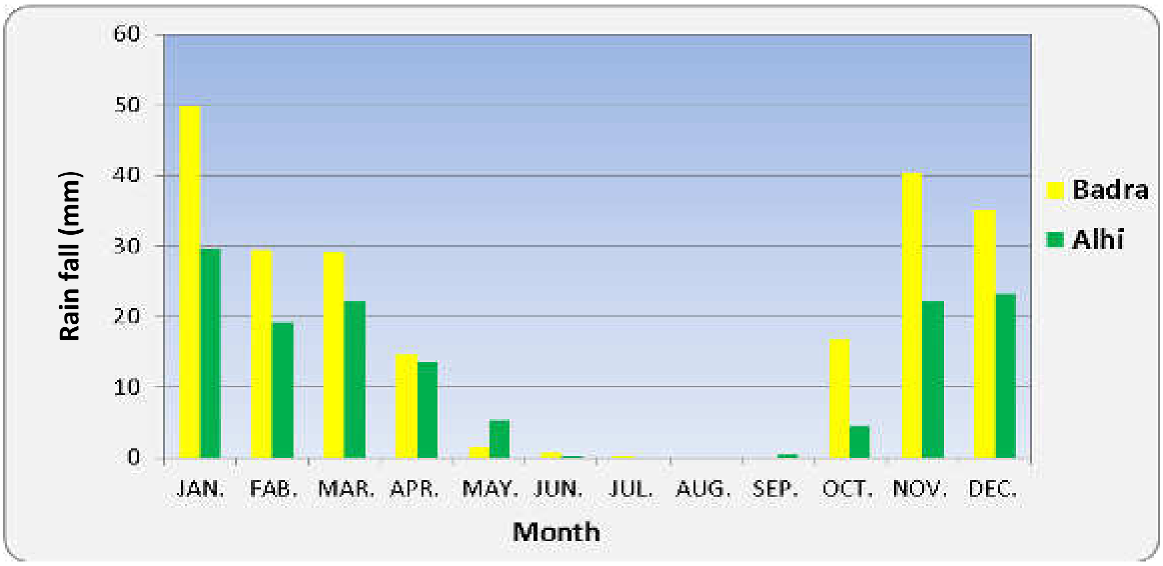


Figure2.3: Mean monthly Rain fall mm in Badra & Alhi stations years 1976-2007.

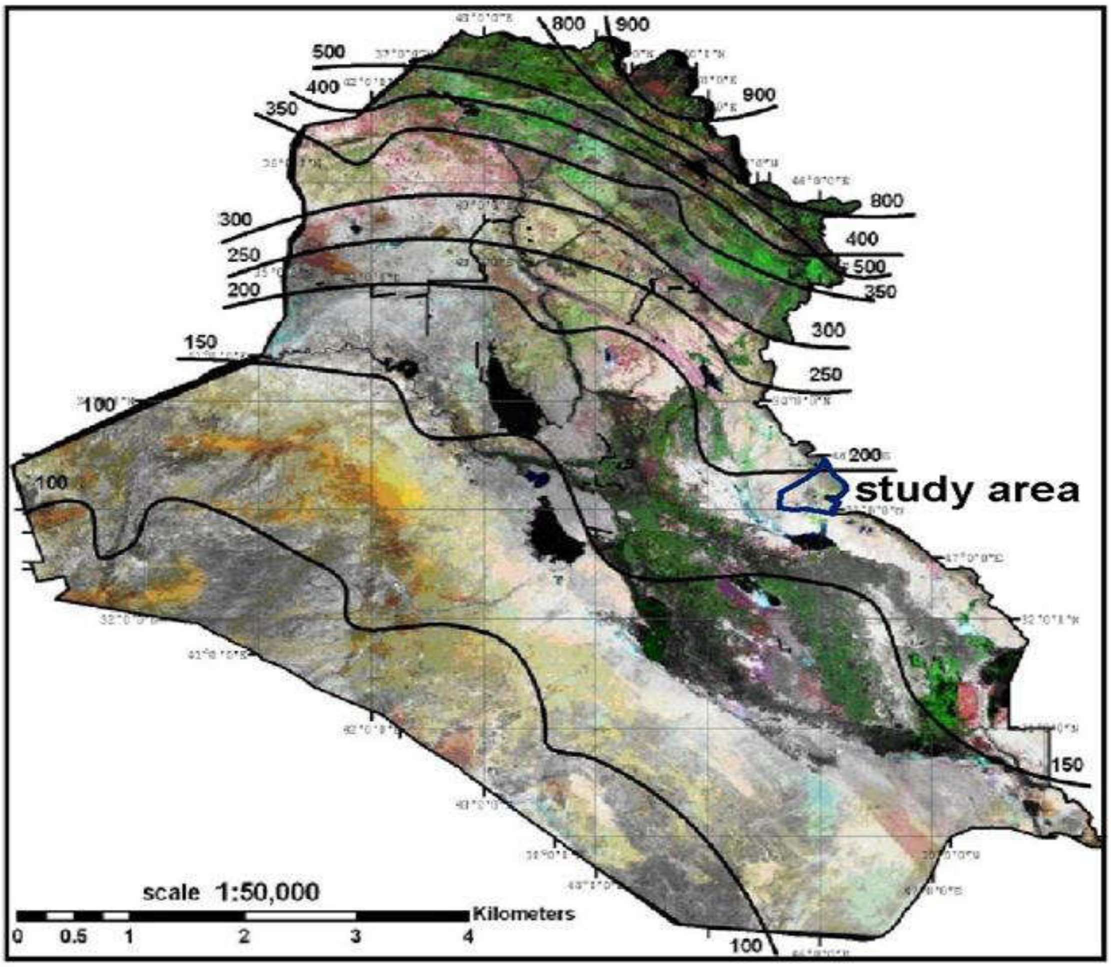


Figure 2.4: Contour map of Mean annual rainfall in Iraq, (Climatological Atlas of Iraq, Iraqi Meteorological Organization, Climatological Section, 2003)

B-Temperature

The mean annual temperature in the study area is about 24.5 C° for the period 1976-2007 as shown in Figure 2.5, 2.6 and 2.7. The annual temperature increase gradually from middle of April to middle of October. These months represent the summer season that is characterized by increasing in temperature, the mean maximum is in July 45.6 C° and 45.0 C° in August. In the winter season the temperature falls gradually from the middle of October reaching to a minimum in January (the coldest month of the year) at

16.1C°.The mean annual values of maximum and minimum temperature are 31.8 C° and 17.4 C° respectively (Iraqi Meteorological Organization).

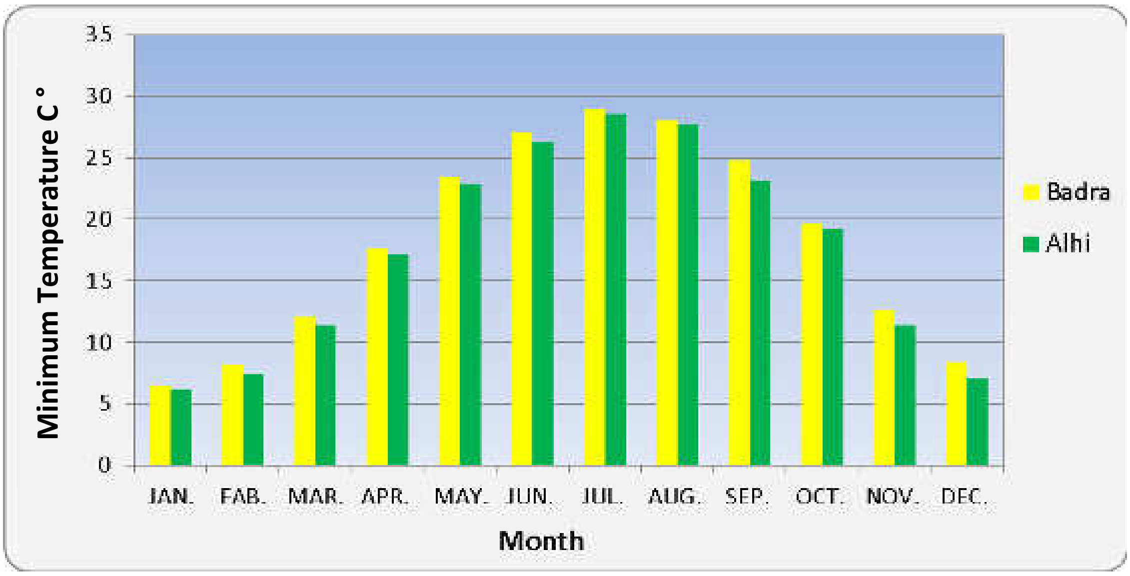


Figure 2.5: Minimum Mean Monthly Temperature C° in Badra & Alhi stations years 1976-2007.

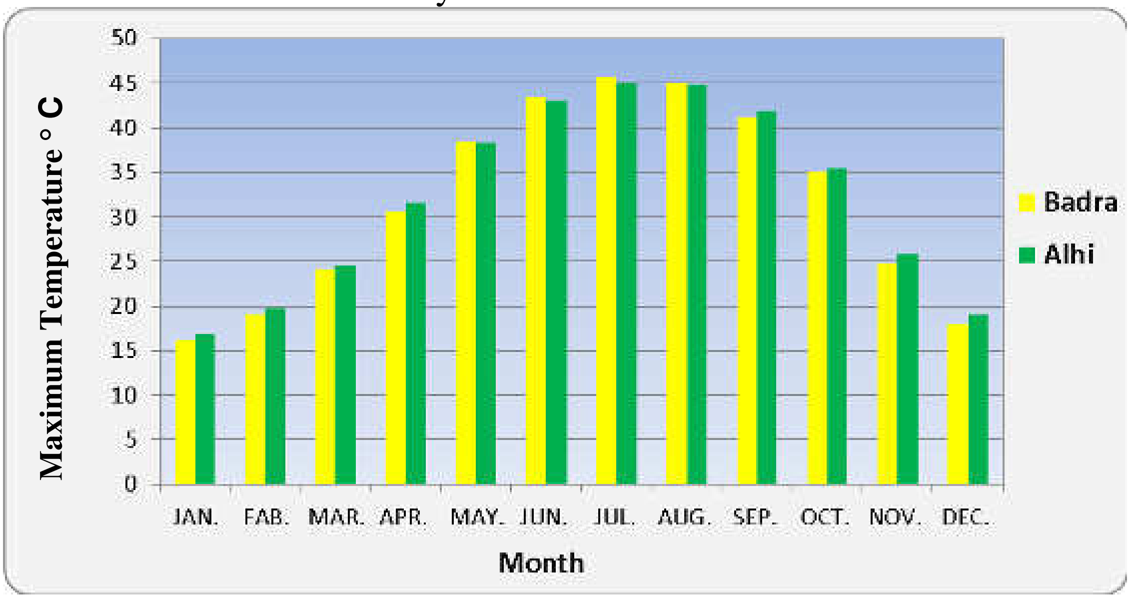


Figure 2.6: Maximum Mean Monthly Temperature C° in Badra & Alhi stations years 1976-2007.

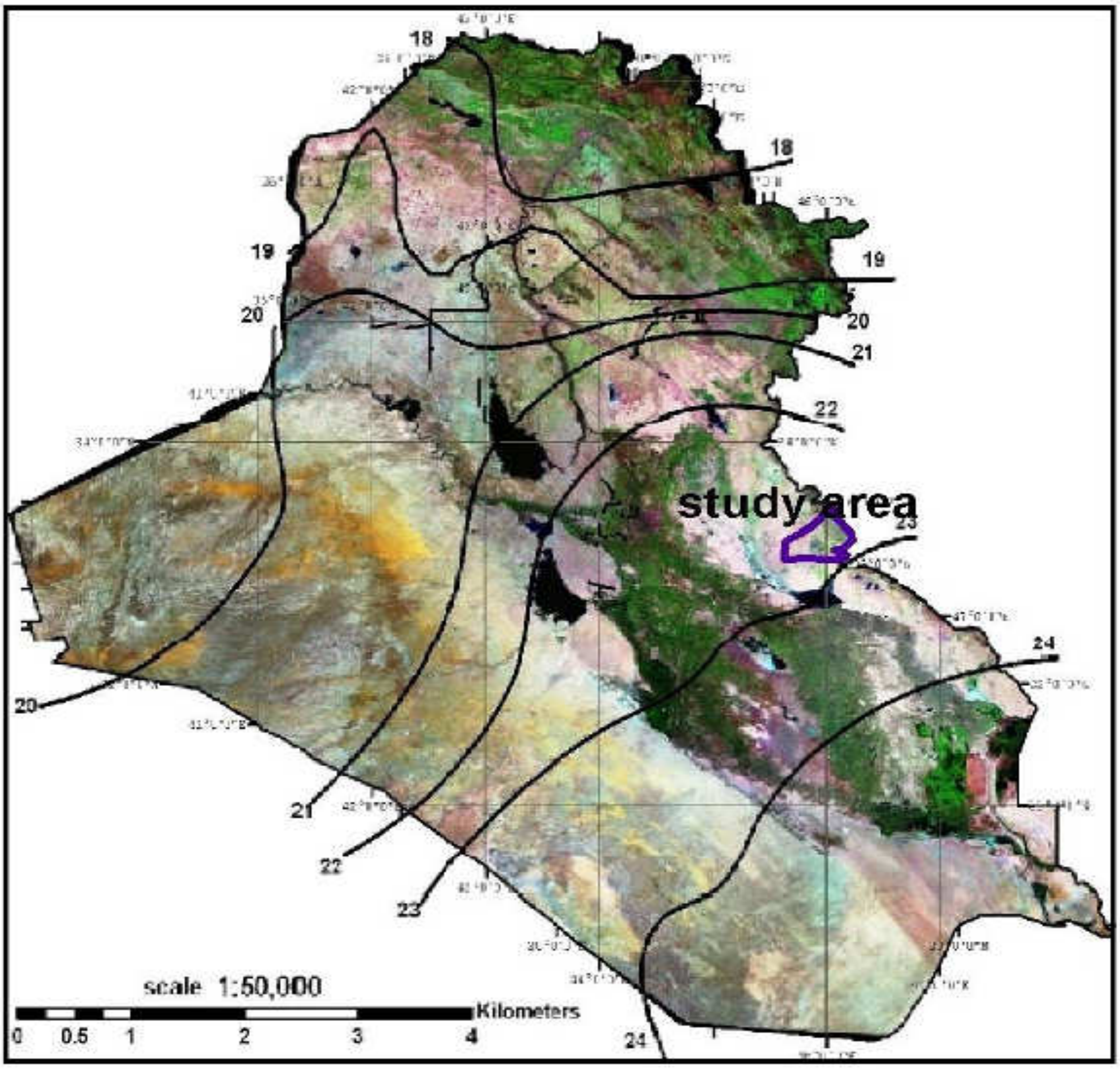


Figure 2.7: Contour map of Mean annual temperature in Iraq. (Climatological Atlas of Iraq, Iraqi Meteorological Organization, Climatological Section, 2003)

C-Relative Humidity

The Mean Monthly Relative Humidity percentage for year 1976 to 2007 in some region, shows that Badra , and Alhi Meteorological Stations have a range of the maximum mean monthly Relative Humidity percentage during January as follow , 76- 22% and 72.33-23.8% respectively , (Tables 2.1 and 2.2, Fig 2.8).

The mean annual Relative Humidity % for Badra , Alhi meteorological stations are as follow, 43% and 44.58 % respectively **.** The maximum Relative Humidity percentage that during January is due to higher rainfall percentage.

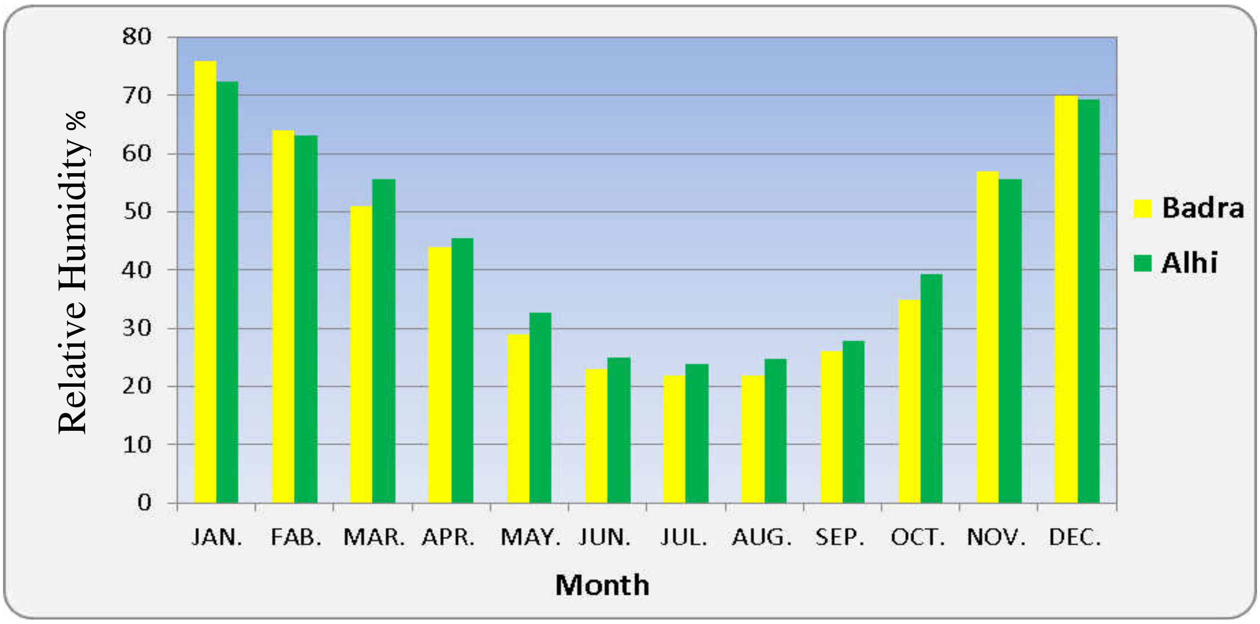


Figure 2.8**:** Mean Monthly Relative Humidity percentage in Badra & Alhi stations years 1976-2007

D-Evaporation

The mean Evaporation value is considerably increased during the summer months due to high temperature, clear sky that gloves a direct effect in addition to the intensified sunray during the day time .The mean monthly evaporation for the years 1976-2007 in the study area shows minimum evaporation during January 62.6 mm in Badra station and 100.7 mm in Alhi station, the maximum evaporation during July reaches 500.2, 708 mm for Badra and Alhi meteorological stations respectively. The mean annual Evaporation for Badra, Alhi meteorological stations as follows, (261.73mm), (359.7mm) respectively**.** (Figure 2.9, Tables 2.1 and 2.2).

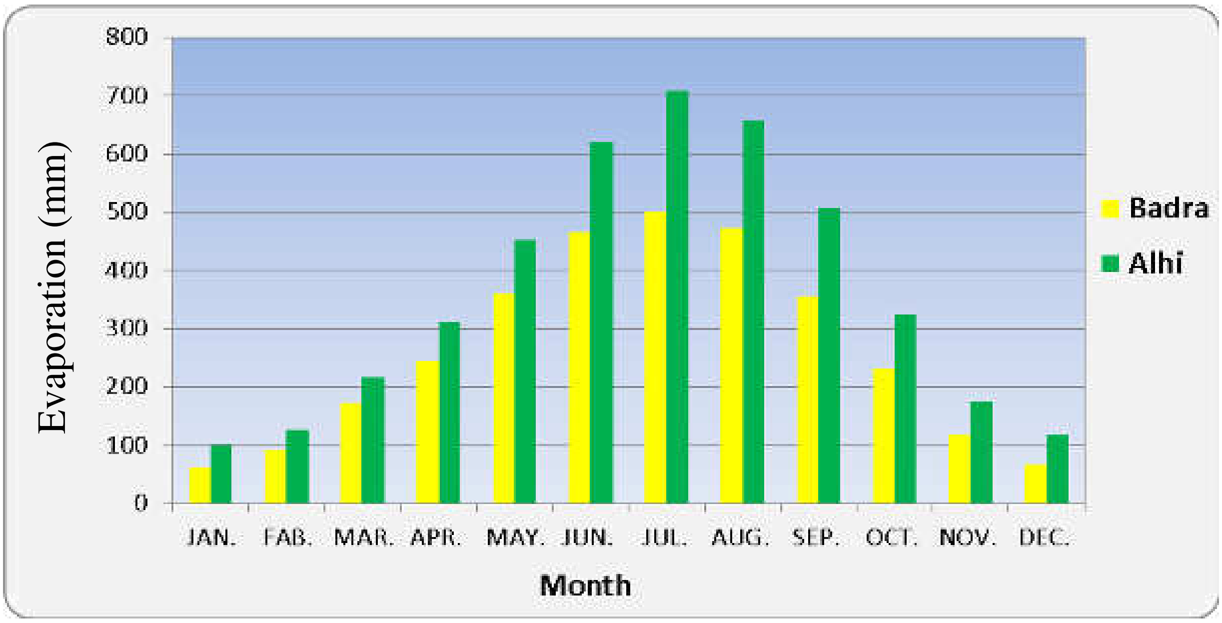


Figure 2.9: The mean monthly evaporation mm in Badra & Alhi stations years 1976-2007.

E-Wind speed and direction

The mean monthly wind speed (m/s) for the years from 1976 to 2007 in some regions according to Badra, and Alhi Meteorological Stations range from the maximum mean monthly wind speed during July to the minimum values during December as follows4.0 -2.1, 6.1 -3.7 m/s respectively. The mean annual Wind speed for Badra, Alhi meteorological stations is as follow 3.0, 4.6 m/s respectively**.** (Figure 2.10 and 2.11, Tables 2.1 and 2.2).

