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USING REMOTE SENSING DERIVED INDICES TO MONITOR VEGETATION COVER CHANGES OF BABYLON

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Abstract

Vegetation is critical for ecosystem, energy balance, biochemical cycles of water, carbon, nitrogen and the monitoring of its changes are essential for maintaining environmental quality. This study aims to evaluate the potential of using Normalized Difference Vegetation Index (NDVI), Soil-adjusted Vegetation Index (SAVI) and Normalized Difference Water Index (NDWI) to monitor vegetation cover change over Babylon governorate for the period of 2000-2016. The study focused also on minimizing the effects of soil background by using the standard adjustment factor L=0.5 and improving vegetation canopy spectra. A Moderate Resolution Imaging Spectroradiometer (MODIS) of spatial resolution 250 m was used to derive NDVI, SAVI and NDWI indices. The NDVI values were strongly responded to seasonality with highest NDVI values during winter and spring periods in compared with the lowest values during the 5-months summer period from May to September. The shape of NDVI and SAVI trend was quite parallel and SAVI values were more than NVDI values for the seventeen studies years. The results showed that NDWI was more sensitive to the vegetation cover variation in compared to NDVI and SAVI. According to NDVI, SAVI and NDWI values, 2004, 2006, 2013, 2014 and 2016 were high density of vegetation cover with highest values in 2014. While years of 2000, 2005, 2008, 2009 and 2012 were low vegetation cover with lowest values in 2000. Calculation of NDVI anomaly proofed as a useful for monitoring vegetation cover change over large area further to measure the range of vegetation biomass variations in reference to the standard deviation of the previous years.

Key words : Remote sensing Indices, Vegetation cover changes, NDVI, NDWI, Soil adjusted Vegetation Index (SAVI).

Introduction

Vegetation cover change is vulnerable to several factors of population growth, climate change, land use and pollution. Under the field -oriented vegetation cover monitoring studies, sampling and the vast amount of needed information are the main limitations of any applied monitoring system. Remote sensing can resolve such limitation of the repeated measurements or observation to evaluate changes or continuation of any natural resources or phenomena over a large geographic area (Ouattrochi and Pelletier, 1991). The Normalized Difference Indices like Vegetation and water indices (NDVI and NDWI) are the most commonly used at a wide range of applications. NDVI is an index of photosynthetic activity, where the active vegetation absorbs most of red spectrum and the stressed vegetation reflects more red spectrum (Tucker, 1980). The another remote sensing derived index NDWI is strongly related to the vegetation canopies water contents and sensitive to changes in vegetation moisture conditions (Chen *et al.,* 2005). The reflectance at NIR is affected by the internal leaf structure, while the reflectance at SWIR is affected by both water content and the structure of the spongy mesophyll in vegetation canopy Ceccato *et al.* 2002). The NDWI sensitivity to detect the changes in water contents valuables its usefulness for drought monitoring studies compared to NDVI, which does not directly responding to vegetation greenness (Jackson *et al.,* 2004, and Gu 2007). Satellite-derived indices have recently verified as effective and practical solutions to monitor the vegetation cover status and overcome the limitations of observing and analysis of field-oriented researches (Tucker, 1980, Ceccato *et al.* 2002, and Gu *et al.* 2007). Whether in the assessing or monitoring, Satellite-derived indices have seen widespread use in vegetation dynamic, biomass production, vegetation degradation studies, land cover classification, soil moisture and carbon sequestration or CO_2 flux (Reeves 2001, Kurtz *et al.* 2009, Wang 2004 and Wylie *et al.* 2007). Despite of its importance in rangeland monitoring studies, NDVI values affected by many factors like total plant cover, plant and soil moisture and bare ground cover. In an attempt to overcome these limitations, numerous studies incorporated different vegetation indices to represent the vegetation status, while others developed an index that accounted soil brightness influences like Soil Adjusted Vegetation Index (SAVI) (Huete 1988 and Kurgat 2011). Accurately monitoring real time spatio-temporal vegetation cover change may provide decision makers timely information for effective planning (Gu *et al.* 2008). Thus, this study aims to evaluate the role of: incorporating satellite-derived indices (NDVI and NDWI) and soil brightness correction (SAVI) to improve the capability of satellite-derived indices for monitoring of vegetation cover change of Babylon.

