# Application of Remote Sensing and GIS Techniques for Surface Soil Description of AL-Hammar Marsh (Southern of Iraq)

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**Abstract**

Soil is an essential part of any terrestrial ecosystem. Physical and chemical properties have studied for many years for agriculture and soil conservation. These studies usually require field sampling and laboratory analysis that are time-consuming. Remotely sensed data are an alternative that provide reliable information at low cost save in efforts and time. The objective of this study was to evaluate the usefulness of Landsat ETM+ data and GIS techniques to classify soil in wet land area (Marsh region) south of IRAQ.
In this study, satellite remote sensing data have been processed and manipulated in computerized GIS manner to build-up digital information database in order to detect the soil classification and some of its chemical properties that affect on the spectral response of soil in the overall study region.

The main results of this study show that the selected visible bands in the digital visual interpretation process are considered as the best for identifying soil-mapping units.
The digital map of unsupervised classification gives good presentation of some of the main land cover classes and merges the others, whereas the supervised classification gives good presentation of the main land cover classes with overall accuracy of (99.7%).

## 1- Introduction

Remote sensing is the science of acquiring, processing and interpreting images that record the interaction between electromagnetic energy and matter [10]. Remote sensing plays an increasingly important role as a tool for inventorying, monitoring and managing the natural resources.

The soil types are specified by traditional classification method includes the laboratory tests that require time, effort, and cost in comparison with remote sensing that compensate these variable. Therefore, a capability of data extraction by using digital satellite images with GIS (Geographic Information System) an effective technique for different soil investigations [9].

The basic purpose of this study is to utilize Remote Sensing techniques and Geographic Information System (GIS) to produce a digital soil map which contains, land cover, soil classification, (texture, elasticity and plasticity) and some of chemical properties which mostly affect the spectral behavior of soil and the nature of the soil of Hammar marsh.

## 2- Soil Spectral Characteristics

The soil is a complex mixture of materials having various physical and chemical properties that can affect the absorptions and reflectance characteristics of the soil.
The goal of soil remote sensing is to extract the radiance of interest from all the other radiance components being recorded by the sensor system [8].
The spectral reflectance characteristics of soils are a function of several important characteristics, including: [8]

- soil texture (percentage of sand, silt, and clay) and moisture content,
- organic matter content,
- iron –oxide content,
- surface roughness**,**
- soil color

## 3-Methodology of the Work

This work divided into following three steps:-

(a) Site investigations:

- GPS measurement.
- Soil samples collecting.

(b) Laboratory work includes:

- Soil samples analysis.
- Digital satellite image processes and classification.

(c) GIS process and digital geotechnical map production.

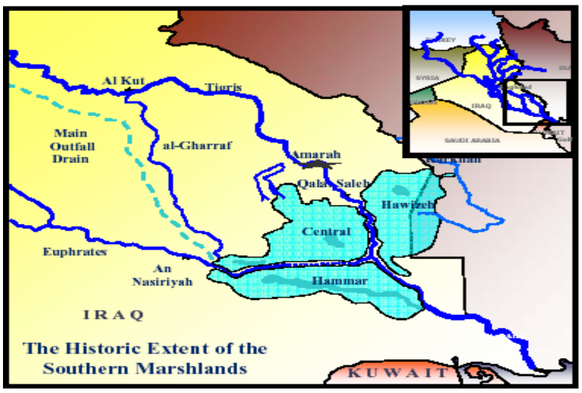
## 4- Study Area

AL-Hammar marsh was formed 600A.D. The synclinal subsidence is still going on. This accounts for the dense marshes. The depressions were filled with deposits with lime; yet the subsidence is still going on. Shallow marshes would be dry in summer, while deep marshes would be lake, the water depth was between (1-2) m, and in some places it reaches to 7 m. This means that part of the lake is below sea level. In AL-Hammar Lake, for example most of the area is less than 4 m above sea level. Permanent marshes constitute fourth of the flood marsh, therefore Euphrates and its tributaries make put of Al-Hammar marsh area; but only a small part of its water passes AL-Hammar marsh through a new channel which connects this lake with Shut-Arab 8km north Basra. Therefore, Tigris loses most of its water in the marshes. In the borders of the marshes, natural plants grow densely such as reeds and rushes, while rice and millet grow in the borders while over flood seasonally.