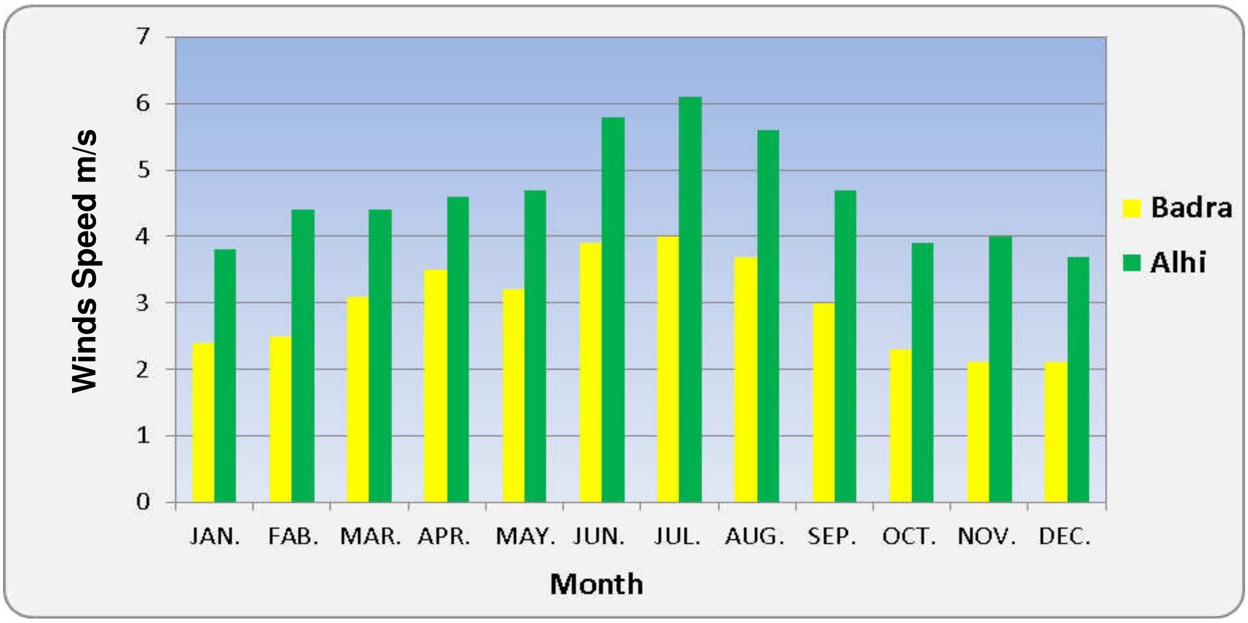


Figure 2.10: The monthly average mean winds speed (m/s) in Badra & Alhi stations years 1976-2007.

The wind directions of the studied meteorological stations (Table 2.3), shows that the general (Main) monthly wind directions is NW direction followed by N wind directions for Badra & Alhi meteorological stations.

Table 2.3: The percentage of the mean monthly wind direction for Badra & Alhi Meteorological Stations in the period 1976-2007, (Iraqi Meteorological Organization).

station	NW %	N %	SE %	W %
Badra	68	18	14	-
Alhi	86	5	-	3

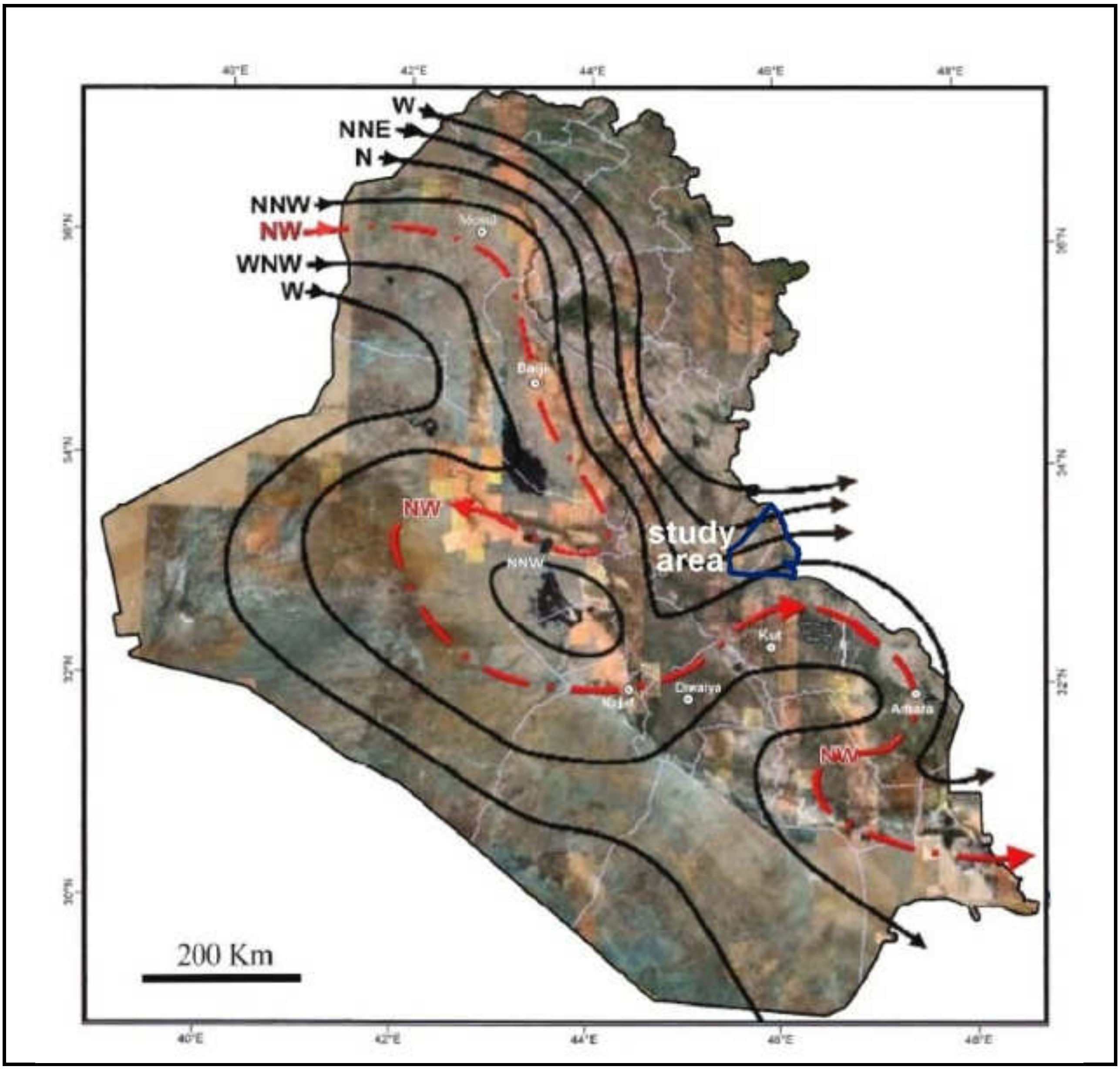


Figure 2.11: Contour map of wind direction in Iraq. (Climatological Atlas of Iraq, Iraqi Meteorological Organization, Climatological Section, 2003)

F-Sand/ Dust Storms

The mean monthly Sand/Dust storm recorded in Badra and Alhi Meteorological Stations are as shown in (Figure 2.12). The results indicate that the study area suffers minimum Sand / Dust storm ranging between 0 to 5 days/month during the study period from 1976- 2007 with the exception of 3 years, when the proportion of dust storms become 7 days/month during 1979.1981 and 1984.

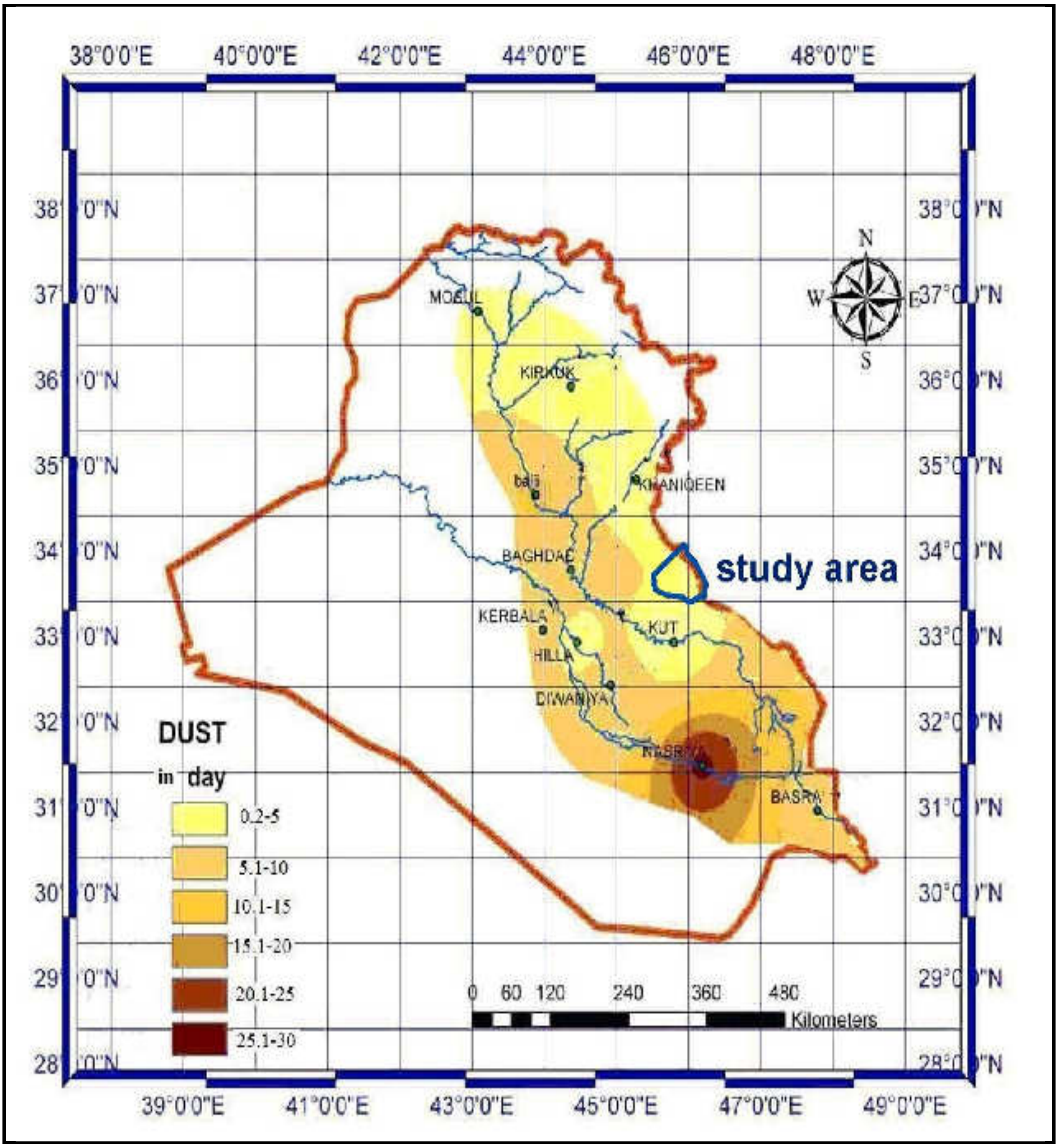


Figure 2.12: Mean Monthly Number of days/month of Dust storms that distributed over Middle & southern Iraq (Al- Khafaji, 2009).

CHAPTER THREE

THE DATA AVAILABLE AND METHODOLOGY

CHAPTER THREE

THE DATA AVAILABLE AND METHODOLOGY

3.1 Theoretical background

The advent of the space age opened a whole new dimension in our ability to observe, study , and monitor planetary (including Earth) surfaces and atmospheres on a global and continuous scale. This led to major developments in the field of remote sensing, both in its scientific and technical aspects. In addition, recent technological developments in detectors and digital electronics opened the whole electromagnetic spectrum to be used for detecting and measuring ever finer details of the emitted and reflected waves that contain the "fingerprints" of the medium with which they interact. Space borne imaging spectrometers from the visible to the far infrared are being developed to acquire laboratory quality spectra for each observed surface pixel or atmospheric region, thus allowing direct identification of the surface or atmospheric composition.

Remote sensing can be defined as: the science and the art of obtaining information about an object , area , or phenomenon through the analysis of data acquired by a device that is not contact with the object , area or phenomenon under investigation , by using electro-magnetic radiation which is reflected or emitted from an object.(Lillesand, 1994)."Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it .This is done by sensing and recording reflected or emitted energy and processing , analyzing , and applying that information (Canada Center for Remote Sensing CCRS, 2004). The use of remote sensing techniques to study desertification processes type of environments has been extensively applied in various projects during the past decade.

3.1.1 Historic Overview

In 1859 Gaspard Tournachon took an oblique photograph of a small village near Paris from a balloon. With this picture the era of earth observation and remote sensing had started. His example was soon followed by other people all over the world. During the Civil War in the United States aerial photography from balloons played an important role to reveal the defense Positions in Virginia (Colwell, 1983). Likewise other scientific and technical developments this Civil War time in the United States speeded up the development of photography, lenses and applied airborne use of this technology. Table3.1 shows a few important dates in the development of remote sensing.

After the wars in the 1950 remote sensing systems continued to evolve from the system is developed for the war effort. Colour infrared (CIR) photography was found to be of great use for the plant sciences. In 1956 Colwell conducted experiments on the use of CIR for the classification and recognition of vegetation types and the detection of diseased and damaged or stressed vegetation. It was also in the 1950 that significant progress in radar technology was achieved (Appendix .1).

3.1.2 Essential Background of Remote Sensing

The basic concept of remote sensing depends on the fact that all objects on the Earth reflect (scatters) or emits energy. Thus, two main points have been concerned , which are (a) the proportion of electromagnetic radiation reflected, absorbed , transmitted and backscatter varying in different earth features, as well as different environmental condition, and (b) the wavelength dependency.

Remote sensing is classified into three types with respect to the wavelength region, (1)Visible and Reflective Infrared Remote Sensing ; (2) Thermal Infrared Remote Sensing, (3) Microwave Remote Sensing (GEOG, 2006).

It is possible to use remotely sensor data to distinguish properties of objects because objects have their own spectral signatures. A course inspection of the reflectance of objects using albedo as a measurement shows that different type of land cover reflects different portion of the incident electromagnetic energy (figure 3.1 shows the Electromagnetic spectrum). A fine inspection of the reflectance of objects, using spectral reflectance curve, showed that not only the total energies that are integrated over the spectral frequency reflected by objects are different but also the energy at Earth wavelength interval. This allows recognizing the type of condition of an object to be specifically identified (GEOG, 2006).

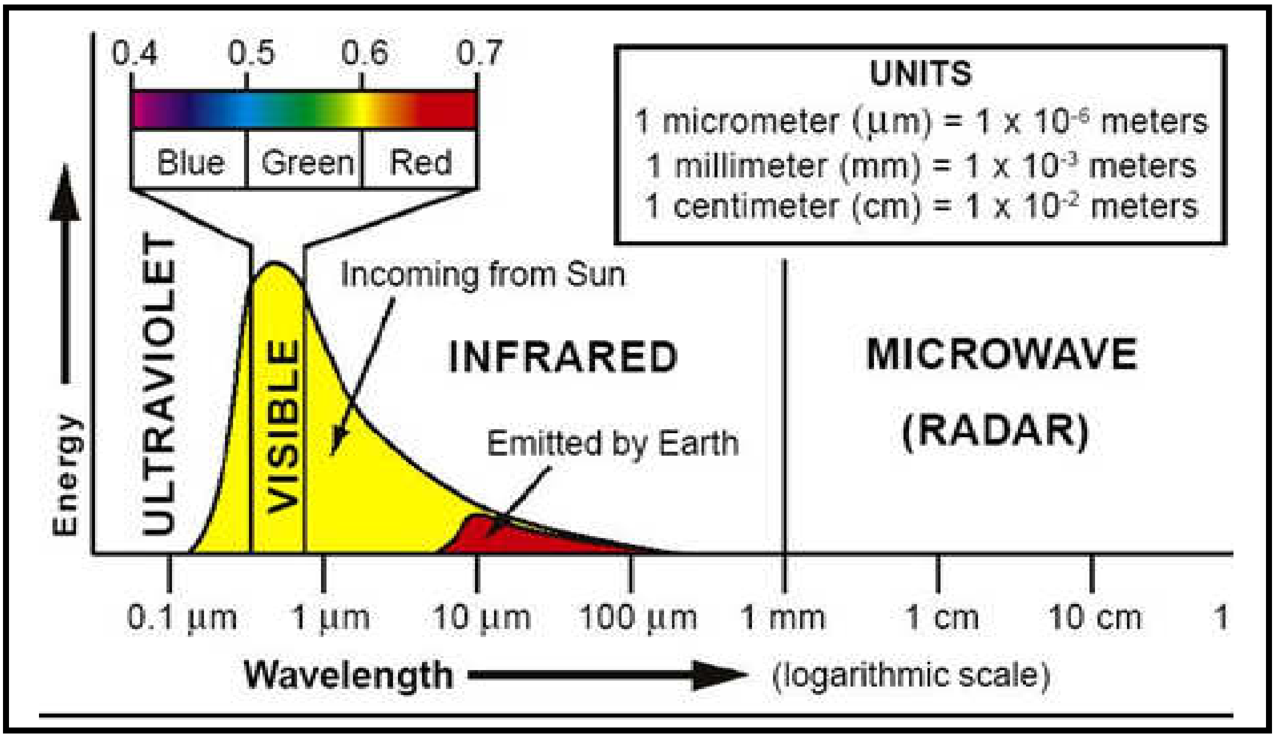


Figure 3.1: The range of wavelengths known as the electromagnetic spectrum. Our eyes can only see a small part of this energy known as visible light (see zone marked "visible light"). (Randall B. Smith, 2006).

The process of remote sensing is illustrated in figure 3.2, (after Canada Center for Remote Sensing CCRS) and consists of the following elements:

1. Energy Source or Illumination (A) the first requirement for remote sensing is to have an energy source which illuminates or radiates electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere (B) as the energy radiating from the travels to the target, it will come in contact with, and interact with the atmosphere, as it passes through it. This interaction may take place **a** second time as the energy travels from the target to the sensor.

3. 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.

4. Recording of Energy by the Sensor (D) after the energy has been scattered by(or emitted from) the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation from the target.

5. 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 are processed into an image (hardcopy and/ or digital).

6. Interpretation and Analysis (F) the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target.

7.**Use of Information (G)** the final element of the remote sensing process involves the use of the information (often in combination with other data) to obtain a better understanding of the target, to compare characteristics and summary measures of different targets , or to explain variations in target characteristics and measures.

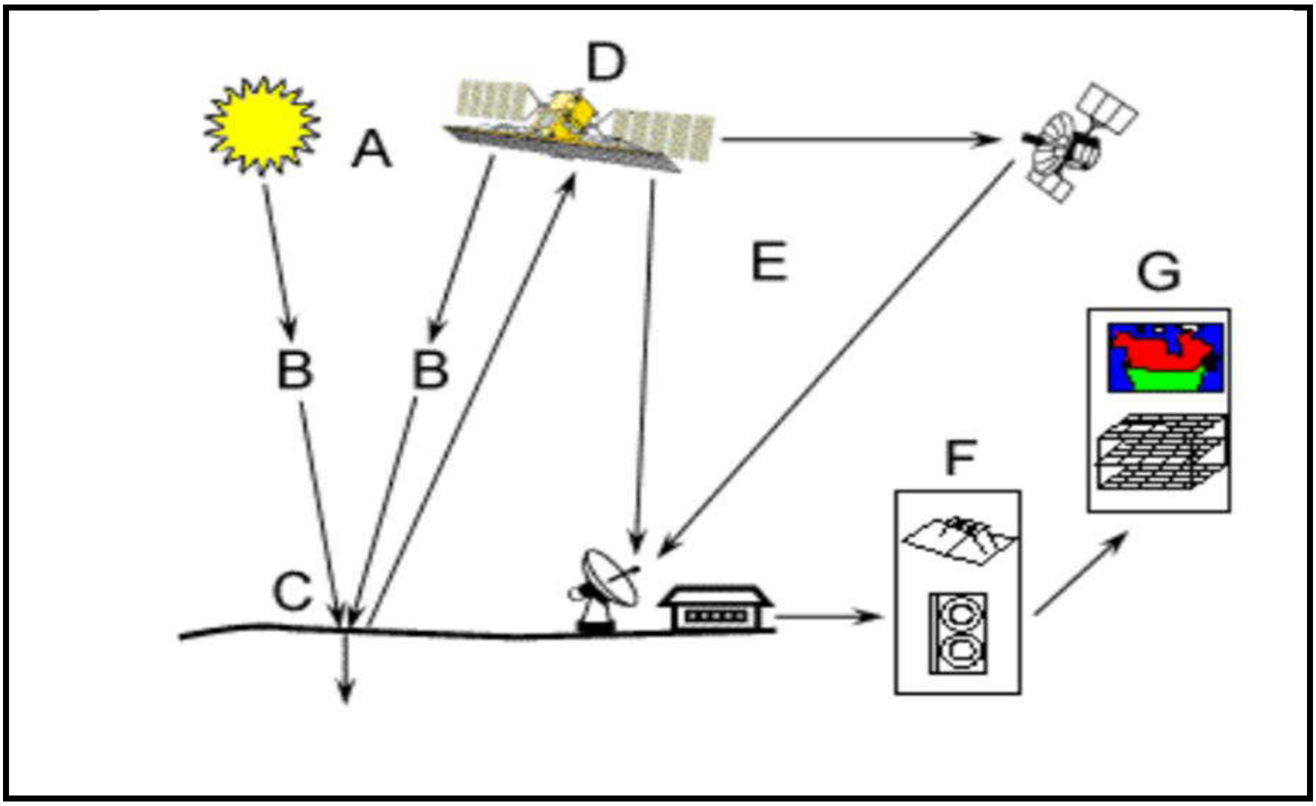


Figure 3.2: The process of remote sensing (Canada Center for Remote Sensing, 2004).

Remote sensing images have four different types of resolutions: spectral, spatial, radiometric, and temporal:

-**Spectral resolution:** It refers to the dimension and number of specific wavelength intervals in the electromagnetic spectrum to which a sensor is sensitive, or different classes of features and details in an image can often be distinguished by comparing their responses over distinct wavelength ranges. Broad classes, such as water and vegetation, can usually be separated using very broad wavelength ranges, the visible and near infrared as show in (figure 3.3).

-**Spatial resolution**: It is a measure of the smallest angular or linear separation between two objects that can be resolved by the sensor , or refers to the size of the smallest possible feature that can be detected.

- **Radiometric sensitivity:** While the arrangement of pixels describes the spatial structure of an image, the radiometric characteristics describe the actual information content in an image. Every time an image is acquired by a sensor, its sensitivity to the magnitude of the electromagnetic energy determines the radiometric resolution. The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy .The finer the radiometric resolution of a sensor , the more sensitive it is to detecting small differences in reflected or emitted energy.(Canada Center for Remote Sensing CCRS) .

-**Temporal resolution:** refers to the length of time it takes for a satellite to complete one entire orbit cycle. The revisit period of a satellite sensor is usually several days. Therefore the absolute temporal resolution of a remote sensing system to image the exact same area at the same viewing angle a second time is equal to this period.

3.1.3 Spectral Reflectance and Spatial Characteristics

The physical and chemical characteristics of materials define their spectral reflectance and remittance spectra that can be used to identify them. The spectral reflectance refers to the ratio of the reflected radiant energy to that incident on a body. Identification of many Earth's surface features is primarily a function of the spectral response of these features (Swain & Davis , 1978). Spectral reflectance curves, shown in Figure 3.3, can be depended on to identify and map the surface feature of interest. The spectral characteristics of various Earth surface features do not remain static; they are changed with geographic location and time. Temporal change in spectral response can be either natural or caused by human beings. In remote sensing, change detection techniques can be used to monitoring the temporal changes.

