COMPARISON OF SOIL SALINITY BETWEEN LABORATORY ANALYSIS AND REMOTE SENSING DATA IN AL-JAFARAH, LIBYA

SAMIRA A. ATMAN

UNIVERSITI SAINS MALAYSIA

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by

SAMIRA A. ATMAN

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LIST OF ABBREVIATIONS

MSS	The Multispectral Scanner
TM	Thematic Mapper
ETM	Enhanced Thematic Mapper
Cm	Centimeter
Mm	Millimeters
Ds	De Siemens
RS	Remote Sensing
C°	Degrees Celsius
EC	Electric conductivity
FOW	Food Agricultural Organization
ARC	Agricultural Research Center
NASR	National Authority for Research
GIS	Geographic Information Systems
GPS	Global Positioning System
IR	Infrared/red
NDIV	Normalized difference vegetation index
VI	Vegetation index

PERBANDINGAN KEMASINAN TANiH ANTARA ANALISIS MAKMAL DAN DATA PENDERIAAN JAUH DI AL-JAFARAH,LIBYA

ABSTRAK

Matlamat penyelidikan ini adalah untuk memeta ruang taburan tanah masin di lokasi yang berbeza di dataran Al-jafarah dan menentukan tahap kemasinan tanah dan membandingkannya dengan imej yang diperoleh daripada satelit landsat 7 ETM+. Sejumlah enam puluh (60) sampel dikumpul secara rawak daripada permukaan tanah pada kedalaman di antara 10-50 cm. dan diukur kandungan tanah selaras dengan Prosedur Piawaian Makmal Libya. Data kajian diperoleh daripada ujian makmal dan imej satelit landsat ETM+ 2010. Landsat 7 ETM+ (Enhanced thematic mapper plus) digunakan untuk memeta dan mencerap tanah masin di kawasan kajian. Keputusan yang diperoleh daripada makmal dan imej satelit apabila dibandingkan menunjukkan bahawa tanah masin hanya terdapat di kawasan paya. Keputusan mnunjukkan bahawa kawasan pasir terbentang luas di sepanjang dataran Al-jafarah. Ia juga boleh dicerap daripada imej yang dikelaskan bahawa tanah bergaram (Sebkha) terentang luas di bahagian barat laut dataran Al- jafarah, iaitu di longitud 11°30´ , 12° 30´, dan latitud 32° 30´, 33° 30, dan terletak di kawasan barat kajian. Hal ini kerana kadar kemasinan tanah di kawasan kajian adalah kurang daripada 2 dS/m (tidak masin), di samping pantulan spektrum yang tinggi bagi tanah kering dan tanah mendapan (tidak masin), iaitu di sekitar (Nilai DN 120-230).

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ABSTRACT

The aim of this research is to map the spatial of the distribution of saline soils in the different locations in the Al-jafarah plain and to determine the level of salinity in the soil and compare against the satellite images landsat 7 ETM+. Sixty samples were collected randomly from the 10-50 cm surface soil layer and measured for salt content in accordance with Libyan laboratory standard procedures. Data collected for this study involves laboratory testing and satellite images landsat ETM+ 2010. Landsat 7 Enhanced thematic mapper plus (ETM+) was used to map and observe saline soil in the study area. The results derived from the laboratory and satellite images, when compared against each other, have found that the saline soil is present in marshes, none in other areas. The results showed that the sand areas were expanded over Al-jafarah plain. It can also be observed from classified images that the salty lands (Sebkha) spread in northwestern Al- jafarah Plain limited between the longitudes of 11°30´ , 12° 30´, and latitudes 32° 30´, 33° 30´ in the western area of the study area, because the rate of salinity in the study areas is less than 2 dS/m (non saline), alongside existence of high spectral reflectance response of dry and sedimentary soils (non saline), it is around (120-230 DN value).

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Images are characterized by dual functionality; images can be used as a source for the provision of qualitative and quantitative spatial data at both exploratory and detailed levels in different time periods (Karima, 2008; David, 2010), and they can also be used in creating maps, topographic charts and various thematic maps such as geographical, geomorphological, vegetation and soil maps (Ahmed *et al*., 2009; Lillesand and Kiefer, 1994).

