Monitoring of Land Degradation in Alluvial Plain in Iraq by Using Geomatics Techniques

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Abstract. Iraq faces a major environmental problem represented by severe deterioration, which threatens its food security. Many natural and human factors combine to make it, and it has dire environmental, economic, social and cultural consequences, most notably the loss of productive lands, the movement of sand dunes, severe sand and dust storms, and the resulting increase in air pollution. This study attempts to identify the development of the problem, analyze its causes and consequences, and propose a number of solutions to address it. In this article Remote Sensing techniques have been used to monitoring land degradation in (Alluvial Plain) of Iraq for the stage (1976 - 2021) using different sources of data such as satellite images (Landsat 1-5 MSS 1976, Landsat 5 1996 TM, Landsat8 2016 and sentinel 2 2021), also more than one software was used such as ENVI 5.3 and Erdas image 2015 to extract information from above images, Erdas imagine 2015 was use to sub set area of study, layer stack, merge resolution and classification stage, Arc GIS 10.7 use to make database and maps production), the article used supervise and unsupervised classification techniques to obtain the results, the article indicated that there is a big problem in the 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 2016 and 2021. Finally, the article found a deterioration in the soil class during the stages from 2016 (988.547 Km2) to 2021 (1342.398 Km2) and a decrease in the area of vegetation cover from (1931.596 Km2) in (2016) to (1632.695 Km2) in (2021).

1. INTRODUCTION
Desertification is land degradation in arid, semi-arid, dry and sub-humid areas, collectively known as drylands, resulting from many factors, including human activities and climatic variations (Vogt, et al., (2011)). Desertification It is an imbalance in the ecological balance in the components of ecosystems and
the loss of their vital properties through the acquisition of new characteristics that were not known to them in the past due to natural and human factors [Baartman, et al., (2007)]. Land degradation is a negative trend in land condition, caused by direct or indirect human-induced processes including anthropogenic climate change, expressed as long-term reduction or loss at least one of the following: biological productivity, ecological integrity or humans value, Arid, semi-arid, dry, and sub-humid areas, constitute drylands [UNEP,1992]. Land degradation It is the land that suffers from a decrease in productivity, biological or economic diversity, or a lack of agricultural crops for a reason or others, resulting from the wrong use of the land or due to human activities or climatic factors [National Action Program to Combat Desertification in Iraq,2015]. There are a lot of articles and researches which investigate the Land Degradation in Iraq and around the world, here under some of them which in direct related to the scope of work: (Abdallah, 2018) The study was conducted in a local area of the city of (Al-Souda city) in the Kingdom of Saudi Arabia in the year 2018 for the purpose of assessing the land cover of the area with coordinates (18° 16' 02" N) and (42° 22' 05" E) and at an altitude of 3000 m above sea level through field surveys. Samples were taken from Soil from four different sites within the study area, for an area of (10 * 10) km² and a depth of (0 - 30) cm, the techniques of geographic information systems, a spatial analysis tool, were used to study soil characteristics and then conduct an assessment of the risks of soil erosion and salinization, and the result was that a large part of the study area is classified in the risk category High and very large degradation, as the study referred to the method of minimizing the damage of degradation, maintenance and management of the study area in the Kingdom of Saudi Arabia.  