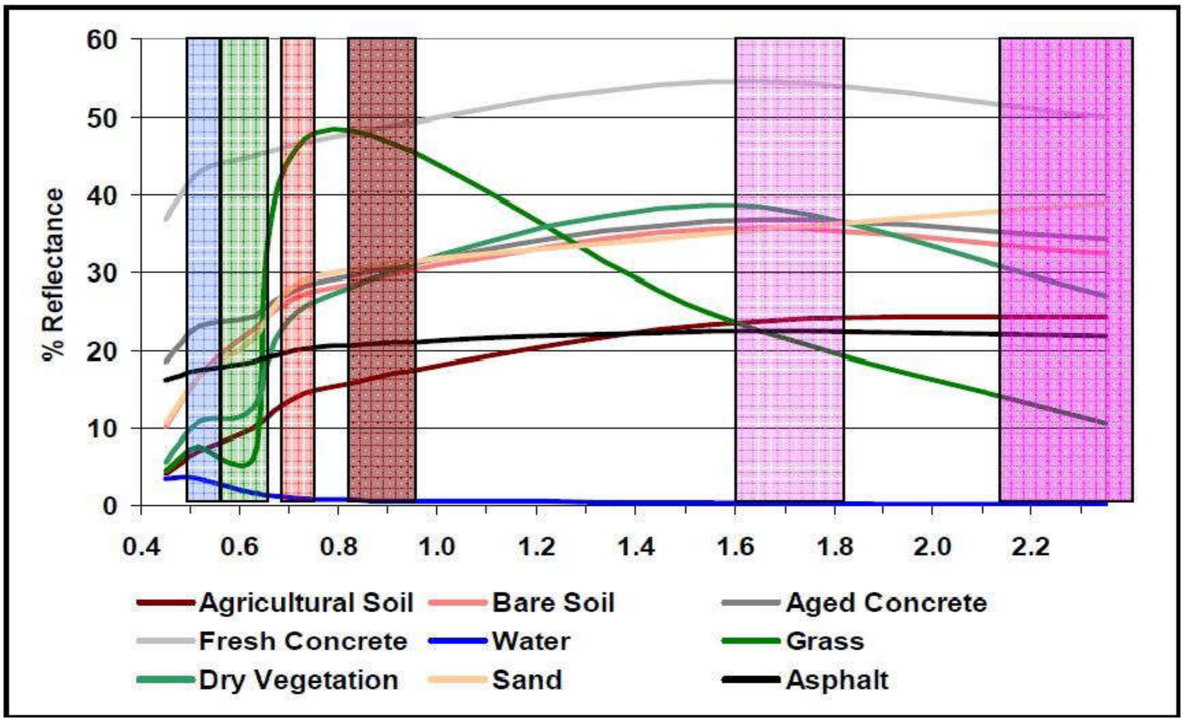


Figure 3.3: Spectra of Sample Cover Types and Landsat TM/ETM$^+$ Bands.

In addition to spectral reflectance (*i.e.,* color or tone), a human analyst will employ other criteria in the visual-cognitive process of interpreting remote sensing imagery: texture, pattern, size, shape, shadow, and context, among other visual cues. In contrast, however , most methods for computer-assisted classification of digital remote sensing data that do not involve a human observer utilize a “per-pixel, spectral data-alone” approach.

It is important to note that there is a spectral similarity among distinct land cover classes. For instance, bare soil, sand, and aged concrete have similar reflectance in several of the Landsat bands. So, too, do asphalt and agricultural soil, shadows cast by steep slopes in a rural setting or by tall structures in an urban setting can appear similar to water. These spectral similarities between natural covers and anthropogenic land uses are problematic for per pixel, spectral data alone, classification techniques, the spectral resolution of the individual Landsat bands and some useful applications of each show in (Appendix .2).

3.2 The integration of remote sensing and geographic information systems (GIS)

GIS is defined as a computerized system that facilitates the phases of data entry, data analysis and data presentation especially in cases dealing with georeferenced data (Rolf & Knippers , 2004) . In more precise, GIS is defined by Rolf & Knippers (2004) as follows: A GIS is a computer based system that provides the following four sets of capabilities to handle georeferenced data:

1. Data capture and preparation.
2. Data management (storage and maintenance).
3. Data manipulation and analysis.
4. Data presentation.

For the users of remote sensing , it is not sufficient to display only the results obtained from image processing. For example, to detect land cover change in an area is not enough, because the final goal would be to canalize the cause of change or to evaluate the impact of change. Therefore the result should be overlaid on maps of transportation facilities and land use zoning. In addition , the classification of remote sensing imagery will become more accurate if the auxiliary data contained in maps are combined with the image data (Geerken , 2005).

The integration of remote sensing and geographic information systems (GIS) has been widely applied and been recognized as a powerful and effective tool in detecting land use and land cover change (Harris and Ventura 1995), and in understanding and monitoring desertification processes . GIS technology provides a flexible environment for entering, analyzing and displaying digital data from various sources necessary for desertification identification, change detection and database development.

3.3 Methodology of the Work:

The data were combined from image data satellite, topographic map, in addition to the ancillary data such as climate data and field observations, The general methodology followed for this research is presented in the flow chart in Figure 3.4, it shows the main processes in gathering and analyzing the remotely sensed data as well as field observations and GIS operations.

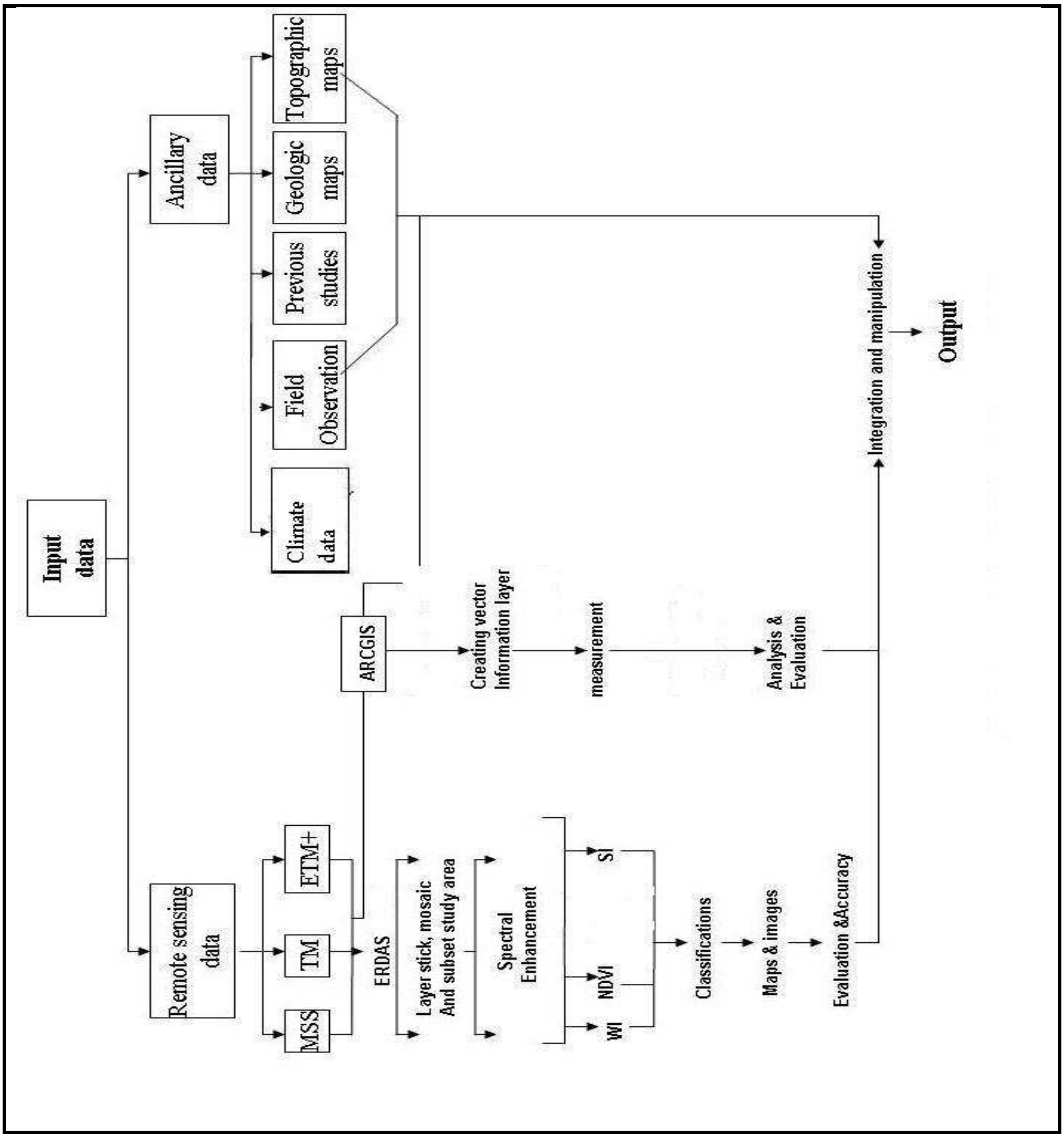


Figure 3.4:Flow chart of suggested methodology in the present study

3.4 The data available

3.4.1 Landsat data Overview

The Landsat earth observational satellites have been in operation since 1972, with the launch of ERTS-1 , later named Landsat , and with the launch of the second satellite in the series in 1975. The first Landsat carried an imaging multispectral scanner (MSS), with four spectral bands and a nominal 80 meter ground resolution. Landsat 4 and 5, launched in 1982 and 1984, respectively, carried both the 80 meter MSS , as well as an improved sensor , the Thematic Mapper (TM), possessing six , rather than four , reflective bands and one thermal band, as well as a higher spatial resolution (30 meters for the reflective bands, and 120 meters for the thermal band). Landsat 7, launched in 1999, carries the Enhanced Thematic Mapper+ (ETM), spectrally nearly equivalent to Landsat 4 and 5 TM. Notable differences were the inclusion of a 15 meter panchromatic band , and the improved spatial resolution (60 meters) for the thermal band. Table 3.1 summarizes the properties of both the Landsat 4/5 TM and Landsat 7 ETM+.

The Landsat sensors used in these project six reflective multispectral bands with 30 meter spatial resolution (see Table 3.1). Each of these bands renders reflectance in 256 grey or brightness levels, and the nominal time between revisits of the Landsat satellites is 16 days.

- **Landsat data used in this study**

The study area is covered by one scene of the Landsat MSS, TM and ETM+ (Figure3.4 show the Landsat images covered the study area). Multitemporal Landsat (path 180 / row37) MSS (dated July 04, 1976), (path 167/ row 37) TM (dated August 13, 1990 and September 2000) and ETM+ (dated May 25, 2007) imageries remotely sensed dataset were assembled to desertification analysis in the study area. These images data are downloaded from (U.S. Geological Survey website). The main characteristics of these satellites imagery are illustrated in Table 3.1 and Figure 3.5.

Table 3.1: Image characteristics for available data.

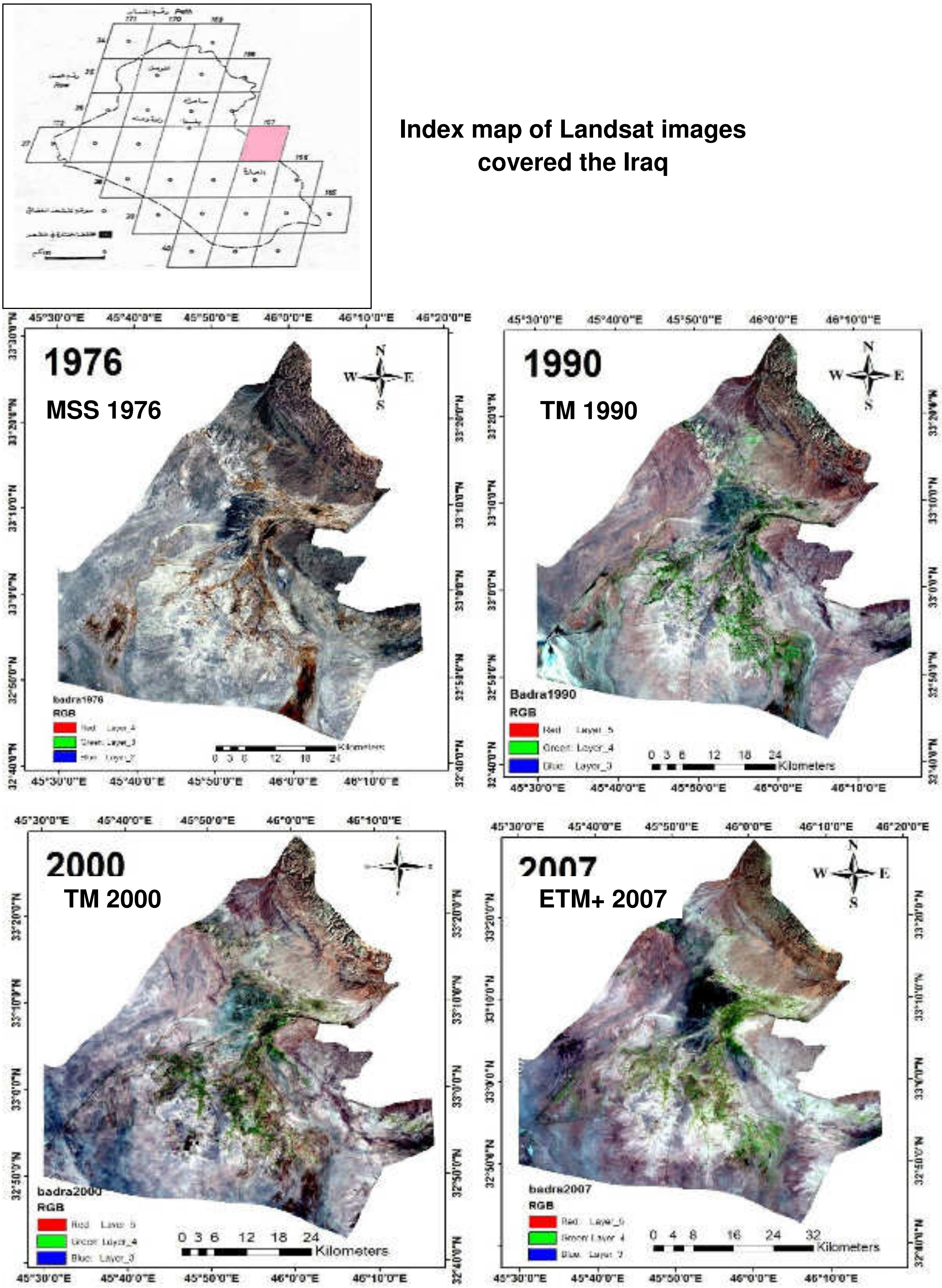
BAND	MSS Spectrum	Pixel Size	TM Spectrum	Pixel Size	ETM+ Spectrum	Pixel Size
1			0.45-052 μ m blue	28.5 m.	0.45-052 μ m blue	28.5 m.
2	0.5-0.6μmgreen	57 m.	0.52-0.6 μ m green	28.5 m.	0.52-0.6 μ m green	28.5 m.
3	0.6-0.7μ m red	57 m.	0.63-0.69 μ m red	28.5 m.	0.63-0.69 μ m red	28.5 m.
4	0.7-0.8μm NIR	57 m.	0,76-0.9 μ m NIR	28.5 m.	0,76-0.9 μ m NIR	28.5 m.
5	0.8-1.1μ m IR	57 m.	1.55-1.75 μm SWIR	28.5 m.	1.55-1.7μ m SWIR	28.5 m.
6			10.4-12.5 μ m TIR	57 m.	10.4-12.5μ m TIR	57 m.
7			2.08-2.35μ m SWIR	28.5 m.	2.1-2.35μm SWIR	28.5 m.
8			-------	-----	0.52-0.9 μm panchromatic	14.25 m.

3.4.2 Ancillary data

The ancillary data were collected from different reports , previous studies, and different digital and hard copy of different thematic maps which are:

1- Topographic maps with scale 1/100.000 and 1/250.000 of the area study. Since the study area is located on two map, so we did merge two maps after doing the geometric correction and subset the study area, Figure 3.6 and 3.7.

Figure 3.5: Landsat images (MSS, TM, and ETM+) cover the study area.



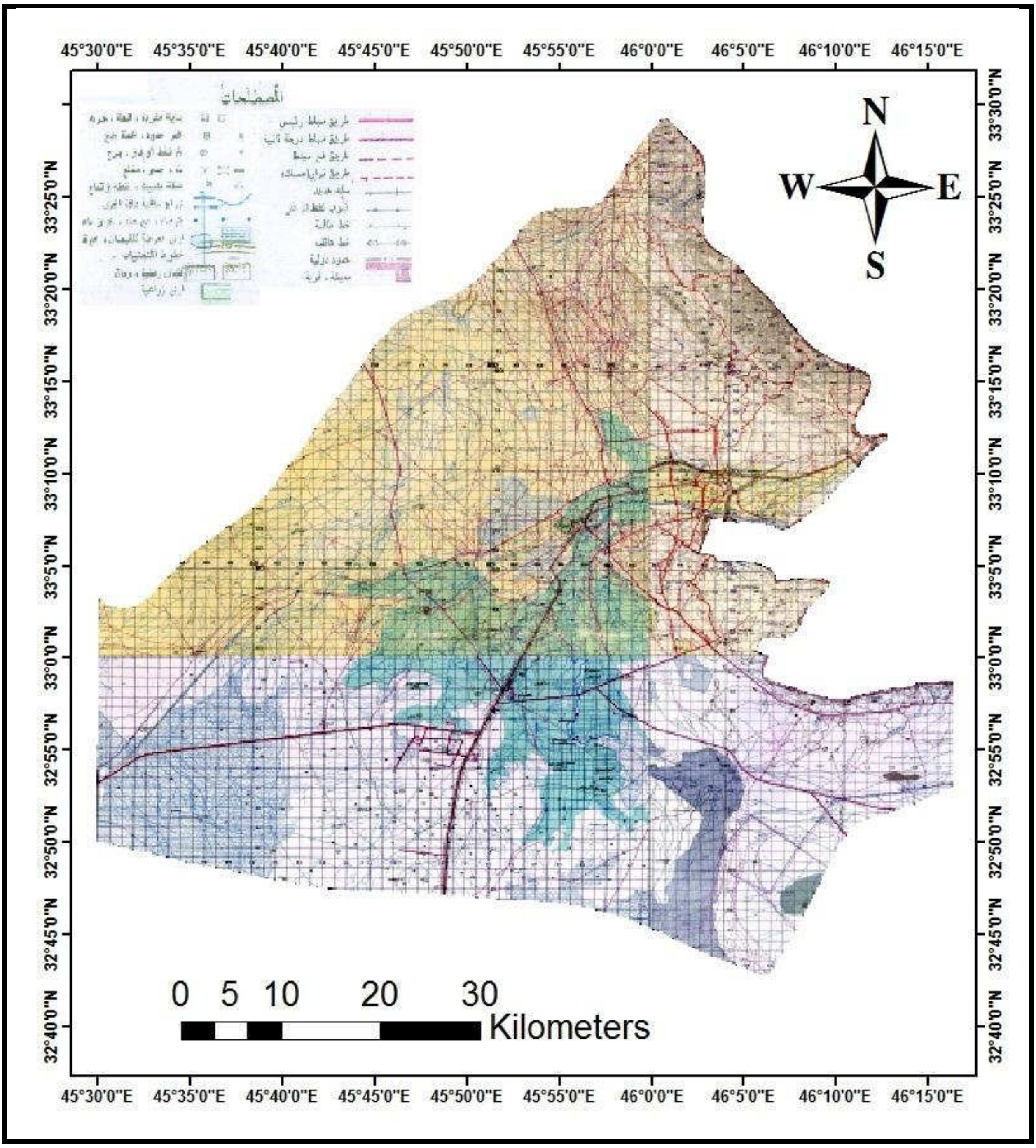


Figure 3.6: Topographic maps of the study area with scale: 1/ 250.000.

2-Geology, Geomorphology, Hydrogeology, Tectonic, Climate and Landuse maps of Iraq with scale 1: 1 000 000, which help us to understand the nature of the study area and the visual interpretation of satellite images.

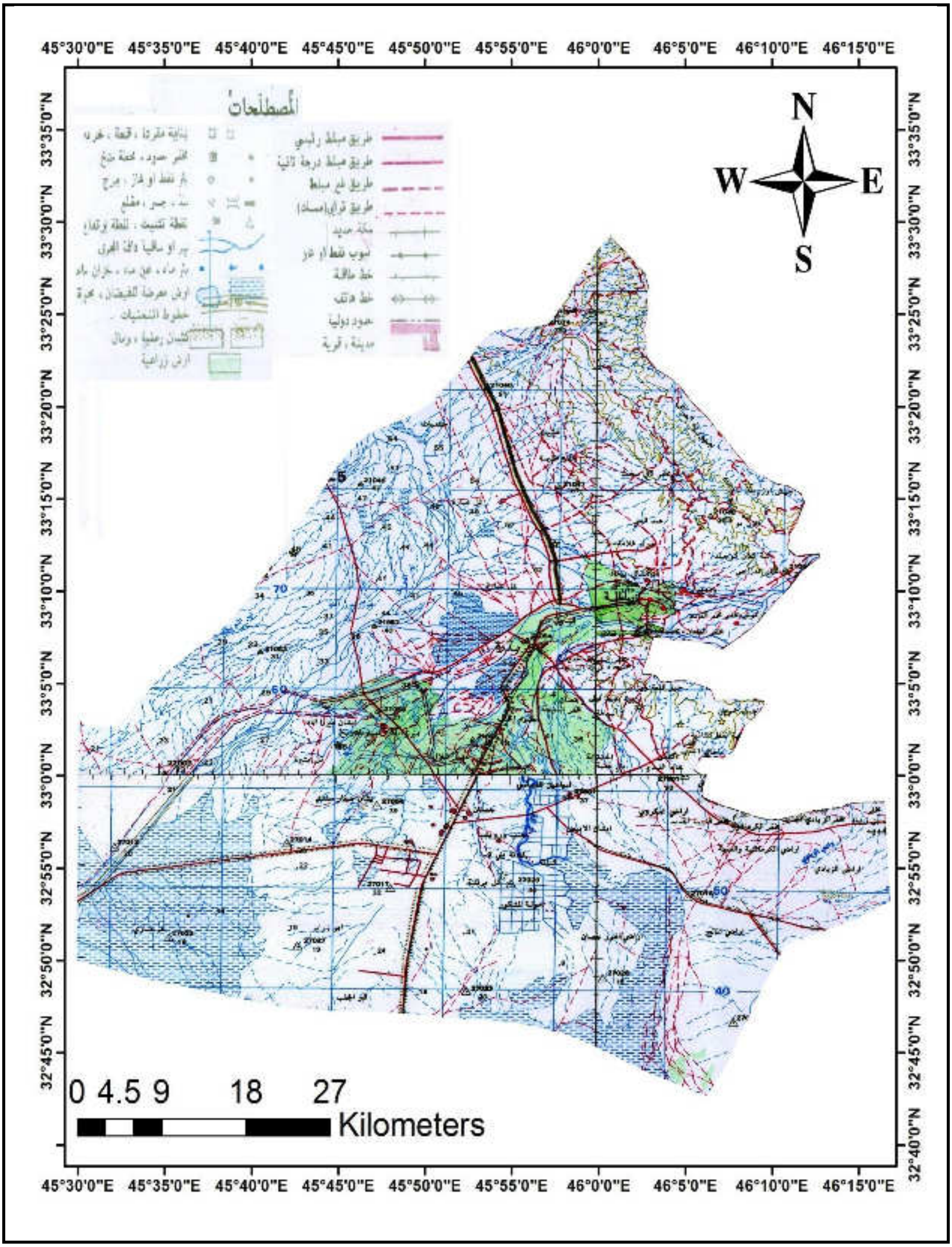


Figure 3.7: Topographic maps of the study area with scale: 1/ 100.000.