About 88% of AL-Hammar land is not cultivable. The cultivable land is used to grow summer crops only because of the over flood. Rice grows in the over flood land and the land which can be irrigated. There are mainly along the river, streams and channels. Millet grows in the land that is not irrigated.

Al-Hammar marsh lies south of Euphrates river and extends from Nassriya in the west to Basrah suburbs at Shatt Alarab in the south of Iraq, about (300)km south of Baghdad. Its length is about 90 km with width is between (25-30) km.

Locally study region extends between latitude ($31^o00'$-$31^o30'$) north and longitude ($46^o24'$-$47^o18'$) east, as shown in the fig.(1).



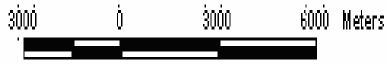




**Fig. (1) Location of Study area**

Climate is regarded one of the main factors in soil formation and natural plant distribution and in the geological processes. Thus, it is considered the basis for soil classification.

Compared with the central and southern parts of Iraq, the weather in marshes area is humid in summer. In winter, it is cold at night. The climate of the area usually describe as continental, dry, hot in summer, and cold and with little rain in winter.

From the structural view, the studied region is located within the unstable shelf (Mesopotamia zone), which involves subsurface faulted sedimentary beds as well as subsurface folds (Anticlines). The study area is part of the southern flood plain. The study area was affected by the erosion and deposition processes during the late geological periods (Pleistocene and Hallocene). These processes essentially affected the Euphrates deposits during flood periods, which are characterized by bedding, homogeneity and consist of clay, silt and sand. The upper cover of the studied region consists of salty deposits mixed with marine deposits and it is located above late cretaceous deposits, which may be more than 200m, thick**.**

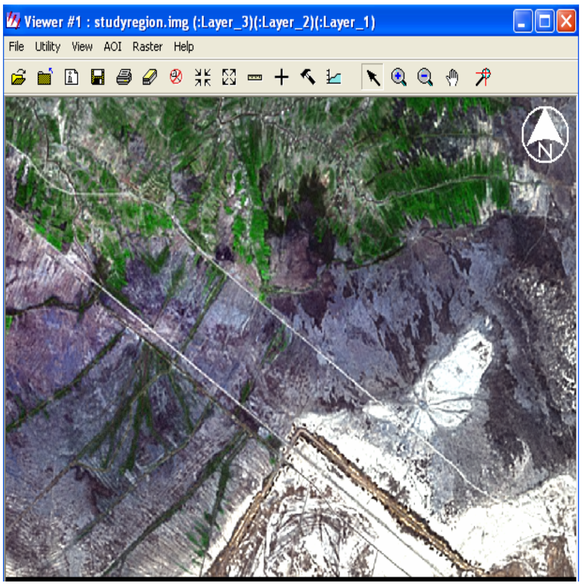
### 4-1 Description of Soil

The study area lies in the lower part of Mesopotamia; it was formed as a result of deposits Euphrates as it flows to Al-Hammar. The soil was subject to overflow (to form marshes) because of the low land, some low lands were always flooded. It is called Al-Hammar marsh. From physiographical point of view, marsh soil is called haur soil; the surface soil has dark color with high percentage of organic matter, which has soft consistency, clayey sedimentation texture. The subsoil is soft, clayey to clayey with little porosity and permeability. There are reduced layers near the surface; this makes drainage of this ineffective. In addition, the soil is highly saline with high ground water level is high especially in the cultivated areas. It was noted the following physiographical units in the area:

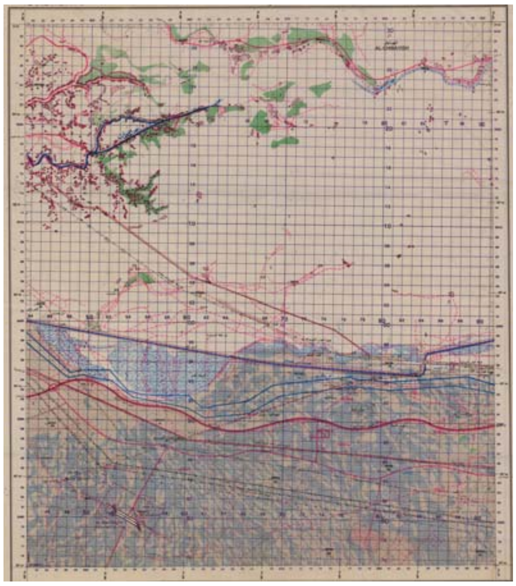
- Haur soil (Marsh soil),H
- Silted Haur soils, SH
- Levees( River and Irrigation),L
- Basins,B
- Sand Dunes,D