(Du et al,2018) examined the NDWI, VCI, NDDI, VHI, LSWI, and TCI indices in VGTB river basin (central Vietnam) utilizing data of MODIS images from 2001 to 2016. They found that all indicators of vegetation were much sensitive to drought in the basin, also their performance was varied depending on the type of plant. The NDDI index was much sensitive to rainfall. Finally, they recommended for using VHI and NDDI for monitoring of drought in the forest and agricultural lands respectively. (Al-Quraishi et al,2018) [30] investigated drought case in some regions of Sulaimaniya Governorate (the Iraqi Kurdistan) during 18 years. They used Landsat images to derive drought indices such as NDWI, NDVI, and LST for the years 1990, 2007, and 2008. Furthermore, they used SPI index as a meteorological drought index. They concluded that vegetation cover was reduced in 2008 and area of Dukan Lake was decreased in 2007 and 2008. They found that the combined SPI and NDVI maps the cruel effect of drought on vegetation, which happened in year 2008. (Yacoub and Tayfur, 2017) used six meteorological drought indices to detect the drought properties over Trarza region in Mauritania from 1970 to 2013. These indices were Log SPI, Gamma SPI, Normal SPI, CZI, DI, and PN. They computed the values of above indices according to one, three, six-, and twelve-months’ periods. They illustrated that the Gamma SPI and CZI had the same predictions, while Log SPI registered extreme drought predictions in the monthly periods. They found in three, six-, and twelve-month's period, the Gamma SPI and Log SPI gave the same results, while the CZI and Normal SPI gave fewer drought periods and more wet cases.  

(Tran et al,2017) applied band ratio method to assess drought case from 1989 to 2016 over TuyPhong region of Vietnam based on Landsat TM and OLI images. They used VHI, VCI, and TCI indices. Moreover, they used MODIS data to generate VHI index. They found that results of Landsat data were more useful in drought monitoring in small regions compared with MODIS. (Choudhary et al., 2017) In this study, the change in the land cover of the city of Astrakhan / Russia during the period (2000/2007/2015) was studied, taking into consideration the temporal and spatial dynamics of land, use Landsat satellite images were obtained through the Earth Explorer website and measured the changes in the city of Astrakhan / Russia then used the method of supervise classification at the above-mentioned years and classified it into six categories (water bodies, agricultural lands, bare lands, forest, settlement, mangroves) and through field Surveys, the classification accuracy was increased and then the stage of producing maps, the results showed a severe degradation in vegetation cover and a decline in water cover in different parts of the study area,
and this change is considered unprecedented within 15 years, as urban sprawl on agricultural areas has been shown, and this can used a great impact on high temperatures and climate change.

Bayati, (2017). by GIS studied 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. (Gibbs and. Salmon, 2015) used four concepts were used to mitigate soil degradation at the global level during the period (1990-2011), and these concepts (monitoring through satellites, biophysical models, monitoring abandoned lands, previous databases) were classified and evaluated as percentages of degradation according to the type of model. Each year the researcher used one of those concepts that mentioned above, there are no consistent estimates of land degradation among the above mathematical models indicating a worldwide degradation during the study period, such as areas in eastern Argentina, central Africa and the Siberian plateau.

(kalaf, 2012) analyzed the desertification phenomenon in Karbala holy government using land sat images (MSS, TM, ETM+ and spot image for the year 1976,1990,2001 and 2011 respectively). A set of indices where used in this study such as (TCT, NDVI, EMI and NDWI) in addition to supervise classification process, the results of the analysis showed that the study area suffers from severe desertification Wind and sand dunes erosion, water erosion, urbanization, less Water sources, especially in the western part of them, and the results of the analysis are also shown the rate of desertification decreased between (1976) and (2001) and increased during the period from (2001 to 2011), especially sand dunes, at a rate of (8.78) km2 per year, and the emergence of the waterlogging problem At a rate of (0.65) km2 per year and an increase in urban area at a rate of 0.38 km2 per year In addition to the effects of bad weather conditions during that period.

(Hadeel and jabbar, 2010) Through the techniques of geographic information systems, a study of land degradation in the province of Basra for the period (1990-2003) was based mainly on some maps and aerial images to design a special system for the study area, and this system included the effect of the main factors causing the increase in degradation, the article also included an analytical and statistical study According to the available data, the summary of the most important results of increase in sand dune encroachment from (4118.3 Km2) to (4558.1 Km2). (Bai1 et al., 2008) 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, such as California, the African continent at the equator, southern China, eastern Asia, large areas of Siberia, and the taiga located in the North American continent, where 1.5 billion people live in these areas, 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 COLLECTD

2.1. Data Collection
Satellite images where all available satellite images for the study area were used since 1976, 1996, 2016, 2021, using Landsat MSS, TM, Sentinel-2 and landsat8 sensors with the same specifications and characteristics[USGS].

