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Monitoring Vegetation Area in Baghdad Using Normalized Difference Vegetation Index

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Abstract

Vegetation monitoring is considered an important application in remote sensing task due to variation of vegetation types and their distribution. The vegetation concentration around the Earth is increase in 5% in 2000 according to NASA monitoring. This increase is due to the Indian vegetable programs. In this research, the vegetation monitoring in Baghdad city was done using Normalized Difference Vegetation Index (NDVI) for temporal Landsat satellite images (Landsat 5 TM& Landsat 8 OIL). These images had been used and utilize in different times during the period from 2000, 2010, 2015 & 2017. The outcomes of the study demonstrate that a change in the vegetation Cover (VC) in Baghdad city. (NDVI) generally shows a low value of plant cover. The highest NDVI values were occur in 2000 and the lowest values for both years 2015-2017. This change is due to a correlation of climate indices such as precipitation, temperature, and dust storms. This study present that (NDVI) method is a powerful and useful way of monitoring vegetation. The calculation of vegetable areas show (43.3, 37.4, 9.1, and 22.7 Km^2). The result were evaluated using (Environment for Visualizing Images ENVI) Ver. 4.8 package.

Keywords: (NDVI), Classification methods, Image processing, Remote Sensing.

مراقبة مساحة الغطاء النباتي في بغداد بأستعمال مؤشر الفرق المعياري للغطاء النباتي

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الخلاصه

يعتبر رصد الغطاء النباتي تطبيقًا مهمًا في مهمة الاستشعار عن بعد نظرًا لاختلاف أنواع النباتات وتوزيعها. يزداد تركيز الغطاء النباتي حول الأرض بنسبة 5٪ عن عام 2000 وفقًا لرصد وكالة ناسا ، وتعزى هذه الزيادة إلى برامج الخضروات الهندية. يتضمن هذا البحث رصد الغطاء النباتي في مدينة بغداد باستعمال معامل الغطاء النباتي الطبيعي (NDVI). ولإنجاز هذا البحث تم استعمال صور فضائية لمنطقة الدراسة ملتقطة بأقمار صناعة مختلفة , الراسم الموضوعي (TM) لسنتين (2010,2000) وتصوير الارض التشغيلة (OLI) لسنتين (2017,2015) وصنفت هذه الصور باستخدام تقنية تصنيف المراقب (المسافة الدنيا). وأظهرت نتائج الدراسة حدوث تغير في الغطاء النباتي في مدينة بغداد. يرجع هذا التغيير إلى ارتباطه بالعوامل

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المناخية مثل هطول الأمطار ودرجة الحرارة والعواصف الترابية. توضح هذه الدراسة أن طريقة (NDVI) هي طريقة فعالة ومفيدة لرصد الغطاء النباتي. يظهر حساب المساحات النباتية (43.3 ، 37.4 ، 9.1 ، 22.7 كم^2). تم تنفيذ منهجية العمل باستخدام برنامج ENVI 4.8 .

1. Introduction

Cover of land is a biotic component and natural state of the earth's surface. The land is modified by human activities and climate changes to make a variation on the cover of land. The most significant part of global environmental change is the change in land cover. The cover of land influences the earth's surface by a few processes, for example cycle of energy, vegetation primary productivity, circulation of the atmosphere, vegetation productivity, cycle of the biogeochemical, etc. [1]. The process of detecting changes in an object's state over time by observing it at certain intervals is called change detection; it often able to determine tentative effects by using multi-temporal data-sets [2]. Vegetable lands can be broadly described as ground that uses food productions, and it is divided into two categories: farms (man-made land) and forests (natural land) that are cared for by humans. Iraq has forests, farms, green areas and is distinguished by its palm trees [3].

It is said that vegetation (such as grasslands, parks, and forests) in urban megacities has a major impact on improving the quality of life and cooling urban hotspots [4]. The urban vegetation can reduce land surface temperature by shading and altering evapotranspiration, monitoring Albedo and CO_2 sequestration [5], climate parameters, human activities and socio-economic. There are two factors that have a direct and indirect impact on vegetation coverage such as environmental and urban influence. Changes in the Baghdad city vegetation are particularly monitored with climate indices such as precipitation, temperature, relative humidity, and evaporation. These climate indices mainly affect soil characteristics which leads to change growth of vegetation [6].

