STVI calculating the changes in vegetable cover for a vegetated environment in west Iraq

Taghreed A.H. Naji[1], Nawal K. Ghazal[2], Hanaa I.Ali[2]

[1]Department of Physics, College of Education for Pure Sciences Ibn Al-Haitham, Baghdad

[2]Department of Physics, College of Sciences, Baghdad University, Baghdad, Iraq

E-mail: han.iali65@yahoo.com

Abstract

Remote sensing provide the best means to monitoring change in vegetation over a wide range of temporal scales over large areas. In this study, the vegetation index which has been applied known as the Stress Related Vegetation Index (STVI) on in the area around the Euphrates River and part of Al-Habbaniyah lake which located at western side of the river in Ramadi city, Al-Anbar province at Iraq to study the vegetation cover changes and detect the areas of changes, using two satellite sensors multispectral images such as TM and ALI, after geometric correction procedure to rectifying these images. The STVI-4 index result was the best than other vegetation indices (STVI-1 and STVI-3) to discriminate the vegetable cover distribution. The differencing image and statistical characteristics have been implemented to delineate and calculate the areas of changes in agriculture land.

Key words

Remote Sensing, Vegetation Indices, STVI Indices, Change Detection.

Article info.

Received: Mar. 2014
Accepted: Jun. 2014
Published: Sep. 2014

تقدير مؤشرات النباتات المتعلقة بالاجهاد (STVI) لِحساب التغييراتِ في الغطاءِ النباتي، لبيئةِ مزروعةِ في غرب العراق

تغريد عبد الحميد ناجي[1], نوال خلف غزال[2], هناء اسماعيل علي[2]

[1]قسم الفيزياء، كلية التربية للعلوم الصرفة ابن الهيثم, جامعة بغداد

[2]قسم الفيزياء، كلية العلوم, جامعة بغداد

الخلاصة

تقانات الاستشعار عن بعد توفر افضل وسيلة لرصد التغير في الغطاء النباتي على نطاق واسع من المديات الزمنية ولمساحات واسعة. تم في هذه الدراسة, تطبيق مؤشرات الغطاء النباتي الذي يعرف باسم تقدير مؤشرات النباتات المتعلقة بالاجهاد (STVI) على المنطقة حول نهر الفرات وجزء من بحيرة الحبانية الواقعة الى الجانب الغربي من النهر في مدينة الرمادي, محافظة الانبار في العراق لدراسة تغيرات الغطاء النباتي والكشف عن مناطق التغير, باستعمال اثنين من صور متعددة الاطياف لمتحسسات الاقمار الصناعية مثل TM و ALI, بعد اجراء التصحيح الهندسي لهذه الصور. وقد وجد من النتائج ان مؤشر النبات (STVI-4) كان الافضل من بقية مؤشرات النباتات (STVI-1 وSTVI-3) في الكشف عن توزيع الغطاء النباتي. تم تطبيق صورة الفرق والخصائص الاحصائية مثل المتوسط والانحراف المعياري لتحديد وحساب مساحات التغير للغطاء النباتي.

Introduction

One of the most common applications of remote sensing is vegetation assessment and monitoring via vegetation indices. However, most of the widely used vegetation indices appear to be less applicable in arid and semi-arid lands of Iraq. Indices those are less dependent on infrared response, such as the Perpendicular Distance (PD54) and Soil Stability Index (SSI) have been shown to be more appropriate spectral indices in Iraq arid and semi-arid lands [1].

Vegetation indices combine reflectance measurements from different points of the electromagnetic spectrum to provide information about vegetation cover on ground. Healthy green vegetation has distinctive reflectance in the visible and near-infrared regions of the spectrum. At visible and in particular red wavelength, plant pigments strongly absorb the energy for photosynthesis, whereas in the near-infrared region, the energy is strongly reflected by the internal leaf structures. This strong contrast between red and near-infrared reflectance has formed the basis of many different vegetation indices involve numeric combinations of the sensor bands that record land surface reflectance at various wavelengths [2].

