Using Remote Sensing and GIS in Measuring Vegetation Cover Change from Satellite Imagery in Mosul City, North of Iraq

M. F. Allawai1, B. A. Ahmed2

1. Baghdad University, College of Science, Physics Department
2. Baghdad University, College of Science, Remote Sensing and GIS Department

*Corresponding author email: b_ali_ahmed@yahoo.com

Abstract

The aim of the study is the assessment of changes in the land cover within Mosul City in the north of Iraq using Geographic Information Systems (GIS) and remote sensing techniques during the period (2014-2018). Satellite images of the Landsat 8 on this period have been selected to classify images in order to measure normalized difference vegetation index (NDVI) to assess land cover changes within Mosul City. The results indicated that the vegetative distribution ratio in 2014 is 4.98% of the total area under study, decreased to 4.77% in 2015 and then decreased to 4.54% in 2016, after then decreased to 3.59% in 2017, then increased to 4.39% in 2018. Land cover change of the area was identified using Normalized Difference Vegetation Index (NDVI) technique. Highest NDVI value was found in 2015 (6.26%) which denotes presence of moderate-high vegetation cover at that time period. After 2015, highest NDVI value was found following a decreasing trend (6.05% in 2016 and 5.96% in 2018) which clearly represents the vegetation cover change in the study area, also Green Normalized Difference Vegetation Index (GNDVI) is studied in this paper. Statistical properties for NDVI and GNDVI were illustrated has been computed. From the results of this study one can clearly notice that there are the spatial variation in the vegetal cover from 2014 to 2018 in Mosul city, north of Iraq.

Keywords: Land Cover Change, Remote Sensing, NDVI, GNDVI, Mosul City, Landsat Satellite Imagery.
1. Introduction

Satellite imagery is an excellent way to monitor the earth's surface cover and the ongoing changes. Quick monitoring requires the application of certain techniques to distinguish the image style. Technologies are the use of change detection techniques. Change detection is the process of distinguishing differences in the case of objects or phenomena by observing them in different periods of time, including the ability to determine temporal effects using a multi-temporal data set [1]. Typically, change detection procedures must include data generated by the same mobile sensor on the satellite (like that) with the same spatial accuracy, spectral accuracy, and spectral radiation and to some extent at the same time of day [2]. The Normalized Difference Vegetation Index (NDVI) is the most accurate method of digital processing of spatial visualization in the presentation of vegetation. Where it is based on the fact that plants show a high reflectivity in the wavelength range near the red wavelength range [3]. The values of NDVI have a range of (-1 to +1). In general, the result is positive, indicating that the cell has a plant cover, and the higher the resulting positive value, the greater the plant's greenery and density and vice versa with regard to the negative values that indicate the non-green surface parameters. Therefore, the evidence of vegetative differences is used to distinguish between diseased and healthy plants [4]. The major objectives of the study are to assessment vegetal cover changes of the studied area using Normalized Difference Vegetation Index (NDVI), Green Normalized Difference Vegetation Index (GNDVI) for the period (2014-2018).

2. Description of the studied area

The area of study in this research included the city of Mosul as shown in figure 1, which lies within the boundaries of the province of Nineveh, Mosul is located 400 km (250 miles) north of Baghdad, located on the west bank of the Tigris River, the number of the population of Mosul, according to estimates in 2003 about 1.4 million people, while believed that the current number of approximately 1.376 million people. In this research, Landsat 8 satellite data were used for the Operational Land Imager (OLI) and eleven spectral channels and during the time period of 2014/6, 2015, 2015, 2016, 2017 and 2018 within coordinates 424949°19. E, 363737°48 " N.
3. Data and Methodology

The basic concepts, available imagery sources and classification techniques of remote sensing imagery related to vegetation mapping were introduced, analyzed and compared. Vegetation cover mapping were provided to iterate the importance of thorough understanding of the related concepts and careful design of the technical procedures, which can be utilized to study vegetation cover from remote sensing imagery [5]. Table 1 illustrates Landsat 8 provides metadata of the bands such as type of sensors, channel spectral etc., which have been used to obtain the results of this study.

