Time Series Analysis of Changes in Land Cover Based on Spectral Indexes in Dohuk Governorate

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Abstract

The main aim in this study is to detect and analyze changes in land cover in Amadiya district in Dohuk Governorate, northern Iraq whose area is \(2775.21\) km\(^2\) and the district is located astronomically between longitudes (01\(°\)04’ 43), (17\(°\)08’ 44) to the east, The district extends between two circles of latitude, which are (16\(°\)50’ 36) and (30\(°\)21’ 37) To the north , during the period between 1999-2019 using spectral indicators, to assess the appropriateness of the spectral indicators used in determining and monitoring changes in land cover and vegetation cover. Where the values of six spectral indices were extracted from the Landsat ETM and 8 Landsat OLI satellites data, which are NDVI, NDBI, SAVI, BI, NDWI, and IPVI satellites. The study concluded the percentage of vegetation cover index represented by the two indicators NDVI, SAVI, and IPVI was increased, at the expense of the rest of the indicators used in the study, as it represented 40.483636, 40.483733 and 40.483733\%, respectively, in 2019, while the percentage of 21.258759, 21.193281 and 21.176142\%, respectively, in 1999. This indicates that the plant indicators are the best used indicators that benefit the study area. The indicators are SAVI, NDVI, IPVI, which show that the increase in the plant was ranked first in the northwestern part of the region, followed by the second rank, the northeastern part, and the southwestern part was ranked second. The third, while the southeastern part ranked fourth, which has the lowest percentage of plants in it, because this part of the region has been greatly exploited by the urban class.

Keywords: NDVI, SAVI, IPVI, BI, Dohuk.

1. Introduction

Vegetation cover and land uses are indicators and measures of environmental degradation, so it is necessary for the continuous monitoring of the land cover and analyze the changes, whether positive or negative, and this helps the availability of long time records of satellite visuals, as in the series of Landsat satellites that have a major role in monitoring ecosystems and their interactions with the atmosphere on over the past decades, the great development in the applications of remote sensing, the use of spectral indicators, the conduct of statistical equations, the ease of application, the speed of implementation and the low cost, helped many studies to detect changes and deterioration in the land cover, monitor and analyze it, and create databases for multiple periods of time [1].

A number of studies also discussed changes in land use and land cover in dry and semi-arid regions. The studies dealt with in their applications the spectral indicators and worked on the amending and new indicators that are easy to calculate and analyze according to the nature of the study case. As for the studies that discussed the land cover, including: Both Rouse and Silleos, demonstrated the ability of the NDVI to detect biomass, plant distribution, plant density, and area [2,3].

As for Huete, he developed the modified plant index for soil SAVI with a number of indicators in order to improve the results of extracting plant values and reduce the influence of other conditions, whether the atmosphere or the topography [4]. Röder et al. analyzed land cover change using Landsat time series data and geographic information processing. The Macedonia region in northern Greece provides an ideal test case to study the effect of multifunctional human lands for land use typical of the European Mediterranean region where natural plant complexes have been found. It is closely intertwined with arable land with different densities. The Landsat TM, ETM satellite data series that support different types of analysis have been used to contribute to giving a comprehensive view of the transitions of land use and the related impacts of land degradation. The main aspects in this context are to assess the progressive trends and factors controlling natural and semi-natural areas. And assessing changes in land use categories using the analysis of changes and land use classifications that included rangelands, arid areas, non-irrigated arable lands, as well as irrigated arable lands, water bodies and urban areas [5]. Jamalabad, mentioned that it is possible to use the BI arid soil indicator to distinguish soils without vegetation cover [6].
Al-Asadi, explained that the IPVI index is one of the vegetation indicators for mathematical formulations or spectral band transformations that highlight the spectral properties of green plants, as the plant indicators work on the basis of highlighting the difference between RED and NIR [7].

AL-Saeedi pointed that the use of the NDWI water index distinguished and monitored water bodies from other lands, as soils appear darker on the visible, due to the absorption of the incident radiation energy by the water stored by the surface soil, especially in the visible and infrared ranges close to the spectrum, causing a decrease in the amount of The part reflected to the sensor [8].