Additionally, land and survey charts of crop and water requirements are necessary data that can be obtained through remote-sensing. Additionally salinity can be monitored and controlled by referring to maps of the Earth, by organizing maps of the main drainage structures, assessing the waterlogged areas and determining the degree of salinity (Lotfy, 1997; Hekmat and Bassam, 2008; Karima, 2008).

The use of Landsat 7 visual imagery has created a new dimension to the spatial analysis of soil salinity in arid areas, as the images have enabled the identification of saline soils in large areas with high accuracy and less effort and time. In contrast, the soil analysis laboratory was established to provide expertise, equipment, and training for the analysis and characterization of soils and geologic sediments. Currently, the laboratory analysis of soil using conventional methods requires a lot of time, money and effort, as well as equipment and expertise for the detection and characterization of soils.

The use of quantitative methods and the computer in the study of Earth sciences, geography and agriculture have led to the transformation of some sciences into applied sciences, concerned with the study of environmental problems using scientific methods that aim to formulate many models and theories (Habibah and Arumugam 2005; Birkhofer *et al*. 2008; Bjørnar, 2007; Gorkin, 2011).

Soil salinity in irrigated areas is becoming a serious problem for agriculture, especially in arid and semi-arid climates. Saline soil conditions have resulted in a reduction of the value and productivity of considerable areas of land throughout the world. Salinity commonly occurs in irrigated soil, due to the accumulation of soluble salts introduced from the continuous use of irrigation waters containing high or medium quantities of dissolved salts. Saline soils are characterized in general by poor ventilation due to the presence of a high water level; these soils are also very poor in organic matter content, with a percentage not exceeding 0.5%. Thus, this soil has become a major problem in the agricultural activity, and could not be used for farming except under extreme circumstances, after reclamation by washing and drainage. Thus, it would be useful for agriculture sector if soil salinity could be identified and mapped highly and at low cost (Ahmed , 1988)

Therefore this study, attempts to map and monitor the salt-affected soil in the region under investigation, using the efficient technique of remote-sensing as opposed to the conventional ground surveying methods. Remote-sensing is one of the most effective technologies used in the gathering of information (TM.ETM.MSS), particularly after the tremendous developments made regarding cameras, photographic techniques, aviation and satellites (Farifteh *et al*., 2006). Multiple studies have stressed the importance of Landsat visuals to monitor changes in land cover patterns and map, into multiple types of soils and visuals land cover within their spatial distribution. This study aims to analyze the values of salinity based on reflectance indices provided by images and laboratory data to identify areas affected by salinity. The study uses a survey representation method to ascertain the types of soil salinity and the transition from one soil group to another by the use of shading symbols and colours. The issue of demarcation between types of soil is considered to be one of the basic issues in the setting up of maps of the soil. This study aims to use archived remote sensing images with Landsat 7 ETM+ (RGB) data for delineating, mapping, classifying, and detect of salt-affected soils in the Al-jafarah plain.

1.2 Research problem

Land degradation and desertification are considered to be the main threats to agricultural sustainable development, especially in arid and semi-arid regions. Soil salinization is one of the most common land degradation processes in arid and semi-arid regions, where evaporation exceeds over rainfall. Soil salinity limits food production in several countries of the world. The estimates of world salt-affected soils differ (Taher, 1984; Water report, 2010.

Soil salinity problems in Libya began to be noticed after extensive agricultural activities coupled with an increasing population, through the use of lands suitable for farming and an overdraw of fresh groundwater to the extent of causing seawater intrusion. In addition, the nature of the harsh climate featuring low rainfall ranges and high temperatures also contributed to the soil salinity problems.

There is also a lack of the advanced detailed and analytical studies of the local soil. Most of the studies adopted in official agriculture government were based on the results of previous studies undertaken by foreign investment companies.