The vegetation cover of the city of Bagdad is influenced by climatic factors. In Baghdad city, rainfall happen about four months from January to May. It is characterized by variations in temperature between day and night, summer and winter. This will offer an expanded field to study change of vegetation due to the changing behavior of these climatic factors. However the Normalized Difference Vegetation Index (NDVI) is mostly used to deal with variations of vegetation that result from the changing of climate conditions [7].

Vegetation can be divide to forests, trees, and fields and has a unique of spectral signature, the reflective characteristics varies according to different vegetation types. By distinct spectral signature, it is normally able to identify healthy or unhealthy. The spectral reflectance of the vegetation is affected leaf pigment, cell structure and water content. Deciduous trees have a higher reflectance in the near infrared is an example. Figure (1) indicates the spectral reflection of the vegetation.

- *Visible reflectance*

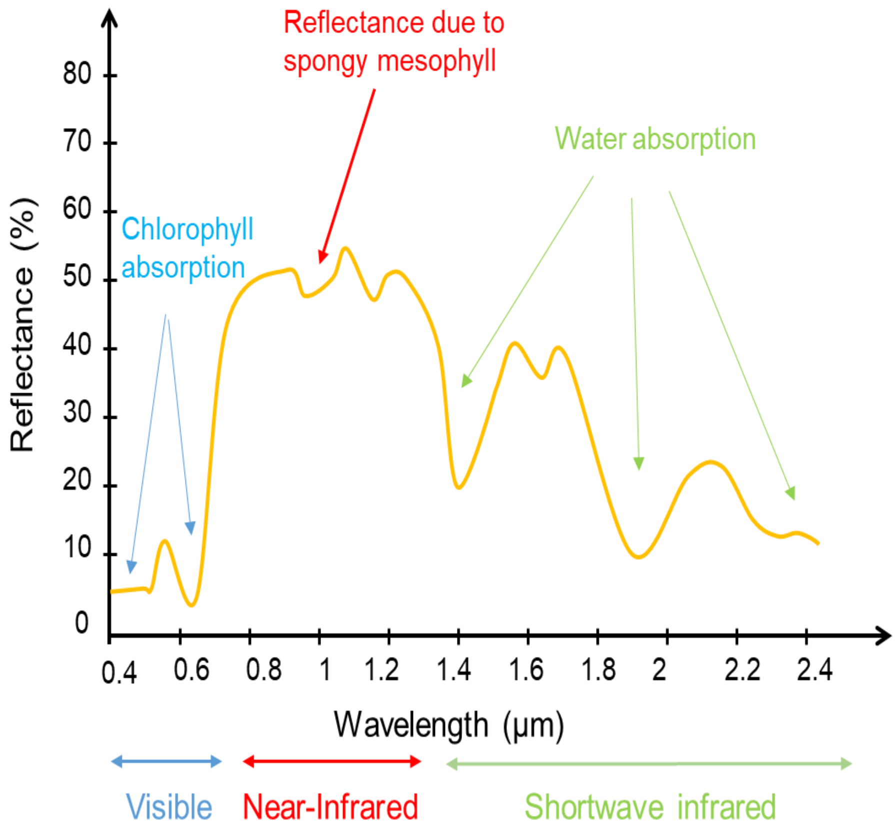
Sun light is mainly absorbed by the leaf pigments in the visible region of the image. In the blue and red wavelengths, the energy is absorbed strongly by chlorophyll, so uninfected vegetation shows green color.

- *Near Infrared reflectance*

Due to the cellular structure of the leaves, especially the spongy mesophyll, healthy vegetation has a much higher reflectance in the near infrared (NIR) region than in the visible region. Thus, healthy vegetation is easily identifiable by its high NIR reflectance and low noticeable reflectance in the visible region.

- *Shortwave Infrared reflectance*

In short-wave infrared wavelengths, the reflection is affected by the structure of vegetation and the water content. There is a high absorption wavelength of 1.45, 1.95, and 2.6 μm. After that, the



reflectance generally increases because the water content of the leaves is reduced outside the SWIR zone [8].

Figure -1 The spectral reflectance of vegetation (The chlorophyll pigment absorb the Blue (4.5µm), Red (6.5 µm) parts, and reflect the Green (5.5 µm)

The aim of this study is to find the difference in calculation of vegetation areas in Baghdad city for time periods by NDVI. NDVI was derived from Landsat imagery.

