REMOTE SENSING MONITORING OF CHANGES IN SOIL POLLUTION A CASE STUDY IN A REGION IN BAGHDAD, IRAQ

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Abstract:
One of the main environmental problems which affect extensively the areas in the world is soil salinity. Traditional data collection methods are neither enough for considering this important environmental problem nor accurate for soil studies. Remote sensing data could overcome most of these problems. Although satellite images are commonly used for these studies, however there are still needs to find the best calibration between the data and real situations in each specified area. Landsat satellite (TM & ETM+) images have been analyzed to study soil pollution (Exacerbation of salinity in the soil without the use of abandoned agricultural for a long time) at west of Baghdad city of Iraqi country for the years 1990, 2001 & 2007. All of the three scenes consist six bands (without the thermal band), changes are determined by applying supervised classification (Maximum Likelihood) technique. Then using Raster to Vector (R to V) Transform technique. ArcGIS 9.1 program is used to apply the supervised classification and the R to V transforms techniques in order to determine the results.
Keywords: Remote Sensing, Monitoring and Soil pollution.

استخدام تقنية الاستشعار عن بعد لرصد التغيرات في تلوث التربة، دراسة حالة منطقة في بغداد، العراق

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الخلاصة:
واحدة من المشكلات البيئية الرئيسية التي تؤثر على مناطق واسعة في العالم ملوحة التربة. الطرق التقليدية لجمع البيانات ليست كافية للنظر في هذه المشكلة البيئية الهامة وغير دقيقة لدراسات التربة. بيانات الاستشعار عن بعد ويمكن التغلب على معظم هذه المشاكل. على الرغم من شيوع استخدام صور الأقمار الصناعية لهذه الدراسات، ولكن لا تزال الحاجة للبحث عن أفضل المعايرة بين البيانات والواقع الحقيقي. القمر الصناعي لاندسات (نوع الراسم ألغرضي والراسم ألغرضي المحسن) حللت الصور لدراسة تلوث التربة (استفحال الملوحة في التربة المتروكة دون الاستغلال الزراعي لفترة طويلة) غرب مدينة بغداد / العراق للسنوات 1990 و 2001 و2007 جميع هذه الصور خلال السنوات ثلاثة تتألف من ست حزم (بدون الحزمة الحرارية)، التغييرات في حالة التربة حددت من خلال التصنيف الموجه تقنية (الاحتمالية القصوى). ثم استخدام التحويل مصفوفة إلى متجه استخدم برنامج ArcGIS 9.1، لتطبيق التصنيف الموجه وتقنية التحويل مصفوفة إلى متجه ومن ثم استحصال النتائج.
الكلمات المفتاحية: الاستشعار عن بعد، مراقبة، رصد وتلوث التربة.

Introduction:

Soil Salinity, as a term that refers to the state of accumulation of the soluble salt in the soil. Soil salinity can be determined by measuring the electrical conductivity of a solution extracted from a water- saturated soil paste. The electric conductivity as EC_e (electrical conductivity of the extract) with unit of decisiemens per meter ($Ds.m^{-1}$) or millimohoh per centimeter (mmhos/cm) is an expression for the anions and cations in the soil. From the agriculture point of view, saline soils are those, which contain sufficient natural soluble salts in the root zone to adversely affect the growth of most crops (see Table 1). For the purpose of definition, saline soils have an electrical conductivity of saturation extracts of more than 4 $dS.m^{-1}$ at 25 ˚C [1].

Table 1: General ranges for plant tolerance to soil salinity.