3-Climatic data which affects the desertification phenomena in area is collected from two meteorological stations, Badra and Al-Hai stations which records the climatic elements such as rainfall, wind speed , wind direction, temperature, evaporation ,and relative humidity for the period 1976-2007 for Alhi stations and 1994-2007 for Badra station.

3.4.3 Software used in this study

During this study two different software packages are used:

1**- ERDAS IMAGING** (version 9.2): The functionalities currently available in ERDAS Imagine allow the user to produce highly accurate multispectral images for various uses. This short essay will focus on the processes and techniques used to derive these images , and showcase the tools available in ERDAS Imagine that can be used to create many kind images.

2- **ArcGIS** (version 9.3): The ESRI Arc GIS system is an integrated geographic information system ArcGIS provides a scalable framework for implementing GIS for a single user or many users on desktops, in servers , over the Web, and in the field. ArcGIS is an integrated family of GIS software products for building a complete GIS. It consists of four primary frameworks for deploying GIS.

- ArcGIS Desktop an integrated suite of professional GIS applications. Most users recognize this as three products: ArcView, Arc Editor, and Arc Info.
- Server GIS- Arc IMS, ArcGIS Server, and ArcGIS Image Server.
- Mobile GIS Arc Pad and ArcGIS Mobile for field computing.

ESRI Developer Network (EDN) Embeddable software components for developers to extend GIS desktops, build custom GIS applications, add custom GIS services and web applications, and for creating mobile solutions.

3.4.4 Field observations

Field work was carried out in May, 2011and February, 2012. Preliminary image classification and RGB composite images of the study area was printed to indicate target areas to be surveyed depending on the accessibility of each site. The data were collected from different sites depending on the different soil types in the study area. Each site was registered by using GPS technology (Garmin12) to allow for further integration with the spatial data in a geographic information system (GIS) and image classification system and also to check any differences in position of an object identified in the ground compared to the imagery. The information collected from the department of agricultural in the study area and work observations about the presented pure land cover is used successfully to assess the classification process and results.

CHAPTER FOUR

DIGITAL IMAGE PROCESSING

CHAPTER FOUR

DIGITAL IMAGE PROCESSING

Introduction

The aim of image processing is to evaluate the advantages of digital analysis and interpretation of satellite imagery, and the contribution of the techniques of improvement of remotely sensed data applied to desertification in the study area.

4.1 Pre-processing

The primary data of the sensors does not accurately represent the ground targets that have been photographed because these data are sometimes distorted during the scanning process and the conversion to digital data. There are many factors that lead to this distortion, such as the atmosphere and its impact on the energy received by the sensor. Movement of the sensor during scanning , the movement of a carrier, whether aircraft or satellite and earth's rotation under Sensor during its movement. Result of all these factors give radiometric distortion , geometric distortion and systematic and random noise in the data recorded by the sensor. Therefore , the digital values of the units digital image do not represent exactly the energy reflected by the target ground return, and also that the spatial location of the target ground on the digital image is not associated with the exact location on the ground, This requires a correction process to the preliminary data called data restoration or preprocessing . The data received from the sensor is repaired or corrected or processed before you begin treatment that lead to the improvement of data and extract information from them (El Hassan, 2004).

In order to make qualitative interpretations from an image by simple visual comparison and to combine information from the different dates in a color composite display, or to perform quantitative analysis such as spectral classification and change detection, the following process should be make:

A-Georeferencing, Transform, and Resampling Maps

Topographic maps with scale (1/100000) and (1/250000) have been digitized throughout large format A0 scanner, georeferencing process has been performed to change the coordinate system of digitized maps to the (UTM). This process has been implemented using the ERDAS Imagine. First order transformation has been chosen and Nearest Neighbor resampling method is used.

B-Layer Stack and Extracting (subsetting) of the Area Study

Image data may include several bands, each band is a set of data file values for a specific portion of the electromagnetic spectrum of reflected light or emitted heat (red, green, blue, near-infrared, infrared, thermal, etc.) or some other user-defined information created by combining or enhancing the original bands, or creating new bands from other sources (ERDAS Field Guide ,1999).

Landsat images files often come in one-band-per-image files and the layer stack procedure will work to combine them into one multi-band image. Landsat TM band 6 (thermal band) typically has 60-meter resolution , and Landsat ETM$^+$ the panchromatic band (band 8) typically has 15-meter resolution, while the other bands have 30-meter resolution. If the panchromatic band is stacked into the output file, bands 1 through 7 will be resampled to 15-meter pixel size, some spectral definition will be lost, and the file size more than quadrupled. For Landsat data, layer stacks bands 1 through 5 and band 7. Keep the panchromatic band and band 6 as separate files (Figure4.1).

Subsetting refers to breaking out a portion of large file into one or more smaller files. Image files contain areas much larger than a particular study area. In these cases; it is helpful to reduce the size of image file to include only the area of interest (AOI). This not only eliminates the extraneous data in the file, but it speeds up processing due to the smaller amount of data process; and can be important when dealing with multi-band data (ERDAS Field Guide, 2008). The targeted area locates in east of Iraq as shown in Figure3.8.

C-Image Merging process

Landsat 7 ETM+ data are acquired at three different resolutions. The multispectral bands (bands 1-5, 7) are collected at 30 meters, the thermal band (band 6) is collected at 60 meters, and the panchromatic band (band 8) is collected at 15 meters. To obtain an image with high spatial and spectral resolution, it is necessary to perform spatial merge process between panchromatic image (band 8) date 2007 which have spatial resolution (14.25m) merge bands with (28.5) and low spatial color image, The only requirement prior to following these process is to ensure that all of the data are georeferenced or that all of the data cover the same geographic area (AL-Ahbaby, 2005) . New satellite enhanced image will be produced using principal component method and cubic convolution resampling techniques, as shown in resulting Figure 4.2.

This technique gives relatively high resolution colored image (14.25 m.), whereas helped to distinguish a small scale features which was not clear in the origin image (AL-Hmedawy, 2008) .Note that while it is also possible to merge the multispectral data with the 60-meter thermal band, this procedure is not recommended because of the loss of data that would occur at the 30-meter scale.

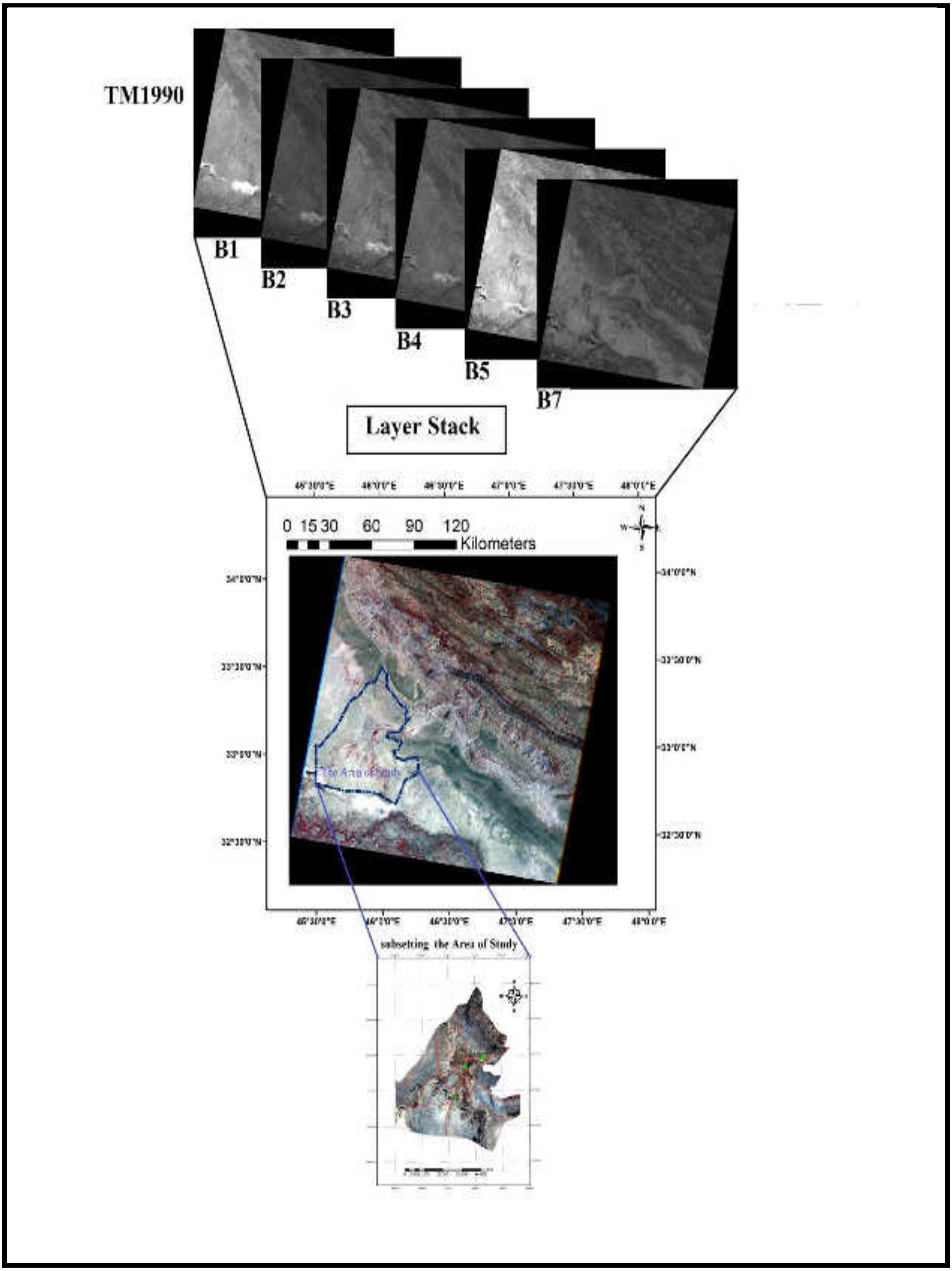


Figure4.1: Layer Stack and subsetting the Area of Study.

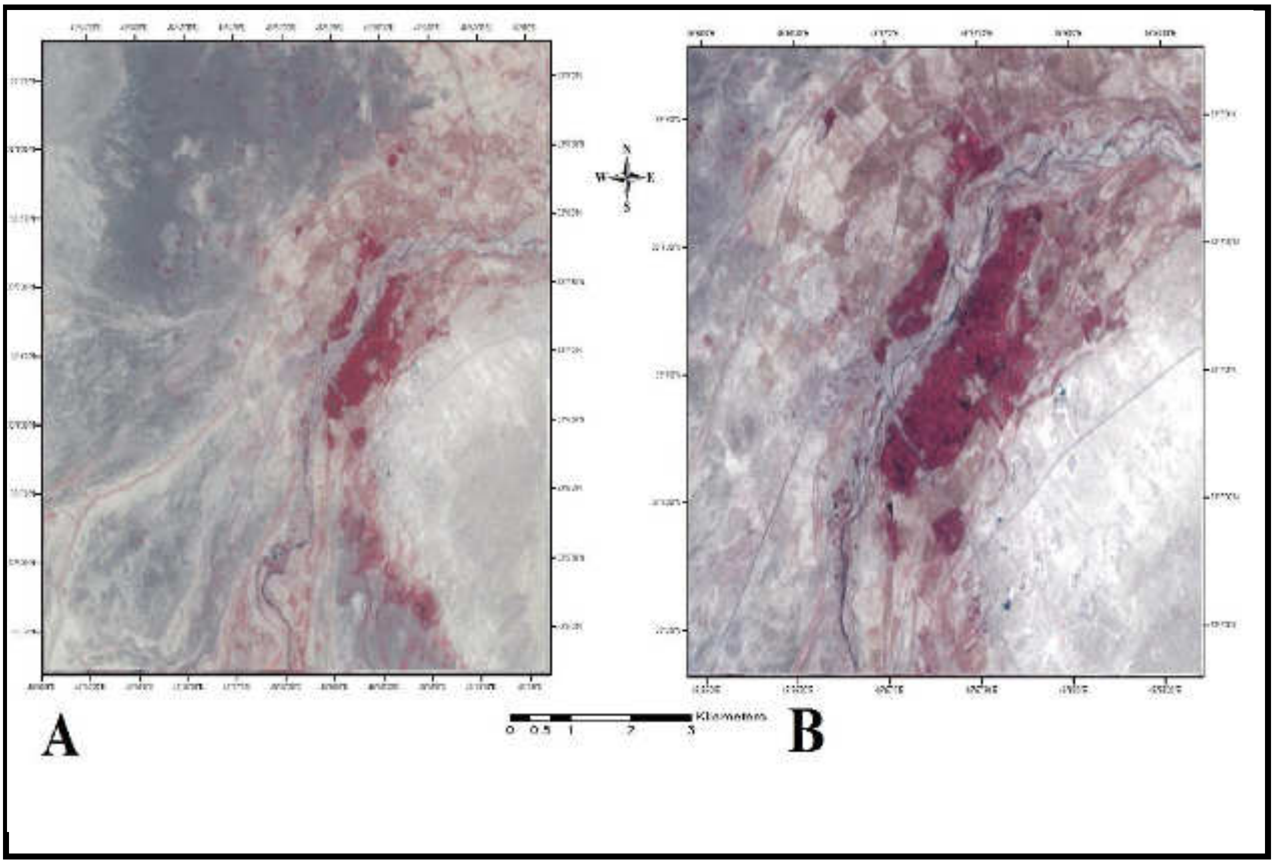


Figure 4.2: Merge process between satellites images with band 8. A) Before Merge B) After merge.

4.2 Image Enhancement and transformation

Image enhancement is the process of making an image more interpretable for a particular application (Faust, 1989). Enhancements are used to make visual interpretation and understanding of imagery easier. Thus, for each application and each image, a custom adjustment of the range and distribution of brightness values is usually necessary. In addition image transformation typically involve the manipulation of multiple bands of data, whether from a single multispectral image or from two or more images of the same area acquired at different times (i.e. multi temporal image data). Either way, image transformations generate (new) images from two or more sources which highlight particular features or properties of interest, better than the original input images (CCRS 2000).

In order to identify land cover pattern in the study area and monitoring that variations in the state and spatial distribution of desertification phenomena, several enhancement techniques have been used which explain in full detail as follow:

4.2.1 Normalized Difference Vegetation Index (NDVI)

The NDVI is a commonly used vegetation index derived from remotely sensed measurements of electromagnetic energy in the red and near-infrared spectral regions. To determine the density of green on a patch of land must observe the distinct colors (wavelengths) of visible and near-infrared sunlight reflected by the plants. As can be seen through a prism, many different wavelengths make up spectrum of sunlight. When sunlight strikes objects, certain wavelengths of this spectrum are absorbed and other wavelengths are reflected. The pigment in plant leaves, chlorophyll, strongly absorbs visible light (from 0.4 to 0.7 µm) for use in photosynthesis. The cell structure of the leaves, on the other hand, strongly reflects near-infrared light (from 0.7 to 1.1 µm). The more leaves a plant has, the more these wavelengths of light are affected, respectively. Figure 4.3.

In an effort to monitor major fluctuations in vegetation and understand how they affect the environment, 20 years ago Earth scientists began using satellite remote sensors to measure and map the density of green vegetation over the earth by carefully measuring the wavelengths and intensity of visible and near-infrared light reflected by the land surface back up into space, scientists use an algorithm called a (Normalized Difference Vegetation Index NDVI) to quantify the concentrations of green leaf vegetation.

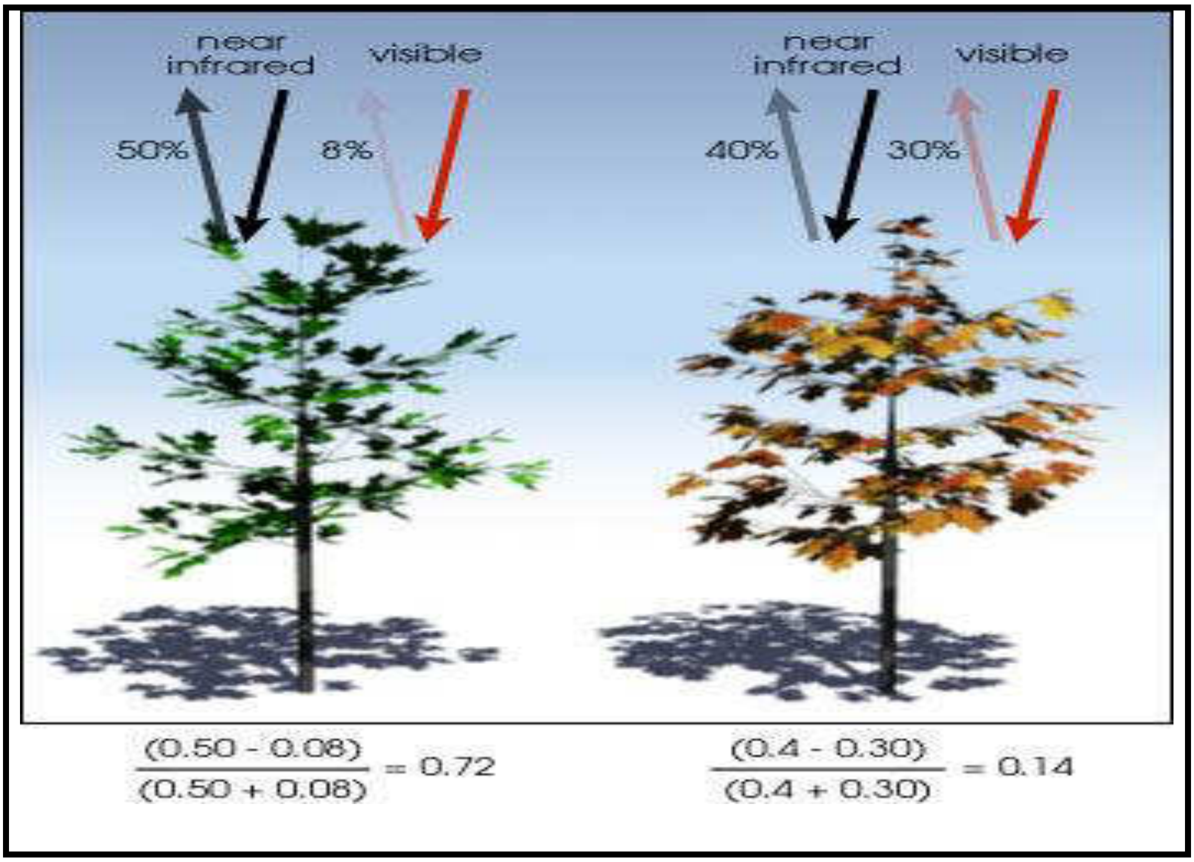


Figure 4.3: NDVI is calculated from the visible and near-infrared light reflected by vegetation. Healthy vegetation (left)absorbs most of the visible light that hits it , and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation (right) reflects more visible light and less near-infrared light. The numbers on the figure above are representative of actual values, but real vegetation is much more varied. (NASA Website).

The NDVI is an index that provides a standardized method of comparing vegetation greenness between satellite images.

The formula to calculate NDVI is:

NDVI = (NIR-RED)/ (NIR + RED) ……(AL-Hmedawy, 2008)

In this study, we will make the modification of using only the Red image band instead of the whole range of visible light. Thus, our formula will be:

NDVI = [(B4-B3)/ (B4+B3)]

Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1); however, no green leaves gives a value close to zero. A zero means no vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves.

In this study, the NDVI calculated from four periods of Landsat MSS 1976, TM 1990, 2000 , and ETM^+ 2007 data based on the Normalized difference between the bands 3 (Red) and band 4 (Infra) spectral values. The resultant NDVI images in figure 4.4 . It has interval grey scale from -1 to 1 with 8 bit , where the brighter values indicate pixel of green vegetation , while the darker values have little or no vegetation , which is indicating the condition of vegetation cover, and all vegetation pixels has pixel value more than 0.01. The raster map was divided into two classes depending on its histogram using the 0.01 as a threshold number.

Figure 4.5 four periods 1976, 1990, 2000 and 2007 are shown. The maximum density of vegetation is located in the central part of the study area, the vegetation cover is 44.624 km^2 in 1976 and increased in 1990 to be 127.226 km^2 then decreased in 2000 to be 100.501 km^2 then high decreased in 2007 to be 61.987 km^2 (Fig.4.5) . The density of vegetation in study area in four periods displays in Fig.4.6.