Lack of studies on the saline soil and techniques of mapping in the Al-jafarah Plain where existing research and reports only covered some natural aspects affecting the composition of the soils. Although there are some recent studies in relation to soil salinity, those studies rarely involved the usage of remote sensing data. Therefore, it would be useful to know the spatial coordinates of the distribution of saline soils in the Al-jafarah plain to understand the mechanisms governing the process of reliable monitoring and to consider effective analysis techniques to be employed. This could be achieved through information extracted from the data of remote sensing images and the results of laboratory analyses to analyze the local soil in the region, detect distributions of saline soils, determine their range and identify affected areas.

1.3 Research questions

This research was carried out to answer the following research questions:

- What are the coordinates and spatial of the distribution of saline soils in the different locations and direction in the Al-jafarah plain.
- Is there any differences between the results of the data obtained by way of laboratory analysis and remote sensing?

1.4 Research objectives

The objectives of the present study were as follows :

- To analysis soil salinity in Al-jafarah plain.
- To identify the spatial of the distribution of saline soils in the different locations in the Al-jafarah plain.
- To map the spatial of the distribution of saline soils in the different locations in the Al-jafarah plain using data from laboratory analysis and remote sensing.

1.5 Importance of the research

It is difficult to say how much land is prone to salinity in the studied area, as some projects in this region indicated to the salinity becomes a problem as a result of bad irrigation, ‘waterlogging’ and overlapping sea-water (Ranbir, 1996; Homer, 1999). Therefore, the need to develop measures to reduce excess salt has become urgent. Under low soil fertility in this region, given the growing importance of Al-jafarah plain , this study will reveal the potential value of the use of remote-sensing techniques to detect soil salinity.

The importance of this study of the saline soil in the northern part of Al-jafarah plain is reflected in the status of this area, which is considered as an agricultural hub; the state is seeking, through investment in projects deployed on its soil, to achieve some self-sufficiency. The study also seeks to find ways to prevent further salinization in soils of low and medium-salinity conditions through the reclamation of these type of soils, although it is very costly. Therefore, the practical importance of the study is reflected in the following point:

- To clarify the distribution and spread of the areas affected by salinity, and identify and measure the soil`s salinity through determining ‘spatial variation’ and using satellite images of the studied area as well as laboratory analysis.

The fundamental difference between current study and other studies carried out in Libya is that this research study is characterized by the use of data from laboratory analysis and remote sensing as a basic panel with which to signify specific information on soil salinity in the study area.

1.6 Organization of the thesis

To achieve the study objectives, this thesis is divided into six chapters. Chapter one is an introductory chapter, which presents the issue of study, including the Research problem**,** research objective, research question, and finally the importance of the study.

Chapter two**,** presents a review of the literature which is divided into studies related to soils, remote sensing and soil salinity in Al-jafarah, and those studies related to other areas. This chapter will evaluate previous studies relevant to the subject.

Chapter three, background of the study area, present a paradigm that shows the relationship between the soil quality, its physical and morphological properties and the natural conditions prevailing in the studied area.

Chapter four describes the research methodology in detail and reviews methods of data collection to determine how they will be used in the study. Also outlined, are the statistical methods used, the types of curricula used in the study, the methods used for collecting samples, and the approach used for analyzing the data.

Chapter five discusses the results; this chapter includes an analysis of the study data and explains the mutual influence between the variables and the most important results that have been obtained. This chapter reflects the results obtained from the study, and the validity of the assumptions made. Finally, Chapter six provides a summary, conclusions and recommendations from the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to review previous studies which have discussed the concept of soil salinity, factors affecting the soil salinity, conventional methods to determine soil salinity, sensors used to determine soil salinity, the advantages and disadvantages of remote sensing and conventional methods in determining the saline soils, and studies that have relied on a different methodology to determine soil salinity.

2.2 Concept of soil salinity

Soil salinity is a severe environmental hazard (Hillel 2000) that impacts the growth of many crops. Human-induced salinization is the result of salt stored in the soil profile being mobilized by extra water provided by human activities such as irrigation (Everitt, 1994.)