Salinity (EC_e, ($dS.m^{-1}$)	Plant response
0 to 2	Mostly negligible
2 to 4	Growth of sensitive plants may be restricted
4 to 8	Growth of many plants is restricted
8 to 16	Only tolerant plants grow satisfactorily
Above 16	Only a few, very tolerant plants grow satisfactorily

Remote sensing is the science and technology by which the characteristics of objects of interest can be identified, measured or analyzed without direct contact. Each object has unique and different characteristics of reflection or emission in different environment [2]. Remote sensors usually record electro magnetic radiation (EMR) which travels at a velocity of 3×108ms-1 from the source directly through the vacuum of space or indirectly by reflection or reradiation to the sensor [3]. As such, EMR represents a High-speed communications link between the sensor and remotely located phenomena [3].

The objective of this study is to use Landsat TM data for the delineation, mapping, classification and temporal change detection of salt-affected soils in the agriculture areas around the city of Skaka, north of Saudi Arabia. Remote sensing using Landsat TM data, coupled with image processing techniques are expected to provide effective and efficient means for inventory and monitoring the extent of this problem where vegetation cover is used as an indicator for soil salinity. 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 reduction of the value and productivity of considerable areas of land throughout the world. Salinity commonly occurs in irrigated soil because of the accumulations of soluble salts introduced from the continuous use of irrigation waters containing high or medium quantity of dissolved salts.

Management of the salt balance to mitigate its adverse effects on agriculture output is required. Management includes application of excessive irrigation water for leaching excess salts, providing soil drainage, and using proper agronomic practices such as growing salt-tolerant crops. Unfortunately, most of these requirements are rarely provided leading the world to problems of salinity [4].

Spectral reflectance of soils is determined by their physico-chemical properties, in particular humus content, texture, iron oxides, mineralogy, carbonates, gypsum, and water soluble salts. Moisture content and surface roughness also play an important role. As spectral reflectance response is the result of numerous soil properties, spectrally-derived maps may delineate important information about surface soil conditions, which has been indicated in many previous studies. Conventional soil categories are based on both surface and sub-surface soil characteristics, but remote sensing techniques also may be used as an aid to soil survey [5].

Soil salinization is the process of enrichment of a soil in soluble salts that results in the formation of a salt-affected soil [6]. It may occur naturally or as the result of poor management practices. Irrigation modifies the balance of soil hydration by generating an extra supply of water; this supply is always associated with added salts and consequently results in the

soil becoming salty and unproductive in the absence of rational management. If the salinity problem cannot be immediately remediated, either for physical, technological, or economic reasons, the land will eventually become totally unproductive and will be abandoned. Consequently, soil salinity seriously threatens the productivity of irrigated land and the livelihoods of the farmers who depend on the affected land [7].

To combat soil salinization, different technical measures and strategies have been developed in the past century, which can be categorized into physical amelioration, biological amelioration, chemical amelioration, hydro technical amelioration and electro-reclamation. However, the success of a reclamation project depends to a large extent on the choice and implementation of the method; it requires a detailed, comprehensive preliminary survey of local conditions and careful definition of the requirements of each reclamation method [8].

However, soil salinity is quite time- and space-dynamic since salinization is the consequence of different complex processes of salt redistribution that depend on natural conditions, system features, agricultural practices and drainage management. In addition, observing the returns and benefits of drainage (the most common salinity control option) takes such a long time (often more than 25 years) that instantaneous measurements of salinity do not reflect current conditions/trends [9]. Large numbers of studies have proven that remote sensing is a useful and promising method to identify salt-affected soils, especially those with high salinity [10], [11]. Used supervised classification, spectral extraction, and matching techniques to investigate types and occurrences of salts in the semiarid regions of the United States–Mexico border areas [12]. In China, applied an approach combining Landsat TM data transforms with the depth and mineralization rate of groundwater to map soil salinity [13]. In Egypt, have detected and monitored salinization from changes in surface characteristics, expressed from vegetation indices and tasseled cap transformations, and from changes in radiometric thermal temperature, and linked its acceleration to a specific year [14]. In Mexico, an adjusted normalized difference vegetation index derived from Landsat TM data, called combined spectral response index, is reported to have high negative correlation with salt contents [15].