Al-Daghestani and Muhammad explained the use of remote sensing data as one of the modern methods of preparing a set of maps for planning and economic development purposes in the Bashiqa area, northeast of the city of Mosul. The map of the morphotectonic effect on the surface drainage system indicates the presence of anomalies in the intensity and locations of gully erosion, which were documented in the form of a contour map in which these sites were determined based on the USGS system [9].

Al-Allaf and Narameen used unsupervised classification of data (1989, 2009) from the data (1989, 2009) of the American satellite Landsat. The results showed that we obtained six land cover types (dense forests, open forests, pastures, agricultural lands, soil and rocky lands). Were these all lands types identified and compared with the land control points of (65) samples and for both of the data. The accuracy of classification of the spatial data was calculated and evaluated depending on the scales used for this type of studies, which include: the error matrix of the percentage of each type and for the map as a whole. The accuracy of both of the data (1989, 2009) were (84.62%) and (83.08%) respectively and that indicates a good accuracy for both classifications. Also the statistical scale (Kappa) was used to calculate the accuracy which was (0.81 and 0.79) respectively for the two data classified for the year (1989 and 2009). The change in the covers in the period between the data collection showed that there were increases in the open forests, pastures and the agricultural lands with percentages of (2.924%, 3.78% and 1.225%) respectively. The high increase was in the open forests and pastures. But the increase was slight in the total area of the agricultural lands. From the other hand, we see a loss in the area of the dense forests, soil and the rocky lands. The highest loss was in the dense forests (2.242%) and rocky lands (1.918%), while the loss in the soil was slight (1.769%) [10].

The study by Viana et al. aims for the long-term LULC analysis in the Beja region in Portugal based on a series of lands with an area of about 1145 km² for a period of 21 years. The satellite OLI Landsat TM 30 meters for a period of 21 years from 1995-2015, where the satellite data was used to calculate the NDVI vegetation coverage index and the NDWI water index, where the NDVI index is the most used indicator for monitoring vegetation changes globally due to its strong and easy interpretation, and the NDWI index was used to clarify water features. The results of the classification showed the predominance of temporary crops with agricultural forest areas in the region, as the region is characterized by extensive cultivation with complex agricultural patterns, where the important areas are occupied with temporary crops with natural plants and forest cultivation areas. The area is widely covered with temporary crops with agricultural forest areas as well as Cork oak trees exploit the vast landscape areas of agricultural forests, and the water areas had a similar pattern of increase it increased by 7% of the total area in 1995 and 11% in 2015 with a significant increase in the period from 2010-2011. As for agricultural classes, temporary crops were with the category of agricultural forest areas. Temporary crops with the category of agricultural forest areas were clearly predominant as they occupied Total area close to 63% in 1995, however, this category decreased significantly from 1995 to 2015, about 11%, and the permanent pasture group did not differ significantly. In 1995 to 2015, it occupied an area of about 12% - 13%, and forested areas differed more. Over a period of 21 years where the occupied area was between 11% (maximum area) and 8% (minimum area) in particular, from 2003 to 2010 - 2011, little or no change in the LULC was detected, possibly due to the measures of the Common Agricultural Policy of 2003 [11].

Karanam studied the Urban Differences Index in mapping urban change using Landsat TM multi-time satellite data from 2005 to 2015 on a city in the eastern part of India. Spectral indicators were used, including NDBI and BUI. The spectral differences were in Buildings, open spaces, plants, and water areas. These differences were studied by creating two-dimensional spectral diagrams for the NDBI and BUI index. Remote sensing images are mainly used, as well as monitoring and detecting changes in land cover that occur frequently in urban and semi-urban areas as a result of continuous urbanization and the conversion of satellite images Industrial, i.e., satellite data into a map of the land cover using manual interpretation and classification is a long process, but by using the NDBI index in extracting the change map of the land cover that is mapped through the computational treatment of the urban difference index using the formula for the NDBI index on this area, so the results indicated that the accuracy of the map was 93.9% That is, the indicator can be used to achieve the goal of mapping b Reliable shape and high efficiency [12].