Table 1. Some of the information and Landsat-8 imagery used in this study.

| Type of sensor        | Channel Spectral | Georeferencing         | Date         |
|-----------------------|------------------|------------------------|--------------|
| Operational Imager    | 4                | PATH=170, ROW=037      | 2014/06/09   |
| Land (OLI)            |                  |                        |              |
| Operational Imager    | 5                | PATH=170, ROW=037      | 2014/06/09   |
| Land (OLI)            |                  |                        |              |
| Operational Imager    | 4                | PATH=170, ROW=037      | 2015/06/12   |
| Land (OLI)            |                  |                        |              |
| Operational Imager    | 5                | PATH=170, ROW=037      | 2015/06/12   |
| Land (OLI)            |                  |                        |              |
| Operational Imager    | 4                | PATH=170, ROW=037      | 2016/06/14   |
| Land (OLI)            |                  |                        |              |
| Operational Imager    | 5                | PATH=170, ROW=037      | 2016/06/14   |
| Land (OLI)            |                  |                        |              |
| Operational Imager    | 4                | PATH=170, ROW=037      | 2017/07/19   |
| Land (OLI)            |                  |                        |              |
| Operational Imager    | 5                | PATH=170, ROW=037      | 2017/07/19   |
| Land (OLI)            |                  |                        |              |
| Operational Imager    | 4                | PATH=170, ROW=037      | 2018/07/17   |
| Land (OLI)            |                  |                        |              |
| Operational Imager    | 5                | PATH=170, ROW=037      | 2018/07/17   |

The ratio between the spectral reflections at the near-infrared wavelength (0.85-0.88) μm and the red wavelength (0.64-0.67) μm on their total is calculated using the following equation [6]

\[
\text{NDVI} = \frac{\text{NIR} - \text{visible Red}}{\text{NIR} + \text{visible Red}} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (1)
\]
Figure 2 shows that NDVI is calculated from the visible (red) and near-infrared light reflected by vegetation. Healthy vegetation (left) absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation (right) reflects more visible light and less near-infrared light. The numbers on the figure above are representative of actual values, but real vegetation is much more varied. Figure 2. Shows the scientific meaning of the vegetation cover guide [7].

In this study, the ratio of vegetative cover was determined in the city of Mosul based on satellite images of Landsat 8, and figure 3 illustrates the work steps followed in this research.

3.1 Image Classification

Reflections measured by satellite sensors depend on the local characteristics of the earth's surface. Multi-spectral image classification is an important step in the extraction of thematic

\[
\text{NDVI} = \frac{(\text{NIR} - \text{Visible RED})}{(\text{NIR} + \text{Visible RED})}
\]

\[
\text{GNDVI} = \frac{(\text{NIR} - \text{Visible Green})}{(\text{NIR} + \text{Visible Green})}
\]

% Calculation using ArcGIS 10.1 of each items

Figure 3. Show the flowchart of the methodology
information from satellite images [8]. The aim is to automate this as much as possible by using suitable image processing and image analysis software. A variety of classifications methods exists. The general purpose of digital classification is to automatically make all pixels in land use categories or categories. Multi-spectral data are usually used for this classification. The digital classification process is an important basis in the study of land use and land cover. The classification process is based on the numerical values of the multiple domains and is based on two types of classification: supervised classification and unsupervised classification, in each method, there is a special method of training, the process by which the computer operates with classification controls such as the number of categories and the statistical criteria for each category [9]. The use of the method used to carry out the classification process requires the Training samples for each species expected to be in the area under study. In this method, each unit of the image is classified on the basis of the degree of convergence and matches with the training samples in terms of spectral response and some statistical calculations. There are several methods of the categorization of the vector, has been used in this research one of these methods called maximum likelihood classification that method of classification The amount of correlation and variation of the spectral response of the training samples is calculated together, and on the basis of which the unknown pixels are distributed to those known categories. In order to do this properly, the method is based on the assumption that modules of training are distributed systematically. That the regular imposition in the distribution of these units must be for all spectral channels used, thus, the spectral value and matrix of difference and correlation can be calculated for each set of training samples used. The many calculations that this method relies on to classify each unit of the image is the only thing in this way that makes it slow to implement and expensive compared to other methods, yet it achieves high accuracy results [10]. The classification process is a representation of the data of the studied phenomenon (vegetation) according to its real location and depends greatly on the extent of similarity or difference between the values of the elements of the phenomenon, i.e. the extent of self-correlation between the elements of the phenomenon. The function of spatial analysis of the important functions in the information system, this function is used to create maps showing the vegetation cover in the study area [11]. Figures (4, 5) show classification of satellite image using Maximum likelihood classifier for a period (2014-2018) in Mosul city. The Landsat images were classified into four classes represent water, vegetation, soil and urban areas.
From the previous figures, the blue color represents the water (the water bodies and the rivers), the green color represents the vegetation, the yellow color represents the soil and the gray color represents the urban.

Figure (4, 5) shows that the results of the vegetation index calculation for the period (2014-2018). The areas falling to the north-west and the south -west of the study area was a good plant density (large vegetation cover) with values ranging from 4.98% to 4.39%. From this figure, it is found that high density was only present in 2014. After that due to anthropogenic disturbances or other related reasons, this area started to lose the vegetation cover, from 2015 to 2017 caused losses in soil productivity (decline of soil quality) is cumulative. Thus, the

Figure 4. Shows classification of satellite image using Maximum likelihood classifier for a period (2014-2018)

Figure 5. Show the land-cover classification for Mosul city for period 2014 to 2018
highest value found was 4.39% for 2018. This clearly shows the conversion of moderate-deep vegetation cover to low or low – moderate vegetation cover from 2014-2018 time period.