Area of Study:

The location of study area was in Iraq, west of Baghdad within longitude (38º33) (36º91) northwards and latitude (44º18) (36º37) eastwards, has area of (318846.8) hectare. Studied area has been dominated by agriculture, Irrigation channels, drainage, besides bare land influenced by salts (salt affected soils).

Data Sources:

Satellite image captured from Landsat-5 (TM) in march (1990) , Landsat-7 (ETM+) in march (2001) and Landsat-7 (ETM+) in march (2007) respectively with six bands ranging from first to the seventh except the sixth band in following wave length (0.45-0.515 (0.525-0.605), (0.63-0.69), (0.76-0.90), (1.55-1.75), (2.09-3.35) Micrometer, with pixel size (28.5 ×28.5) m. were used to monitor the patterns of annual changes in plant cover using ERDAS program V.9. Also the ArcGIS V.9 software package was used, shown in (Figure 1).

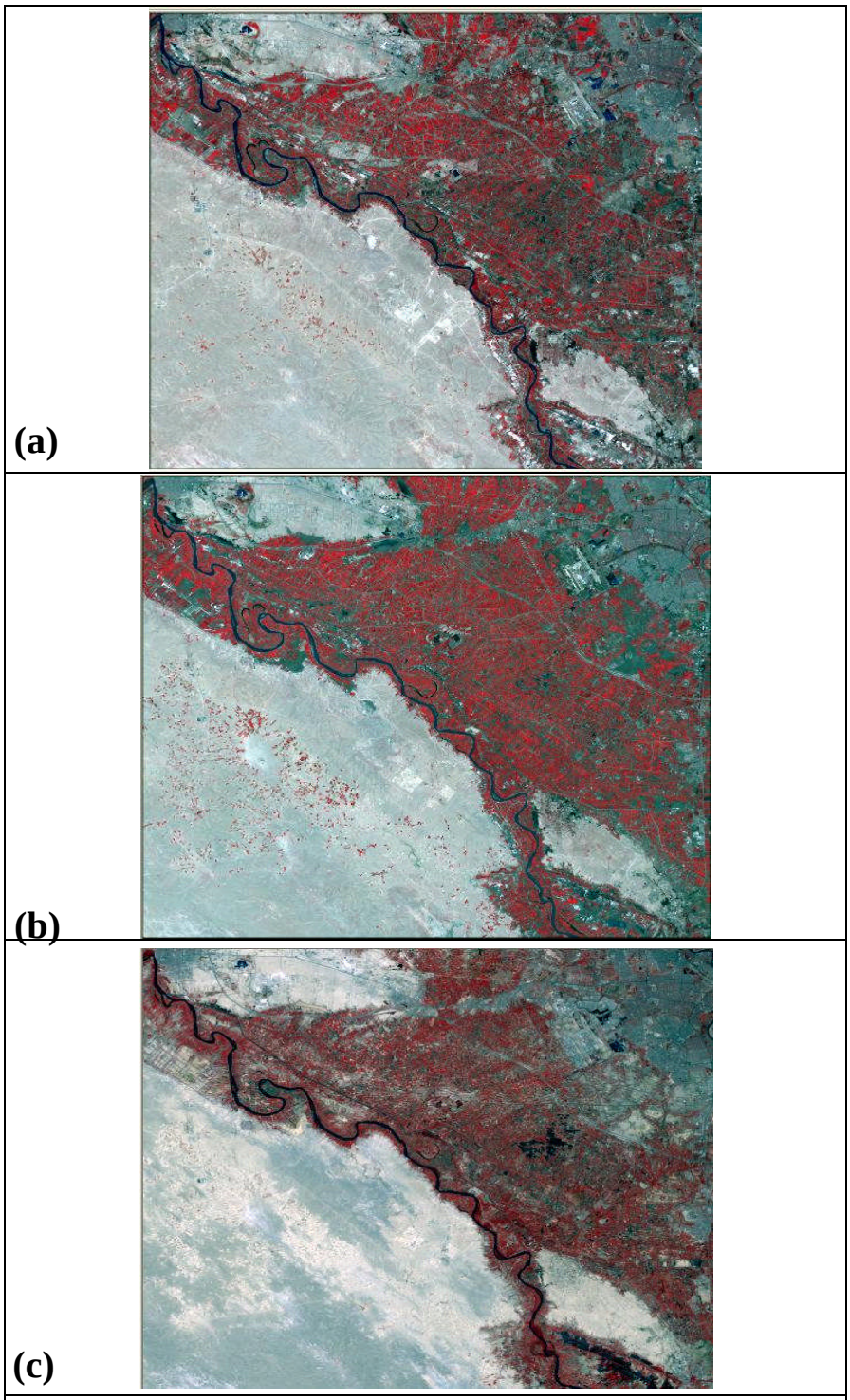

Figure .1 : Baghdad satellite image acquired on :
(a)Landsat image satellite(TM) for the year March 1990
(b) Landsat image satellite (ETM+) for the year March 2001
(c) Landsat image satellite (ETM+) for the year March 2007

Methodology:

After field operations of the study area (west of Baghdad, 30 km west of the city) for determining the situation of land use and cover, and what factors prevailing there. The focus was on soil conditions in terms of activity. It was noted that some areas have been affected by clear layers of salt and these salts have almost paralyzed activity soil. Collected surface samples of the affected area with salt, extracted soil filtrate, which relies on analysis of soil, estimated the electrical conductivity of soil extracts (ECe) was (147m-1 dS.).See (Figure 2).