The numerous vegetation indices have been proposed, modified, analyzed, compared and classified. These have been grouped into four types including slope-based, distance-based, orthogonal transformation and plant-water sensitive vegetation indices on the basis of the spectral bands they used and the means by which these are combined [3].

Remotely sensed data has been applied successfully to the assessment and monitoring of vegetation cover, land degradation, forestation and deforestation, floods, fire and many other applications. The reason for using this technology in environmental studies is that it can provide calibrated, objective, repeatable and cost-effective information for broad regions and it can be empirically related to field data such as vegetation cover, collected by ground-based method. Due to the importance of vegetation cover in the determination of land condition, a large number of remote sensing techniques have been suggested and used to extract vegetation information from remotely sensed images [4].

Multispectral medium-resolution satellite imagery is one of the most widely used forms of remote sensing data for many environmental applications. The availability of extensive archives of this imagery makes it suitable for broad-area operational monitoring programs. All the images were acquired in dray seasons to minimize the contribution of green ephemeral vegetation, maximize solar irradiance and land surface reflectance and also exclude cloud cover from the imagery. The Hyperion sensor is the first hyperspectral imager on-board NASAS Earth Observing -1 (EO-1) satellite that was launched on 21 November 2000. The EO-1 satellite follows the same orbit as Landsat 7 by about one minute. The spatial resolution of Hyperion is 30 m and standard scene is 7.7 km wide and 42 km long [5].

This research presented three of plant-water sensitive vegetation indices group, such as STVI-1, STVI-3 and STVI-4 to detect and evaluate the vegetable cover for the Ramadi city west of Iraq.

Study area and available data

The research in this paper addresses the study area above of the site Al-Habbaniyah Lake, the western side of the Euphrates River located in Ramadi city lie in Al-Anbar province. The available data for this region were used to illustrate the effect of performing STVI indices are multi-temporal satellite images with different sensors are shown in Fig.1-(a). The first is Thematic Mapper (TM) exposure at 4 of March 1990 onboard Landsat-5 satellite, composed of 7 packs, and the second is Advanced Land Imager (ALI) exposure at 16 of March 2003 onboard the Earth Observer-1 (EO-1) satellite, composed of 10 packs, respectively.

These temporal images were geometrically corrected and previewed, then followed by smaller size extracted were (738 × 1027) pixels with three bands combination (R: 5, G: 4, and B: 3) and (R: 9, G: 6, and B: 5), with the same spatial resolution of (30 m) for all these spectral bands. This area includes a diversity of land cover classes interspersed with large areas of cultivated, bare and land. While several rural lands cover types of cultivated vegetation such as crops, and grass, also pasture land and characterize the surrounding landscape.

Methodology of work

1- Geometric correction

The geometric distortion of the satellite image can be occurred according to many reasons. It can be divided into systematic and non-systematic (or random) distortion. It is necessary to correct before using. The precision of geometric correction depends on the ground control points (GCPs). Image to image registration is a procedure to determine the spatial best fit between two images that overlap the same scene. In the sake of two images for the same scene cannot be meaningfully compared.

Typically image registration is carried out by tying together points (GCPs) on a target image and a reference image or map. The transformation is a least squares solution it is given by the following equation [6]: Calculate new output pixel locations and relate image location to map location using "mapping polynomial" functions

$$X' = a_0 + a_1X + a_2Y + a_3XY + \ldots\ldots + a_n x^n$$

$$Y' = b_0 + b_1X + b_2Y + b_3XY + \ldots\ldots + b_n Y^n$$

Using these mapping functions calculate correct map locations (X' ,Y') for input pixel locations (X,Y) Before applying the coefficients to create the rectified output image, it is important to determine how well the transformation derived from the least-squares regression of the GCPs account for the geometric distortion in the input image. The method used most often involves the computation of the root-mean-square error (RMSerror) for each of the ground control points. The greater the number of points used to define the transformation, the more accurate the transformation is within the net of points.

2-The stress related vegetation indices (STVI)

This study reviewed and tested the different groups of the STVI vegetation indices and found that the STVI-4 performed better than other indices in this vegetate environment of a Ramadi city and part of Al-Habbaniyah lake. They appear the STVI indices such as (STVI-1 and STVI-3) to be less sensitive than STVI-4 index to different soil and vegetation types. Thus, this study proposes STVI-4 index as an appropriate adjunct to field methods in assessing and monitoring of vegetation condition. This index can be applied to images from different times to detect changes in vegetation cover over time.