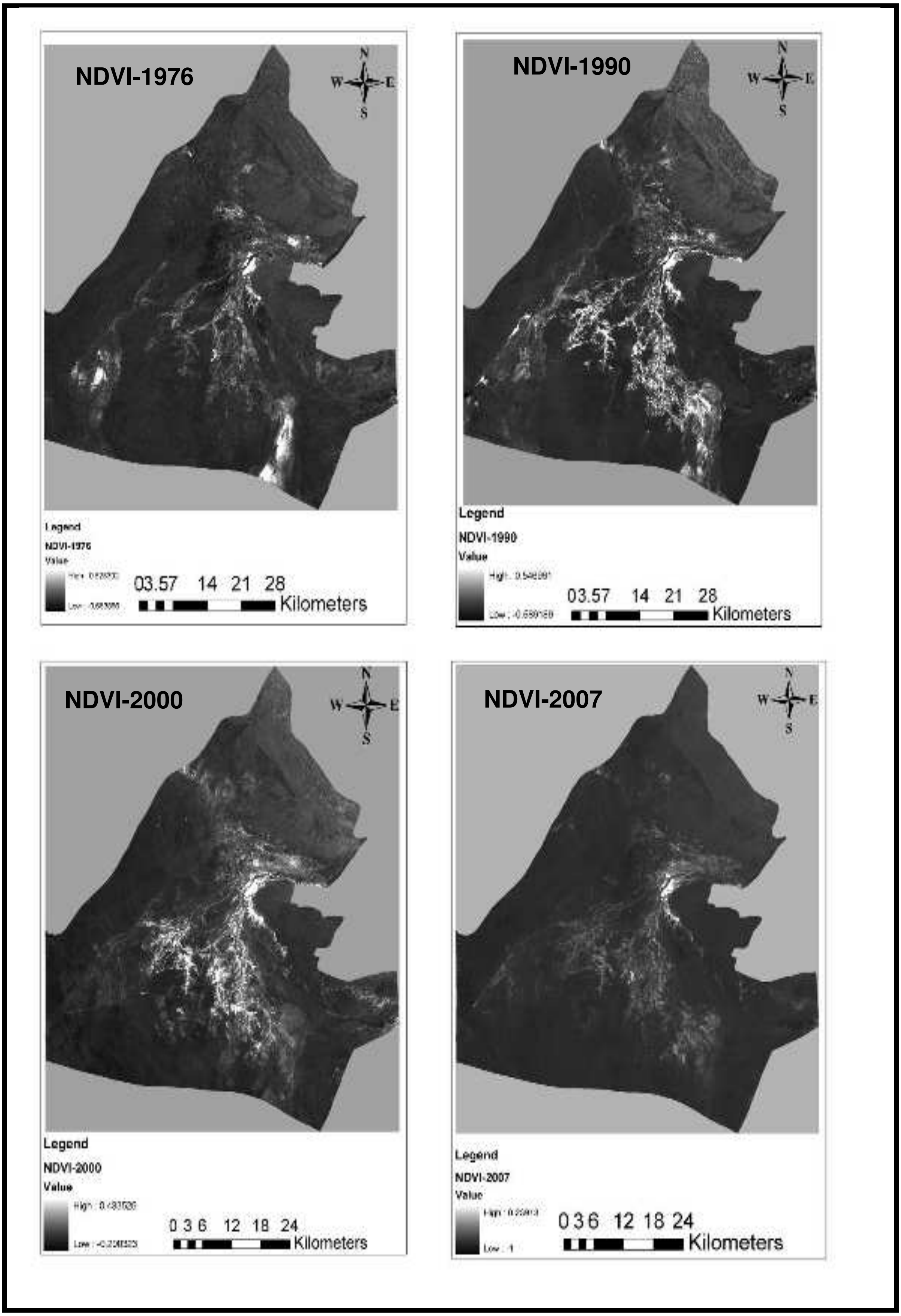


Figure 4.4: NDVI in 1976, 1990, 2002 and 2007.

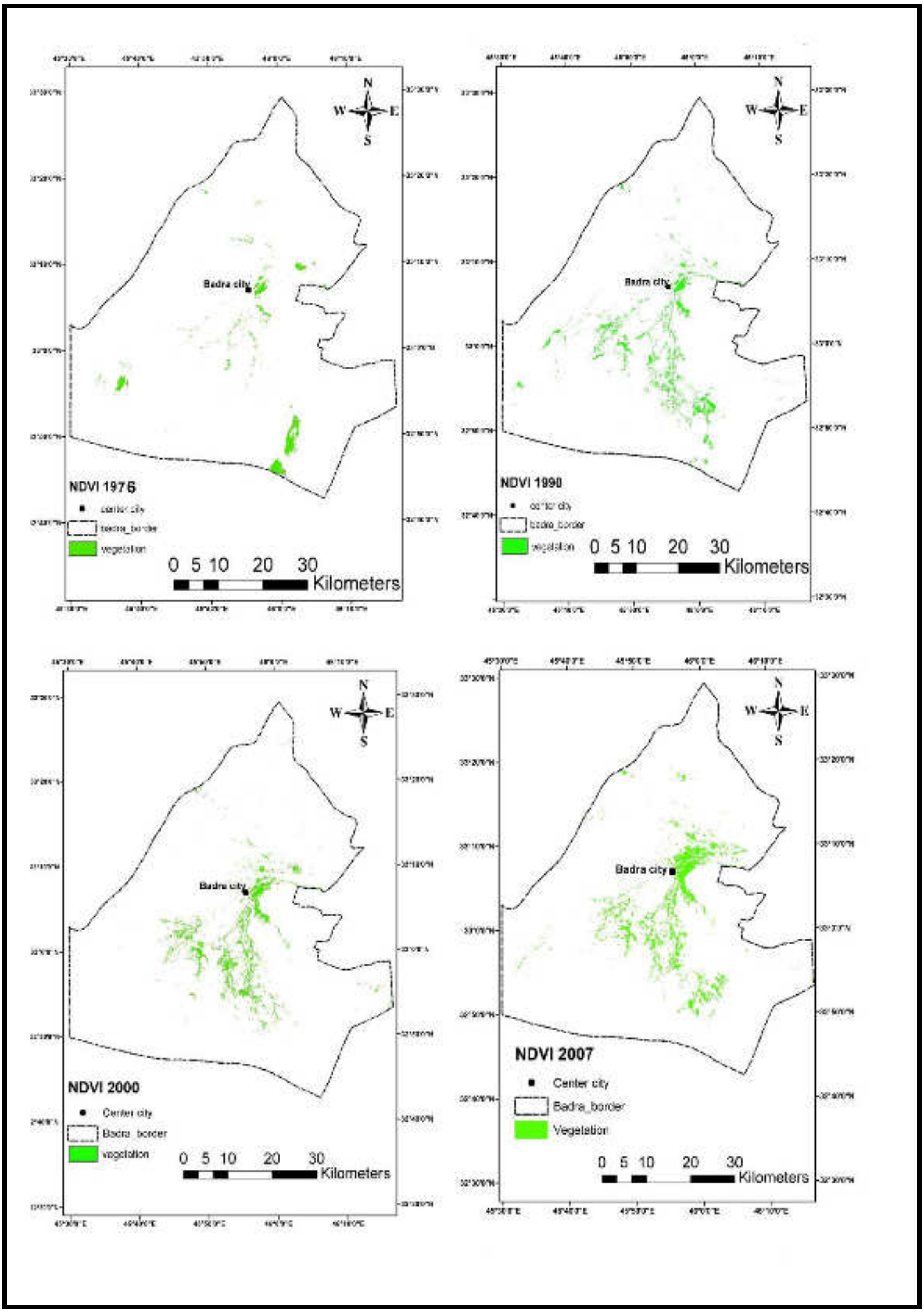


Figure 4.5: Vector of NDVI in 1976, 1990, 2000 and 2007.

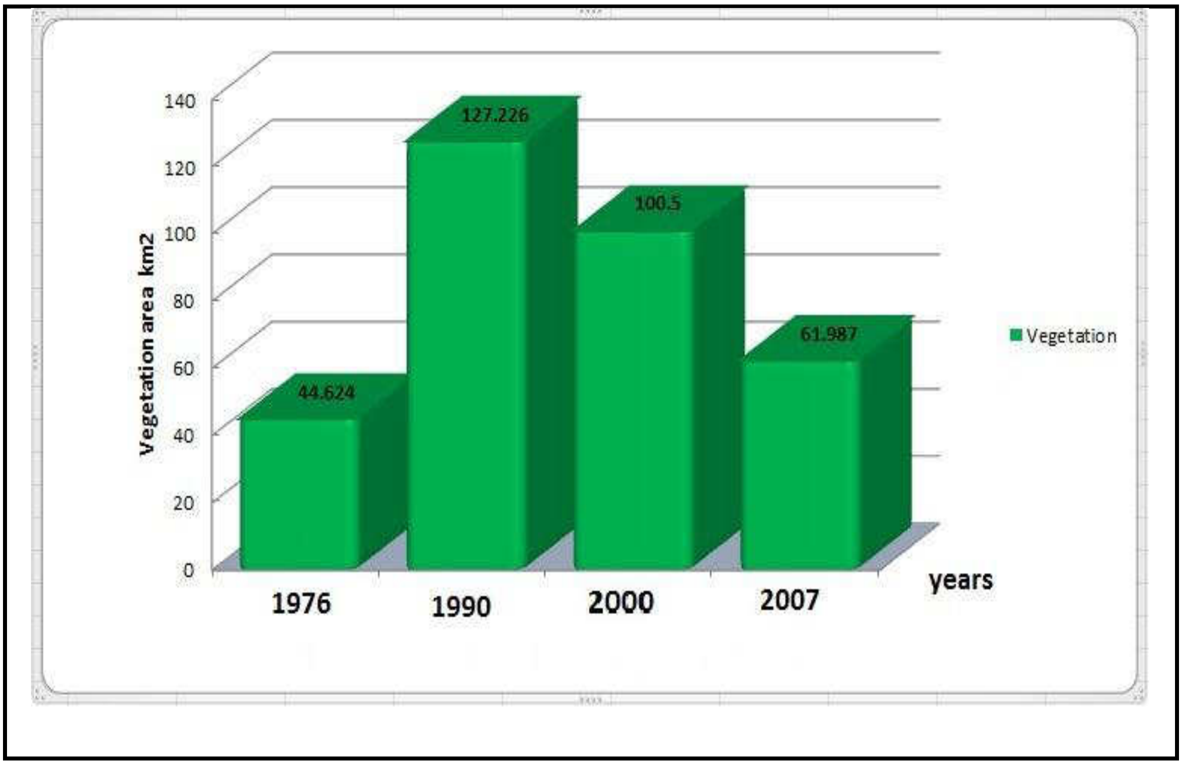


Figure 4.6: Histogram showing vegetation density in study area for the four periods.

4.2.2 Water Index (WI)

The Role of Remote Sensing in Surface Water Mapping

Remote sensing techniques provide important capabilities to map surface water features and monitor the dynamics of surface water. Although active microwave sensors [e.g., the synthetic aperture radar (SAR)], are capable of penetrating darkness, clouds, and tree canopies at the longer wavelengths; they have limitations in discriminating water features from non-water covers when wind-induced waves or emergent vegetation roughen the water surface (Alsdorf e*t al*., 2007; Smith, 1997). Passive microwave measurements can also detect water features in the presence of cloud cover and dense vegetation. But the spatial resolution is very coarse (e.g., 25 km at 37 GHZ frequency on the Special Sensor Microwave /Imager) due to the weak radiation received by the sensors (Sippel *et al*., 1994; Smith, 1997). The data from passive visible/infrared sensors are more accessible and the interpretation of the imagery more straightforward than data from SAR imagery, although visible/infrared imagery can be affected by poor weather conditions and dense vegetation canopy. The commonly used passive visible / infrared sensors for water feature delineation include the Landsat Multispectral Scanner (MSS), Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+).

In this study, water index calculated from data of the related Landsat bands of MSS , TM, and ETM+ within the periods 1976 , 1990 ,2000 and 2007 respectively on the basis of the following simple formula:

WI = NIR +SWIR /2 ……..…(Abbas, A., 2010)

All raster data of WI are converted to vector data and monitored in figure 4.8 for four periods 1976, 1990, 2000 and 2007. Figure 4.7 showing Histogram of water density in study area for the four periods.

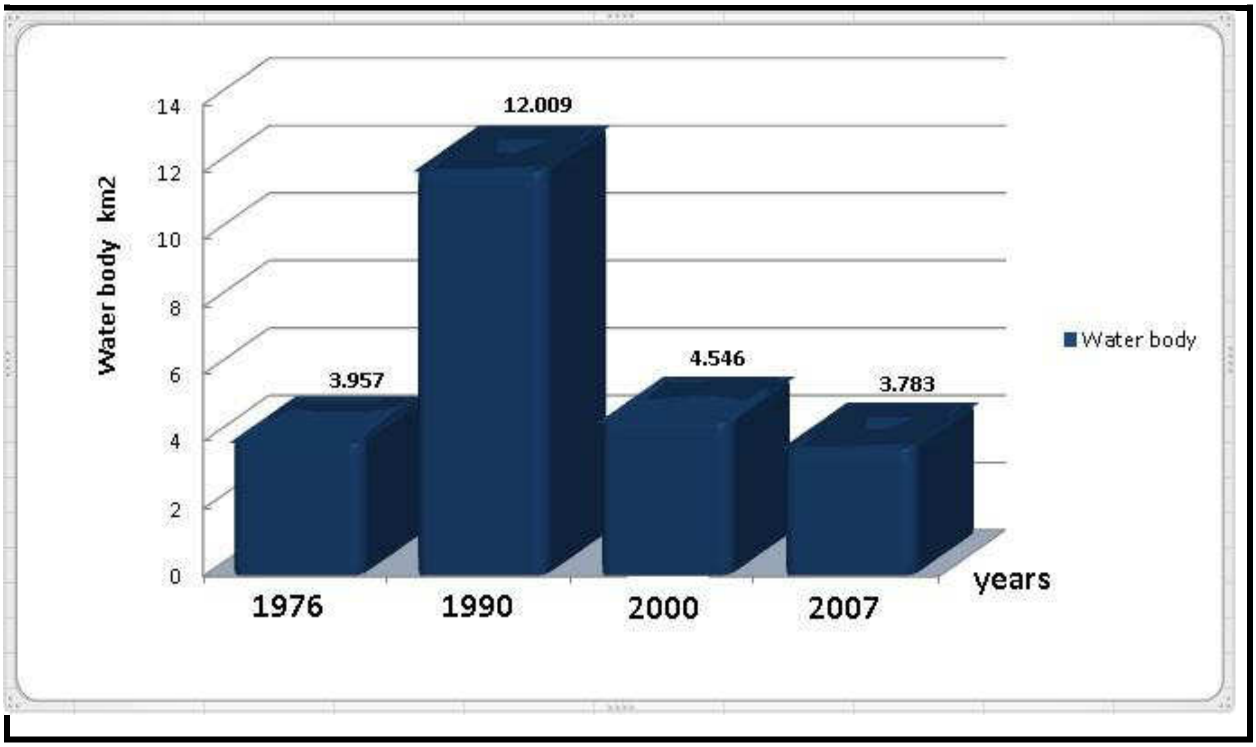


Figure 4.7: Histogram showing Water density in study area for the four periods.

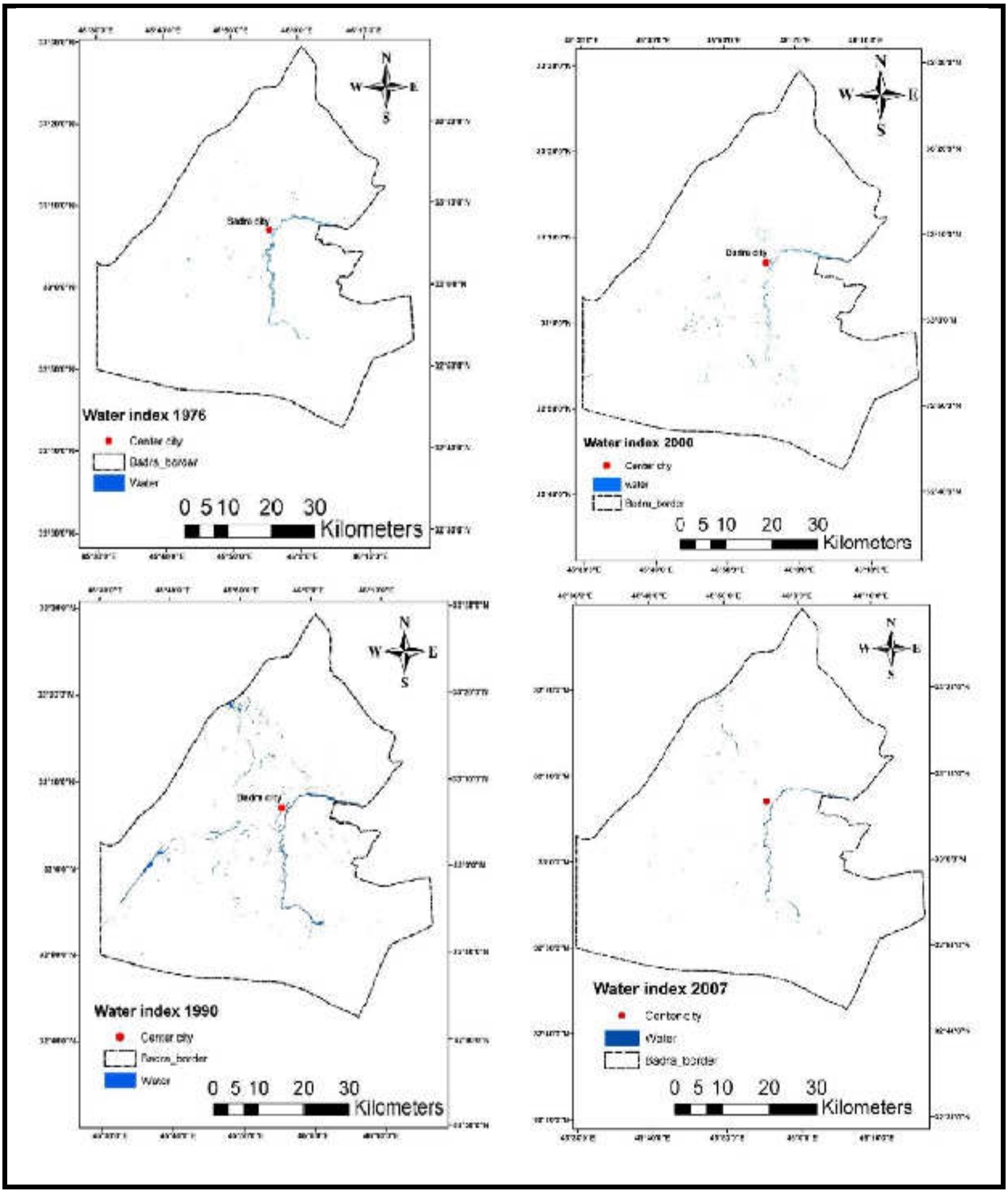


Figure 4.8: Vector of Water Index in 1976 and 1990.

4.2.3 Salinity Index (SI)

Salinization is the concentration of salts in the surface or near-surface zones of the soil and is a major process of land degradation (Thomas and pMiddleton, 1993). It is a natural process resulting from high levels of salt in the soil , originating from landscape features that allow salts to become mobile (movement of the water table) and from climatic trends in favor of salt accumulation. Alternatively, it may occur resulting from management practices (USDA, 1998). The latter, human-induced , salinization is often referred to as 'secondary salinization' to distinguish it from naturally affected soils (Thomas and Middleton, 1993). Salinization occurs when the following conditions occur together (USDA, 1998):

- presence of soluble salts in the soil
- high water table
- high rate of evaporation
- low annual rainfall

Typical natural spots in semi-arid areas where salinization occurs are areas that receive additional water from below the surface which evaporates, leaving the salts behind, as at the base of hillslopes, the rims of depressions and the edges of drainage ways and in flat, lowlying areas surrounding shallow water bodies (USDA, 1998). Human-induced salinization can be due to poor cultivation techniques; the indirect effects of irrigation schemes; vegetation change; sea water intrusion and disposal of saline wastes (Thomas and Middleton, 1993). FAO (1990) reported that about 20 to 30 mha (million hectares) worldwide are severely affected by salinity and an additional 60 to 80 mha are affected to some extent. At global scale, soil salinization is spreading at a rate of up to 2 mha per year. FAO country estimates suggest that 75% the irrigated area in Iraq is at least moderately saline, with as much as 20 to 30% of the irrigated area not farmed because of salinity. No current, accurate assessment is available because of neglect in the irrigation sector over the past two decades. High levels of salt in the soil affect the ability of plant roots to take-up water, and the effect on plants is similar to that of drought. In the information sheet of the USDA (1998), some indicators of soil salinity are given as well as some suggestions of how to manage salinity problems.

Remote Sensing has the ability to predict soil salinity accurately. It saves labor, time and effort when compared to field data collection of lands at risk of white death (salinization). Satellite data has a great potential for monitoring salinization in both spatial and temporal extents (Abbas, 1999). Past research shows mapping and assessing of soil salinity using remote sensing data like aerial photography, videography, infrared thermometry and multispectral scanners. Remote sensing appears to offer several advantages over the conventional ground methods used to map and monitor soil salinity:

- Remote sensing is timely, faster than ground methods and provides better spatial coverage.
- Remote sensing data can be used as input into a geographic information system (GIS) for further analysis and comparison to other data. Sensors with improved resolution are able to recognize more details for better results and precision.
- The users can select the band or bands required for their particular needs.
- Using remote sensing, soil salinity can be mapped both directly, by reflectance from bare soil, or from the salt crust, and indirectly from vegetative coverage and health. Saline soils with visible salt efflorescence on the soil surface are easier to map using remote sensing and are considered to be strongly saline soils.

- Vigorous growth and type of vegetation are easily recognized in satellite images. Therefore, plant vigor and type can be used to identify the extent of soil salinity. Such areas are usually moderately to weakly saline.

In this study , In order to detect the salt affecting soil in the study area and thus differentiating it from vegetation cover , the Soil Salinity Index (SI) was generated as a simple model which has been developed to generate an image , the SI derived from the green band and red band:

SI= (Green + Red) / 2 ……(Abbas, A., 2010)

MSS, TM and ETM were used respectively to generate this model, and detect saline soil which appears with high reflectance (Figure 4.10).

Finally, all raster data of Salinity Index are converted to vector data and monitored in figure 4.11 , for four periods 1976 , 1990 ,2000 and 2007, then Calculating the area of saline land show in figures 4.9.