2. The study area

The studied area in this work is Baghdad which is the capital of Iraq, as shown in Figure (2). It lies in (33° 10′, 33° 30′ N) and (44° 10′, 44° 36 ′E) with an area of 204.2 km^2. Baghdad city is divided into two residential parts: first lies on the eastern side of Tigris river and named Rasafa. Second lies on the western side of Tigris river and named Karkh. The city lies on the banks of this river. Baghdad city is located between the main cities to the north and south, Basra is 445 km away from it to the south, while Mosul is 350 km to the north, and Erbil is 320 km away [9]. The average height of Baghdad city is 34 m above the level sea. Baghdad's population census is about 8,126,755 with population density 49,019 in 2018 according to [10]. This city is characterized by the abundance of palm trees, which represent the most widespread tree in these areas. Baghdad's climate is hot and dry in summer and cold and humid in winter due to the low and flat topography of the city [11].

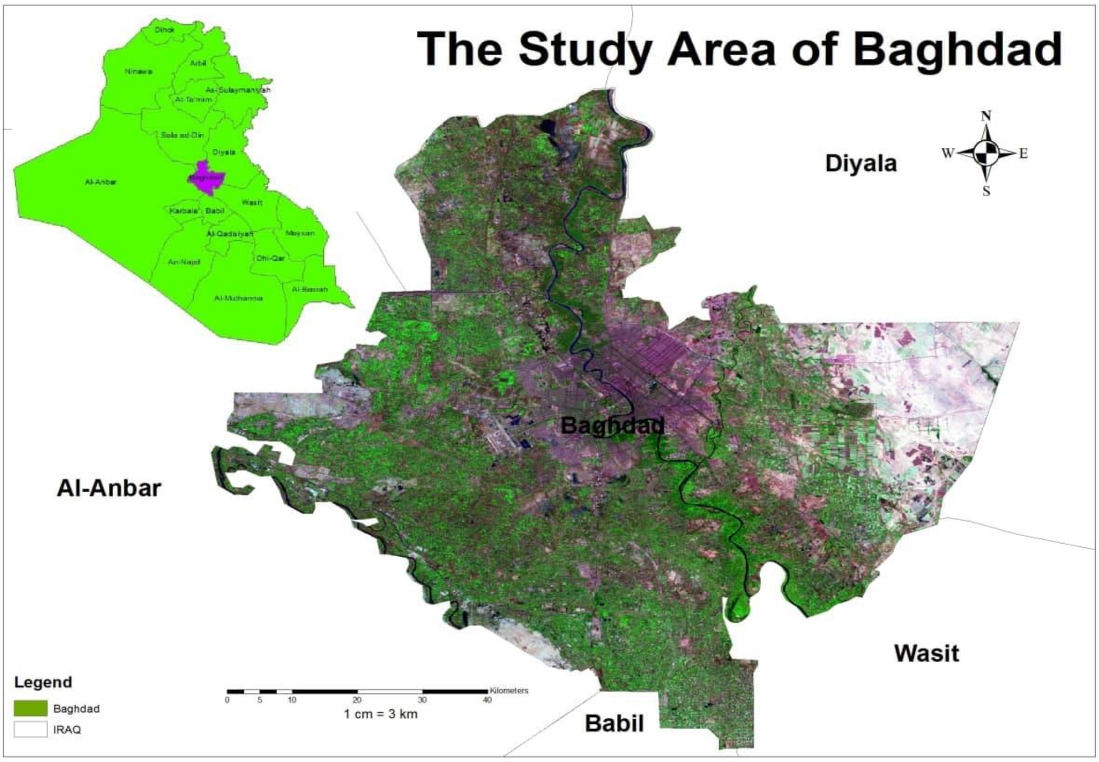


Figure -2 Study Area (Baghdad city, Iraq)

3. Satellite Image Processing and Methods

3.1. *Download satellite images*

The present study depends on the following available data, as listed in the table (1):

Downloads were performed from the Website of Geological Survey (USGS) Earth Explorer (https://earthexplorer.usgs.gov).