According to Ghabour and Daesl, 1996 saline horizon means a horizon of the pooling of salts dissolved in the water, which contains more than 2% of dissolved salts (more than 30 ml Smenz / Cm -25 m). white salt crust is a white layer covering the surface of the marsh soils. Initial salinization occurs with the beginning of the development of the soil. Furthermore, salinity is formed with the formation of the soil where the source of salts determined the materials of origin and the level of the salt-rich groundwater. Resistance to this type of salinity is difficult and costly, because it involves halting or reversing the formation processes of the soil (Adnan, 1978). Secondary salinization was defined by Vik*ie al*.,(2010) the transformation of non-saline to saline soils as a result of the introduction of an irrigation system due to either the increase of the level of groundwater or an increase in the concentration of salts in the irrigation water. Soil salinity is caused by various factors which will be discussed in the following section.

Soil salinity can be determined by measuring the electrical conductivity of a solution extracted from a water- saturated soil paste. From the agricultural point of view, saline soil is those, which contains sufficient neutral soluble salts in the root zone to adversely affect the growth of most crops. For the purpose of definition, saline soil has an electrical conductivity of saturation extracts of more than 4 dS/m at 25°C (Richareds, 1954. P,1914).

Soil salinity caused by natural or human-induced processes is a major environmental hazard. This requires careful monitoring of the soil salinity status and its variation, so that trends towards degradation can be curbed and thus sustainable land cover and management can be secured. In arid and semi-arid ecosystems, as in Libya's case, salinization is a major threat to the productivity of agricultural land. The presence of salinity trailing in soil or water at certain amounts adversely affects water use in agriculture, and is expected in the presence of a range of climatic conditions, and geological and underground water (Taher, 1984; Water report, 2010)

2.3 Factors affecting the soil salinity

2.3.1 Nature factors affecting the soil salinity

Soil salinity problems began to be noticed after extensive agricultural activities, through the use of lands suitable for farming and an overdraw of fresh groundwater to the extent of causing seawater intrusion. In addition, the nature of the harsh climate featuring low rainfall ranges and high temperatures also contributed to the soil salinity problems. This naturally-occurring, or human-induced soil salinity , is the result of poor management practice, as well as the impact of the prevalent climate. This conditions is clear and widespread over areas where evaporation is much greater than the amount of precipitation, namely, types of dry and semi-dry climate. In such climates, the washed-away soil and salt deprivation is low, thus leading to a higher concentration of salt in the head rock and the water, whether surface or groundwater (David, 1999; Carl, 2006 ; Gordon and Ferdn, 1983)..

Over long periods of time, as soil minerals weather and release salts, these salts are flushed or leached out of the soil by drainage water in areas with sufficient precipitation. In addition to mineral weathering, salts are also deposited via dust and precipitation. In dry regions salts may accumulate, leading to naturally saline soils. Which occurred in large parts of Australia (Abdul Moneim, 1995). Human practices also can increase the salinity of soils by the addition of salts in irrigation water. Proper irrigation management can prevent salt accumulation by providing adequate drainage water to leach added salts from the soil. Disrupting drainage patterns that provide leaching can also result in salt accumulations (Lotfy1997; Declercq *et al.*(2009) .

According to Jassem Alrabiay (1980) the accumulation of salts in the southern part of the Alluvial Plains of Iraq were due to overlapping set of factors including evaporation, the rise of deep groundwater, irrigation water quality, as well as a lack of interest in any sort of irrigation drainage water in excess of the needs of the plants. The study undertaken by Nasser Alsaaran (2000) to the south area of Saudi Arabia, assessed soil salinity and sodium levels by identifying the values of salinity, the total ion concentration of chlorine, sodium adsorption ratios, and their impact on agricultural production. That study attributed the reason for the accumulation of salts in the part of the south area of Saudi Arabia was due to the rise of deep groundwater and irrigation water quality. In a Hungarian study by Tibor Tóth (2008), groundwater was proved to be the main source of salt accumulation in the study area, because of an increase in the salt concentration in those areas where the groundwater table rose to 100-180 cm in depth under the surface during the investigation period.