Materials and Methods

Babylon governorate has been selected as a study area. Geographically, Babylon is situated in the middle of Iraq, within 33º and 32º north latitude and 45º and 44º east latitude. It has a flat topography with annual rainfall between 50 and 200 mm. Euphrates is the main source of irrigation, where the governorate is famus with wheat, barely, maize cotton and sesame cultivation, as well as vegetable crops. Babylon occupies 1.3% of the total area of Iraq and comprises four districts of Hilla, Mahaweel, Musayyib, Hashimiya.

The Moderate Resolution Imaging Spectroradiometer (MODIS) data were used in this study due to freely downloaded at a wide range of wavelengths in 36 spectral bands. The MOD44 16-day composite 250 meter spatial resolution for the period from 2000 to 2016 data were georeferenced and acquired from the United States Geological Survey (USGS) database. The acquired images were used to calculate the NDVI, NDWI and SAVI indices. The ArcGIS ver. 10.1 software was used for processing and indices calculations according to the following equations:

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

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR} \quad (2)$$

$$SAVI = \frac{NIR - RED}{NIR + RED} \times (1 + L) \quad (3)$$

Where: NIR is the Near Infrared, RED is the red and SWIR is the short *infrared.* L is the soil brightness correction factor with value varies by the amount of vegetation cover: L=0 in very high vegetation regions; L=1 in areas with no vegetation regions and L=0.5 is the default value works well in most situation with moderate vegetation cover (Tucker 1980, Huete 1988 and Gao 1996).

Results and Discussion

The results of evaluation Babylon annual- vegetation cover trend in the basis of NDVI are shown in the fig. (1), where the trend is calculated for 12 months of each studied year from 2000 to 2016. The NDVI values showed wide variations, where the highest-vegetation cover were during winter and spring periods in compared with the low-vegetation cover during the 5-months summer period from May to September. The highest-vegetation cover were in March with average NDVI value of 0.292 and the lowest- vegetation cover were in Jun and July with NDVI values of 0.2 and 0.195 respectively. This monthly patterns of change are attributed to the seasonality, where the vegetation cycle closely responds to the climatic variability (Anyamba and Eastman 1996, Saleska *et al.* 2007, Helldén and Tottrup 2008 and Erasmi *et al.* 2009).

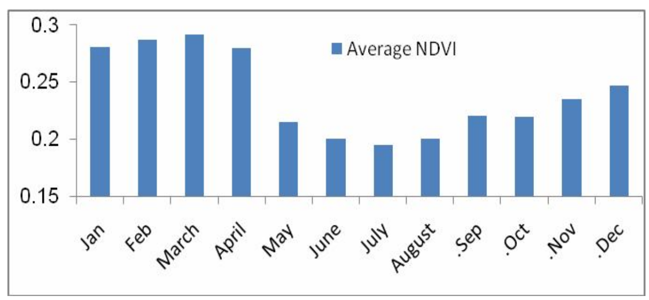

Fig. 1: Average monthly NDVI over Babylon governorate for the period from 2000 to 2016.

The average in each of the studied years for the three different indices: NDVI, NDWI and SAVI are presented in fig. 2. The shape of NDVI and SAVI is quite parallel and SAVI peak is much higher and sharper than NDVI peak. The improvement of SAVI over NDVI was to extract the influence of the soil background on the spectral reflectance. At constant L of 0.5, which is much larger than red reflectance the SAVI values increased compared to NDVI with keeping behaved like the NDVI. The considering of the soil noise is important to improve the vegetation indices to exclude the differences unrelated to the vegetation cover signals. This verifies work of SAVI to reduce the soil background reflectance and increasing the vegetation dynamic responses was done by numerous studies (Alsdorf 2007, Almutairi *et al.* 2013, Kurgat *et al.* 2014 & Vani and