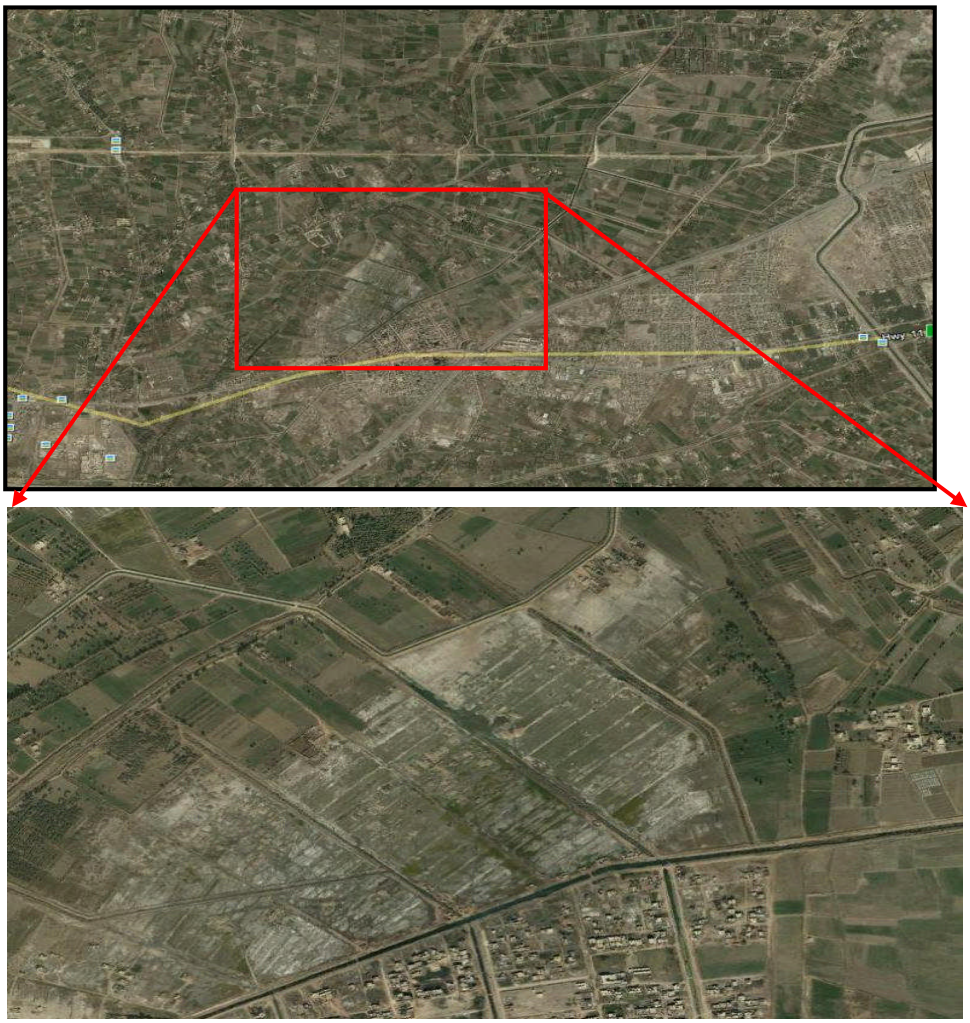

Figure 2: profile showed the area was affected by saline salts.

The coordinates of the region were taken by using the GPS device and then projected them on the satellite image by using the software then the following steps were applied. ArcGIS v. 9.1.

1. classifiy satellite images for the three years (1990, 2001 and 2007) supervised classification using a technique (Likelihood Maximum).
2. Convert the image satellite from (Raster to Vector) for the purpose of identifying the affected area with salt.
3. Deleted the regions outside the study area and at the same time calculate the area of the degraded regions.
4. Compare the situation in the region of study for three years

(Figures 3, 4 and 5) represent the classification (Maximum Likelihood) results. And, (Table 2) shows some details about the area of the region affected by the salt for the years 1990 and 2001 to 2007.