Table 1- Satellite images parameters for Baghdad city, [12&13]

parameters	2000	2010	2015	2017
Spacecraft Identifier	Landsat_5	Landsat_5	Landsat_8	Landsat_8
Collection Category	T1	T1	T1	T1
Data Type Level-1	TM_L1TP	TM_L1TP	OLI_TIRS_L1TP	OLI_TIRS_L1TP
Sensor Identifier	TM	TM	OLI_TIRS	OLI_TIRS
Map Projection Level-1	UTM	UTM	UTM	UTM
UTM Zone	38	38	38	38
Datum	WGS84	WGS84	WGS84	WGS84
Date	29/12	9/12	7/12	12/12
Resolution	30 m	30 m	30 m	30 m

3.2. Normalized Difference Vegetation Index (NDVI) Calculation

NDVI was used to distinguish vegetation cover from other types of land cover and determine its density. It also allows identifying and visualizing vegetation areas on the map as well as detecting abnormal changes in the growth process. Result in most plants having a green coloring (low reflection). A lot of green light is reaching human eye, because human eye sees a lot of plants. 0.4 to 0.7 µm chlorophyll in plant leaves is usable for photosynthesis. On the other side, the cell structure of the leaves gives plants a greater photosynthetic activity at a wavelength of 0.7 to 1.1 µm than at 1.0 µm. Digital processing methods for satellite images in the presentation of vegetation cover, is based on the fact that the plants exhibit high reflectivity in the wavelength range near infrared and low reflectivity wavelength range (red). It represents the ratio of the difference between the spectral reflectance at the near infrared wavelength and the red wavelength of their total [14]. Equation (1) is the formula that used to calculate NDVI [15].

$$NDVI = \frac{(NIR-Red)}{(NIR+Red)} \quad (1)$$

Table 2 shows an information of Landsat bands used Eq. (1). The NDVI values range between (−1 to 1). The dense vegetation refers to more positive NDVI value, and the surface without vegetation has a NDVI value close to zero or decreasing negative e.g. soil, urban and bodies of water [16].

Table 2- Information of Landsat bands

source	bands	Wavelength(µm)
Landsat 5(TM)	3 (Red)	0.631-0.692
	4(NIR)	0.772-0.898
Landsat8 (OLI)	4 (Red)	0.636-0.673
	5 (NIR)	0.851-0.879

3.3 Ratio Vegetation Index RVI

The Ratio images give a measure of the difference in reflectance of the same surface for two separate portion (bands) of the electromagnetic spectrum. The ratio of Red to NIR (bands 4 and 3, respectively for TM, ETM+, and OLI can be used because vegetation has a very high reflectance in the infrared wavelength and low in the red wavelength). This is useful for estimating the fractional portion of net radiation going into soil heat flux in energy balance**,** due to differences in solar elevation. The values of NIR & Red bands are average values for the reflectance curves at those wavelength intervals. In a ratio image the black and white extremes of the gray scale represent pixels with the greatest difference in reflectivity between the two spectral bands. The darkest signatures are areas where the denominator of the ratio is greater than the numerator. Conversely the numerator is greater than the denominator for the brightest signatures. Where denominator and numerator are the same, there is no difference between the two bands. Different types of vegetation and soil may have different index values. This index has a range of 0 to infinity, as shown in equation 2 [17].

$$RVI = \frac{NIR}{RED} \quad \mathbf{(2)}$$

Where:
NIR= is the near-infrared reflectance.
RED= is the red reflectance

4. Results and Discussion

The equation (1) was used to calculate the NDVI for each scene period, the results calculator in ENVI 4.8. Figure (3) shows the NDVI distribution for each period as in the captions.