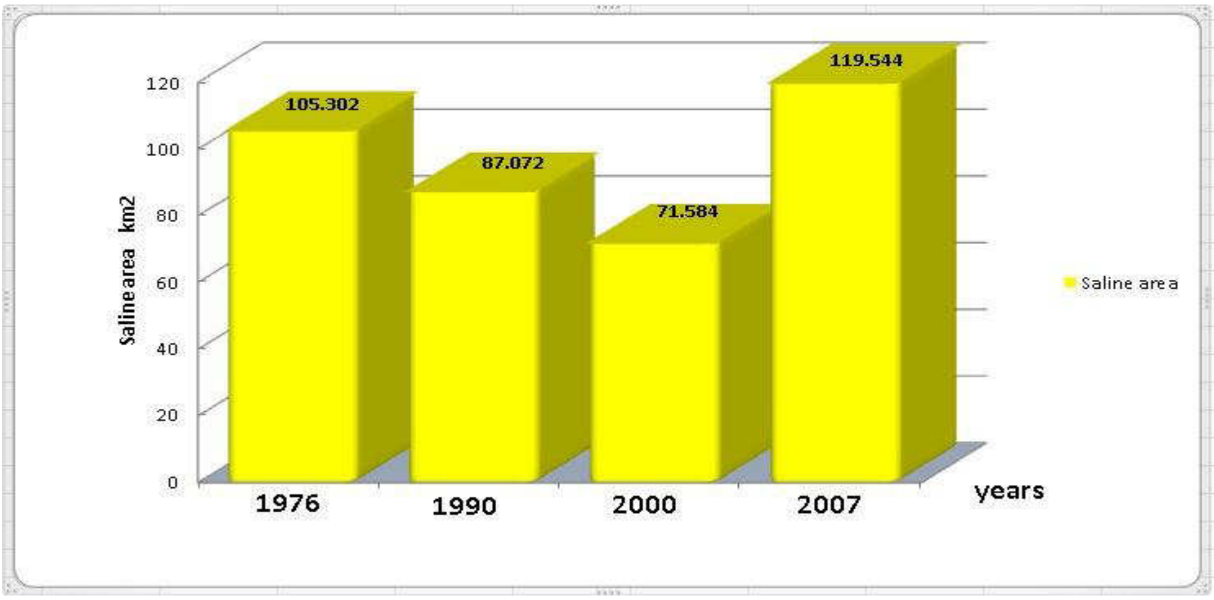


Figure 4.9: Histogram showing Saline density in study area for the four periods.

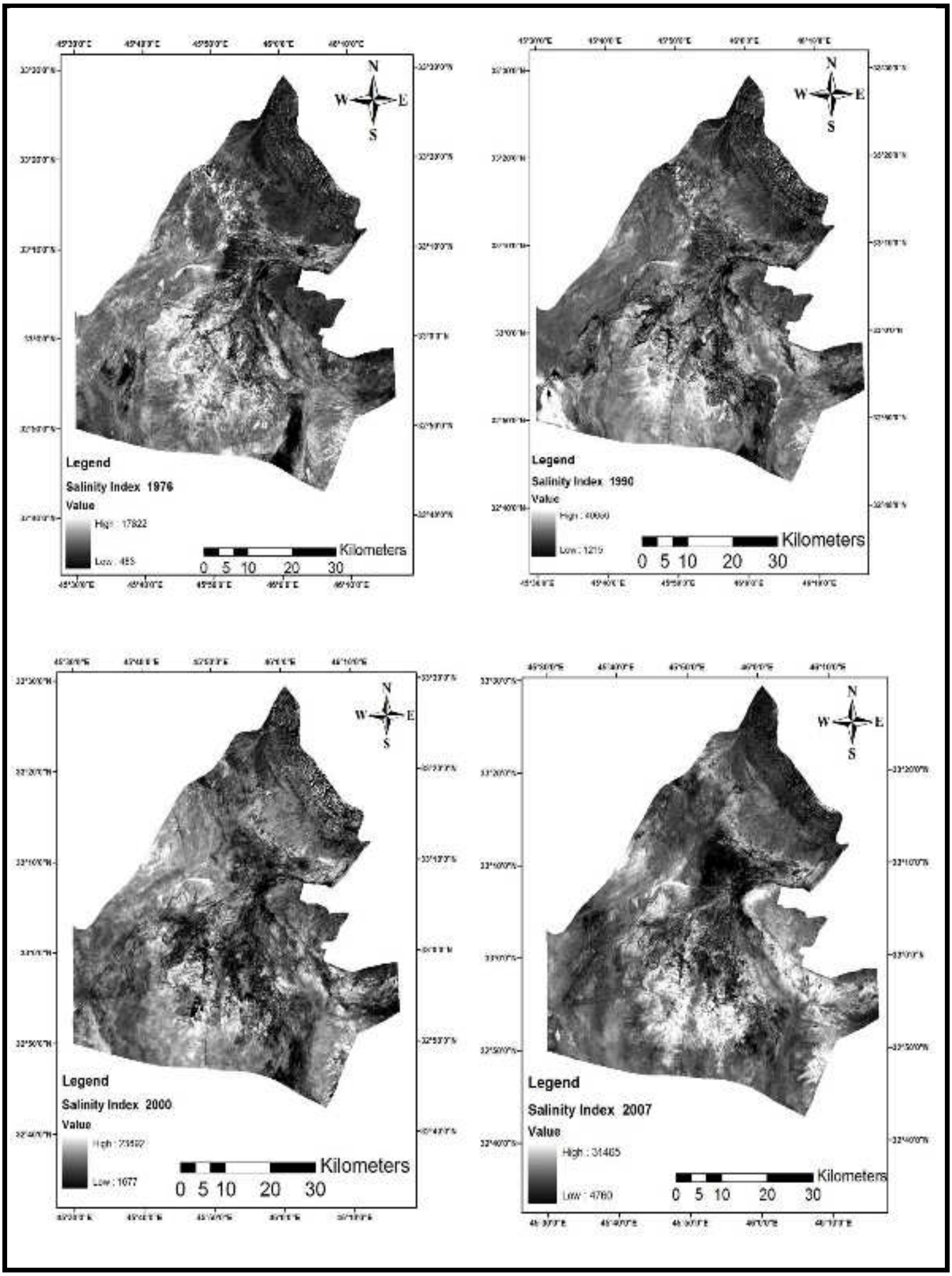


Figure 4.10: Salinity images in 1976, 1990, 2002 and 2007.

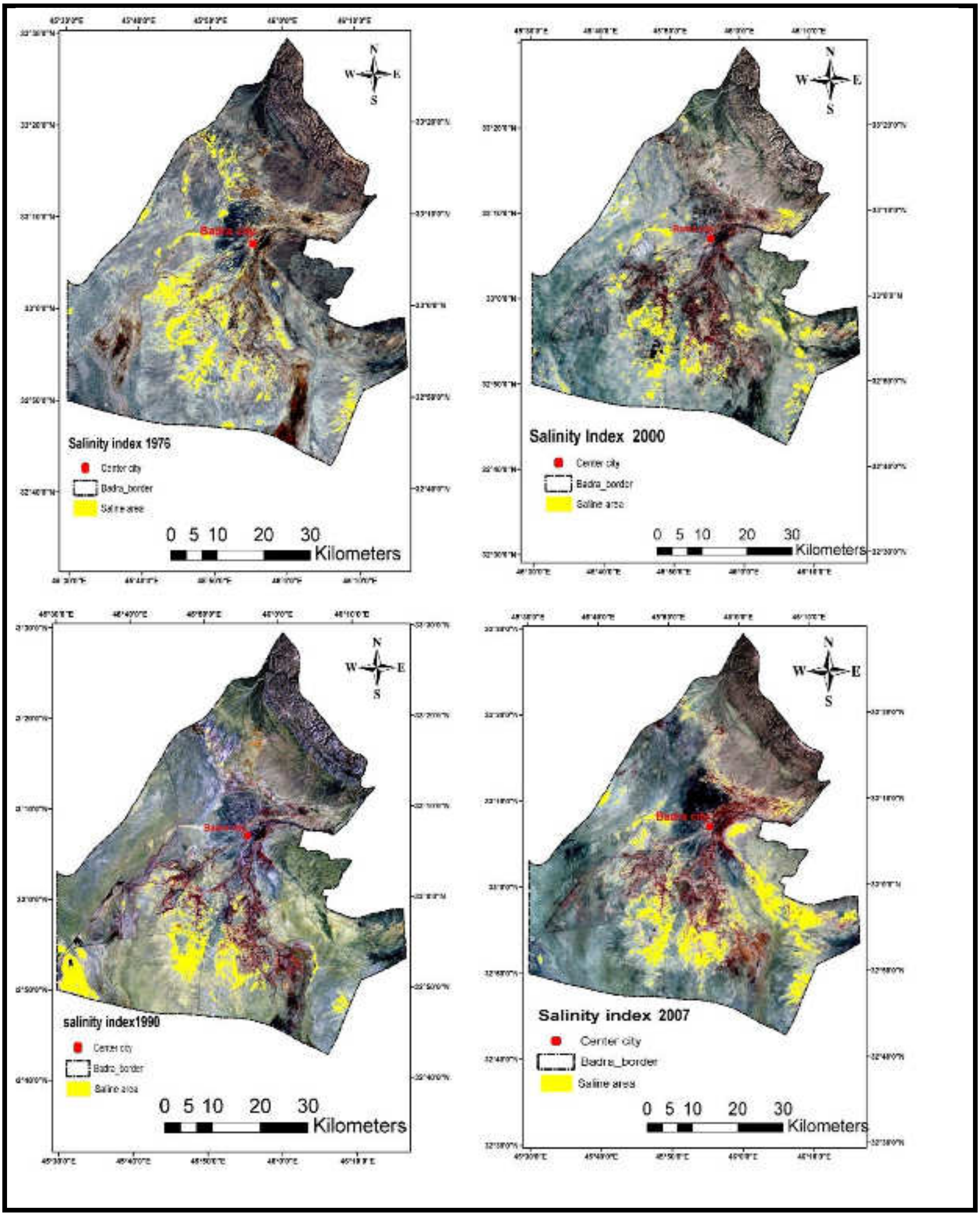


Figure 4.11: Vector of Salinity Index in 1976 and 1990.

4.2.4Change Detection

Change detection by remote sensing is widely used for environmental and desertification monitoring and agricultural applications (Fischer, 1995). Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Change detection is an important process in monitoring and managing natural resources and urban development (Singh, 1989).

The concept of change detection using satellite images is primarily based on quantifying the amount of change in radiance values, over some threshold , occurring in the same pixel of two images acquired in two different dates. Timely and accurate change detection of Earth's surface features provides the foundation for better understanding relationships and interactions between human and natural phenomena to better manage and use resource. Many change detection techniques have been developed (Change detection techniques, 2003). Change detection involves the application of various image analysis techniques to multi-temporal images, in order that variations in the state and spatial distribution of objects and phenomena can be quantified successful change detection studies require careful consideration of all external influences on the reflected EMR signal , within and between multi-temporal images (Abbas ,2010).

MacLeod and Congalton (1998) described four important aspects of change detection for monitoring natural resources: detecting if a change has occurred , identifying the nature of the change, measuring the areal extent of the change, and assessing the spatial pattern of the change. Lambin and Strahler (1994b) listed five categories of causes that influenced land-cover change: long-term natural changes in climate conditions; geomorphological and ecological processes such as soil erosion and vegetation succession; human-induced alterations of vegetation cover and lands capes such as deforestation and land degradation; inter-annual climate variability; and the greenhouse effect caused by human activities. Successfully implementing a change detection analysis using remotely sensed data requires careful considerations of the remote sensor system, environmental characteristics and image processing methods. The temporal, spatial, spectral and radiometric resolutions of remotely sensed data have a significant impact on the success of a remote sensing change detection project. The important environmental factors include atmospheric conditions, soil moisture conditions and phonological characteristics (Jensen, 1996).

The change detection methods are grouped into seven categories (Change detection techniques, 2003):

(1) Algebra.

(2) Transformation.

(3) Classification.

(4) Advanced models.

(5) Geographical Information System (GIS) approaches.

(6) Visual analysis.

(7) Other approaches , This category includes those change detection techniques that are not suitable to group into any one of the six categories and are not yet extensively used in practice.

4.2.4.1 Change Detection in Study Area

There are dozens of different remote sensing change detection techniques applicable to landuse/ land-cover studies (Lu et al., 2004). Multiple reviews and comparisons of these methods have been conducted with little agreement on an optimal method (Singh 1989، Mass 1999, Coppin et al. 2004, Lu et al. 2004). The methods used in this study are (1) visual analysis, (2) simple algebraic differencing.

I-Visual Analysis Technique

This is the simplest, and probably oldest, of the change detection techniques. Visual analysis was often used to interpret aerial photography in the days prior to digital satellite imagery (Lu et al., 2003). Human experience and knowledge are useful during visual interpretation, two or three dates of images can be analyses at one time, The analyst can incorporate texture, shape , size and patterns into visual interpretation to make a decision on the change , but Cannot provide detailed change information. The results depend on the analyst's skill in image interpretation (Change detection techniques, 2003). It also includes the analysis of multi-date image composites, which involve assigning images of different dates to either a red, green or blue color palette in the imaging software. This means that changes are easily Identifiable, because, depending on the date when they occur, they will appear as different colors composite.

In this study , change detection between the different dates (1976 , 1990 ,2000 and 2007) using Visual interpretation for the four dates was conducted to interpret different land covers .

II- Simple algebraic Technique

The algebra category includes image differencing , image regression , image rationing , vegetation index differencing , change vector analysis (CVA) and background subtraction. These algorithms have a common characteristic, i.e. selecting thresholds to determine the changed areas. These methods (excluding CVA) are relatively simple, straightforward, easy to implement and interpret, but these cannot provide complete matrices of change information , CVA is a conceptual extension of image differencing. This approach can detect all changes greater than the identified thresholds and can provide detailed change information, (Change detection techniques, 2003).

One disadvantage of the algebra category is the difficulty in selecting suitable thresholds to identify the changed areas. In this category, two aspects are critical for the change detection results: selecting suitable image bands or vegetation indices and selecting suitable thresholds to identify the changed areas(Change detection techniques, 2003).Common method of thresholding is the standard deviation method , which only identifies change that occurs within a certain number of standard deviations away from the mean. The only major considerations that need to be taken into account when using methods in this category are which bands, vegetation indices, and thresholding techniques are to be used (Singh, 1988).

In this study, NDVI values were subtracted from each other pixel-by-pixel and it was observed that the resulting images were normally distributed.

4.2.4.2Change Detection by Using Normalized Difference Vegetation Index (NDVI)

Assessing the type, extent, and condition of vegetation over a region is a primary goal of land use investigations. Researchers use data from Landsat and other environmental satellites to determine the number of acres of certain crop types in a region, locate vegetation that is heavily impacted by natural or man-made stresses (NASA, 2000).

The basic concept is that vegetation features can be distinguished from other features because of their different spectral responses in the visible and infrared regions. In order to detect land use or land cover change. However, the remote detection of vegetative change within arid areas is significantly more difficult, with the selection of appropriate methods being heavily scene dependent (Abbas, 2010).

NDVI images have long been used , and are widely accepted as an effective means of estimating vegetation cover. The majority of change detection techniques result in data which is difficult to interpret. The most common of these is Image Differencing (one type of algebraic Technique). Image differencing more specifically vegetation index differencing and is one of the most common vegetation change detection methods, mostly due to its simplicity (Singh, 1988), (Lyon et al. 1998). This method subtracts pixel by pixel the imagery from two dates. The result is a monochromatic (grayscale) matrix of the pixels which have changed through time.

In this study, vegetation change by NDVI images for Landsat MSS 1976, TM 1990 , 2000 and ETM 2002 .The differences change in NDVI vegetation cover images between 1976 and 1990 , between 1990 and 2000, between 2000 and 2007, and between 1976 and 2007 are shown in Figure 4.12 and 4.13.

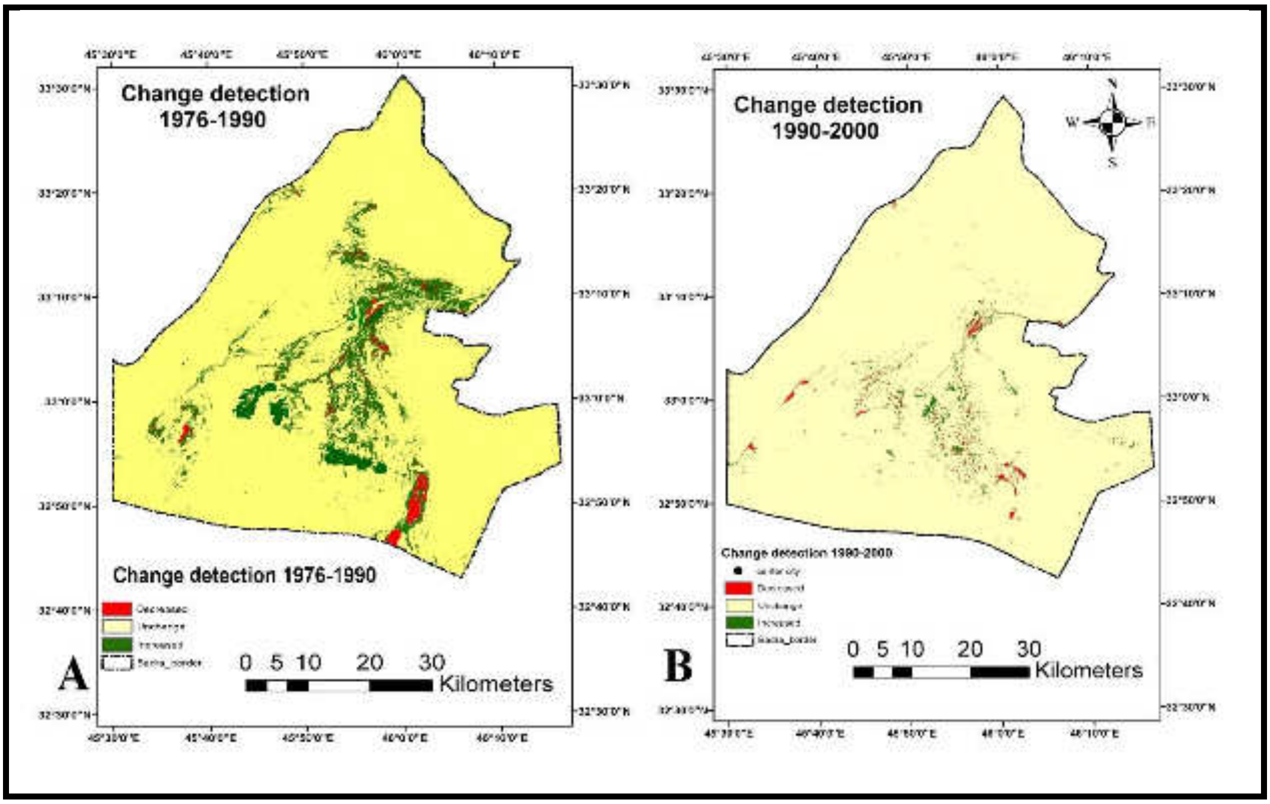


Figure 4.12: NDVI image differencing change for periods 1976-1990 and 1990-2000.

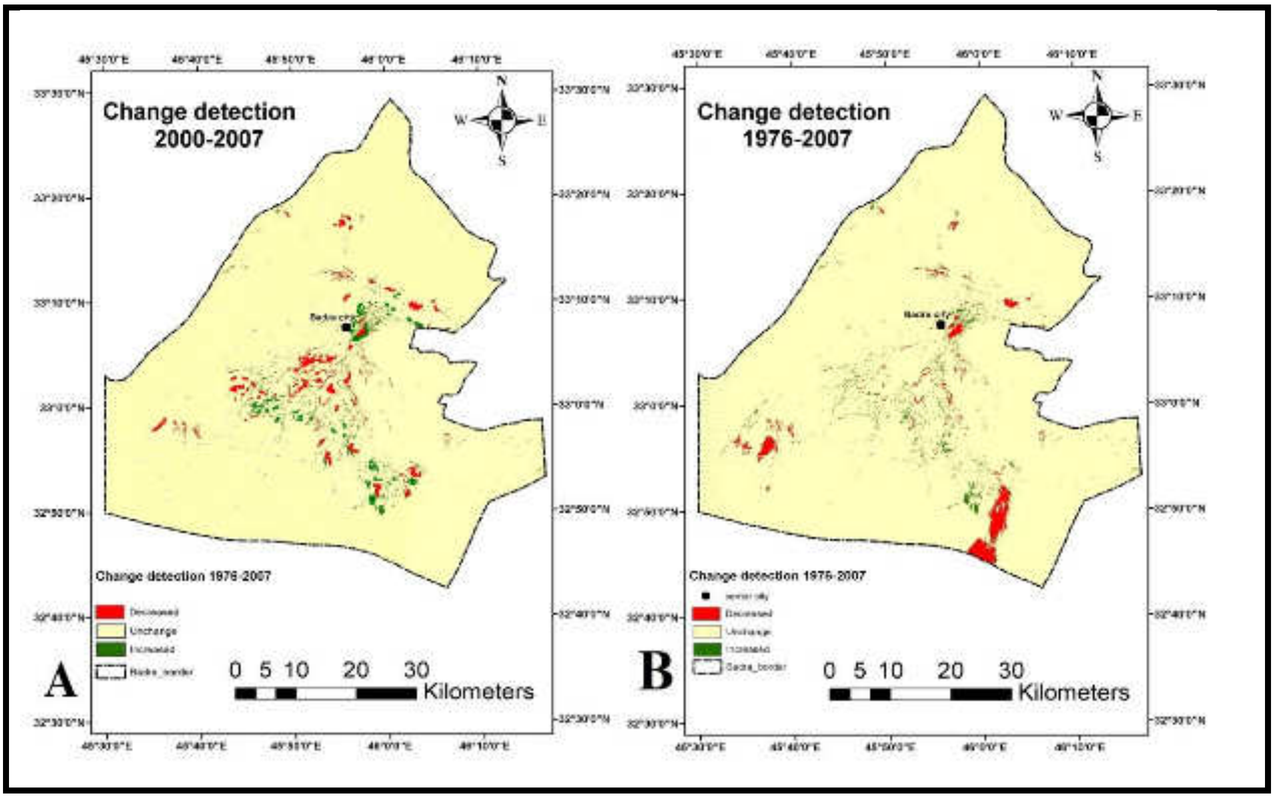


Figure 4.13: NDVI image differencing change for periods 2000-2007 and 1976-2007.

4.2.5 Digital classification technique

Image classification is the process of assigning pixels (multi-spectral data from satellite image) to the desired land use classes (Campbell, 1996). Digital classification technique designed to separate image pixels of specific units from landcover. This technique depends on spectra pattern recognition by automatically statistical process, (Lillesand and Kiefer, 2000).

Fundamentally spectral classification forms the bases to map objectively the areas of the image that have similar spectral reflectance/ emissivity characteristics. Depending on the type of information required, spectral classes may be associated with identified features in the image (supervised classification) or may be chosen statistically (unsupervised classification). (Tutorials Image Processing and Analysis), depending on the type of information to be extract from the original data, classes may be associated with known features on the ground or may simply represent areas that look different to the computer. An example of a classified image is a land cover map, showing vegetation, bare land, pasture, urban, etc. (ERDAS Field Guide).

Several classification routines exist for the classification of multi-spectral imagery including maximum likelihood, minimum distance, and spectral angel mapping classifiers. The classification routines fall into three main categories; distance based, probability based, and angular based decision rules.New classification routines or, more commonly, modifications to existing classification routines are frequently reported in the literature; an indication there is no one ideal classification routine to suit all needs and requirements (Erol and Akdeniz, 1998, Kartikeyan et al., 1998).