2.3.2 Human factors affecting the soil salinity

The main factors causing high soil salinity levels are high irrigation water salinity due to uneven water distribution, under-watering or salts build up in the root zone and salinisation of root zone from shallow water tables. In addition, Aiban *et al.*(1999) focused on the sustainability of irrigated agriculture in arid and semi-arid lands, which depended mainly on the level of soil salinity and the quality of irrigation water of the Al-Hassa oasis in Saudi Arabia. That study tried to investigate the extent of the soil salinity and the quality of the irrigation water and their relationship with vegetation growth. This study attributed the reason for the accumulation of salts in the Al-Hassa oasis to irrigation water quality.

Silva and Uchida (2000) proposed that the sources of salinity (salts in soil and water for irrigation) might have been naturally present as products of geo-chemical weathering of rocks and parent materials. This might have been a direct result of sea-water flooding and intrusion into groundwater resources.

A study by Vernon Parent (2010), showed that saline soils were common throughout Utah, due in part to the arid climate and inadequate rainfall necessary to filter salts out of the plant root zone. Higher salt concentrations can be created by poor soil drainage as well as inadequate irrigation.

Blaylock and Alan Dean (1994) focused on poor drainage as the most common contributor to soil salinity or poor irrigation water. As the plants absorb soil water or as water evaporates, salts from the water remain in the soil. Soil salinity is complex to overcome; salt may be removed from the soil by leaching and watering plants more frequently can reduce salt injury. The adverse effects of soil salinity can also be reduced by promoting vigorous growth through good management.

2.3.3 Factors affecting the soil salinity in the Al-jafarah plain

Al-jafarah plain is arid and semi-arid, and soil salinity is a natural phenomenon where the rate of accumulation of salts resulting from the evaporation of rain water is greater than the amount of precipitation it is unlike regions with wet climates. Although there have been many different studies of the soil in the mentioned area, in terms of soil classification, the issue of soil salinity has received little attention from geographers.

2.4 Conventional methods to determine soil salinity

The test for salinity completed by the soil analysis laboratory has several important objectives. These include, firstly, the provision of an inexpensive means for both agricultural producers and home-owners to test their soil fertility, and to provide fertilizer recommendations (Nanping and Xianjue, 1997; Larisa and Renduo 1999). Secondly, the test would help farmers and the general public diagnose and manage problems associated with soil salinity.

The main objective when collecting a soil sample for laboratory analysis is to ensure that its composition is representative of the conditions that exist in the field (Clain 2001). In accordance with Birkhofer (2008) approach, the testing of a soil sample is a reliable way to assess how salts are affecting plant growth. Although it is quicker and easier to test water samples, a soil salinity test shows the soil conditions around the plant roots, taking into account the influence of soil texture. Identifying current soil salinity conditions and recording salinity trends helps to recognize and predict soil salinity problems. Soil samples are collected and sent to the laboratory for full analysis to identify a wide range of soil properties, including salinity.

According to De Vries *et al.*(2005), anyone carrying out work in a laboratory must be familiar with its code of practice and must also carry out appropriate risk assessments on the particular piece of work that they are undertaking. On completion of the work, all hazardous materials must be safely disposed of and the laboratory must be left in a safe condition.

Salinity is commonly measured by the electrical conductivity (EC) of soil water or saturated paste extract. EC is measured in deciSiemens per metre (dS/m), According to Ahmed (1989), soil salinity can be extracted by two techniques:

A. Electric Conductivity Method: This method uses an inexpensive device for extracting soil water that allows soil salinity to be monitored throughout the season, hence enabling adjustments to be made to irrigation management.

B. Soil Sampling Method: This method uses simple tools such as a shovel or soil sampling auger, and requires no prior equipment purchase or setup. However, this method can only carried out a limited number of times, once or twice a year, and requires a laboratory analysis. Therefore, it may deliver salinity information after the damage is already done, and there is also the cost of analysis to consider.