2.2. Study Area
The study area is a part of Mesopotamian Plain in 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.
3. AIM OF ARTICLE

The aims of this article can be summarized in the following:

1- Monitoring the Land degradation in (Mesopotamia Plain) of Iraq for the stages (1976 - 2021) by use remote sensing techniques.

2- Calculation the variance in areas of land cover types (water, vegetation, soil) for the stages (1976-2021) and determine degradation areas.

Figure (1) satellite image represents selected study area (1976,1996,2016,2021)

4. METHODOLOGY WORK

This article used satellite imagery data from various satellites (landsat MSS to 8, sentinel 2) taken in different stage (1976, 1996, 2016, 2021) with different spatial resolution up to (80 * 80) square meter at a MSS, (30 * 30) square meter at a TM, (30 * 30) square meter at a OLI and (10 * 10) square meter at a sentinel_2.

Above satellite images were downloaded from:

Figure (1) satellite image represents selected study area (1976,1996,2016,2021)
The purpose of taking satellite images in different years is so that the researcher can see the geographical features and the degradation of agricultural lands and monitor the movement of sand dunes and the difference in the areas of study.

Several steps were taken to complete the study for some areas that were decided to be studied due to the source of the data, and the most important of these steps are as follows:

1- Registration: In this study, Image to Image correction method was used, and the ground control points (GCP) were taken into account in this process to be well distributed over the image.

2- Resampling: the correction process may disrupt the size of cells, some of them increase and others are less than what is assumed, so the appointment is made to standardize the size of cells and return them to the original size, this has been reset for all images to remove the displacement states Nearest Neighbor being that preserves linear features and cell values.

3- Determination of the study area: where the Mesopotamian Plain area was taken, as mentioned previously, for specific purposes and with the following latitude and longitude: upper left (44° 55' 20.56'' E to 32° 31' 40.18'' N) and lower right (46° 08' 28.11'' E to 31° 08' 50.18'' N) at zone 38N according to Universal Transverse Mercator (UTM) projected.

4- Using (Image Enhancement): - It is method to increase visual resolution and distinguish between different features such as land sat 8 satellite image.

5- The field survey stage: a field visit was made to the Mesopotamian Plain and take soil samples and ground control points GCP for the purpose of analysis, classification and production of digital maps see appendix (A) explain some image from field survey

6- Classification stage: The classification process was carried out by performing a sorting process for each class in the satellite image according to its spectral reflection, then giving each class a single spectral fingerprint in the classification area, which is different from the rest of the class, thematic maps that produced from this process, will be shown geographical locations of the components of the earth’s surface (maps of land use and land cover).

7- Calculation of land degradation: the changes in the areas occurring in the Mesopotamian Plain region and through the various years by setting a table of land changes in the study area for the stages (1976-2021).

8- Putting some proposals for the purpose of protecting the environment from the dangers of sandy dunes in the various regions of Iraq. Managing all these data, information, and satellite images with the GIS and ERDAS image 2015 program, the procedure of work followed for this thesis are presented in Figure (1-2), the researcher will be show the general steps from gathering, process and analysing data, field survey, GIS work and output stage.
Figure 2. Methodology of study flow chart.
5. Thematic Maps Production

The stages of producing the maps were done by the ARC 10.7 GIS program, after they were analyzed and classified in the Erdas image 2015 program, the classify use Unsupervised classification of the sensors (MSS 1976, TM 1996) and the supervised classification of the sensors (OLI 2016, sentinel 2-2021), then extracting the areas and percentages of the study area and comparing the items through statistical charts and the results were as follows:

5.1. Land covers map 1976

Through the figure (3), the classification of the study area was observing into four categories (Water cover, vegetation, sand dunes, dry and saline soils) where areas and percentages recorded respectively. Sand dunes (3340.306 Km²) (66.06%) vegetation cover (1321.996 Km²) (26.13%) dry soils (297.821 Km²) (5.88%) and water cover (57.956 Km²) (1.14%). see figures (4) and (5) explain with details area and percentage classes of land degradation of 1976.

