Investigation soil degradation in Iraq by using geomatics techniques

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Abstract. In this study Remote Sensing techniques have been used to investigate soil degradation in Iraq (alluvial plain) for the period (1976 - 2020) by using different many source of data such as satellite images (Landsat 1-5 MSS C1 Level, Landsat 4-5 TM C1 Level-1, Landsat 7, Landsat 8, and sentinel 2) and use more than one software like (ENVI 5.3, ERDAS Imagine 2015, Arc GIS 10.7, and Blender). This study focusing on determine the main degraded areas in Iraq, (alluvial plain) chosen because of spread sand dunes. To make the study soberer, ground trothing achieved to verify the real status of the area and collect the data by field visit. Bands G, B, R, and IR from LANDSAT-3 in 1976, 1996 and 2014, the same bands used from Sentinel-2 dated 2021. Unsupervised classification made for images of 1976 and 1996 then supervised classification did for images in 2014 and 2021. The classification was carried out using ERDAS Imagine V.2015 software and areas of the main land uses in the study area were calculated. The results indicate that there is a big problem in the base year 1976, this problem almost disappeared in the second station of work 1996, but it returned back after that through the results for the years 2014 and 2021.

1. Introduction
Land degradation is defined as the change in the gender of the land and its transformation from a land of high productivity to land of unproductivity or less productivity land due to a change in one or all of the physical, biological or chemical characteristics [1].
Land degradation is one of the biggest environmental problems at the level of the earth’s surface, and it is a serious and priority indicator in developing countries that make agricultural land a major resource in the lives of their inhabitants [2].
The problem of drought is exacerbated by many reasons, the most important of which is the decrease in the quantities received from the water of the Tigris and Euphrates rivers, and the building of a large number of dams on the course of the two rivers in the last years.
Degradation of the environmental situation of agricultural lands in the Mesopotamian Plain and south region in Iraq resulting from the impact of climate conditions and water resources a led to an increase in the environmental degradation activity of the lands of both types, degradation of Salty and dry soils and increased activity of sand dunes and their encroachment from their places of formation to other areas Especially after 2003.
In this study Emphasis will be placed on the Mesopotamian Plain in Iraq and studying the variation in soil during periods 1976 – 2021 into 3 stages 1976-1996, 1996-2014, 2014-2021.
This was not the first study of desertification using remote sensing techniques. Many researchers preceded them researches in this field, some of these works reviewed in this study to take their methods and results into consideration to obtain more accurate results in our study.

Abujery [3], through the techniques of geographic information systems, a study of land degradation in the province of holy Karbala for the period (1980-2000) was based mainly on some maps and satellite images to design a special system for the study area, the most important results of land degradation and desertification is sand dune encroachment, waterlogging, salinization and erosion as a face of desertification.

MUTHANNA M. Albayati [4], studied the desertification and its changes regarding to the time, through using different multi band satellite images for area near Ramadi city in Iraq, in this study changes to the land cover monitored to calculating the areas of each parameter to make the comparison for each environmental parameter (soil, agriculture, and water).

Panah and Ehsani [5] The study used remote sensing techniques and satellites image to sensors (MMS, TM, and ETM+) for the period (1977, 1988 and 2000) to studied land cover change in (damghan playa). The result shows the desertification change in the study area for the mentioned period up to 68% and this change is explained on maps.

Z. G. Bai1 and others [6], the study described the land degradation occurring at the global level, its causes, severity and its impact on the ecosystem and its productivity, the researchers used the normalized difference vegetation index (NDVI) and rain indicator in remote sensing techniques In many cities of the world, the result is 24% of the area exposed to a severe degradation, which are numbers that have doubled in recent years through comparison with the statistics of land productivity and other variables.

2. Study Area and Data Collection

2.1. Data collection

Data from MSS (1976) and MSS (1986) TM (1996), ETM+(2006) Land sat 8 (2020), sentinel (2021) sensors were used by ERDAS imagine 2015 and NDVI 5.1, ARC GIS 10.7 software. All images got from USGS web site [7]. Annex(1) has the specifications of satellite images used in the study.

2.2. Study area

The study area part of Mesopotamian Plain the middle and south of Iraq, it is bounded by coordinate upper left (44° 58’ 38” E to 32° 31’ 35” N) and lower right (46° 3’ 27.68” E to 31° 32’ 48.90” N) at zone 38N according to Universal Transverse Mercator (UTM) projected coordinate system and covers area about 7000 Km2, we can see figure (1) to recognized study area from satellite image.