## 5- Data used in the study

Landsat7 ETM+ with resolution 14.25m dated, March 2004 (see fig. 2), Topographic map scale of 1:100 000 (see fig. 3) and reports of previous studies about the study region have been used in this study.




Fig(2) Landsat ETM+ , March 2004
for study area



Fig(3) Topographic map for
study area(1:100000)

## 6- Field and laboratory Work

The purpose of field survey was to observe what the different interpretation units are in reality. The fieldwork was based on the traditional methods and Remote Sensing data. Twenty-five soil samples from different locations were obtained of the study region. The coordinate of these samples are acquired by GPS (Etrex). Number of and locations of soil samples is specified depending on the primary survey of the study area that includes knowing the topography, sloping, draining, current speed, water depth, weather conditions. Unsupervised classification map and spectral response of Earth features from ETM+ also take important in selecting samples number and locations see fig.( 4 ) .

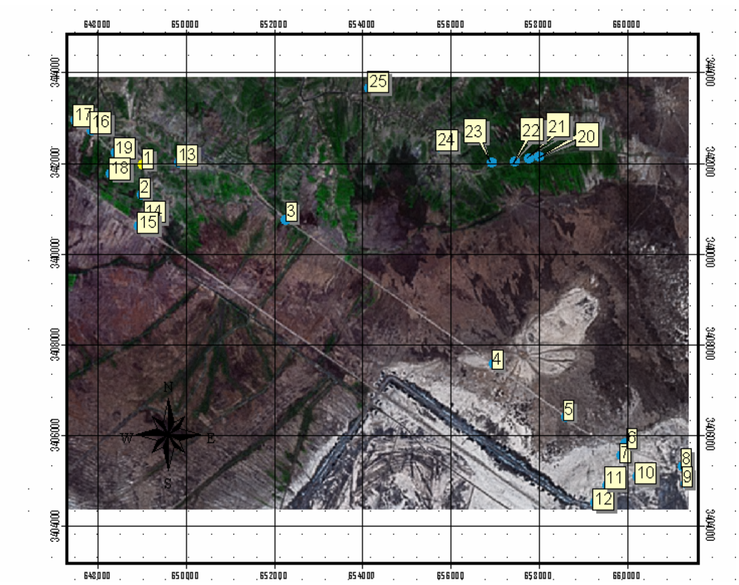


Fig.(4) Study Region with points represent soil samples locations.

## 6-1 Laboratory Tests

Many tests were executed to determine some of the physical and chemical properties that the effect on the spectral properties of the soil.

Physical tests include moisture content, grain size distribution and liquid & plastic limits. While the chemical tests include Organic Matter Content (OM), total dissolved solid (TDS), electrical conductivity (EC) and sulphate content ($SO_3$ ) as shown in tables (1) & (2)