2.5 Sensors used to determine soil salinity

Soil salinity sensors are ideal for the efficient in situ field monitoring of soil salinity with minimal disturbance to the soil profile. Salinity at selected depths can be monitored over a long period with sufficient accuracy. Soil salinity can be measured using a simple field test. An electrical conductivity device will give an indication of the salts in the soil. This test is reasonably accurate for indicating if salts may cause yield losses or soil problems, but sending soil samples away for laboratory testing is strongly recommended to obtain representative results from the field. Also, the use of remote sensing and Geographic Information System techniques have become increasingly important since it enables a variety of satellite-derived data sets to be described and applied in order to understand changes in landscape (Lotfy, 1997). The potential to detect, map and monitor degradation problems, including their spread and effects over time are the main innovations of remote sensing.

Acorrding to Njoku, E. G. (2013), the use various sensors (satellite- and airborne multispectral sensors, microwave sensors, video imagery, airborne geophysics, hyper spectral sensors, and electromagnetic induction meters) and approaches used for remote identification and mapping of salt-affected areas are useful. Constraints on the use of remote sensing data for mapping salt-affected areas are shown related to the spectral behaviour of salt types, spatial distribution of salts on the terrain surface, temporal changes on salinity, interference of vegetation, and spectral confusions with other terrain surfaces.

Several researchers have attempted to detect the distribution and severity of soil salinity with either visual or computer remote-sensing techniques, or by using a combination of both methods. Abdel- Hamid *et al.* (1992), presented a study in which Landsat Thematic Mapper (TM) data were used to identify and map saline areas of the Nile delta in Egypt with reasonable accuracy. Moreover, these affected areas were monitored with the support of ground information using GIS.

Satellite remote sensing has been used to detect land affected by salinity. Multi-spectral optical data from Landsat5 Thematic Mapper (TM) were used to map salinity using geographic information system and remote sensing technologies in an arid region south of Saudi Arabia. Results remote-sensing image techniques of TM data were used to show the spectral classes and corresponding areas of the different land cover covering the region, to delineate and map those areas that were salt-affected (Abdellatif and Mourad, 2012).

The study conducted in Malaysia, by Khaled Salih (2010) to investigated the application of integrated satellite remote-sensing and GIS techniques to assess land cover changes and estimate the soil erosion in the water catchment. Inherent in this research was the interpretation of multi-sensor data collected by several satellite systems, evaluation of the quality of the resulting change information, and the application of remote-sensing and other ancillary data as inputs into a GIS–model to analyze the soil. The results of the study indicated that land-use changes in the study area had produced environmental problems such as water pollution and soil erosion.

Kalra and Joshi (1997) used Landsat (MSS & TM) images during the fallow (April, May), crop (January /February), and rain-fed crop (October) periods and evaluated the capability of multi-sensor data for delineating salt-affected soils in arid Rajasthan. It was concluded that the moderately and severely salt-affected soils were caused by saline irrigation and sodic soils by water irrigation.

Saleh A AL-hassoun (2007) used Multi-temporal Landsat Thematic Mapper (TM) data collected in two years to monitor soils affected by salinity in an arid region north of Saudi Arabia. Results of various remote-sensing image techniques of TM data were used to show the spectral classes and corresponding areas of the different land cover covering the region, to delineate and map those areas that were salt-affected, and finally to monitor the temporal changes in salinity in terms of its severity and real extent for the period under investigation. Results of the study indicated that a serious salinity problem exists and that it is getting worse. Moreover, an urgent salinity management programme is called for to control the spread of salinity and to reclaim the damaged areas to be used for economic agriculture.

2.6. Remote sensing and soil salinity

Remote sensing science is used to establish a theoretical basis for measuring Earth surface properties using reflected, emitted, and scattered electromagnetic radiation and develop the methodologies and technical approaches to analyze and interpret such measurements . Remote sensing science investigations are needed to prepare for new remote sensing measurements of the Earth from space and to ascertain the readiness of candidate technologies for obtaining them. Recent advances in sensor design and data analysis techniques are making some remote-sensing systems practical for monitoring natural and human-induced coastal changes (Xin Zhao, 2005; Peledet *et al.*, 2010; Yuji Murayama, 2011). According to Victor Klemas (2011), hyper spectral imagers can differentiate wetland and coastal land types using spectral bands specially selected for a given application. High resolution multispectral equipment is available for mapping. Thermal infrared scanners can be used to measure water salinity, soil moisture, and other hydrologic parameters.