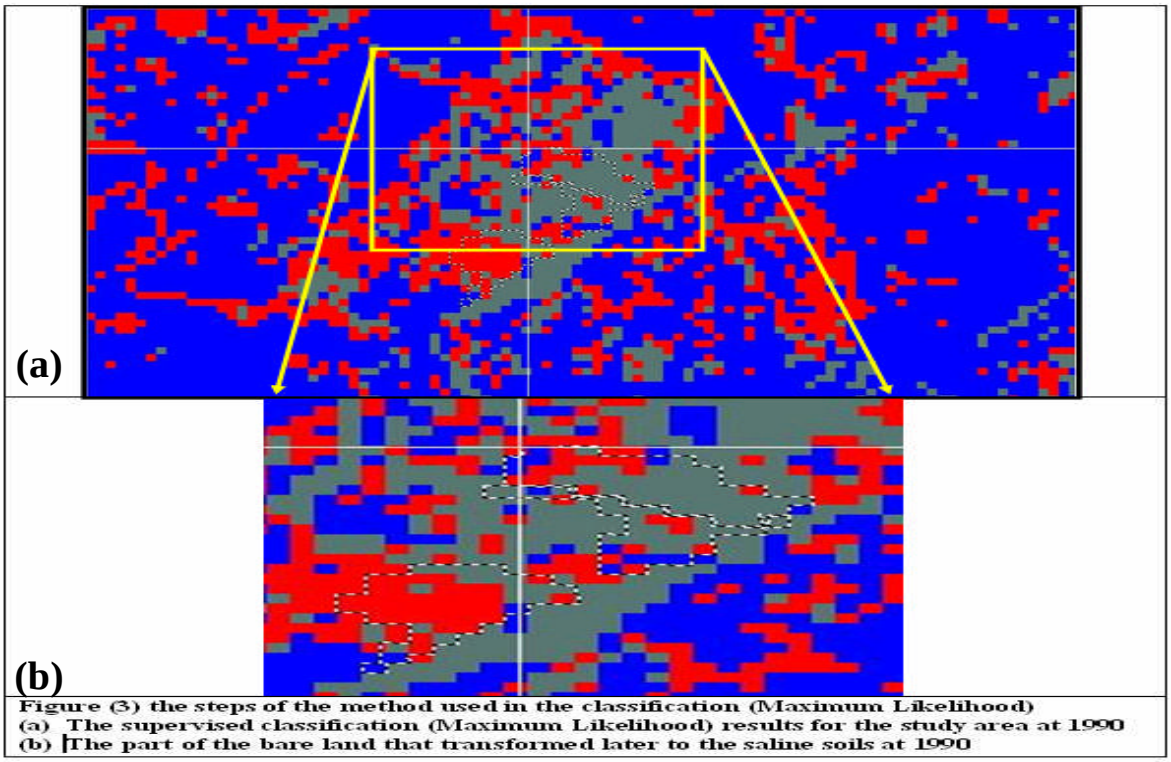

Figure (3) the steps of the method used in the classification (Maximum Likelihood)
(a) The supervised classification (Maximum Likelihood) results for the study area at 1990
(b) The part of the bare land that transformed later to the saline soils at 1990