Table (1) Chemical properties of the soil samples for the study area

Attributes of Om.shp

| Shape | ID | WC% | om% | TDS | EC | So3 |
|---|---|---|---|---|---|---|
| Point | 1 | 47.8092 | 18.83070 | 6.9900 | 13.860 | 3.250 |
| Point | 2 | 29.0420 | 13.67673 | 7.3300 | 14.640 | 3.820 |
| Point | 3 | 30.6499 | 16.99636 | 7.5300 | 15.030 | 1.730 |
| Point | 4 | 48.0263 | 22.83726 | 7.3800 | 14.760 | 4.400 |
| Point | 5 | 45.5276 | 11.12085 | 5.1000 | 10.340 | 0.100 |
| Point | 6 | 21.0090 | 18.78218 | 3.6900 | 15.310 | 7.510 |
| Point | 7 | 33.9467 | 17.72311 | 7.0400 | 14.050 | 3.700 |
| Point | 8 | 14.9395 | 15.19808 | 7.4000 | 14.790 | 2.530 |
| Point | 9 | 6.2202 | 15.51406 | 6.4000 | 12.780 | 0.180 |
| Point | 10 | 11.0537 | 16.23711 | 6.9500 | 13.880 | 4.660 |
| Point | 11 | 22.5260 | 19.17750 | 7.3200 | 14.630 | 7.460 |
| Point | 12 | 23.8307 | 18.32706 | 7.6600 | 15.310 | 2.610 |
| Point | 13 | 38.9115 | 12.22351 | 5.0100 | 10.000 | 0.280 |
| Point | 14 | 13.4023 | 13.85743 | 7.3900 | 14.830 | 0.730 |
| Point | 15 | 25.4262 | 14.93029 | 7.7500 | 15.460 | 1.860 |
| Point | 16 | 19.5411 | 16.53970 | 7.4200 | 14.830 | 0.370 |
| Point | 17 | 35.4755 | 16.25940 | 7.6100 | 15.200 | 3.850 |
| Point | 18 | 43.8718 | 12.67850 | 7.1700 | 14.330 | 3.510 |
| Point | 19 | 24.6825 | 14.45333 | 6.8400 | 13.670 | 1.460 |
| Point | 20 | 33.9538 | 17.39209 | 7.3000 | 14.550 | 4.900 |
| Point | 21 | 37.1603 | 16.47754 | 7.3600 | 14.700 | 4.100 |
| Point | 22 | 28.0012 | 14.30117 | 7.2900 | 14.560 | 1.560 |
| Point | 23 | 13.8804 | 32.49852 | 7.4700 | 14.390 | 1.140 |
| Point | 24 | 19.6429 | 17.77241 | 7.3400 | 14.670 | 1.920 |
| Point | 25 | 22.3510 | 15.11822 | 7.2500 | 15.020 | 1.870 |

**Table ( 2) Physical Properties of Soil Samples**

Attributes of Theme1.shp

| Shape | ID | ESTING | NORTHING | Name | Clay_ | Silt | Sand_ | L.L | P.L | PI |
|---|---|---|---|---|---|---|---|---|---|---|
| Point | 1 | 649020 | 3411876 | ML | 7 | 91 | 2 | 67.61827 | 31.57733 | 36.04094 |
| Point | 2 | 648997 | 3411202 | ML | 27 | 65 | 8 | 47.90643 | 23.03459 | 24.87184 |
| Point | 3 | 652251 | 3410632 | CL | 45 | 44 | 11 | 46.09666 | 25.66667 | 20.42999 |
| Point | 4 | 656986 | 3407346 | CL | 45 | 44 | 11 | 52.71159 | 29.82456 | 22.88702 |
| Point | 5 | 658615 | 3406145 | SC/SM | 32 | 28 | 40 | 40.05954 | 21.26615 | 18.79339 |
| Point | 6 | 659969 | 3405553 | ML | 36 | 56 | 8 | 42.73821 | 28.64510 | 14.09311 |
| Point | 7 | 659871 | 3405273 | SC | 37 | 36 | 27 | 40.52351 | 21.71246 | 18.81105 |
| Point | 8 | 661263 | 3405022 | ML | 24 | 48 | 28 | 32.83935 | 18.40666 | 14.43269 |
| Point | 9 | 661337 | 3404633 | SC/SM | 18 | 21 | 61 | 0.00000 | 0.00000 | 0.00000 |
| Point | 10 | 660246 | 3404909 | SC | 46 | 9 | 45 | 35.27688 | 21.81934 | 13.45754 |
| Point | 11 | 659553 | 3404591 | ML | 30 | 53 | 17 | 37.50445 | 23.80952 | 13.69492 |
| Point | 12 | 659287 | 3404200 | CH | 58 | 34 | 8 | 34.87395 | 22.14286 | 12.73109 |
| Point | 13 | 649826 | 3411911 | SC/SM | 18 | 35 | 47 | 38.80665 | 19.36677 | 19.43989 |
| Point | 14 | 649079 | 3410662 | SC/SM | 17 | 22 | 61 | 0.00000 | 0.00000 | 0.00000 |
| Point | 15 | 648925 | 3410479 | ML | 19 | 56 | 25 | 35.21897 | 25.57437 | 9.64460 |
| Point | 16 | 647857 | 3412647 | CH | 52 | 37 | 11 | 40.99211 | 22.56581 | 18.42630 |
| Point | 17 | 647480 | 3412890 | CH | 50 | 40 | 10 | 57.59888 | 33.92051 | 23.67837 |
| Point | 18 | 648273 | 3411661 | ML | 15 | 76 | 9 | 44.67115 | 24.56038 | 20.11078 |
| Point | 19 | 648406 | 3412158 | ML | 38 | 48 | 14 | 43.57770 | 24.23671 | 19.34098 |
| Point | 20 | 648011 | 3412059 | ML | 10 | 81 | 9 | 52.38568 | 27.43788 | 24.94779 |
| Point | 21 | 657774 | 3412009 | CL | 46 | 42 | 12 | 46.79158 | 24.23469 | 22.55689 |
| Point | 22 | 657460 | 3411935 | CL | 44 | 30 | 26 | 37.68759 | 20.69510 | 16.99248 |
| Point | 23 | 656927 | 3411914 | CH | 56 | 35 | 9 | 43.45056 | 26.66294 | 16.78762 |
| Point | 24 | 655758 | 3412273 | ML | 39 | 55 | 6 | 41.92062 | 23.62480 | 18.29582 |
| Point | 25 | 654154 | 3413615 | ML | 41 | 46 | 13 | 37.36300 | 21.12116 | 16.24184 |