Mandla 2017). In the case of NDWI, the obtained values allow a clear view of the vegetation cover changes of the whole studied period from 2000 to 2016. The NDWI was more responsive than NDVI to the variation of the vegetation cover, where the variation between 2002 and 2003, 2004 and 2006, 2010 and 2011 are clearly observed in fig. 2. The NDWI value decreased noticeably more in 2000 compared to the other years. The main importance of NDWI is removing the variations stimulated by leaf dry matter content, which improving the accuracy of viewing the variation in vegetation conditions (Ceccato *et al.* 2002 and Gu *et al.* 2007). That explains how NDWI allowed a clear view of the difference between years that were much like in NDVI and SAVI values.

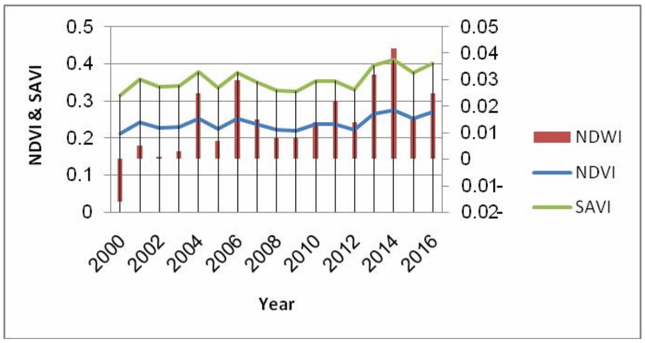

Fig. 2: The vegetation change trends in different indices NDVI, NDWI and SAVI over Babylon for the period of 2000-2016.

Monitoring of vegetation cover change is strongly related to measure a deviation from normal behavior, where the quantitative measure is how each year difference from the reference conditions. Anomalies can be calculated as absolute, relative and standardized difference between current value and the average of previous years. The comparison of NDVI anomaly is generally done based on the reference level: a previous, good or bad year or the average of the previous years, where the period is bounded by data availability (Rembold *et al.* 2010 and Rojas *et al.* 2011). Fig. 3 gives a summary of the variation of NDVI anomalies for the studied period (2000-2016). The Babylon governorate had major

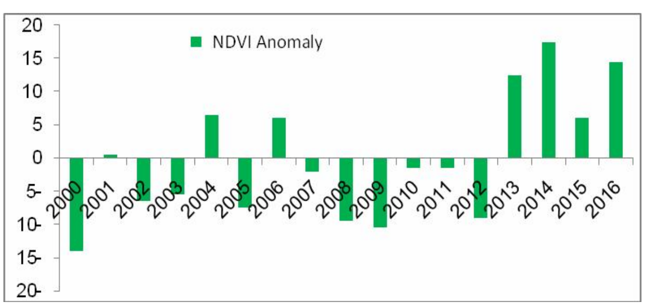

Fig. 3. Annually NDVI anomalies over Babylon for the period of 2000 - 2016.

negative anomalies in 2000, 2002, 2003, 2005, 2007, 2008, 2009 and 2012 with strong negative anomalies in 2000 and 2008, 2009 and 2012. Other notable years of strong positive anomalies are 2013, 2014 and 2016 with values of 12.5, 17.5 and 14.5, respectively. The NDVI anomaly is determined based on the standard deviation of the 17-years set of data to picture the data's anomaly size when compared to the standard deviation value of the studied period. NDVI detects the unnatural variations in vegetation cover, which may be practical tool to monitor vegetation cover change in responding to different factors.

Conclusion

This study verified that remote sensing-derived indices are very attractive for seasonal and inter-annual vegetation cover variations. A MODIS data is suitable for monitoring vegetation cover changes since the data can be easily accessed and well established to extract vegetation information for different applications. Empirically, soil background is one of the several factors that effect on NDVI value. The results showed that SAVI minimizes soil influences from vegetation index NDVI and excluding the differences unrelated to the vegetation cover signals. The used indices NDVI, SAVI and NDWI are characterized by their ease of calculation and can be an alternative in the monitoring of vegetation changes with taking into account the type and resolution of the data for this study.

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