Khalaf and others used spectral indicators and clues in addressing the noise of the digital classification directed at the ground cover of Diyala Governorate in Iraq, where they applied directed classification in the processing of space data to achieve more accurate results through the optimal utilization of digital data using the advanced optimization mechanisms of an ideally directed classification of During work on improving the initial information that enters the classification and thus obtaining a high degree of accuracy and efficiency, and as it is known that the primary raw data that achieve inaccurate ratios in classification due to the overlap of its convergent value (DN), therefore, the current research works to disentangle the link
between the varieties of converging values and expand the variance to achieve a conceptual perception of the numerical values that represent the ground covers by following the indicators that achieve functional integration possibilities for noise treatment for different covers at high classification levels by applying the following indicators NDVI, OSAVI, TCI, CL, SI, BI, WI, DBI on the Landsat OLI 8 data year 2019, and it was implemented through the extension of the ARC GIS 10.7 program, and it achieved a spatial accuracy of more than 87% of the ground cover after it was recorded. The classification accuracy in the initial stages is 48%, based on the Kappa parameter [13], and Explained (Fuentes et) that the NDBI index constitutes a large part of the land cover as it has become very important to monitor the increase in the built up area [14].

This study aimed to:

- Detect changes in land cover in Amadiya district in Dohuk Governorate, northern Iraq, and determining the values of change and the percentage of land cover between 1999-2019.
- Evaluate the spectral indicators used in the study.
- Determine the most changing areas of land cover in the study area.

2. Materials and Methods

Remote sensing applications have been used to assess and manage natural resources, land uses, and land cover in general, and vegetation cover in particular, to maintain sustainability of plant wealth and to interpret and evaluate the current state of vegetation and land cover and determine the changes that have occurred to it. The study adopted the descriptive and analytical approach of the land cover, determining the changes by mathematical equations, the use of spectral indicators, derivation of the values and their representation in the form of maps showing the spatial distribution of the changes and their size, and then analyzing the data using geographic information systems software Arcmap 10.6.1 and The data used are Landsat ETM and Landsat 8 OLI satellite data

| Sensor       | Spatial discrimination | Band  | Date of data   |
|--------------|------------------------|-------|----------------|
| Land sat ETM | 30*30                  | B7_B1 | 11_8_1999      |
| Land sat OLI | 30*30                  | B11_B1| 23_6_2019      |

2.1 The Normalized Difference Vegetation Index (NDVI)

Using the NDVI tool, we obtain a map that showing the density of vegetation cover in the study area by the gray hue, where the greater the brightness indicates the density of the vegetation, and the more ambiguity indicates a decrease in vegetation density. NDVI also defines vegetation cover by measuring the difference between NIR (which is strongly reflected by plants) and red visible light which is absorbed by plants, as when the sun hits Earth's bodies, certain wavelengths of this spectrum are absorbed and reflected in other wavelengths.

2.2 Soil Adjusted vegetation Index (SAVI)

This guide was developed to be an important step for inferring global models through which the dynamic systems between soil and plants can be described through remote sensing data.

2.3 Infrared Vegetation Ratio Index (IPVI)

(15), developed the Index of Infrared Vegetation Coverage Ratio (IPVI) and it was suggested that subtracting red rays from infrared in the numerator of the (NDVI) equation is unnecessary and the index (IPVI) is functionally equal to the index (NDVI), but it is faster than it in The calculation of big data, as its dynamic range is limited to positive values (0-1 or higher than 1), thus eliminating the negative values shown by the NDVI in the absence of vegetation cover.