Each classification routine consists of a series of tradeoffs regarding processing time, model complexity, and classification accuracy. The decision regarding the most suitable classification technique is made on a case by case basis with factors such as spectral severability, number of classes to be identified, processing time and model complexity each playing a role in the decision process.

Usually, classification is performed with a set of target classes in mind. Such a set is called a classification scheme (or classification system). The purpose of such a scheme is to provide a framework for organizing and categorizing the information that can be extracted from the data (Jensen et al, 1996).The proper classification scheme includes classes that are both important to the study and discernible from the data on hand. Most schemes have a hierarchical structure, which can describe a study area in several levels of detail. This classification schemes have been developed by specialists who have inventoried a geographic region. Professionally- this scheme developed by Anderson, 1976. “A Land Use and Land Cover Classification System for Use with Remote Sensor Data”.

Common classification procedures can be broken down into two broad subdivisions based on the method used (CCRS, Randall B. Smith, 2006):

4.2.5.1 The supervised classification

Supervised classification is the process of using samples of known identity (training data) to classify the unknown identity. Knowledge of data and the desired classes are required prior to the classification process and must be obtained from ground truths, aerial photos, or maps. This method depends on the analyzer ability to delineate different characteristics of different patterns of land covers in the studied area. The training area is used for delineation of spectral characteristics of each pattern (class) (Lillesand and Keifer, 2000).

The selection of appropriate training areas is based on the analyst's familiarity with the geographical area and their knowledge of the actual surface cover types present in the image. Thus, the analyst is "supervising" the categorization of a set of specific classes. The numerical information in all spectral bands for the pixels comprising these areas is used to "train" the computer to recognize spectrally similar areas for each class.

Once the computer has determined the signatures for each class, each pixel in the image is compared to these signatures and labeled as the class it most closely "resembles" digitally. Thus, in a supervised classification we are first identifying the information classes which are then used to determine the spectral classes which represent them (CCRS, Randall B. Smith, 2006).

There are several classification algorithms can be applied in supervised classification which include parallelepiped, minimum distance, maximum likelihood and non-parametric (ERDAS, 1999). The most common and well-known supervised classification uses the maximum likelihood technique which employs a decision rule based on the probability (Bayesian probability theory) that pixels belong to a particular class (Campbell,1996).

The supervised classification is applied in the current study based on Maximum Likelihood Classifier Method; this method quantitatively evaluates both the variance and covariance of the category spectral response pattern when classifying an unknown pixel (Lillesand and Kiefer, 1979).

4.2.5.2 Landuse / Land cover (LULC) Classification

According to FAO (2000): Land cover is observed (bio) physical on the earth’s surface. The FAO defines the land use as the arrangements, activities and inputs that people undertake on a certain land cover type. According to these definitions, land cover corresponds to the physical condition of the ground surface, e.g. forest, agricultural land, grassland, urban, while land use reflects human activities such as the use of the land like industrial zones, residential zones, and agricultural fields.

The above definitions establish a direct link between land cover and the actions of people in their environment i.e. land use may lead to land cover change. Generally, land cover does not coincide with land use. A land use class is composed of several land covers. Remote sensing data can provide land cover information rather than land use information.

Land use and land cover (LULC) classes characterize important information of natural landscape and human activities on the Earth's surface (Gong et al. 2011). In recent decades, remotely sensed data have been widely used to provide the land use and land cover information such as desertification, degradation level of forests and wetlands, rate of urbanization, intensity of agricultural activities and other human-induced changes.

A land use and land cover classification system which can effectively employ orbital and high-altitude remote sensor data should meet the following criteria (Anderson, 1971):

1. The minimum level of interpretation accuracy in the identification of land use and land cover categories from remote sensor data should be at least 85 percent.

2. The accuracy of interpretation for the several categories should be about equal.

3. Repeatable or repetitive results should be obtainable from one interpreter to another and from one time of sensing to another.

4. The classification system should be applicable over extensive areas.

5. The categorization should permit vegetation and other types of land cover to be used as surrogates for activity.

6. The classification system should be suitable for use with remote sensor data obtained at different times of the year.

7. Effective use of subcategories that can be obtained from ground surveys or from the use of larger scale or enhanced remote sensor data should be possible.

8. Aggregation of categories must be possible

9. Comparison with future land use data should be possible

10. Multiple uses of land should be recognized when possible

Some of these criteria should apply to land use and land cover classification in general, but some of the criteria apply primarily to land use and land cover data interpreted from remote sensor data.

The most land cover and land use classification often derived from Anderson et.al. (1976) classification (USGS classification) which includes both land cover (resources) and land use (human activities) classification. The system designed for use with remotely sensed data. The Anderson classification is used to classify the land cover and land use class of the study area shown in fig. 4.14.

3.5.5.3 Classification Accuracy Assessment

To assess the quality of the image classifications, various measures including overall accuracy and Kappa coefficient of agreement (or Kappa) were analyzed to compare classification results with the validation or reference data in confusion matrices. Accuracy may be defined, in a working sense, as the degree (often as a percentage) of correspondence between observation and reality (Bakker et al., 2001 in Al-Amiri, 2008). Accuracy is usually judged against existing maps, large scale aerial photos, satellite images or field checks.

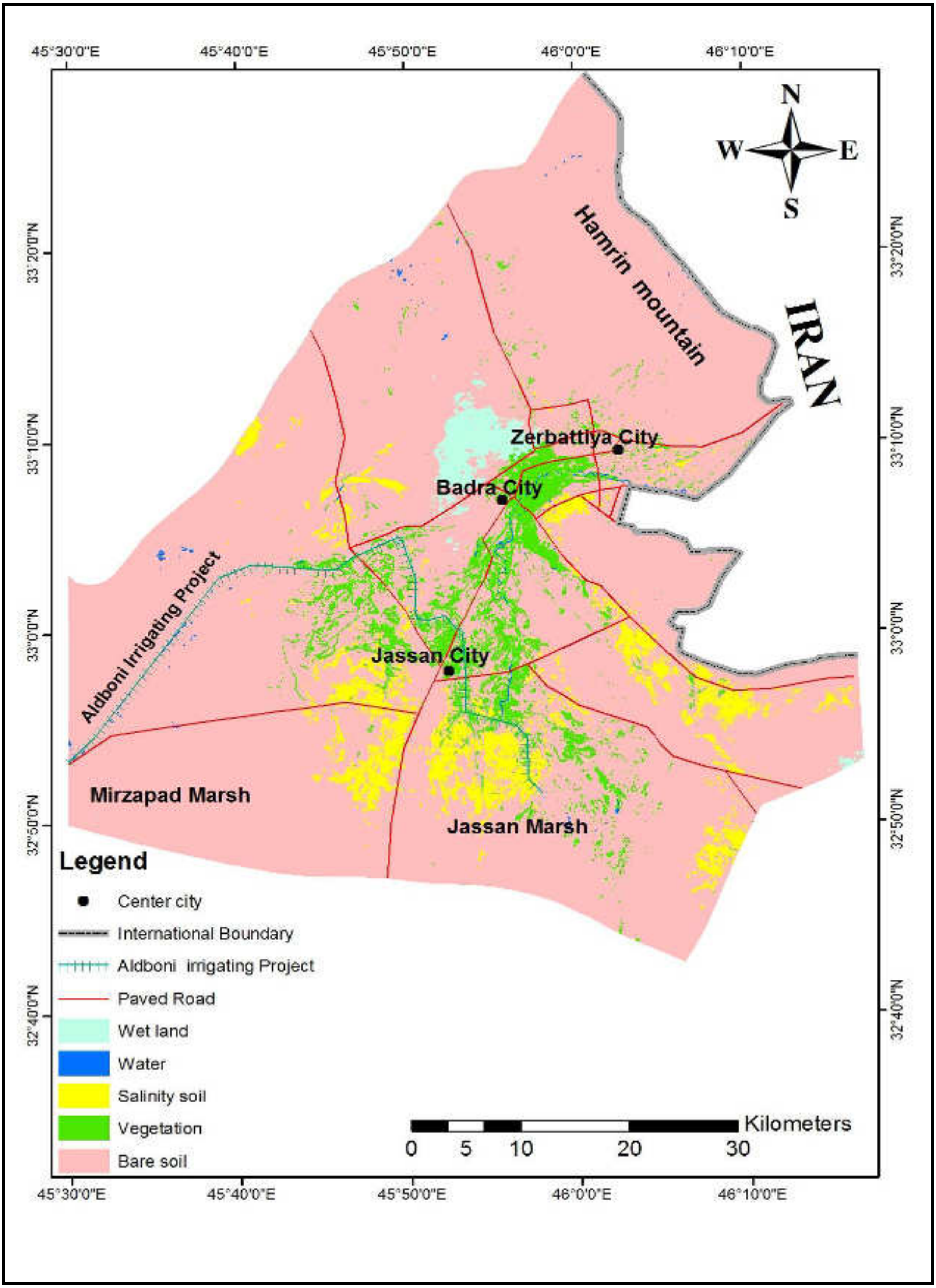


Figure 4.14: Land cover and land use of the study area.

The Overall Accuracy (OA) of the classification results was calculated by dividing the total correct sum of main diagonal cells by the total number of pixels checked in the error matrix. The User Accuracy (UA) is "the probability that a pixel classified on the map, actually represents that class on the field (ground)" and it was calculated by dividing the diagonal value for each class by its row total (Bakker et al., 2001 in Al-Amiri, 2008). Whereas, the Producer Accuracy (PA) indicates the percentage of a reference pixel being correctly classified, and it was calculated by dividing diagonal value for each class by its column total (Bakker et al., 2001 in Al-Amiri, 2008).

Utilizing all elements from the confusion matrix, Kappa coefficient is a measure of the difference between the actual agreement between reference data and a classification and the change agreement between the reference data and a classification (Lillesand & Kiefer 2000). Kappa takes into account both errors of commission and omission, and thus provides a more complete picture of the information comprising the confusion matrix than overall accuracy (Jensen, 2004).

Tables (4.1 and 4.2) show, respectively, the Error matrix and Accuracy Assessment of the five classes, which are resulted from the supervised classification of the Landsat ETM^+ satellite image. Validity of this classification results was performed based on the 100 check points, which were used for validation of the classification used in the image. The achieved Overall Accuracy is 92.00% and a Kappa coefficient is 0.8996.

CLASS	Vegetated Land	Water	Wet land	Salinity soil	Bare Soil	Total
Vegetated Land	18	0	0	0	2	20
Water	0	17	0	0	1	18
Wet land	0	0	19	0	0	19
Salinity soil	0	0	0	17	2	19
Bare Soil	0	0	3	0	21	24
Total	18	17	22	17	26	100

Table 4.1: Error matrixes of Land Use Land Cove from Landsat ETM

Class Name	Reference Total	Classified Totals	Number Correct	Producers Accuracy	User Accuracy	Kappa
Vegetated Land	18	20	18	100.00%	90.00%	0.8780
Water	17	18	17	100.00%	94.44%	0.9331
Wet land	22	19	19	86.36	100.00%	1.0000
Salinity soil	17	19	17	100.00%	89.47%	0.8732
Bare Soil	26	24	21	80.77%	87.50%	0.8311
Total	100	100	92			

Table 4.2: Accuracy assessment of data in error matrix

Overall Classification Accuracy …….(El Hassan , I. M. 2004)

$$\text{Total Accuracy} = \frac{\text{total correct sum of main diagonal cells}}{\text{total number of pixels checked in the error matrix}}$$

Overall Kappa (K^) Statistics = (po - pc)/(1 - pc) …(El Hassan , I. M. 2004)

po = proportion of units which agree = overall accuracy.

pc = proportion of units for expected chance agreement.

CHAPTER FIVE

INTERPRETATION AND DISCUSSION

CHAPTER FIVE
INTERPRETATION AND DISCUSSION

This chapter presents and discusses the results obtained from this study. It includes the presentation of the results of Normalized Difference Vegetation Index (NDVI), Water Index (WI), Salinity Index (SI), and the classification of land cover/ land use (LCLU) in the study area for the Landsat imagery of MSS, TM and ETM+ during the periods 1972, 1990, 2000 and 2007, respectively.

5.1 Normalized Difference Vegetation Index (NDVI)

Rouse et al. (1974) initially proposed the Normalized Difference Vegetation Index *"NDVI"*. The NDVI derived from the ratio of band 3 and band 4 in Landsat MSS, TM and ETM+ images, the data was applied for monitoring vegetation changes in the study area through the years1976 and 2007.

Table 5.1: Area of vegetation covers for each period and its Percentage to the area of study.

Year	Area of vegetation Km^2	Percentage vegetation area to study area
1976	44.624	1.27 %
1990	127.226	3.62 %
2000	100.501	2.87 %
2007	61.987	1.77 %

Table 5.1 shows the area of vegetation cover for the years 76, 90, 2000 and 2007, and the proportion of vegetation to the total area of study. It shows that the largest planted area was in 1990 while the lowest planted area was in 1976. This means that there is a clear deterioration in vegetation cover from 1990 to 2007. The percentage of the vegetation cover was decreased from 3.62 to 1.77% of the total area of study, and the percentages of vegetation cover are very small compared with the total area. Most agricultural land is concentrated in the central part of the study area near Galal Badra River and near the irrigation project called Aldboni channel as shown in (Figure 5.2).

One of the main reasons for the growing proportion of vegetation cover between the years 1976 to 1990 is the setting up of the Aldboni Irrigation project(Figure 5.1), which began on 1985 (Department of Agriculture Badra), which impact positively on the area of vegetation cover, The most important reasons for the deterioration of vegetation cover in 2007 was due to the stop working of Aldboni water project and the continuing disconnection, which led the farmers to leave their land.

Figure 5.1: Aldboni Irrigation project

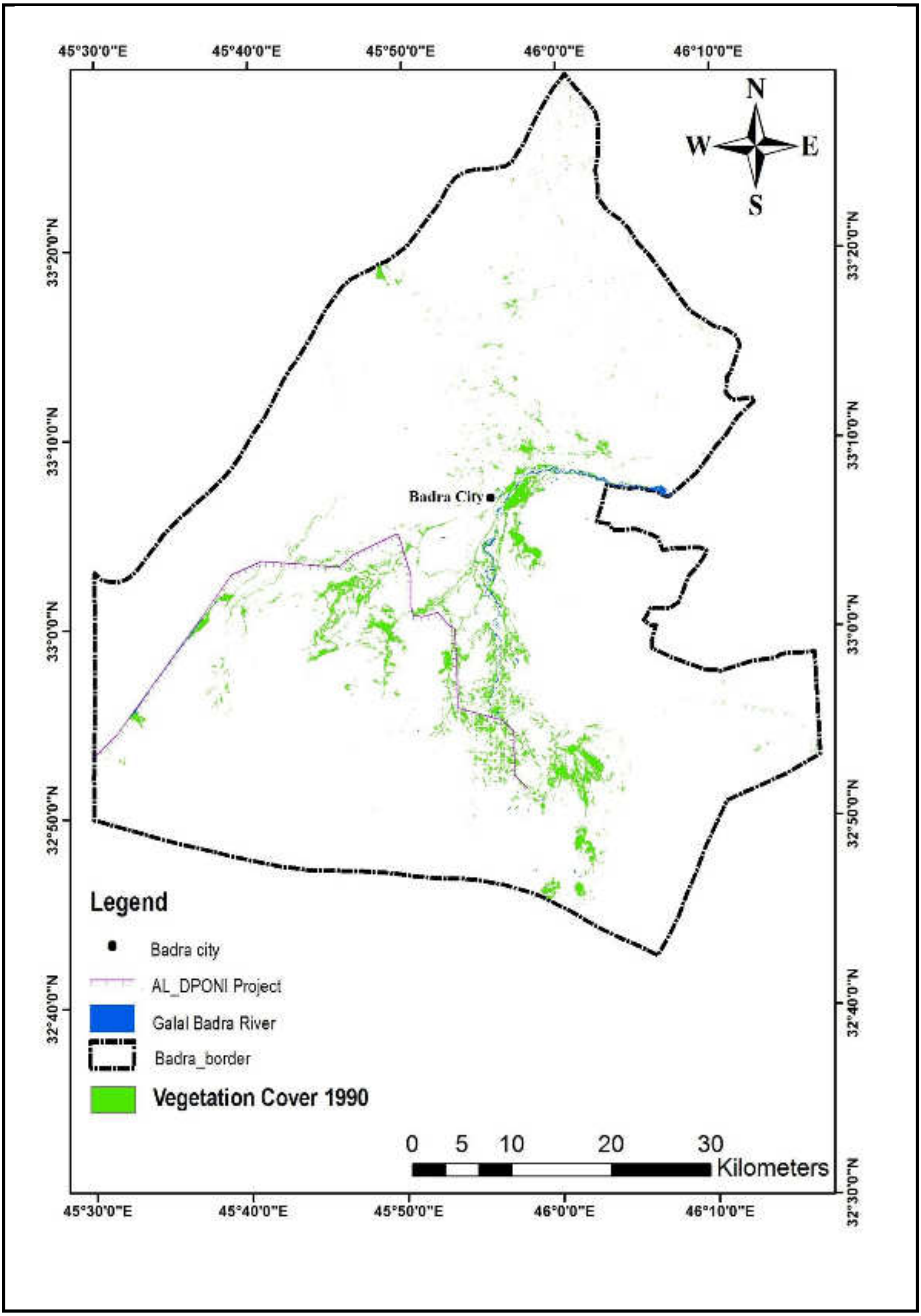


Fig 5.2: Distribution of vegetation covers within the study area in 1990.

5.2 Change Detection by Using Normalized Difference Vegetation Index (NDVI)

In order to get a further idea about the area where most change took place, changing detection techniques has been used to compare NDVI for the period 1976 to 2007. Different images are derived by subtracting the NDVI values of the earlier year from that of the later year which allows the user to conduct simple arithmetic operations on image data. The differences in NDVI vegetation cover between 1976-1990, 1990-2000, 2000-2007, and 1976-2007 as seen in Figures 4.12 and 4.13 shows signs of vegetation changes over the years and with differing spatial extents of the supposed change.

From Figures 4.12 and 4.13, we can get an idea of the spatial distribution of the supposed change. Much of the positive change was in the period 1976 to 1990 and negative change between1990 to 2000 and more negative change between 2000 to 2007. The major trend shows a significant increase in the spatial extent of the cultivated land between 1976 and 1990 and also signs of good status of vegetation cover are observed during 1990, which decreased again between 1990 to 2000 and 2000 to 2007. The reason for the increase in cultivated lands between 1976 and 1990 is the establishment of Aldboni irrigation project, which encouraged farmers to cultivate their lands, which led to the increase in vegetation cover, in addition to the good rainfall in that year with a total rain of 181.1 mm (Meteorological Stations).

Figure 4.13-B shows a general trend during the period between 1976 to 2007, notes that there is a clear decrease and the disappearance of full agricultural areas, especially in the southern part of the study area and most increases and decreases are based in the center part of the study area.

4.3 Water index (WI)

Water index was calculated from data of the related Landsat bands of MSS, TM, and ETM+ during the periods 1976, 1990, 2000, and 2007 respectively. Figures 4.8 represents the state of water bodies in the study area. Figure 4.7 is a histogram showing the statistical results of water bodies in study area. It shows a general increase in water in 1990 and a decrease in 2000 and 2007. The decrease in most surface water in the study area refer to many reasons, such as the decrease in the flow of Galal Badra River from the upstream country as well as to the lack of rainfall in the study area. The major dominant change in the area is the increase during the period between 1976 to1990 and, the highest decrease between 1990 to 2000, and decrease between 2000 to 2007.

Galal Badra is the main river and the only source of surface water resources in the study area. The area of Galal Badra river basin in Iran is about (1650 km^2) and about (300 Km^2) inside Iraq, and most of the discharge of the river depends on what is achieved from the runoff from the Iranian side, while the basin in the Iraqi side provide only a small percentage (3.5%) of the volume of runoff of the river and most of its water flows toward Shuwayja marsh (Ali, 1987). Water levels in the river have risen during the rainy season, while it became dry in the dry season. Therefore, the possibility of building small dams along the river bed will provide a good chance to store the water during the season of high water levels, and then it can be used during the dry season.

4.4 Salinity Index (SI)

Salinity Index, as a term, refers to the state of accumulation of the soluble salts in the soil (Al-Khaier, 2003). The results of Salinity Index (SI) analysis for MSS 1976, TM 1990, 2000 and ETM+ 2007 are presented in Figures 4.10, 4.11.

Figure 4.9 is a histogram showing the statistical results of saline land.The visual interpretation of the resulting SI images show that considerable white patches of saline land, concentrating mainly in the southern part of the area, due to the high albedo of saline land and thus showing a very bright tone, (Figure 5.3).

Fig 5.3: Images of saline land in the study area

The major changes in the saline land was during 1976 to 1990 it appears to decrease and highly decreased during 1990 to 2000, while the highest increase of saline land was in 2000 to 2007. The saline area covers 105.302 km^2 a 1976, and become 87.072 km^2 in 1990 and 71.58 km^2 in 2000. The highest increase of saline soil happened in 2007 when it reached up to 119.544 km^2. The best period of non-saline land was in 2000. An explanation of this, could be found in the fact that the 1990 and 2000 period there was increased in the proportion of agricultural land due to the creation of Aldboni irrigation project in 1985, and the availability of water in Galal Badra river, which helped to reduce saline land.