This index is a variant of plant-water sensitive group, and was designed to respond positively to increasing vegetation response, whereas the existing STVI indices, such as (STVI-1 and STVI-3) decrease with increasing vegetation influence, they were calculated using equations (2, 3 & 4) [7].

$$STVI\_4 = NIR - (RED \times MIR) / (NIR + MIR) \qquad (2)$$

$$STVI\_1 = (MIR \times RED) / (NIR) \qquad (3)$$

STVI_3 = (NIR) / (RED + MIR) (4)

where:

STVI_4 represents Stress Related Vegetation Indes-4.

STVI_1 represents Stress Related Vegetation Indes-1.

STVI_3 represents Stress Related Vegetation Indes-3.

NIR represents near- infrared (band 4) for Landsat TM data, and (band 6) EO1 ALI data.

RED represents red (band 3) for Landsat TM data, and (band 5) EO1 ALI data.

MIR represents middle-infrarad (band 5) for Landsat TM data, and (band 9) EO1 ALI data.

Experimental results and discussions

Geometric correction (image to image) is applied at two satellite images to enable comparison of images from different dates and accurately relates image values to field and other spatially referenced data. After collecting ground control points (GCPs), which can be transformed or warp the raster to map coordinates. Warping uses a mathematical transformation to determine the correct map coordinate location for each cell in the raster. For a first order polynomial model, a minimum of three ground control points is required to calculate the model. In practice, it is better to collect more than three (such as seven) points. The polynomial model is the simplest model and can handle most of the dereferencing requirements. A first order polynomial transformation will shift, scale and rotate your raster. It can be used to rectify scanned maps or satellite images on flat areas. The final Root Mean Square Error (RMSE) for these points is 0.3 pixels, as shown in Table1 and Fig. 1-(a).

Of the STVI indices evaluated, the STVI-4 was a good index to detect and predict of the vegetation changes, it performed better improvement than other STVI indices, and it appears to overestimate the amount of vegetable cover for study area. Because it had positive relationships and showed to very high correlation with vegetable cover, so it was better to interpret than the negative correlations of STVI indices.

For Fig. 1-(b), the STVI-4 index for TM_1990 image is showing decrease of vegetable cover distribution, this decrease can be seen clearly at the boundary shared around (white color in these images) this indicates that the scarcity of water in a certain period and the bad management have been the main reason for this vegetation decrease, generally, the vegetation area is 138.52 km^2 and the vegetable cover about is 22.50 %, as indicator in Table 2. While, STVI-4 index for ALI_2002 image is producing very high increase of vegetable cover, apparently there was an increase in the water level, which led to a clear increase of agriculture land, and this gives the explanation of change detection image has been showed this increase in vegetable cover as shown in Fig.1-(d), it contained agriculture areas about 167.82 km^2 and 27.26 %. Changes in the vegetable cover have been highlighted by subtracting STVI-4 index for TM_1990 image from it for ALI_2002 image, it emerges that increased in vegetable cover. As can be seen from Fig.1-(c), this index shows the same values in the two multi-temporal binary images due to the same vegetation and soil types, which were equal to (185).

The study has been performed and built using ArcGIS9.3, ENVI 4.5, ERDAS.8.3 software's and MATLAB7.9b language.

.

Table 1: Al habbaniyah Lake Region Registration Parameters.

