Variations Size Investigation in Vegetation and Surface Water Body for Central Part of Iraq using Satellite Imagery Bands

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Abstract

The variations in vegetation and surface water body sizes play a huge role in the central region of Iraq, which includes three lakes: Al-Tharthar, Al Habbaniyah and Al-Razzaza Lakes. Several temporal satellite images Landsat TM (1990, 2000 and 2007), Normalized Difference Vegetation Index (NDVI) and supervised classification technique were utilized. The current research herein aims to investigate, evaluate and map the changes of vegetation and surface water bodies throughout the period of time for the study area, to know and explain the influential factors for these environmental changes. The final results would help the authorities for assessment and environmental management. The results showed a significant gap in the environmental variations in the study area from 1990 to 2000 and from 2000 to 2007. The period from 1990 to 2000 showed the highest vegetation cover difference. The year 2007 showed the highest vegetation re-growth. The total water surface area of the three lakes decreased for the years 1990, 2000 and 2007. The surface water area percentages of all three lakes in August of 1990, 2000 and 2007 were about 10.6%, 2.5% and 7.6% respectively. The highest water surface area was in 1990.

Keywords: NDVI; supervised classification; surface water body; GIS; satellite imagery
1 Introduction

Nowadays, environmental modifications have become very critical troubles to human beings. In the last decades, natural sciences have significantly targeted at the issues and risks of contemporary societies. Globally, most environmental threaten has been identified is climate change. It has reached a significant value with a severe influence on society, human life quality and human welfare (1). Vast deforestation due to the industrialization and urbanization, and land degradation due to the wars, natural disasters such as flooding, drought caused by global warming are in common. From recently published studies it is known that the vegetation on the surface of the earth is rapidly changing. Change is occurring to the phonology, the distribution of vegetation on the earth surface and the annual dynamics of photosynthetic activity (2, 3). Iraq is one of the most countries affected by climate change since it is recently experienced various environmental problems, caused by global climate changes, such as drought, desertification and dusty storms.

Remote sensing is a performance where sensors are conducted to identify the intensity of electromagnetic radiation over particular wavelengths from surface material. Concerning environmental investigation and social science field, the satellite has been usually used to acquire this data and concentrated on the land cover on earth. Electromagnetic energy values are registered for a particular number of channels as a digital number value (DN) (4). $NDVI$ has been widely used by many researchers to study changes in the fractional ground cover (5-10). Often there is a relationship between the changes in the vegetation cover and the variations in seasonal weather conditions and the moisture availability in the subsoil. Thus, for this indicator, several researchers have studied this relation between phonological behaviour, climate and land use.

Buermann et al (2003) examined the $NDVI$ time series to relate inter-annual variations with the climate variability. They concluded that during springtime spatiotemporal vegetation variation was strongly correlated to the surface temperature (11). Between 1981- 1991, there was a global increase in photosynthetic activity, due to an increase in temperature. (12). It was found that for the North-East region of Brazil the trends in vegetation greenness were a positive trend that occurred from 1984 until 1990, while a negative trend was detected from 1991 until 1998. These trends followed an inter-annual oscillation of 7 to 8 (13-17). this study covered two vital periods, the first period is 1990 to 2000 and the second period is 2000 to 2007. Each period had its influence on the environment changes in the study area. The factors of socio-political had also played a huge role that influences the environmental changes in the study area for the period 1990 to 2000. The sanctions enforced by the United Nations Security during the years 1990 to 2003 has an impact on the management of agricultural land in Iraq. On the other hand, for the changes in surface water bodies, the main reason is the decrease amount of water from rivers flowing from the upstream countries. Thus, the purpose of the current study as follows: monitoring, assessing, and mapping the environmental changes during
the three periods (Aug. 1990, Aug. 2000 and Aug. 2007) in the central area of Iraq using remote sensing and GIS technology.