2.4 Bare Soil Index BI

The BI index was applied to estimate the value of arid soil in the study area, and it is a digital indicator that combines the spectral bands of near infrared and blue rays to capture changes in the soil. When the near blue and infrared spectral bands are used to enhance the presence of vegetation, that is, it is a natural indicator to determine the difference between agricultural and non-agricultural vegetation cover and characterize bare soil, wastelands and vegetation cover when using the (BI) indicator.
2.5 Normalized Difference Water Index (NDWI)

It is mainly used for extract and analyze plant water content as it is used in crop prediction. Water is used to predict crop yield based on plant water stress. It is used near near infrared ranges because it has an effect on inner leaf structure with green wavelength.

2.6 Normalized Difference Built _ up Index( NDBI )

The NDBI make up such a large part of the land cover, as it has become very important to monitor the increase in the built up area, and it is used to study various sectors such as urbanization, industrialization and other transformations in the built-up areas. It also takes into account the spectral characteristic of urban (built) areas.

| Table 2. Represents the indicators used in the study and their equations. |
|-------------------------------|---------------------------|
| Indications                  | The equation              |
| NDVI                     | NDVI=(NIR-RED)/(NIR+RED)  |
| SAVI                     | SAVI=(NIR-RED)/(NIR+RED)×(L+1) |
| IPVI                     | IPVI=0.5×NDVI+1           |
| NDBI                     | NDBI=(MIR-NIR)/(MIR+NIR)  |
| NDWI                     | NDWI=(GREEN-NIR)/(GREEN+NIR) |
| BI                       | BI=(((MIR+RED)+(NIR+BLUE))/((MIR+RED)+(NIR+BLUE)))+100×100 |

3. Results and Discussion

The equations of the spectral Indices were applied to the study area and the values of the spectral indices used in the study were extracted and the results were as follows:

- First: the results of the Normalized Difference Vegetation Index NDVI
  The values of the NDVI index were extracted as in Figure (1) according to the equation in Table (1), where the change was evident in the size, density, spread and distribution of vegetation cover in the period between 1999-2019, where the NDVI values in 1999 indicated the higher category 0.541667, while the category was The few are 0.333 - as for the medium category, it was 0.05934, but in the year 2019, the higher category was 0.62264 and the lower category was 0.2471 - as for the medium category it was 0.2803 - in other words, the plants increased in 2019 over the year 1999, meaning an increase in the value of the NDVI index was observed in 2019 from 1999.

- Second: The results of The soil Adjusted vegetation Index SAVI:
  The results of the soil-adjusted plant index were shown in Figure (2) as in the equation mentioned in Table (1), where the values in 1999 were confined to the upper category 0.1808, the middle class 0.08872 and the lower category- 0.4977, while in 2019 the higher category was 1.683. The middle class is 1.1703 and the low category 0.379, meaning that there is a significant increase in the value of the SAVI index between 1999_2019, as the value of the index increased in 2019 from 1999.

- Third: Results of the Bare Soil Index BI:
  The results of the bare soil index showed that there is a change in the percentage of the index from 1999 to 2019, as the percentage of the index increased in the middle and low categories, while the higher category decreased the ratio between the two years, meaning that in 1999 the higher category was 81.39, while in 2019 the higher category was 77.1199. As for the medium category for the year 1999, it was 70.238391. As for the year 2019, the medium category was 72.2945, meaning that there is a slight increase in it. As for the few in 1999, it was 54.213 and the flag for 2019 was 86.0333, so there was an increase from the year 1999 and Figure No. (3) represents the results of the bare soil index BI.

- Fourth: Results of the Normalized Difference Built _ up Index NDBI:
  Figure No. (4), represents the indicator of urban areas, and from the equation that was applied that mentioned in Table No. (1) that the higher category for the year 1999 was 0.4258 and the middle category was 0.0434, while the fewest category was 0.38596 - while the values in 2019 were the higher category. 0.4325, the average category is 0.08309- and the low category is 0.4325, meaning that there is a slight increase in the NDBI index in 2019 compared to 1999.