## 7- Satellite ETM+ image classification

The result of unsupervised classification by K-mean method is shown in figure (5)

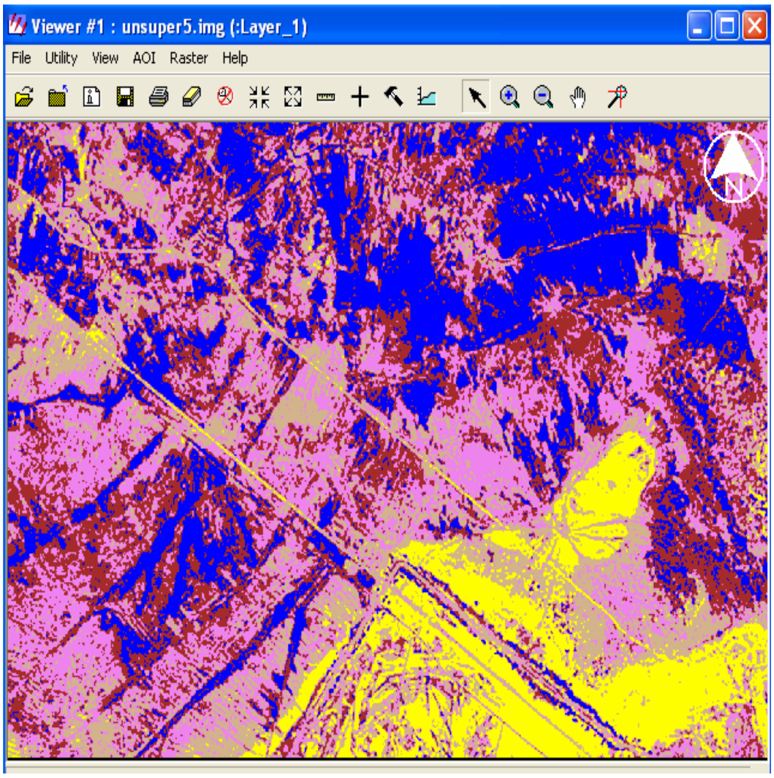



Fig. (5) Classified image of the study region by K- Mean method.

For supervised classification method , Six areas are selected as training areas which represent the main three land covers classes in the area water, vegetation and soil with four subclasses types included (CL,SC/SM,CH, and ML). The spectral response for these training areas is shows in figure (6).