2 Study Area

The territory of Iraq is located within the coordinates of longitude 45°38' to 45°48'E, and latitude 29°5' to 37°22'N., which covers a total area of 435,052 km$^2$. Geographically this area can be divided into four main regions as the following:

- The desert (west of Euphrates river), which forms about half area of Iraq (198,000 km$^2$).
- Mesopotamia (between the upper Tigris and Euphrates rivers).
- Highlands (mountainous terrain), which is located in northern Iraq, which represents one-quarter of Iraq's area.
- Lower Mesopotamia, the alluvial plain extending from around Tikrit state to the Arab Gulf.

The central part of Iraq extends between latitude 32° 13’ to 34° 6’ N and longitude 42° 20’ to 44° 40’ E. It represents an area of 326,056 km$^2$, which is about 7.4% of the total area of Iraq. It includes the whole or parts of several cities such as Baghdad capital, Diyala, Babil, Karbala, Al Anbar and Salah ad-Din. Besides, it also covers the whole or parts of three lakes: Al-Tharthar Lake, Al Habbaniyah Lake and Al-Razzaza Lake (see Figure 1).

![Figure 1: Study area](image)

The climate of the study area has great variation in temperature between summer and winter seasons, as well as between day and night during the year, it reaches to maximum degrees of about (45-50) °C. The ranges of annual rainfall are about 100 - 180 mm (3.9 and 7.1 in). Most of the rainfall occurs from December through April (18).
3 Materials and Software Packages

Several Images from Landsat TM cover the study area for the period from 1990 to 2012 with the interval of several years have been used to analyze the environment changes, in the past two decades, for the central region of Iraq. The images which have been downloaded with path 169/row 37 (August 14, 1990), (August 19, 2000) and (August 18, 2007) that were applied in this study. The website of (www.earthexplorer.com) has been used to obtain data used in this study. ER Mapper and ArcView GIS were used for image processing and analyzing.

3.1 Preprocessing

The TM data must first be converted to reflectance, a physical measurement for calculating the tasselled brightness cover, greenness, and wetness indices, which directly applicable for Landsat 7 ETM+ TOA reflectance data (19). Reflectance calculated from Landsat data is called “top of atmosphere” (TOA) measurement and can be used with Landsat 5 TM data using a further transformation (20). After downloading the satellite images of Landsat 5 TM, the data were processed as follows:

Convert Landsat 5 TM data to the equivalent Landsat 7 ETM+ data using the following expression:

\[ \text{DN7} = (\text{Slope}_\lambda \times \text{DN5}) + \text{intercept}_\lambda \]  

Where DN7 is the Landsat 7 ETM+ equivalent DN data, DN5 is the Landsat 5 TM DN data, and the slope and intercept are band-specific numbers given by the inverse of those found in [13].

Radiometric Correction: Before converting to reflectance data, one must convert the DN data to radiance. This is done using the following expression:

\[ L_\lambda = (\text{gain}_\lambda \times \text{DN7}) + \text{bias}_\lambda \]  

Where L is the calculated radiance [in Watts / (sq. meter * um * ster)], DN7 is the Landsat 7 ETM+ DN data. sun,\( \lambda \)

Convert radiance data to reflectance data: It can be calculated using the following expression:

\[ R_\lambda = \frac{\pi \times L_\lambda \times d^2}{E_{\text{sun,}\lambda} \times \sin(\theta_{\text{SE})}} \]  

Where R is the reflectance (unitless ratio), L is the radiance, d is the earth-sun distance (in astronomical units). \( E_{\text{sun,}\lambda} \) is the band-specific radiance emitted by the sun, and\( \theta_{\text{SE}} \) is the solar elevation angle.

3.2 Derivation of NDVI

The \( \text{NDVI} \) was computed from the Landsat TM image data using the following formula:

\[ \text{NDVI} = \frac{\text{Band 4} - \text{Band 3}}{\text{Band 4} + \text{Band 3}} \]  

Where Band 3 is the red band (0.63–0.69 mm) and Band 4 is the near-infrared (0.63– 0.69 mm) of the TM image data (21).
3.3 Supervised Classification

The supervised classification technique is a common method used to analyze data in remote sensing technique and depend on the size of the area which needs to be classified. This classification technique is a process of sorting all pixels into a limited number of individual classes, or categories of data.