Figure (3) Land cover classification map of the study area 1976 by using unsupervised classification technique
5.2. Land covers map 1996

Through the figure (6), the classification of the study area was observing into five categories (Water cover, vegetation, sand dunes, dry and saline soils, Wet soil) where areas and percentages recorded respectively. Sand dunes \((438.355 \text{ Km}^2)\) (8.66%) vegetation cover \((2329.413 \text{ Km}^2)\) (46.06%) dry soils \((538.0699 \text{ Km}^2)\) (10.63%), water cover \((393.518 \text{ Km}^2)\) (7.78%) and wet soil \((1189.371 \text{ Km}^2)\) (23.51%). see figures (7) and (8) explain with details area and percentage classes of land degradation of 1996.
Figure (6) Land cover classification map of the study area 1996 by using unsupervised classification technique
Figure (7) Area of Land Cover classification (TM 1996)

Figure (8) Percentage Area of Land Cover classification (TM 1996)
Figure (9) Land cover map of the study area (2016) by using supervised classification technique

5.3. Land covers map 2016

Through Figure (9), the classification of the study area was observed to be classified into six categories (Water cover, Low density vegetation cover, high density vegetation cover, sand dunes, dry and saline soils and Wet soil) where areas and percentages are recorded respectively. Sand dunes (988.547 Km²) (19.54 %),
Low density vegetation ($880.421 \text{ Km}^2$) (17.4%), high density vegetation cover ($1051.175 \text{ Km}^2$) (20.78%) dry soils ($505.905 \text{ Km}^2$) (10.63%), water cover ($306.396 \text{ Km}^2$) (6.05 %) and wet soil ($1325.954 \text{ Km}^2$) (26.21%). See figures (10) and (11) explain with details area and percentage classes of land degradation of 2016.

Figure (10) Area of Land Cover classification (OLI 2016)

Figure (11) Percentage Area of Land Cover classification (OLI 2016)
5.4. Land covers map 2021

Through Figure (12), the classification of the study area was observed to be classified into six categories (Water cover, Low density vegetation cover, high density vegetation cover, sand dunes, dry and saline soils and Wet soil) where areas and percentages recorded respectively. Sand dunes (1342.398 Km$^2$) (26.53 %), Low density vegetation (844.811 Km$^2$) (16.7 %), high density vegetation cover (581.52 Km$^2$) (11.52%) dry soils (562.225 Km$^2$) (11.11%), water cover (391.357 Km$^2$) (7.73 %) and wet soil (1336.087 Km$^2$) (26.41%). See figures (13) and (14) explain with details area and percentage classes of land degradation of 2016.

**Figure (12)** Land cover map of the study area 2021 by using supervised classification technique
Figure (13) Area of Land Cover classification (Sentinel-2 2021)

Figure (14) Percentage Area of Land Cover classification (Sentinel-2 2021)
6. Time series Analysis for the Land Cover Maps

Through the data and comparing land cover classes for years (1976, 1996, 2016 and 2021), we obtained the following results:

**Table (1) Results Areas of Land Cover classification (1976-2021)**

| Classes                        | Area in Km² | Area in Km² | Area in Km² | Area in Km² |
|--------------------------------|-------------|-------------|-------------|-------------|
|                                | 1976 Jun    | 1996 April  | 2016 Jun    | 2021 January |
| Water cover                    | 75,956      | 393,518     | 306,396     | 391,357     |
| Low vegetation cover density   | 1,321,996   | 2,329,413   | 880,421     | 844,811     |
| High vegetation cover density  | 1,051,175   |             | 1,051,175   | 581,520     |
| Sand dunes                     | 3,340,306   | 438,355     | 988,547     | 1,342,398   |
| Wet soil                       | /           | 1,189,371   | 1,325,954   | 1,336,087   |
| Dry and salty soil             | 297,821     | 538,0699    | 505,905     | 562,225     |

The results can be arranged in the following Table (2) Which compares the areas between the varieties for the years (19976-1996), (1996-2016), (2016-2021), then compares each class separately and represents them with an illustrative graph, and taking into consideration calculate the area of vegetation cover (high and low) for the year (2016-2021) with one variety (vegetation cover).