Remotely sensed data has great potential for monitoring dynamic processes including salinization. Remote sensing of surface features using aerial photography, videography, infrared thermometry, and multispectral scanners have been used intensively to identify and map salt-affected areas (Robbins and Wiegand 1990)

Salinity indices have been closely correlated with measured values, yet significantly under estimate the salinity of zones with high levels of salt exposure. Sumfleth and Duttmann (2008) for example, modified a methodology to predict soil property distribution in paddy soil landscapes using terrain data and satellite information as indicators. In addition Metternicht and Zinck (1997) provided an approach for mapping salt- and sodium-affected surfaces by combining digital image classification with field observation of soil degradation features and laboratory determinations in the semiarid valleys of Cochabamba, Bolivia. Multispectral data acquired from platforms such as Landsat, SPOT, and the Indian Remote Sensing (IRS) series of satellites had been found to be useful in detecting, mapping and monitoring salt-affected soils (Dwivedi and Rao 1992). Band ratios of visible to near-infrared and between infrared bands have proven to be better for identifying salts in soils and salt-stressed crops than individual bands. Craig *et al.,* (1998) carried out a procedure to assess the production and effectiveness of reclamation efforts. Those results illustrate practical ways to combine image analysis capability, spectral observations, and ground truth to map and quantify the severity of soil salinity and its effects on crops.

An important study prepared in this field was that of Ferranti in Brazil in 1982, which aimed to determine the contribution of remote-sensing to problems of irrigation, drainage, and salinity. In addition to the study, he was preparing to address the growing problem of water logging and salinity in the soil for the International Research

Technology in Irrigation and Drainage and Salinity in Washington. Based on remote-sensing data Landsat ETM bands 4,3,2 .

Ming Liang *et al.*(2011) proposed a method of modelling that utilizes data from the American land resources satellite Landsat TM/ETM to monitor the condition of flood water overlapping with the soil. In India, Manchaned (2002) carried out a soil survey and mapping using remote-sensing technology. The mapping scale was 1:50,000 as smaller and more detailed soil mapping (1:10000 scales) was not possible due to the coarse spatial resolution of the satellite data. However, the data provided by IRS was expected to provide information on a larger scale (1:25,000 to 1:12,500). Digital remote-sensing and the use of GIS are yet to gain momentum in addressing the various issues of soil surveys especially in Libya.

2.7 The advantages and disadvantages of remote sensing and conventional methods in determining the saline soils

The expenditure of time and effort in characterizing and monitoring the salinity condition of a large area with conventional soil sampling and laboratory analysis procedures becomes impractical. Soil salinity is too variable and transient to be appraised using the number of samples that can be practically processed using conventional soil sampling and laboratory analysis procedures. Furthermore, the conventional procedures do not provide sufficient detailed spatial information to adequately characterize salinity conditions or to determine its natural or management-related causes.

A more rapid method of field-measurement using remote sensing is needed. Additionally, this assessment technology should enable the spatial relations existing within extensive areal data sets to be ascertained. It should also provide a means of evaluating management effects and proving changes or differences in an area's salinity condition over time Verma *et al*. (1993). But when interpreting images for this purpose, an important factor which must be recognized is that the soil surface is not always visible in the image; in most cases it will be covered by vegetation, agricultural crops and buildings. The most important characteristic of saline soil is the large amount of dissolved salts that hinder or prevent the natural growth of agricultural crops. These salts are concentrated in layers or horizons of the soil sector, creating what is known as the diagnostic subsurface horizon, also known as the saline horizon (Provin *et al*, 2001).

Soil salinity is generally characterized by the total dissolved solids (TDS) or the electrical conductivity (EC) of the soil solution. The two are closely related but EC is more often measured. There are several different approaches to measure soil EC. The appropriate procedure may be selected depending on the type of information needed in a particular situation. When a rapid in situ measurement of the field's apparent EC (bulk soil EC) is desired, measurement based on non-contact terrain EC sensors including electromagnetic (EM) systems may be used. Such a procedure has often been used for characterizing the salinity of large fields, but it generally has a lower accuracy than those based on EC measurement performed on the water extracts of soil in a conventional laboratory (Rhoades,1996; Singh & Srivastav, S.K. 1994).