- Fifthly: the results of the Infrared Vegetation Ratio Index IPVI:
  The results of the IPVI index as in Figure 59 showed that the highest category for the year 1999 was 1.270, the middle class was 1.029, the fewest category was 0.8333, the top category for 2019 was 1.3113, the middle class was 1.1411, and the few were 0.8764, meaning that there is a slight increase in the IPVI index. Between the two years.

- Sixth: the results of the Normalized Difference Water Index NDWI:
  Figure No. (6) showed the results of the NDWI index, where the highest category in 1999 was 0.3675 and the lowest category was 0.4854 - as for the medium category it was 0.1483 - but in 2019 the highest category was 0.275, while the medium
category was 0.5593 - while the fewest category was 0.2972 - and this shows there is a loss in the water index between the two years.

Figure 1. Represents the normalized Difference vegetation index.

Figure 2. Represents soil modified vegetation index SAVI.

Figure 3. Represents the bare soil index BI.
Figure 4. Represents the Normalized Difference Built up Index (NDBI).

Figure 5. Represent the infrared vegetation ratio index IPVI.

Figure 6. Represent the water index NDWI.
Table 3. Represents the values extracted from the six (6) indicators used in the study for the period between 1999-2019.

| Indicator | 1999 | 2019 |
|-----------|------|------|
| NDBI      |      |      |
| SAVI      |      |      |
| NDVI      |      |      |
| NDWI      |      |      |
| IPVI      |      |      |
| BI        |      |      |

By analyzing the indicators, it was found that there were clear changes in the percentage of each indicator during the twenty years between (1999-2019), as it included changes in plant indicators and urban areas as well as arid soil and water. When comparing the percentage of change in the areas of indicators for the study area, it was found that the percentage change in the indicator BI and NDBI, NDWI decreased in 2019 and were 14.862973, 1.260704, 17.846613%, respectively, after it was 23.885501, 12.295254, 24.63977% in 1999, while it was found that there was an increase in the plant indicators which are IPVI, NDVI, SAVI, and the percentage for all these indicators was on For the year 2019, 40.483636, 40.483733, 40.483733%, while the percentages for the year 1999 were 21.258759, 21.193281, 21.176142%, respectively, meaning that there is a clear increase in vegetation at the expense of the indicators of bare soil, urban areas and water, and the reason may be due to the natural regeneration of plants in the region or Afforestation operations by officials in the study area. The increase in vegetation was in the first place in the northwestern part of the region, followed by the second place in the northeastern part. The southwestern part ranked third, while the southeastern part ranked fourth, which is the lowest percentage of plants in it, because this part of the region has been greatly exploited by urban class Where the percentage of plants in this part of the region, the southeastern part was 15.825913% in 1999 In 2019, the percentage constituted 16.98895%, meaning that there was a slight increase in the percentage of plants between 1999 and 2019. As for the increase in plants, it was in the northwestern part, and the percentages were as follows for the year 1999 30.11467,% As for the year 2019, the percentage was 29.713% It is followed by the northeastern part, where the ratio was for 1999 is 30.010849% In 2019, the percentage was 27.580376%. Finally comes the southwestern part, which accounted for 24.048% for the year 1999 In 2019, the ratio was 25.716813%.

Conclusions

This study reached to determine the ground covers that cover the Amadiyah district and the changes that occurred during the time periods from 1999 to 2019 through the use of spectral indicators of land uses and land cover for the years 1999, 2019 and were as follows:
Classification by indicators is one of the appropriate methods for the study area and similar areas, as it can be relied upon in classifying highly undulating and high lands, because the nature of classification by indicators depends on mathematical equations specific to each indicator. In contrast to the directed classification, which was found to be inappropriate for the study area and similar areas.

In the study area, the forests were mostly in the northwestern and northeastern direction, followed by the southwestern and southeastern part. For this reason, we find that there is a great variation in the vegetation cover from high density to medium density. The dense cover is found on the slopes facing the wind, because these facades receive a higher amount of rain Compared to other facades, this is why it had a less dense vegetation cover.

The different ground covers were not fixed in their positions, but rather moved in the direction of negative and positive, due to the different activities in the study site (positive and negative).

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