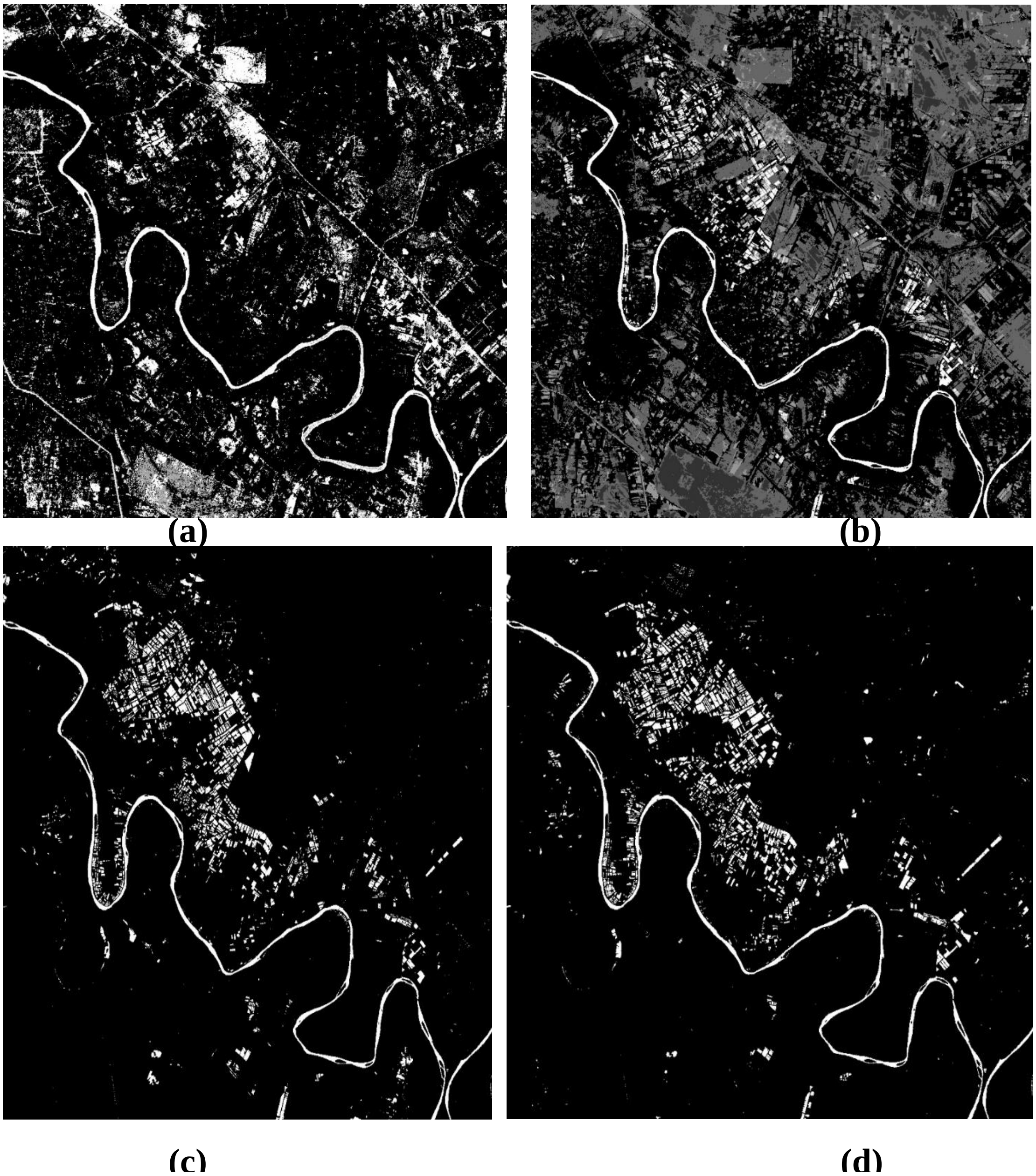


Figure -3 The NDVI distribution in (a) December 2000, (b) December 2010, (c) December 2015, and (d) December 2017