4 Results and Discussion

4.1 NDVI Evaluation

Vegetated and non-vegetated areas were separated based on threshold values to classify NDVI for 1990, 2000 and 2007 respectively. NDVI less than 0; the pixels represent non-vegetation and larger than 0, the pixels represent vegetation. Threshold values are ranging from 0-0.26, (0.26-0.35), (0.35-0.6) and (0.6-1), which represent the poor, moderate, good and high vegetation cover respectively (see Figure 2).

It can be observed that the percentage of irrigated and high vegetation cover decreased during the two years (1990 and 2000), while the poor vegetation cover increased. Figure 2b shows a general increase in bare soil in the study area since it escalated from 4.006 km$^2$ to 19230.6 km$^2$ in 1990 and 2000 respectively. The high difference between the vegetation area and poor vegetation area (bare area) during the period 1990–2000. The period for the highest vegetation coverage was in 1990.

The max vegetation escalation occurred from 2000 to 2007. The period of 2007 witnessed the highest vegetation regrowth. In addition, results presented a general growth in vegetation cover in 2007 as shown in Figure 2c, where the increase from 1% to 40% and 18% to 23% for the good and high vegetation cover respectively.

![Image](attachment:image.png)

a) Aug. 1990
b) Aug. 2000.

c) Aug. 2007

Figure 2: Classification map of NDVI

The statistical distribution and the total measured area of each class for the three periods were illustrated in Table 1, which shows the statistical distribution and the total measured area of each class for the three years of 1990, 2000 and 2007.

Table 1: Distributions classes of vegetated area derived from NDVI maps.

| Category of vegetation cover | Value | 1990  |   | 2000  |   | 2007  |   |
|-----------------------------|-------|-------|---|-------|---|-------|---|
|                             | Area, km² | %    |   | Area, km² | % | Area, km² | % |
| Poor                        | 0.0 – 0.26 | 4.006 | 0.01 | 19230.6 | 58.98 | 6693.14 | 20.53 |
| Moderate                    | 0.26 – 0.35 | 5701.84 | 17.49 | 3092.29 | 9.48 | 2212.54 | 6.79 |
| Good                        | 0.35 – 0.6  | 15410.2 | 47.26 | 541.23 | 1.66 | 13262.5 | 40.68 |
| Irrigated & high            | 0.6 - 1     | 8015.15 | 24.58 | 6173.83 | 18.93 | 7811.12 | 23.96 |

When the pixel values of NDVI less than 0.26, they represent the poor vegetation cover (desert vegetation). These pixels are naturally desert vegetation as shown in Figure 3. The number of pixels has increased from 0.01% to 58.98% for 1990 to 2000 respectively, due to the expansion of land affected by desertification. Meanwhile, the moderate, good and high vegetation covers
were decreased during the same periods: from 17.49% to 9.48%, 47.26% to 1.66% and 24.58% to 18.93% respectively, as illustrated in Table 1 and Figure 4.

![Figure 3: Desert grasses in the study area](image)

![Figure 4: Relationship between vegetated area and time for the study area](image)

When the pixel’s value of NDVI is larger than 0.35, they belong to good and high vegetation irrigated areas, especially near the banks of Euphrates and Tigris rivers and the surrounding area. In these areas, the NDVI of agriculture land was higher than zones of sparse vegetation which are far from rivers particularly in the western part of the study area.

These phenomena show that the most affected areas with desertification were in the western part of the study area; it can be explained by the increasing of salinity in soils and the movement of dunes which devastated many groves, farms and agricultural lands.