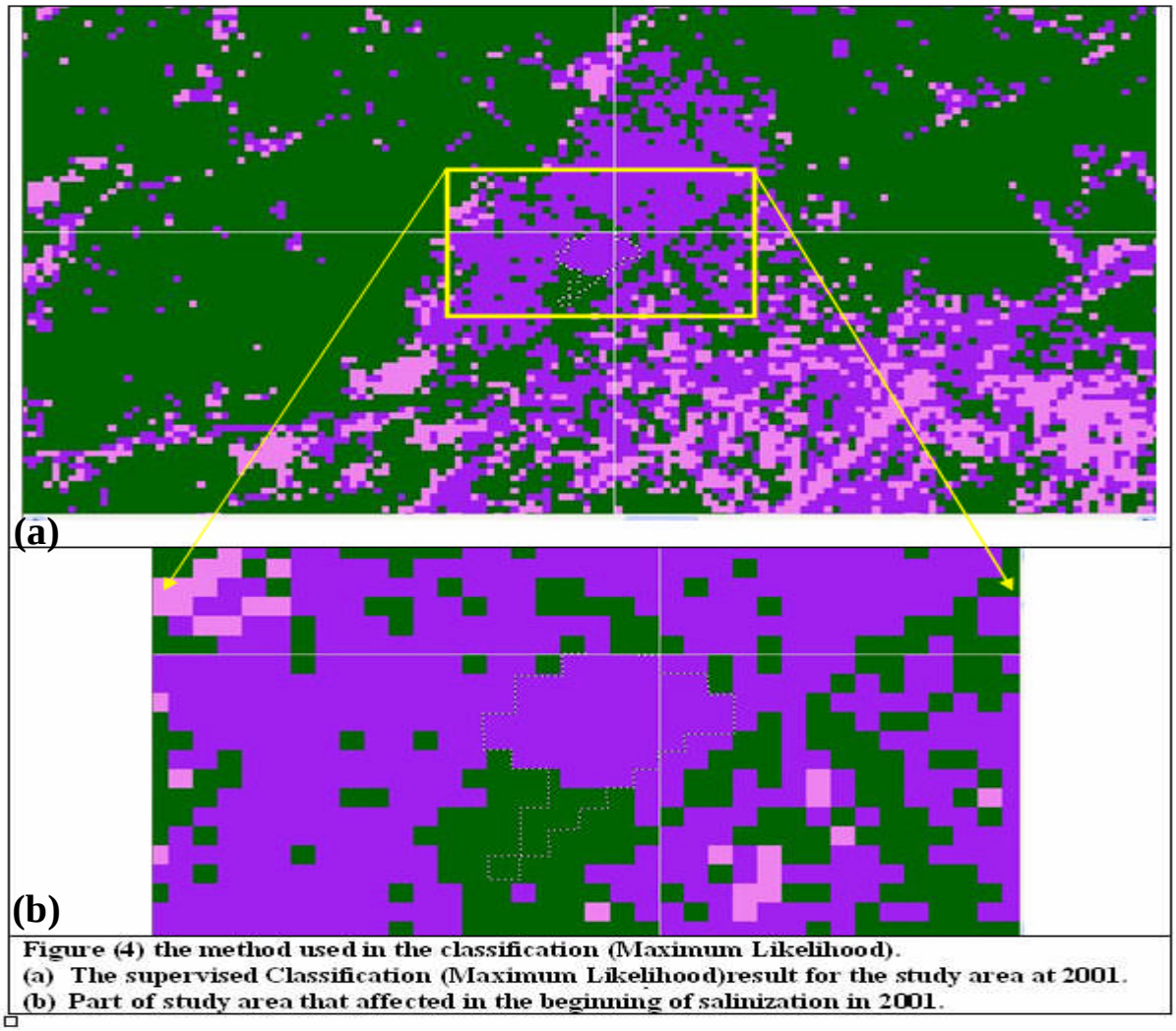

Figure (4) the method used in the classification (Maximum Likelihood).
(a) The supervised Classification (Maximum Likelihood)result for the study area at 2001.
(b) Part of study area that affected in the beginning of salinization in 2001.