Ghabour and Daels (1993) concluded that the detection of soil degradation by conventional means of soil surveying requires a great deal of time, but remote sensing data and techniques offer the possibility of mapping and monitoring these processes more efficiently and economically. However, to assess the accuracy of using satellite images to map and monitor salinity it is necessary to compare these with the results of field measurements of salinity.

2.8 Studies related to soils, remote sensing and soil salinity in Libya

In 1973, a French company called Ajafly worked on an exploratory study using aerial photography in order to determine the quality of vegetation, however, this study did not determine the morphological characteristics of the soil. Nevertheless, in 1978, the Department of Soil in the Ministry of Agriculture examined the exploited and unexploited agricultural areas in Tarhuna, Azawia and Souq Al-khamis by taking aerial photographs and through field visits. They found that most areas were covered by poor and sandy soil and would require a long time period for reclamation; this was confirmed by Khaled and Adnan (1984), in their study about the soil in the field.

Furthermore, a yearly study was conducted by the Soviet company Slkhoz Export in 1980, on a 1.66 million hectare area 200 mm to the north of the line of rain to determine the suitability of the soil for the use of agricultural products, produce classification maps of the soil, record the productivity of the agricultural land and improve the use of the land. This study was one of the most successful studies in the region in terms of area width and accuracy. The company aimed to obtain aerial photographs from Russian satellites and samples were also taken from a large area of soil in the study region for analysis in a laboratory. The results of that study, which were presented on digital maps, displayed the soil types. The results of those analyses were still used in the present day by important centres and governmental institutions in Libya. Some of these results will be used in the current research, as they constitute the main reference for most researchers in this area (from Adnan Gandelt's point of view1978), and the Russian Studies were the first studies in the region in terms of size and results.

Another important study was conducted by Ahmed (1988) regarding the saline and alkaline levels in the soil, in terms of the origin, characteristics, and methods of reclamation. A further study by Ahmed (1997) indicated how the soil turns saline; this included the significant decline from using irrigation water, as well as the critical influence of the ground water level and its relationship to salinity. A relationship was found between the ground water level and salinity in the study area.

Khalid (2000) explored the nature of the composition and classification of land in Libya, with a focus upon the distribution of morphological characteristics and natural and chemical properties of the soil. Actually, this study depended on the results of two other studies, which were written by the Russians and the Centre of Water and Soil. This study resulted in complete agreement with what had been stated in the earlier studies. This gave a holistic view of the types of soil rather than focusing on a specific area of Libya. It also analyzed the natural factors that affected the soil formation in the area studied, such as the climate. Furthermore, it discussed the important and the most influential factors involved in the formation of saline soil. The aim of their study was to obtain and develop the major categories and other minor types of soil, making it the largest study of reference for researchers in the field.

Karim El Bakry (2001) and Khalid Ramdan (1995) studies aimed to determine the types of soil located in the Surman area and identify the natural and chemical properties alongside the cultivation problems. The results showed that the area were covered by sandy soil, except for a few other were as in the north. Perhaps the most important detailed study was conducted by the Research Centre of Soil and Water in Tripoli, Libya, during the period of 2004 to 2006. Part of their study aimed to complete previous studies by exploring soil areas that had not been previously studied in the remaining areas of Al-jafarah plain. It was agreed with the Centre of the National Bureau to study what remained of the western region area, as represented by the topographical paintings in 2004 and 2006. The study was located in the area between longitudes 11^{o} 45´, 12^{0} 15´ and latitudes 30^{0} 32´, 33^{0} 00´ in the western region of Libya (west of Al-jafarah). The area was estimated to be 134,000 hectares, using digital maps, and the use of geographic information systems. The study produced a base map indicating the existing landmarks of the region.

According to studies by ACR (2004, 2006), the ratio of grain size (sand-silt-clay) soil can be placed into three main groups, namely:

1- Sandy soil.
2- Alluvial soil.
3- Clay soil.