**Table (2) Results with differences in areas between the classes**

| classes                        | Different In Areas (1976-1996) | Different In Areas (1996-2016) | Different In Areas (2016-2021) |
|--------------------------------|--------------------------------|-------------------------------|-------------------------------|
| Water cover                    | + 335,562                      | -87,122                       | + 84,961                      |
| vegetation cover               | + 1,007,417                    | -397,835                      | -505,265                      |
| Sand dunes                     | -2,901,951                     | + 550,192                     | + 353,851                     |
| Wet soil                       | +1,189,371                     | + 136,583                     | +10,133                       |
| Dry and salty soil             | +240,248                       | -22,164                       | +56,32                        |

This table explains the results with differences between stations, comparison occurred to discuss the status.
Area of water expanded from about (75.956) Km² in the first class 1976 to more than 300 Km² after the making Al-Dalmaj reservoir inside the area of interest. Figure (15) explain the results.

From 1976 to 1996 vegetation areas expand to more than (1007.417) Km² and while sand dunes reduced to about (-2901.951) Km², which mean there is a planned treatment at that time, but vegetation returned to reduce (-397.835) Km² area in 2016 comparing with 1996 and he continued to lose green cover until year (2021) to reach (-505.265) Km² also sand dunes areas expanded from 438.355 Km² in 1996 to about 988.547 Km² in 2016 then to more than (1342.398) Km² in 2021. Figures (16) and (17) explain the vegetation expansion and sand dunes reduction respectively.
All results and discussion can be illustrated carefully by Figure (18) which explains the comparison for all items in the four stations of the study in single integrated chart.

Figure (17) Full Result and comparison to Areas classes (1976-2021)

7. CONCLUSION

The problem of degradation has increased in this year (2021) for many reasons: the most important is the lack of rain and wrong use of land, the shortage of water coming to Iraq, and the phenomenon of land degradation has become a problem that extends to the public life of people in the aspects, starting with the decline of green areas, in addition to the effect of the phenomenon of frequent dust storms and intensively, which is exacerbated the degradation problem in Mesopotamian plain. Through satellite images (MSS 1976, TM1996, OLI 2016, Sentinel 2021) and maps created by remote sensing technology and geographic information systems, the results proved the changes occurring in the study area (Land cover), the deterioration of agricultural lands in generally, this area increases over time on the Mesopotamian Plain. The study proved, through the various indicators that were used, and through field surveys, that there is a deterioration in the study area, represented by an increase in the area of sand dunes from \(988.547 \text{ Km}^2\) in (2016) to \(1342.398 \text{ Km}^2\) in (2021) and a decrease in the area of vegetation cover from \(1931.596 \text{ Km}^2\) in (2016) to \(1632.695 \text{ Km}^2\) in (2021). Climate changes such as (high temperatures, less rain, wind speed, etc.), human factors and the nature of the land (Alluvial plain) made it vulnerable to the problem of desertification and land degradation. The movement of sand dunes increased since the year (2014-2021),
and most of the expansion was from the western and northwestern direction to the east, according to the movement of the direction winds.

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[14] https://www.usgs.gov/
[15] https://scihub.copernicus.eu/dhus/#/home
Appendix (A)

Some image from field survey represented (training area sample, sand dunes, high vegetation cover, low vegetation cover and dry soil).

[16]  https://glovis.usgs.gov/app?fullscreen=1
Sand dunes classes

Water Recourse

Agriculture Land Area
Natural over