Total (RMS) Error = 0.312 m							
GCP No.	*Base TM Scene, 1990*		*Warp ALI Scene, 2003*		*Error (meter)*		*RMS Error (meter)*
	X	**Y**	**X'**	**Y'**	**X**	**Y**	
1	**233.00**	**300.00**	**278.00**	**321.00**	**0.25**	**-0.13**	**0.28**
2	**82.00**	**302.00**	**135.00**	**322.00**	**0.00**	**0.62**	**0.62**
3	**148.25**	**7.75**	**197.50**	**43.25**	**-0.06**	**-0.22**	**0.23**
4	**317.75**	**30.50**	**358.25**	**65.00**	**-0.02**	**0.06**	**0.06**
5	**847.00**	**420.00**	**861.00**	**435.00**	**-0.04**	**0.07**	**0.08**
6	**969.00**	**561.50**	**977.00**	**569.00**	**0.01**	**-0.02**	**0.03**
7	**108.00**	**444.00**	**160.00**	**458.00**	**-0.14**	**-0.37**	**0.39**

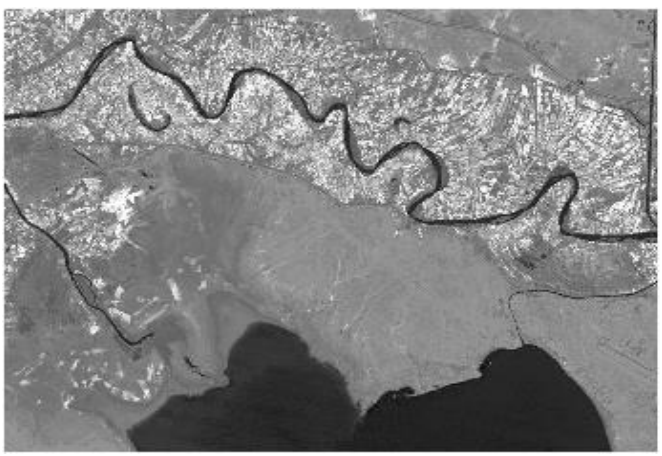
Table 2: Characteristics of STVI-4 vegetation indices for both TM & ALI Satellite images.

Data	*Date*	*Agriculture area*	*Agreculture cover %*	*Mean*	*Stander deviation*
TM	**1990**	**138.52 km^2**	**22.50**	**25.57**	**74.38**
EO1	**2003**	**186.04 km^2**	**30.227**	**49.46**	**98.94**
Change detection image	**167.82 km^2**		**27.26**	**36.08**	**86.68**