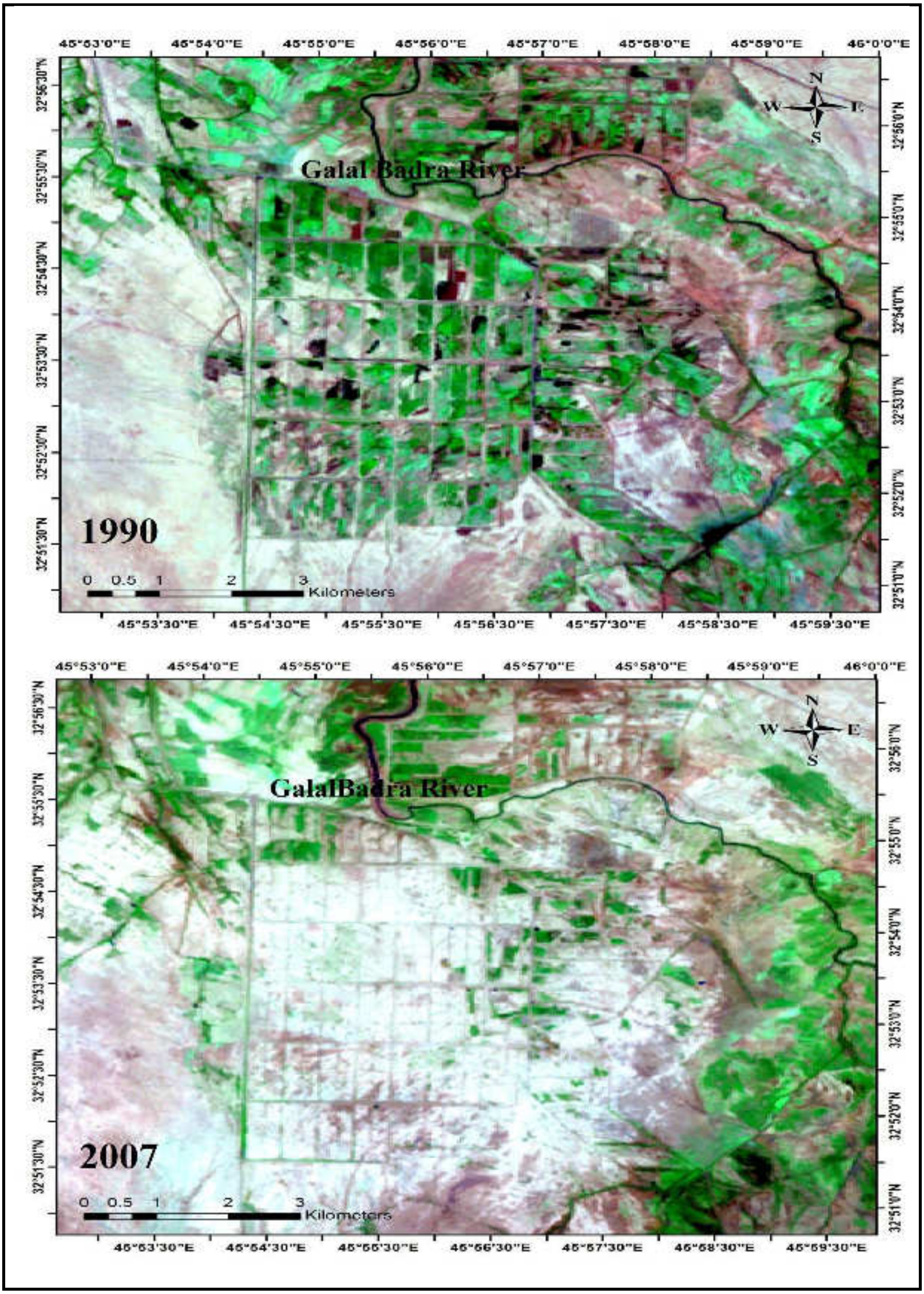


Fig 5.4: Images showing the deterioration of vegetation cover by Salinity.

Fig. 5.4 shows the agricultural land near the city of Jassan (south Badra city) for the 1990 and 2007 years. The effects of salinity are very clear where the agricultural land turns to barren land and salty. The reasons for this deterioration of these lands is the lack of water in Galal Badra river and the interruption of water in the Aldboni project, which led to the lack of cultivation and concentration of salt on the surface layer, bearing in mind that these lands and according to field observations are fertile land and suitable for agriculture. These results have also confirmed the dynamics of change, which was taking place during the period from 1976 to 2007.

5.5 Land use and land cover classification (LULC)

The USGS classification by Anderson et.al. (1976) was used to classify the land use land cover class for satellite image ETM+ (2007). The supervised classification is applied in the current study depending on Maximum Likelihood Classifier Method. The study area could be classified into five classes. These classes represent five major features in the study area (vegetation, water, wetland, saline land and bare land, as illustrated in figure 4.14.

According to LULC classification results, land cover classified as Bare Land areas 93.22%, Saline Land 3%, Vegetation 2.56%, wetlands 1.12% and Water 0.5%. Based on these results, Bare Land area is the largest land cover class in the study area (Table 5.2). Major Bare Land areas are located north and west of the study area and on its edges.

The vegetation land is located in the central part of the study area near Galal Badra River and Aldboni Irrigation project. The vegetation class represents in a different type, the distinguish between these types are impossible because the limited spectral resolution of Landsat images, but we can recognize vegetation types from visual interpretation and field observations. The main type of vegetation in the study area includes the palm groves, barley, wheat, grass land and other types.

LULC classification shows a limited amount of water in the study area compared with the total size of the area, and Galal Badra River is the main river and the only source of surface water. Saline land is concentrated near agricultural land or abandoned agricultural land due to the lack of water for irrigation and that most of these lands are fertile and suitable for reclamation because it is covered with thin layers of salt. Figure 5.5 Shows Images of some types of land cover in the study area.

Table 5.2: Results of the land use land cover classification for 2007 satellite image, showing area of each class.

Class Name	Area (km^2)	Area (%)
Bare Land	3265.4	93.22%
Vegetation	89.7	2.56%
Water	3.4	0.1%
Wet Land	40.	1.12%
Saline Land	103.5	3%
Total	3502	100%

Accuracy analysis is applied to the classified satellite image (2007) with the aim to confirm the accuracy of the classification. To do this, over 100 random reference control points are identified on the study area map for the 5 classes. The point distributions are made in proportion to the field distributions of the classes. Total accuracy rate (total number of accurate pixels / number of pixels taken as reference) is calculated to be 92.00% and kappa statistics value is 0.8996 (Tables 4.1 and 4.2).

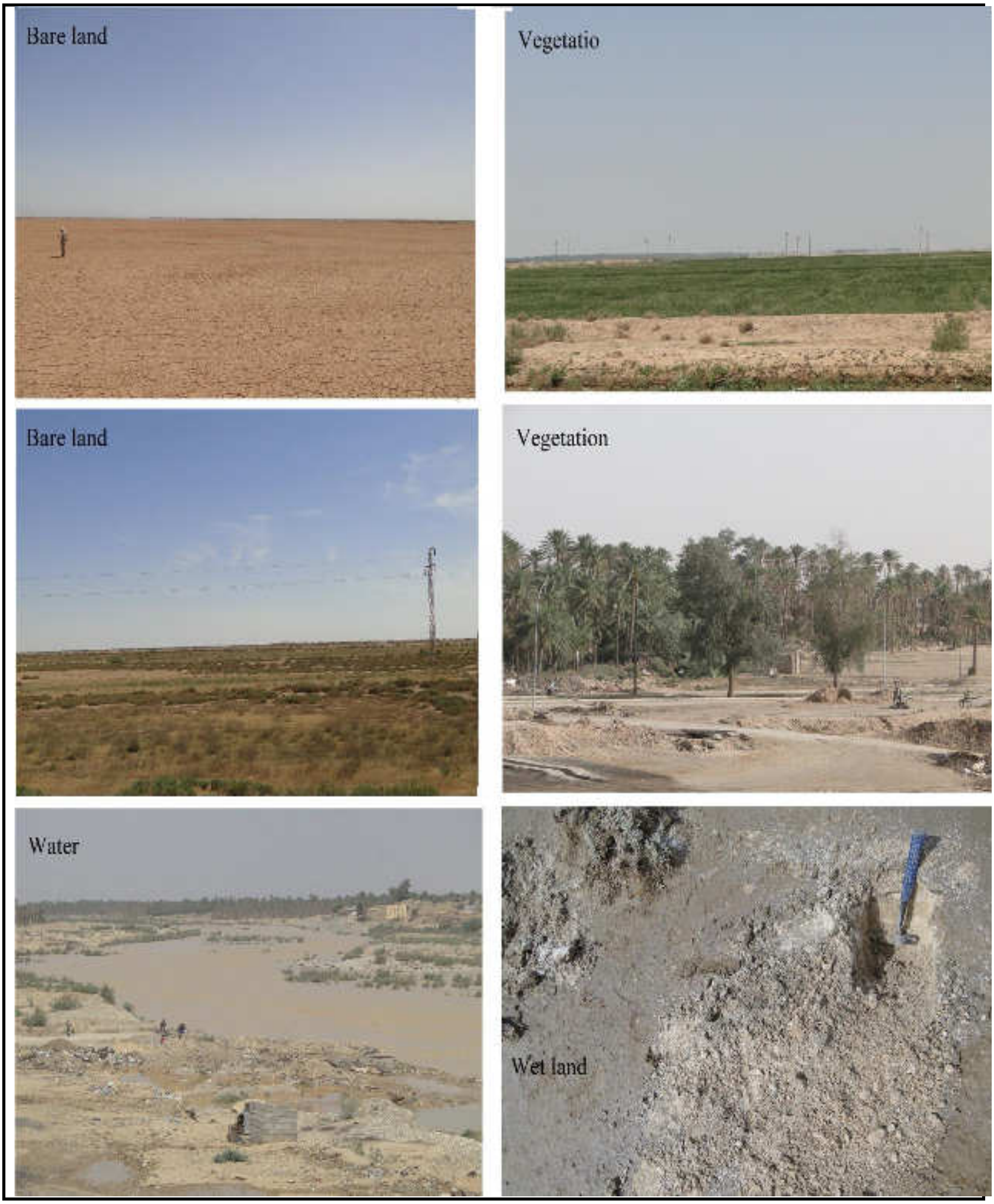


Fig 5.5: Images of some types of land cover

5.6 Desertification Rate and Dynamics of change

Table 5.3,5. 4 and 5. 5 show the desertification rate in the study area for three periods. When the NDVI and WI rate has a value, less than (1) then the area is considered to be affected by desertification process (Negative). Also when (SI) rate has value more than (1) the area is considered as affected by desertification process (Negative). Table 5.3 illustrates that the rate of change of major factors causing desertification during the periods 1976 and 1990 , NDVI , WI, and SI are negative for 1976 , while the rate of change presented in Table 5.4 and 5.5 shows positive change during 1990 and negative change in 2000 and 2007.

Depending on the visual interpretation of the change map for the periods 1976-1990, 1990-2000 and 2000 -2007, statistical results , in addition to climatic data and information obtained during field surveys, it can be seen that a significant differences between different years are clear.

The data gained from 2007 image shows the area severely affected by desertification. In this regards, findings of SI illustrate that the sandy area and salty land has increased during 1976, decrease during 1990 and 2000, and highly increase in 2007, while both the NDVI and WI, are low in 1976, very high in 1990 and low in 2000 and 2007.

Table 5.3: The relationship between (NDVI, WI and SI during the periods 1976 and 1990.

				1976		
1990	**Area in Km^2**			**NDVI**	**WI**	**SI**
				44.64	**3.96**	**105.3**
	NDVI	**127.22**	**Rate of change**	**0.35**		
	WI	**12.01**			**0.32**	
	SI	**87.07**				**1.2**

Table 5.4: The relationship between (NDVI, WI and SI) during the periods 1990 and 2000.

<table>
<tr><td></td><td colspan="3"></td><td colspan="3">1990</td></tr>
<tr><td rowspan="5">2000</td><td colspan="3" rowspan="2">Area in Km^2</td><td>NDVI</td><td>WI</td><td>SI</td></tr>
<tr><td>127.22</td><td>12.01</td><td>87.07</td></tr>
<tr><td>NDVI</td><td>100.5</td><td rowspan="3">Rate of change</td><td>1.26</td><td></td><td></td></tr>
<tr><td>WI</td><td>4.546</td><td></td><td>2.64</td><td></td></tr>
<tr><td>SI</td><td>71.58</td><td></td><td></td><td>1.21</td></tr>
</table>

Table 5.5: The relationship between (NDVI, WI and SI) during the periods 2000 and 2007.

<table>
<tr><td></td><td colspan="6">2000</td></tr>
<tr><td rowspan="5">2007</td><td colspan="3" rowspan="2">Area in Km^2</td><td>NDVI</td><td>WI</td><td>SI</td></tr>
<tr><td>100.5</td><td>4.54</td><td>71.58</td></tr>
<tr><td>NDVI</td><td>61.987</td><td rowspan="3">Rate of change</td><td>1.62</td><td></td><td></td></tr>
<tr><td>WI</td><td>3.78</td><td></td><td>1.2</td><td></td></tr>
<tr><td>SI</td><td>119.55</td><td></td><td></td><td>0.59</td></tr>
</table>

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

The results obtained from this study lead to several conclusions and some recommendations for further studies:

6-1 Conclusion

1-Remote sensing data is a powerful tool in the study and monitoring of desertification phenomenon, especially after applying different digital Processing techniques such as NDVI, WI, SI, and classification which have proved effective techniques in mapping the land cover changes and show the impact of desertification in the study area.

2- The result of NDVI shows that the vegetation cover is highly increased in 1976-1990 period and decrease in 1990-2000 and 2000-2007 periods, the main reason in this increase of vegetation cover is the setting up of Aldboni Irrigation project which impact positively on the vegetation cover in study area, in addition to availability of water in the river Galal Badra. The lack of water in Galal Badra River and interruption or unavailability of water continuous in Irrigation Aldboni project lead to degradation of vegetation cover in 1990-2000 and 2000-2007 periods. Therefore, the water is the main factor of land degradation and desertification in the study area.

3- The result of WI shows a highly increase in 1976-1990 period and decrease in 1990-2000 and 2000-2007 periods, Galal Badra River represents the only source of natural surface water in the study area and most of the discharge of the river depends on what is achieved from the runoff from the upstream country (the Iranian side). The decrease in surface water in the study area was in 1990-2000 and

2000-2007 periods due to the decrease in the flow of the Galal Badra River from the upstream country as well as to the lack of rainfall in the study area.

4- The result of SI shows that the major change of the saline land during 1976 to 1990. It shows a regular decreased from 105.302 Km^2 in 1976 to 71.584 Km^2 in 20000. This may be due to increase of portion of agricultural land and the availability of water which led to the reduction of saline land in the study area. From 2000 to 2007 the saline land covers 119.544 Km^2, and this might be due to the irregular work of Aldboni Irrigation project.

5- Supervised classification used for land use land cover (LULC) classification to satellite image of Badra city in 2007 with total accuracy 92.00%. According to LULC classification results, land cover is classified as Bare Land areas (93.22%), Saline Land (3%), Vegetation (2.56%), wetlands (1.12%) and Water (0.5%). Accurate LULC maps can play an important role in aiding land use and land cover management as well as helping in deciding what sort of lands are best suited for sustaining land use and land cover and in what manner this land use and land cover should be practiced.

6- Based on the visual interpretation of the change map for the period 1976, 1990, 2000 and 2007, statistical analysis, climatic data, in addition to information obtained during field observations, ancillary data and relevant literature, its´ clear that a significant land cover changes has taken place during the addressed periods, positive change from 1976 to 1990 and the negative changes from 1990 to 2000 and 2000 to 2007.

6.2 Recommendations:

Based on the findings of the above mentioned, following recommendations may be made:

1- Using and integration of remote sensing techniques with Geographic Information Systems (GIS) as accurate, low-cost and safe to assess and monitor desertification processes in semi-arid areas, which provide valuable information on the impact of desertification processes in the study area and to develop appropriate methods to combat them. Therefor the establishment of early warning system based on remote sensing techniques with geographical information systems (GIS) to collect baseline data relevant to all aspects of desertification process for all Iraqi area.

2- Using high resolution Images such as Quick Bird, IKONOS, and Spot data with the Landsat data is necessary to achieve accurate monitoring of desertification. These data provide detail and accurate information on the kinds of vegetation.

3- The shortage of water is the main factor of land degradation and desertification in the study area. Therefore, a study of possible to establishment of a dam or series of dams along Galal Badra River to store water during the rainy season and turn it into irrigation canals during the dry seasons, which provide an opportunity to invest agricultural land, increasing vegetation cover and reduce the impact of desertification processes.

4- Maintenance program must be made to improve Aldboni irrigation project to assure the water flows regularly, as well as using patrols to reassure farmers of the availability of water, which helps to increase the area of vegetation. Aldboni Irrigation project is the best project to create a successful cultivation and increase the vegetation cover in the study area.

5- Popular awareness of desertification is crucial to achieve the objectives and requirements of sustainable development. Citizens should be aware about the importance of natural resources and not to be excusive in using them.

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APPENDICES

Appendix .1: Milestones in the History of Remote Sensing (after Indian Institute of Remote Sensing).

1800 Discovery of Infrared by Sir W. Herschel
1839 Beginning of Practice of Photography
1847 Infrared Spectrum Shown by J.B.L. Foucault
1859 Photography from Balloons
1873 Theory of Electromagnetic Spectrum by J.C. Maxwell
1909 Photography from Airplanes
1916 World War I: Aerial Reconnaissance
1935 Development of Radar in Germany
1940 WW II: Applications of Non-Visible Part of EMS
1950 Military Research and Development
1959 First Space Photograph of the Earth (Explorer-6)
1960 First TIROS Meteorological Satellite Launched
1970 Skylab Remote Sensing Observations from Space
1972 Launch Landsat-1 (ERTS-1) : MSS Sensor
1972 Rapid Advances in Digital Image Processing
1982 Launch of Landsat -4 : New Generation of Landsat Sensors: TM
1986 French Commercial Earth Observation Satellite SPOT
1986 Development Hyperspectral Sensors
1990 Development High Resolution Space borne Systems
First Commercial Developments in Remote Sensing
1998 Towards Cheap One-Goal Satellite Missions
1999 Launch EOS : NASA Earth Observing Mission
1999 Launch of IKONOS, very high spatial resolution sensor system
1999April 15 LANDSAT 7 is launched, carrying the ETM+ instrument which features a 15m panchromatic band and a 60m TIR band in addition to its six 30m bands(VIS, NIR & SWIR).
2000 The following systems are scheduled to be launched:
ADEOS-2 , IRS-P6 , ENVISAT-1, EOS PM-1, JASON-1, METEOSAT8, ORBVIEW 4 ,RADARSAT 2.

Appendix .2: Table 3.2: The spectral resolution of the individual Landsat bands and some useful applications of each, (Canada Center for Remote Sensing CCRS).

Band	Wavelength Range (µm)	Application
B1	0.45 - 0.52 (blue)	soil/vegetation discrimination; bathymetry /coastal mapping; cultural/urban feature identification
B2	0.52 - 0.60 (green)	green vegetation mapping (measures reflectance peak); cultural/urban feature identification
B3	0.63 - 0.69 (red)	vegetated vs. non-vegetated and plant species discrimination (plant chlorophyll absorption); cultural/urban feature identification
B4	0.76 - 0.90 (near IR)	identification of plant/vegetation types, health, and biomass content; water body delineation; soil moisture
B5	1.55 - 1.75 (short wave IR)	sensitive to moisture in soil and vegetation; discriminating snow and cloud-covered areas
B6	10.4 - 12.5 (thermal IR)	vegetation stress and soil moisture discrimination related to thermal radiation; thermal mapping (urban, water)
B7	2.08 - 2.35 (short wave IR)	discrimination of mineral and rock types; sensitive to vegetation moisture content
B8	0.52-0.9 Panchromatic	Useful to enhance of spatial resolution

ألمستخلص

واحدة من اهم القضايا التي ظهرت في الآونة الأخيرة والتي تواجه العراق والعالم هو التهديد المستمر لتدهور الأراضي والتصحر نتيجة للعوامل المناخية والأنشطة البشرية. ان تقنية الاستشعار عن بعد ومرئيات الأقمار الصناعية تلعب دورا رئيسيا في تطوير القدرة عالمية ومحلية لرصد تدهور الأراضي وعمليات التصحر في الأراضي الجافة وكذلك في العراق. وقد زادت عمليات التصحر في العراق وخصوصا في الجزء الأوسط والجنوبي بسرعة، وكرست الكثير من الجهد لتحديد ودراسة أسبابه وآثاره.

تقع منطقة الدراسة في مدينة بدرة في محافظة واسط شرق العراق(180 كم جنوب شرق مدينة بغداد) وتبلغ مساحة منطقة الدراسة حوالي (3500 كم^2). تم تطبيق تقنية الاستشعار عن بعد وتحليل الصور الرقمية ونظم المعلومات الجغرافية لمراقبة عمليات التصحر في منطقة الدراسة (منطقة بدرة) للفترة من عام 1976 والى 2007.وتم استخدام اربع صور فضائية للقمر لاندسات للسنوات 1976 ،1990، 2000 ، 2007 بالإضافة الى البيانات المساعدة مثل الخرائط الطبوغرافية والبيانات المناخية والمعلومات الحقلية لتقيين امكانية استخدام تحليلات الاستشعار عن بعد في مراقبة عمليات التصحر.

تم استخدام دليل الغطاء النباتي المعروف NDVI ودليل الملوحة SI ودليل المياه WI لتحديد الغطاء النباتي والمناطق المائية والاراضي الملحية ولكشف التغيرات التي جرت عليها خلال الفترات الاربع من عام 1976 الى2007.وكذلك تم استخدام طريقتين للكشف عن التغيرات اولا ، طريقة الكشف عن التغيرات المباشرة في المؤشرات بين الفترات الاربع وتحليلها بواسطة استخدام التفسير البصري ، بالإضافة الى التحليل الاحصائي. ثانيا ،كشف التغيرات عن طريق استخدام دليل الغطاء النباتي NDVI لتحديد وتحليل مناطق التغييرات في الغطاء النباتي على مدى الفترات الاربع. كما تم استخدام التصنيف المراقب لإنتاج خارطة استخدامات وغطاء الارض (LULC) حيث تم تصنيف منطقة الدراسة الى خمسة اصناف (النبات ،الماء، الاراضي الملحية، الأراضي الجرداء).

أظهرت نتائج استخدام دليل الغطاء النباتي NDVI ودليل الملوحة SI ودليل المياه WI ومن خلال استنتاج معامل التصحر بان هناك تغير ايجابي خلال الفترة من 1976 الى 1990 ،في حين ان هناك تغير سلبي خلال الفترات من سنة 1990 الى 2000 ومن سنة 2000 الى 2007 . وتعتبر سنة 1976 اسوأ فترة من عمليات التصحر وتدهور الاراضي بينما تظهر سنة 1990 افضل فترة للنمو وزيادة الغطاء النباتي ،بينما اظهرت نتائج كشف التغيرات عن طريق استخدام دليل الغطاء النباتي NDVI ان معظم التغيرات حدثت في الجزء الاوسط من منطقة الدراسة وتصنف على انها شديدة التأثر بعمليات التصحر. أظهرت نتائج التصنيف المراقب لخارطة استخدامات وغطاء الاراضي ان مساحة الاراضي الجرداء هي الاكبر حيث تغطي اكثر من 93% من مساحة منطقة الدراسة، وأن مساحة الغطاء النباتي والاجسام المائية محدودة جدا مقارنة مع مساحة المنطقة الكلية.

وزارة التعليم العالي والبحث العلمي
جامعة بغداد
كلية العلوم
قسم علوم الأرض

مراقبة التصحر في قضاء بدرة شرق العراق باستخدام بيانات القمر لاندسات

رسالة مقدمة إلى
كلية العلوم - جامعة بغداد
كجزء من متطلبات نيل درجة ماجستير
في علم الأرض
(التحسس النائي)

من قبل

عمار عبد جاسم الاعرجي

بكالوريوس علوم الارض 1999

بإشراف

أ. د. وليد عبد المجيد

2012