Land degradation in the study area as a result of several factors, including sociopolitical that resulted in modifications in majority farmland of Iraq. Iraq has been suffered from the economics warfare by the enforced by the United Nations Security Council represented comprehensive sanctions a form of economic warfare for the period (1990 to 2003). Reparations of the country’s irrigation system were banned immediately with the execution of comprehensive sanctions.
Dual-use fertilizers and pesticides importing have been banned as well. Alternatively, horizontal expansion of agriculture was started by Iraqi administration especially for the previously uncultivated lands after neglecting these systems for years. Thus, the production has been increased during the sanction (22, 23). On the other hand, a significant reduced in productivity was occurred due to widespread salinization and waterlogging [16]. As a result, major decreases in cultivated lands especially in the central part of Iraq, which influenced by high soil salinity affected by years of poor administration and overexploitation. Furthermore, 75% of irrigated land in central Iraq is saline according to a recent USAID report, and (20-30)% is not farmed due to poor management and salinity (23).

4.2 Waterbody Evaluation

Various methods have been used to identify and draw surface water bodies (24-28). Thus, to understand the changes in the area of the water body, a supervised classification algorithm was used in this study. to classify three Landsat TM images for the years 1990, 2000 and 2007 (see Figure 5).

![Figure 5: Supervised classification map of the study area, Aug. 1990](image_url)

Also, the overall classification accuracy of central Iraq was found to be 75.98 %. While the comparison of the three different years (1990, 2000 and 2007) indicated that the water class suffered from high changes. The classification results of the Landsat TM image of the three years indicate a decline in the total water surface area of the three lakes in the study area (Figure 6).
Total water surface area of the three lakes decreased during the years 1990, 2000 and 2007. The total surface water area in the study area was found to be 3463 km$^2$, 808 km$^2$, 2463 km$^2$ in 1990, 2000 and 2007 respectively. Figure 7 shows the variations of the water surface area and the percentages for the entire surface water area according to the study area for the three classes. The percentage of the surface water area relative to the whole study area is illustrated in Figure 8. It can be seen that the percentages for the entire surface water area according to the study area in August of 1990, 2000 and 2007 were about 10.6%, 2.5% and 7.6% respectively relative to the whole central zone in the current research. The year with the highest water surface area was 1990, while the lowest water surface area was registered in 2000. From the visual interpretation of the Landsat TM imagery in August of the years 1990, 2000 and 2007, it is clearly shown that the total water surface area of the three lakes in the study area around the Euphrates river have decreased significantly.

The decreases in the surface water areas in the study area can be attributed to several reasons. One of the main reasons is associated with the decrease in the water flowing into the Euphrates river from the upstream countries. Another important factor causing the decline is the high temperatures during the summer which leads to increasing rates of evaporation from the water surface, coupled with the limited rainfall during the same period as shown in Figure 8 (17).
5 Conclusions

The study area has suffered from significant environmental changes, during the years 1990, 2000 and 2007. The supervised classification and NDVI technology were used to detect the changes in the central part of Iraq, which obtained good results about the size in vegetation cover and surface water area as follows:

- The natural desert vegetation showed an increase in the total area from 1990 to 2000 of about 0.01% to 60% due to the expansion in land affected by desertification.
- The moderate, good and high vegetation covers were decreased from 17% to 9%, 47% to 1% and 24% to 18% for the years 1990, 2000 and 2007 respectively, which discovered the case of land degradation and desertification in the central part of Iraq.
- On the other hand, high vegetation was increased from 2000 to 2007. The period for the highest vegetation regrowth was in 2007. The increase was from 1% to 40% and 18% to 23% for the good and high vegetation covers consecutively.
- The total water surface area of the study region was decreased for the years 1990, 2000 and 2007 of about 3463 km², 809 km² and 2463 km² respectively.

Numerous necessary steps are required by the decision-makers in Iraq to recover the water level of the water resources. In addition, it is highly recommended to re-activate the water share agreements between the Syrian and Turkish sides to obtain a sufficient water share to feed the rivers and tributaries in Iraq.

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