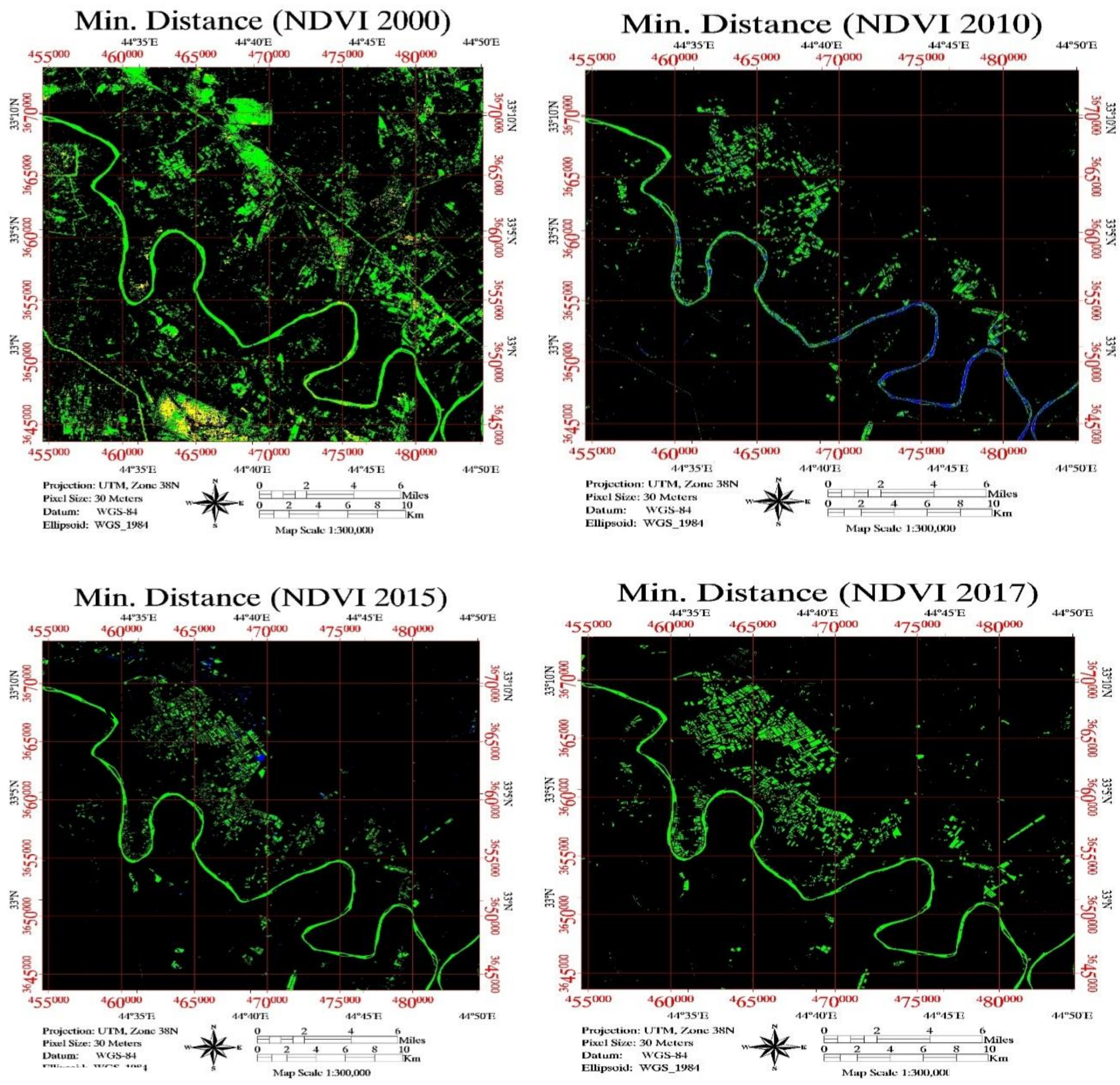
From a simple statistical calculation of the NDVI Images, areas of vegetation will be calculated for each period and shown in the table (2). Note that for all Landsat imagery that used in this research, the ground spatial resolution is 30 m, therefore each pixel in any image represent 900 square meter.

Table 2- The Vegetable Areas Calculation from the NDVI Images

Year	**Vegetation Area, Km^2**
2000	43.3125
2010	37.4675
2015	9.1881
2017	22.77495

Minimum Distance Classification uses training data to identify class means; classification is then done by assigning a pixel to the class with the closest mean. The minimum distance algorithm is also more granular than maximum likelihood classification since it is a faster technique. The minimum distance classifier is used to classify unknown image data to classes which minimize the distance between the image data and the class in multi-feature space. The distance is defined as an index of similarity so that minimum distance is identical to the maximum similarity [18].

The NDVI images are classified for 2000, 2010, 2015, and 2017 by using one of the supervised classification techniques, which is called minimum distance, as shown in Fig. (4). Figure (4) shows the classified images of two types of satellites (LANDSAT 5 and LANDSAT 8). In this study, the vegetation was generally studied where it is not classified specifically such as forests, mature plants etc. Hence, the river in the classified images is shown in Fig. (4) by green color due to it has a plants in it.



(c) (d)

egetation Universal Transverse Mercator (UTM

Geographical Coordinates

Figure 4-Minimum Distance Classification NDVI distribution in (a) 2000, (b) 2010, (c) 2015, and (d) 2017

5. Conclusion

For this research, the Landsat imagery (same spatial resolutions, and different sensors) were used from vegetation monitoring in the Baghdad city as region of interest for period from 2000 to 2017. The NDVI was used as a vegetation detector to estimate the changes in vegetation for the study area. The results show decrease and increase of the vegetation. The work methodology was executed using ENVI 4.8. The area of vegetation decreases from 2000 to 2015 due to the desertification and low precipitation as well as the dust storms. After 2015, the effects of above factors were decreased on that period due to many researches were done about the desertification in the Iraq, therefore the vegetation growing increased. Decrease in the vegetation growing can be clearly appeared by first look to NDVI results. The area for each period was calculated using the binary image extraction method.

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