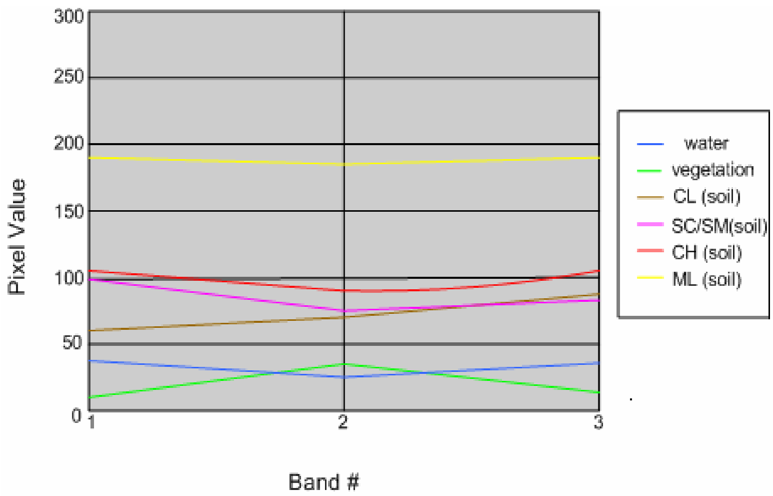
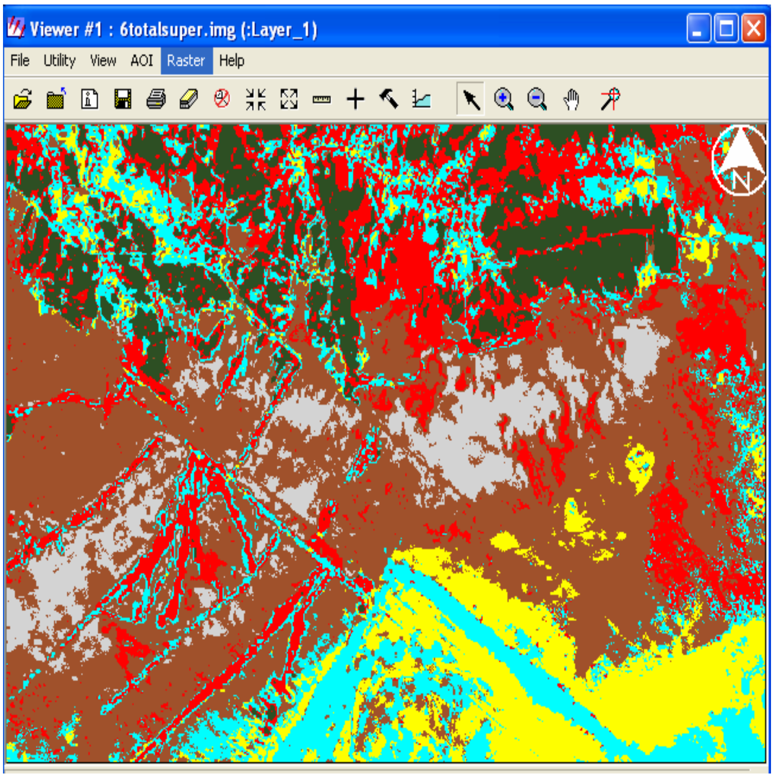



Fig. (6) Spectral response of training Areas

The result of supervised classification by Maximum Likelihood is represented in figure (7).




Fig(7) Supervised classification of study region

The overall accuracy of supervised classification is (99.7%) the accuracy of each class is illustrated in table (3).

Table (3) confusion matrix, for supervised classifications

| | Classes | | | | | | Row Total | User's accuracy % |
|---|---|---|---|---|---|---|---|---|
| | **Water** | **Vegetation** | **Soil (CL)** | **Soil (SC/SM)** | **Soil (CH)** | **Soil (ML)** | | |
| **Water** | 141 | 0 | 0 | 0 | 0 | 0 | 141 | 100 |
| **Vegetation** | 0 | 166 | 0 | 0 | 0 | 0 | 166 | 100 |
| **Soil(CL)** | 0 | 0 | 184 | 0 | 6 | 0 | 190 | 96.84 |
| **Soil (SC/SM)** | 0 | 0 | 0 | 225 | 0 | 0 | 225 | 100 |
| **Soil(CH)** | 0 | 0 | 0 | 0 | 772 | 0 | 772 | 100 |
| **Soil(ML)** | 0 | 0 | 0 | 0 | 0 | 622 | 622 | 100 |
| **Column Total** | 141 | 166 | 184 | 225 | 778 | 622 | 2116 | |
| **Omission Error %** | 0 | 0 | 0 | 0 | 0.77 | 0 | Classification Accuracy | |
| **Producers accuracy** | 100 | 100 | 100 | 100 | 99.22 | 100 | $= \frac{2110}{2116} *100 = 99.7\%$ | |