TM satellite image 1990

ALI satellite image 2003

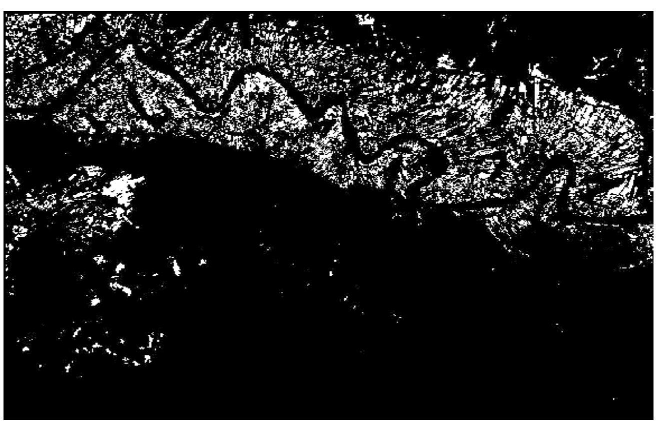
a



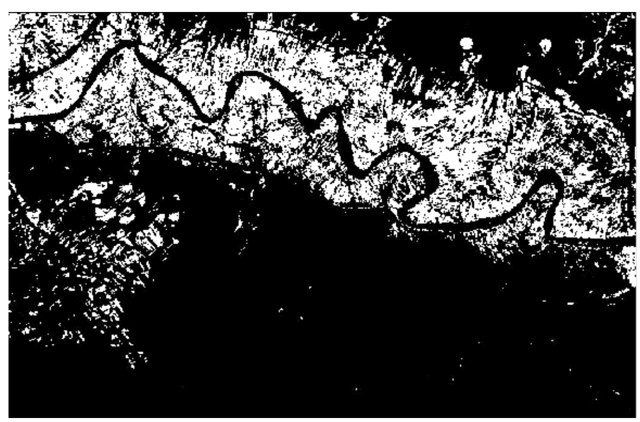
STVI-4 for TM image

STVI-4 for ALI image

b



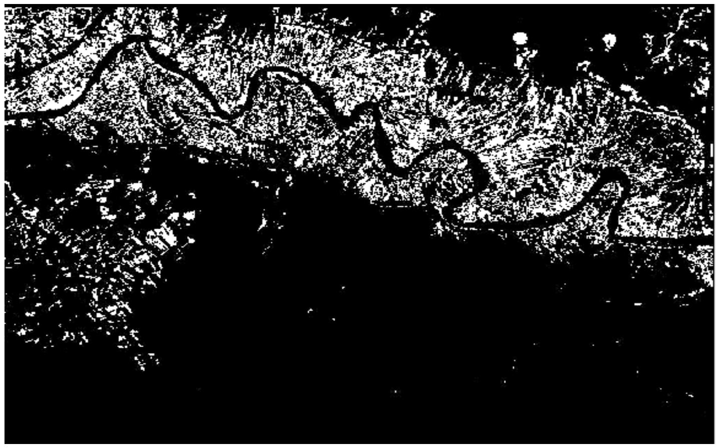
STVI-4 binary for TM image



STVI-4 binary for ALI image

c

Fig.1: a- muilt-temporal a Ramadi city for landsat TM & Geo-Crrected EO-1 ALI, in years 1990, and 2003 (each of size 738 × 1027 Pixels), b, e, & f- the vegetation indices (STVI-4, STVI-1 & STVI-3) effects on the multi-temporal images (1990 and 2003), c- vegetation layers, binaries by (decided threshold =185) for STVI-4 index, d- The changes in vegetation layers, using differencing images method between STVI-4 binaries images.



Change Detection for Both STVI-4 binary images.

d

STVI-1 for TM image

STVI-1 for ALI image

e

STVI-3 for TM image

STVI-3 for ALI image

f

Fig.1: a- muilt-temporal a Ramadi city for landsat TM & Geo-Crrected EO-1 ALI, in years 1990, and 2003 (each of size 738 × 1027 Pixels), b, e, & f- the vegetation indices (STVI-4, STVI-1 & STVI-3) effects on the multi-temporal images (1990 and 2003), c- vegetation layers, binaries by (decided threshold =185) for STVI-4 index, d- The changes in vegetation layers, using differencing images method between STVI-4 binaries images.

Conclusions

The regression for the changing of attributable the Al-Habbaniyah Lake in 1990 year was affected by many factors such as climatic changes, the neglect policy, the economist blockade, operating large dams in Turkey, and the natural of soil surrounded by Lake, which are classified within the eroded materials. So all these reasons, which affect the vegetable cover distribution percentage.

The STVI-4 index can be very useful, moreover, it can provide information about vegetation conditions; it enables a more accurate and spatially explicit estimate of land condition. Study area represents high vegetation cover index value in the areas around the river of images. The STVI-4 index is able to separate all healthy vegetation class, so it was chosen to detect the changes in vegetable cover over time. While the difference image showed the amount of changes were seen between the two periods of time where they occurred.

The research recommends using end member extraction techniques can help to differentiate between similar classes for the germinated vegetation healthy and wet soil.

References

[1] E.M.Elhadi, N. Zomrawi, The Journal of American Science, 6,2 (2010) 171-175.

[2] Z.Shaoing, XuLu, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. XXXVII, B7 (2008)1595-1598.

[3] S. M. J. S. Samarasinfhe, H.K.Nandalal, D. P. Weliwitiya, J. S. M. Fowze, M. K. Hazarika, L. Samarakoon, International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science, XXXVIII, Part 8 (2010) 110-115.

[4] R.A.Rensink, Annu. Rev. Psychol., 53 (2002) 245–77.

[5] J.F.Mas, Int. J. Remote Sens., 20, 1(1999), 139–152.

[6] Albert K. Chong, Chris Pearson, "Geometrically Corrected Digital Images For Resource Mapping And Precision Farming", Proceedings of the Spatial Information Research Centre’s 10th Colloquium, New Zealand, 1998, 64-69

[7] R. Jafari, "Arid Land Condition Assessment and Monitoring using Multispectral and Hyperspectral Imagery", PhD. Thesis, The University of Adelaide, Australia, 2007.