Figure 1. Photo for Map explaining the area of interest, by author.
3. **Aim of thesis**
The aims of the study can be summarized in the following:

1. monitoring the soil degradation in Iraq (Mesopotamian Plain) For the period (1976 - 2021) by use remote sensing techniques.
2. put series of contexts and proposed successful solutions for these lands to attempt reduce sand dune encroachment and land degradation
3. Suggest a suitable methodology to use for other areas to be study in the future.

4. **Study Methodology and Experimental Works**
To achieve the study aims, the following processing steps done:

| Process                  |
|--------------------------|
| Download Images from USGS |
| Pre-processing           |
| layer stack              |
| Subset                   |
| Unsupervised Classification |
| Field Survey – Ground Trothing |
| Supervised Classification |

![Figure 2. Methodology of study flow chart.](image)

4.1. **Pre-processing**
Pre-processing operations, sometimes referred to as image restoration and rectification, are intended to correct for sensor- and platform-specific radiometric and geometric distortions of data [8]. There are many ways of geometric correction that can be classified regarding to the type of processing or data sources. Image to image geometric correction was applied by returning the low resolution image (as source) to the high resolution image which assumed as the base (target) [9]

4.2. **layer stack**
Stacking is the name of the process by which the different bands (or layers) of information are overlaid in one file. This process allows us to display true or false color images. Four bands B, G, R, and IR selected and stacked together for all stages 1976-1996, 1996-2014 and 2014-2021. These bands selected to use regarding to the objective of the study, Where USGS assigned the band combination for each application as in table (1).
Table 1. Band Combination for Landsat [USGS].

| Photo | Bands | Details |
|-------|-------|---------|
| ![Image](image1.png) | 1,2,3 | This composition of colors is as close to true color that we obtain with a Landsat ETM image. In addition it is convenient for studying aquatic habitats. The drawback of this set of bands that they be likely to yield a foggy image. |
| ![Image](image2.png) | 2,3,4 | because of contains the near infrared channel (band 4) land water boundaries are clear and many vegetation types are more obvious, but it has related classification to the image bands 3,2,1,. Since Landsat MSS data did not have a mid-infrared band this was popular band combination. |
| ![Image](image3.png) | 3,5,4 | Since the two shortest wavelength bands (band 1 and 2) are not contained; this is crisper than the prior two images because. Unique vegetation types can be more distinctly determined and the land/water interface is very obvious. Distinction in moisture content is noticeable with this set of bands. This is no doubt the most common band combination for Landsat imagery. |
| ![Image](image4.png) | 7,4,2 | The biggest difference to the 3,4,5 band combination the vegetation is green, but it has similar properties to them NASA selected this band combination for the global Landsat mosaic. |

4.3. Subsetting
Subsetting an image will minimize the amount of data used and stored by subsetting based on specific geographic area [10]. This process made to use only the area of interest from the big size of LANDSAT image which already greater than 180 x 180 Km. This process not just reduce the area of the image but also reduce the time of process and the size of data.
Subsetting made to set the same AOI and corners to all images, this process done for two times one in the beginning to reduce all the processed areas and another one after the geometric correction where a traditional shift happened [4].

![Figure 3. Subset image.](image5.png)
4.4. Classification

The classification of remotely sensed data has long attracted the attention of the remote sensing community because classification results are fundamental sources for many environmental and socioeconomic applications. Scientists and practitioners have made great efforts in developing advanced classification approaches and techniques for improving classification accuracy [11]. Before implementing image classification for a specific study area, it is very important to clearly define the research problems that need to be solved, the objectives, and the location and size of the study area [12].

4.4.1 Unsupervised classification

Unsupervised Classification techniques applied on images in the first station 1976 and second station 1996, where the ground trothing and field visit can’t be happened in the previous time.

4.4.2 Supervised classification

Supervised Classification applied on images in the third and fourth stations dated 2014 and 2021, respectively.

In both techniques, classification operated to get thematic maps contain 5 classes, except images of 1976 where only 3 classes had got. The classes targeted were (Water Cover, vegetation, Sand dunes, wet soil, dry and salty soil). Ground trothing made by field visit and data collected to use as a classification references. Field survey were held twice in 2014 and also 2021. Figure (4) bellow includes photos from the field visits and Annex (2) has more details.