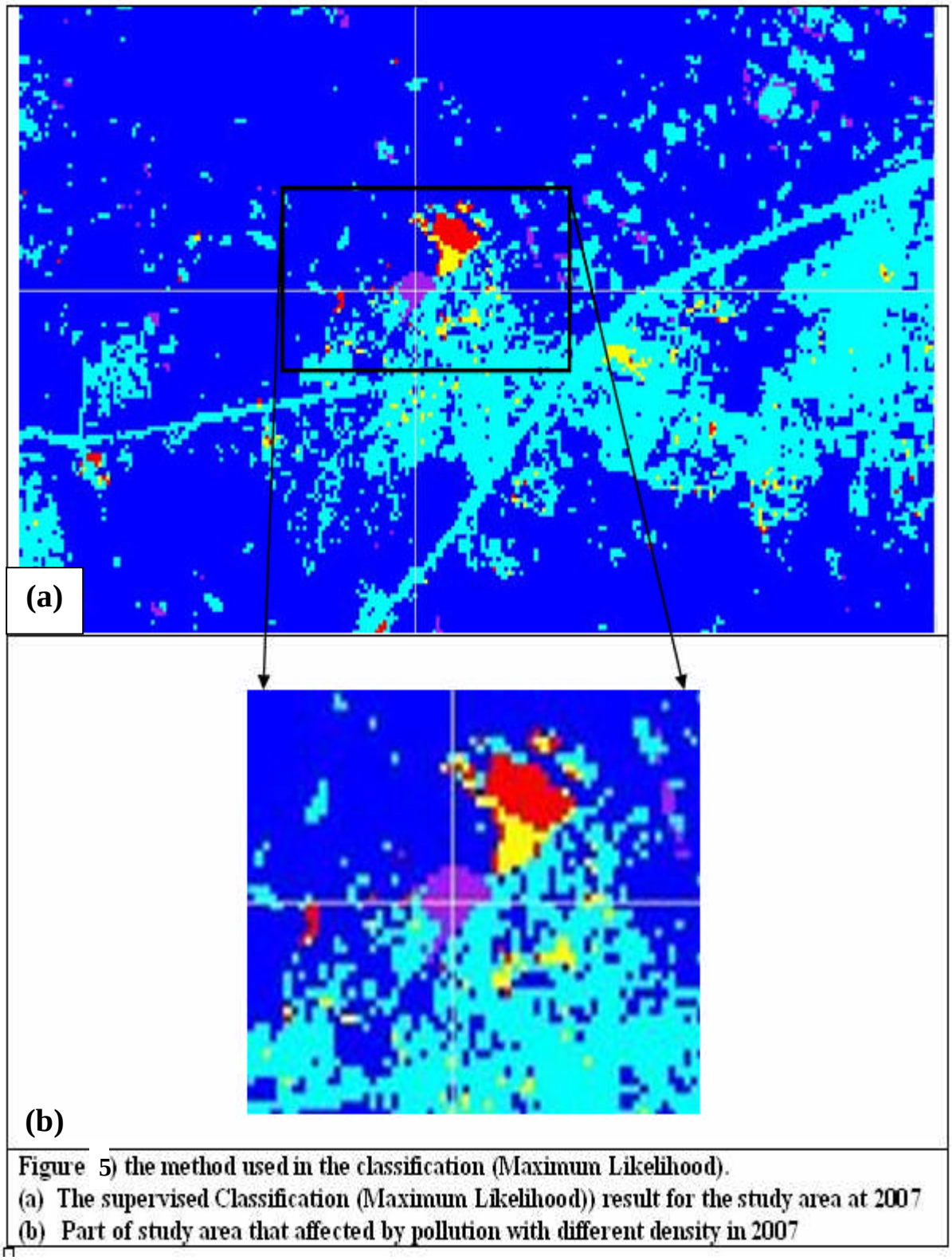

Figure 5) the method used in the classification (Maximum Likelihood).
(a) The supervised Classification (Maximum Likelihood)) result for the study area at 2007
(b) Part of study area that affected by pollution with different density in 2007

Table 2: the status of the study area and the levels of degradation and there area affected by the salt and the sequencing of the years 1990 and 2001 to 2007.

Period of time	1990	2001		2007		
Case of land	Before the degradation	Beginning of degrade case (salinization)		The last level of salinization case		
	Bare land	Saline soil	Bare land	High level of salinity	Medium level of salinity	Low level of salinity
No. of Pixels	166	55	111	55	34	77
The area (in Hectare)	13.48335	4.467375	9.015975	4.467375	2.76165	6.254325

Result and Discussion:

In this study satellite, there set of Landsat TM and ETM+ sensor images were used, they were taken at the year 1990, 2001&2007. Satellite Images were used to monitor land use changes and the salinity affected on soils. The region has been studied at different times and had also been hired to calculate areas by using the supervised classification method; it is forward that transfer the image (raster to a vector) was very effective to calculate the area of the extracted region within the same class. Also the use of visual interpretation of each image had been used, and that interpretation was to a large degree of congruence with what we got from the classification, where the satellite image for the year (1990) was a visual interpretation indicates that it is left as it appeared colored gray-green, and the interpretation of situation in the region for the year (2001) was the situation of the beginning of salinization as the color of many it is tilted in some parts of the White color. In the satellite image (2007) the area was whiter than white and more space and this is evidence on the evolution of the situation towards the depredation in terms of area affected and degree of salinization.

As is clear from the study that the cause of the problem (deterioration of saline soil) was due to leave the land for a long time without farming operations, and this period is about eighteen years since leaving the soil for a long time, activates the physical state of the task within the soil building a capillary, where active this The situation in the dry regions, especially in fine soil textures with high salt to the upper surface of the soil and that the study area during the first period (1990) were not effective in salinization, but agricultural land left for some reason did not invest (which has an area (13.48335) in hectares) was irrigated by flowed method , as farmers adds amount water (in a non-scientific accounts without the water needs of the soil) in the belief that the salt water wash the soil and this is what led to the degradation over time. After a period of time (through 2001) appeared the beginnings of the case of salinization, and divided the region into two parts, the first section is the beginning of salinization, have an area (4.467375) hectare and the second section is an area not affected yet clearly with salt have an area of (9.015975) hectares. Increased size of the area affected by salt during the period (2007) and divided by Severity into three sections, a land of low salinity and an area of (6.254325) hectare, while the second section which is the land of the mid-salinization, and an area (2.76165) per hectare. The third Section of the land where the high intensity of salinization, and an area of (4.467375) hectare.

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