## 8-GIS spatial analyses:

The final step is to produce spatial analysis maps which represent Interpolate grid distribution of some soil characteristics for the study area, such as moisture content, organic matter content, total dissolved solid content, electrical conductivity, and sulphate content as it is shows in figures 8,9,10,11,12.

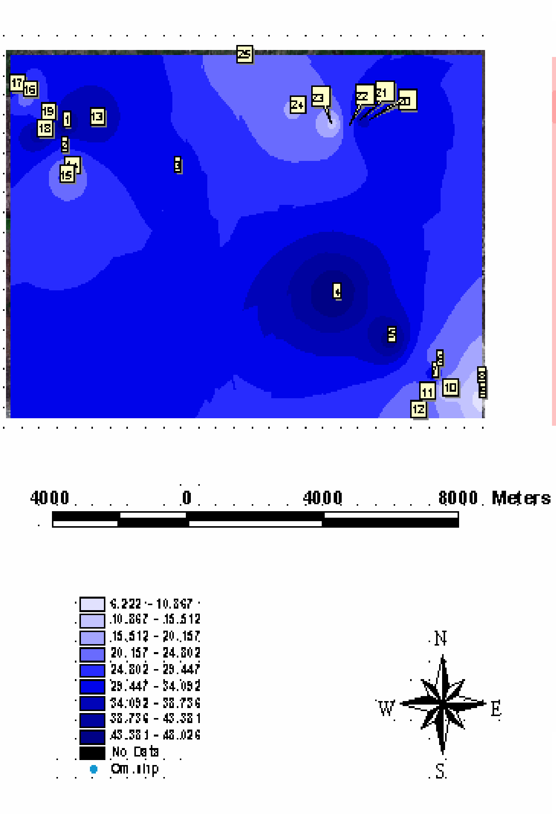



Fig.(8) Moisture Content

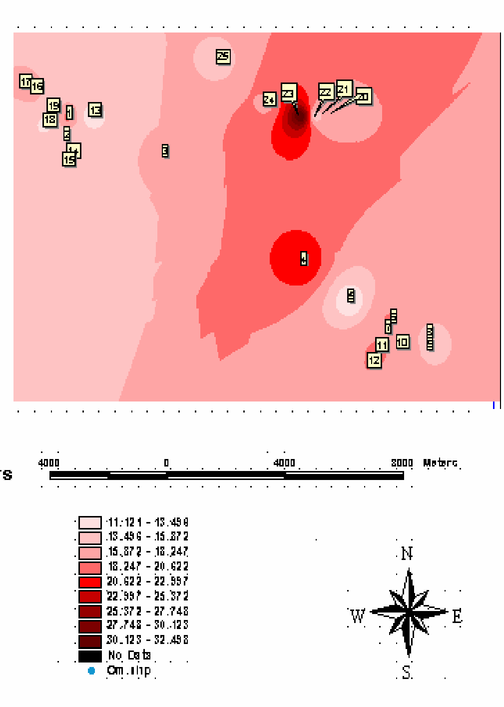
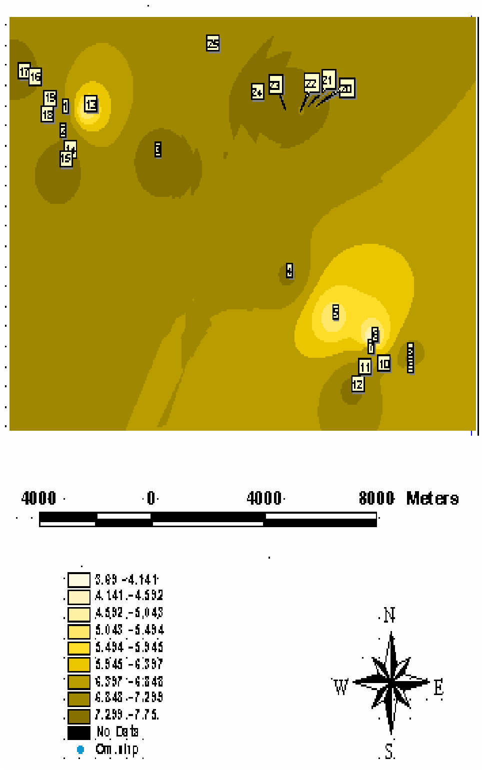
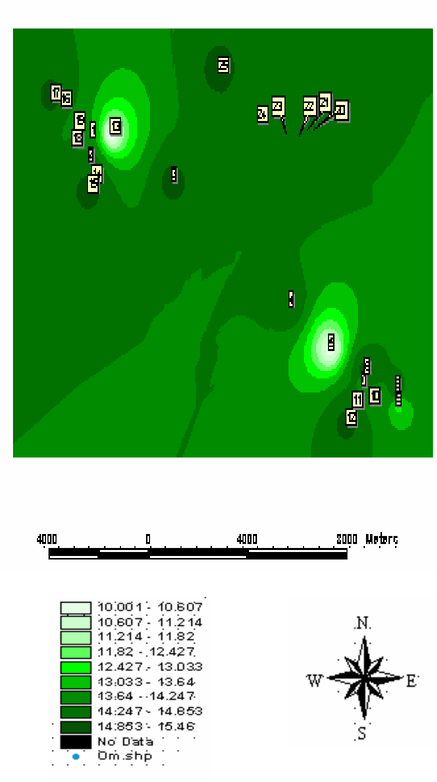