Figure 4. Photos for field visit.
5. Results and discussion
The classification processes produce thematic maps with classes represent the five classes were selected as the target of the study. ERDAS Imagine provide a table as well as the map. Field of area added to the table of classification, this field presented the area of each class which will used for comparison.
Figures (5) bellow explain the results of supervised classification for satellite images dated 2021 as an example of the process and Annex (3) has all the thematic maps produced from the classification. Table 2 illustrate the results of the classification of images for the 4 station.

![Supervised classification of Satellite image dated 2021.](image)

**Table 2. Classification Results for all stations.**

| Class Name                  | Date                  | Area in Km² 1976 | Area in Km² 1996 | Area in Km² 2014 | Area in Km² 2021 |
|-----------------------------|-----------------------|------------------|------------------|------------------|------------------|
| Water Cover                 | 100.201               | 393.518          | 305.965          | 391.357          |
| vegetation cover Low density| 1435.552              | 2329.413         | 768.075          | 844.811          |
| vegetation cover high density| 1287.179             |                  | 581.520          |                  |
| Sand dunes                  | 3429.151              | 438.355          | 989.6355         | 1342.398         |
| wet soil                    | /                     | 1189.371         | 1201.431         | 1336.087         |
| dry and salty soil          | /                     | 538.0699         | 505.905          | 562.225          |

The results can be arranged in the following table:
Table 3. Results with differences in areas between stations.

| Class Name          | Date 1976 | Area in Km² | Date 1996 | Area in Km² | Date 2014 | Area in Km² | Date 2021 | Area in Km² | Differences in Areas 1976-1996 | Differences in Areas 1996-2014 | Differences in Areas 2014-2021 | Differences in Areas 1976-2021 |
|---------------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|--------------------------------|--------------------------------|--------------------------------|-------------------------------|
| Water Cover         | 100.201   | 393.518     | 305.965   | 391.357     | 392.73 %  | 77.75 %     | 127.91 %  | 391.357     | 392.73 %                        | 77.75 %                        | 127.91 %                       | 390.57 %                      |
| Vegetation          | 1435.552  | 2329.413    | 2055.254  | 1426.331    | 162.27 %  | 88.23 %     | 71.15 %   | 99.36 %     | 127.91 %                        | 77.75 %                        | 127.91 %                       | 127.91 %                      |
| Sand dunes          | 3429.151  | 438.355     | 989.635   | 1342.398    | 12.78 %   | 225.75 %    | 135.65 %  | 391.357     | 392.73 %                        | 77.75 %                        | 127.91 %                       | 390.57 %                      |
| Wet soil            | /         | 1189.371    | 1201.431  | 1336.087    | 101.01 %  | 111.21 %    | /         | /                        | /                              | /                              | /                             |
| Dry and salty soil  | /         | 538.0699    | 505.905   | 562.225     | 94.02 %   | 111.13 %    | /         | /                        | /                              | /                              | /                             |

This table explains the results with differences between stations, comparison occurred to discuss the status.

Area of water expanded from about 100 Km² in the first station 1976 to more than 300 Km² after the making Dalmaj reservoir inside the area of interest. Figure (6) explains the results.

Figure 6. Water areas for study stations

From 1976 to 1996 vegetation areas expand to more than 160 % and while sand dunes reduced to about 12%, which mean there is a planned treatment at that time, but vegetation returned back to about the same area in 2021 also sand dunes areas expanded from 438 Km² in 1996 to about 990 Km² in 2014 then to more than 1300 Km² in 2021. Figures (7) and (8) explain the vegetation expansion and sand dunes reduction respectively.

Figure 7. Vegetation areas for study stations
Figure 8. Sand dunes areas for study stations
All results and discussion can be illustrated carefully by figure (9) which explain the comparison for all items in the four stations of the study in single integrated chart.

![Full Result and Comparison](chart)

**Figure 9.** Present and comparison for all items in the four stations.

### 6. Recommendation

From Bird eye view we can quickly find that an alarm to big desertification problem from the positive slope reflect the expanded of sand dunes and negative slope of vegetation in the 2nd and 3rd stages in opposite thing for both in the 1st stage from 1976 to 1996. The main solution recommended is to increase the vegetation areas in this location. Supporting farmers and agricultural companies, providing facilities for agricultural investment and implementing modern irrigation projects are very important factors to facilitate and accelerate these solutions.

![Sand Dunes Areas Km²](chart)

**Figure 10.** Present decrease in sand dunes areas in the 1st stage and expanding in the 2nd and 3rd stages.

![Vegetation Areas Km²](chart)

**Figure 11.** Present expansion of vegetation areas in the 1st stage and decreasing in the 2nd and 3rd stages.
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