3.2 Normalized Difference Vegetation Index

The normalized difference vegetation index (NDVI) is the most extensively used satellite index of vegetation health and density [12, 13]. The NDVI is an index used to identify vegetation and its health through the levels of chlorophyll detected in the leaves. Healthy vegetation absorbs most of the incoming visible, and reflected a large portion (about 25%) of the near infrared (NIR) light, but a low portion in the red band (RED). Unhealthy or sparse vegetation reflects more visible light and less NIR light [14]. In this section, the NDVI technique is used for extracting the various feature presented in the three band satellite image (GREEN, RED and NIR), the NDVI is a simple numerical indicator that can be used to analyze the remote sensing measurements, from a remote platform and assess whether the target or object being observed contains live green vegetation or not, from the equation (1). Vegetation index is calculated by using the reflectance in the red and near infrared bands [15]. The range is theoretically between -1 and +1, where increasing positive values indicate increasing green vegetation and negative values indicate non-vegetated surface features such as water, barren land, ice, snow, or clouds [16]. It should be noted, that the information obtained from NDVI data is mostly used qualitatively, in relation to other NDVI data, e.g. to monitor vegetation over time, or to compare different regions with similar characteristics. The magnitude of NDVI is indicative of the level of photosynthetic activity in the vegetation being monitored. The basic NDVI image gives an indication of where vegetation is present and active, but has limited value beyond that [8].

The results of NDVI have a range from (-1 to 1). In general, the result is positive, indicating that the cell has a plant cover. The higher the resulting positive value, the greater the vegetation and density of the plant. The opposite is true for the negative values that indicate the non-green surface parameters. Therefore, the evidence of vegetative differences is used to distinguish diseased and healthy plants. Figure (6) shows NDVI images for study area. These images display blue area (low value NDVI) which represents no vegetation such as water and other region; while green area (high value NDVI) represent high vegetation such as agriculture land.
3.3 Green Normalized Difference Vegetation Index

Green Normalized Difference Vegetation Index (GNDVI) a variation of NDVI has been developed which uses the green band on of the electromagnetic spectrum rather than the red band. This is referred to as Green Normalized Difference Vegetation Index (GNDVI), defined by [17]:

\[
\text{GNDVI} = \frac{\text{NIR} - \text{Green}}{\text{NIR} + \text{Green}} \tag{2}
\]

The benefit of GNDVI over NDVI is that the green band can cover a broader range of chlorophyll in plants than the red band. This applies to mature plants and can be useful for monitoring yield crop in the late growing season. Figure 7 shows the green vegetation index to highlight the change in vegetation. It was noted that there is a difference between the values of the green vegetation index and values of classification of the satellite images taken with the dates mentioned above.

**Figure 6.** The image resultant by applying NDVI method from 2014 to 2018
Figure 7. The image resultant by applying GNDVI method from 2014 to 2018

Figure 8 shows the statistical comparison between NDVI and GNDVI for the period (2014-2018).

Figure 8. The statistical of NDVI and GNDVI percentage results of the vegetal regions.
The distributions of NDVI and GNDVI in Mosul city for the period 2014-2018 showed the variations of density vegetation due to change in surface area of the water body of the study area represented by Mosul Lake.

4. Conclusions
From the results of this work, several concluding remarks can be drawn and are summarized as follows: The results of satellite image using Maximum likelihood classifier show that vegetation cover decreased from 4.98% in year 2014, 4.77% in year 2015, 4.54% in year 2016, 3.59% in year 2017 and then increased to 4.39% in 2018. While water decrease about 0.4%, 0.38%, 0.27%, 0.48%, and 0.28% for years 2014, 2015, 2016, 2017 and 2018 respectively. Urban area decreased about (16.02 -11.92) % during the period (2014-2016), after that increase when re-reconstruction of building in Mosul city. The (NDVI) and (GNDVI) has been found to be a good indicator for vegetation and land use/land cover changes, and gives the same behavior about the increasing of vegetal cover but the value of the NDVI is greater than the value of GNDVI. This increase can be attributed to interest of people in the cultivation of arid lands and increases the water of the Mosul city for these years. The statistical relationship between NDVI and water area reflected by significance the effective of NDVI as an indicator of vegetation-moisture conditions for Mosul city. Normalized difference vegetation index (NDVI) depends of spectral reflectance of land use cover so the low value of NDVI which represents no vegetation such as water, soil and urban area; while green color area represent high vegetation such as agriculture land and vegetation.

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