Fig.(9) Organic Matter Content




Fig(10) Total Dissolve Solid(TDS)




Fig(11) Electrical Condictivity content (EC)

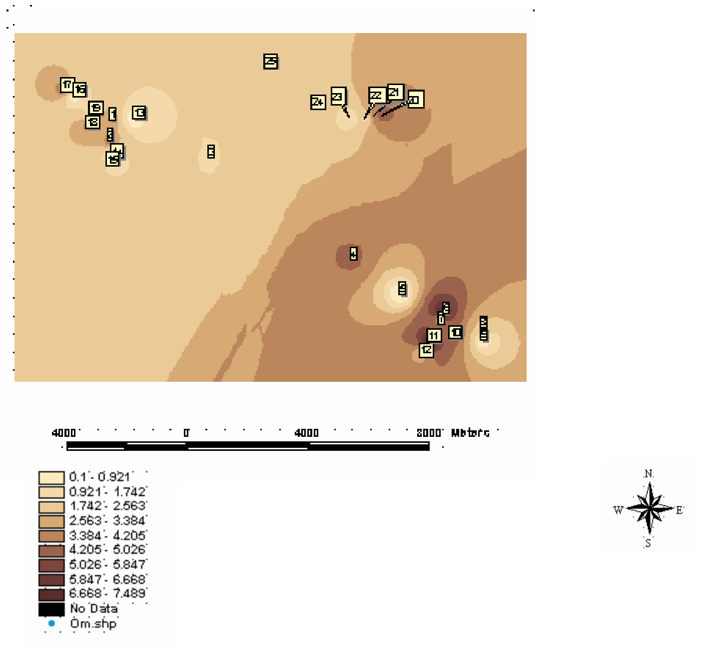



Fig.(12) Sulphate ($SO_3$) content

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## 9-Conclusions

1- Joining of traditional data with RS techniques is very important and essential for soil thematic mapping, also to reduce the efforts and cost in soil investigations that verify the ground truth.

2-Unsupervised classification method is a useful technique to prepare a primitive map for reconnaissance, soil survey, collecting soil samples and to reduce the effort time and cost.

3-Thematic map of soil classification (unsupervised classification) gives good presentation of some classes and merges the others, whereas the supervised classification gives good presentation of the classes with an overall accuracy equal 99.7 %.

4- Using global position system (GPS) in field survey is very essential and important for positioning purposes, and collecting soil samples.

5-Using GIS technique is very important to produce digital thematic maps that show the land cover in the study area.

6-The integration between RS techniques and GIS may give more effective results in production of soil classification maps, and prepare best data base with high technique of digital maps presentation for decision makers.

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