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Comparative Study of SAVI and NDVI Vegetation Indices in Sulaibiya Area (Kuwait) Using Worldview Satellite Imagry

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ABSTRACT

Monitoring vegetation cover is obviously of crucial importance in arid and semiarid zones. This study aimed to explore the relevancy of SAVI (Soil-Adjusted Vegetation Index) and NDVI (Normalized Difference Vegetation Index) to determine vegetation cover using remote sensing imagery and to select one to be used for vegetation mapping at Kuwait national level. A Worldview scene was acquired on 14-April 2012 over "Sulaibiya Area", and used to compare both indices by (i) simulating various spatial resolutions (from 50 cm to 30 m), (ii) studying the effects of radiometric correction, including the atmospheric correction, on the sensitivity of the indices and (iii) varying soil factor for the SAVI to adjust it to different vegetation densities. A complete fieldwork was done simultaneously to Worldview image acquisition and a hybrid classification was used as reference for all comparisons. The results showed that SAVI with a soil factor of (0.9) was best suited to be used in the study area with a coefficient of correlation R2 over 0.9 in all various conditions.

INTRODUCTION

The State of Kuwait is subject to degradation of its vegetation cover due to the adverse effects of climate fluctuations, including temperature and precipitation changes, as well as soil salinity. Anthropogenic pressure has rise to alarming levels and leads to urban growth, camping, overgrazing and agriculture. This last one is uses excessive ground water for irrigation, hence increasing the soil salinity which leads on the long term to vegetation cover degradation. Monitoring vegetation cover in such context both over time and space is of crucial importance (Soleiman and Kamal, 2002). Remote sensing and other geoinformatics techniques such as GIS modeling and spatial analysis have been playing a significant role to produce vegetation maps (Abu Sayed and Sadiq, 2002; Ait Belaid, 2010). Nevertheless, even though remote sensing has been widely used to monitor vegetation cover but still the use of different vegetation indices with different satellite imagery may mislead when performing vegetation change detection (Hadjimitsis et al. 2010; Lu et al. 2004; Ait Belaid, 2003). This study focuses on the comparison of two Vegetation indices, NDVI and SAVI. Both are used worldwide at various spatial scales (Huete, 1988). However, in Kuwait there is a need to evaluate the performance of both of these indices at different spatial resolution to assess the potential one to be used for national scale vegetation mapping/monitoring.

MATERIALS AND METHODOLGY

A very high resolution WorldView-2 image (Digital Globe, 2009) was acquired on 14 April 2012 over Sulaibiya area; (figure 1). The study area was selected because it has vegetation density from very low to very high. The area has also a very well variety of vegetation species such as Tamarix Aphylla, Conocarpus Erectus, Prosopis, Zygophyllum Aatarense, Phoenix Dactylifera, Medicago Sativa. The Sulaibiya is an agricultural area and obviously has large parcels of irrigated cash crop with a very high vegetation density. Figure 2 represents the general methodology flowchart, where the first step consisted to use the panchromatic band to pansharpen the multispectral bands. Hence enhancing their spatial resolution from 2 m to only 50 cm. Pansharpned image was use to classify vegetation cover using a hybrid unsupervised-supervised classification. Only vegetation class was retained for subsequent analysis and it has been transformed from a raster format to a vector-polygon one. During the second step, original WorldView-2 image was also been radiometrically corrected to convert DN to ToA reflectance and next an Atmospheric correction was done to obtain the ground reflectance for each pixel. Resulting images of second step were then degraded to obtain pixel size of 5, 10, 15, 20, 25 and 30 m, with a total of 21 additional images. The fourth step concerned the computation of NDVI and SAVI vegetation indices (equations 1 and 2) for all produced 21 images.

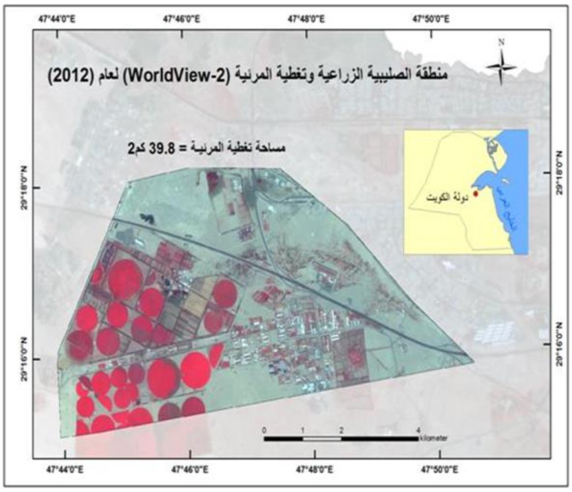


Figure 1: WorldView-2 Image of Sulaibiya Area on 14 April 2012 (False colours composite; RGB=7, 5, 2), Inset: Study area in State of Kuwait

$$NDVI = \frac{\rho_n - \rho_r}{\rho_n + \rho_r}$$

$$SAVI = \frac{(\rho_n - \rho_r) \times (1 + L)}{(\rho_n + \rho_r + L)}$$

Where: ρ_n = *Near Infra-Red (NIR) Band,*
P_r = *Red Band,*
L = Correction Factor (from 0 to 1)

Three values of the soil factors (L) were retained for SAVI; 0.2, 0.5 and 0.9. Hence 84 new raster layers were obtained for both NDVI and SAVI at different spatial resolution and at three radiometric status, respectively, DN, ToA reflectance and Ground Reflectance. Finally, NDVI and SAVI layers were transformed into vector-polygon and overlaid with the vegetation vector produced from classification. Identity function was used to determine vegetation indices values in function of the percentage of vegetation cover in each pixel.

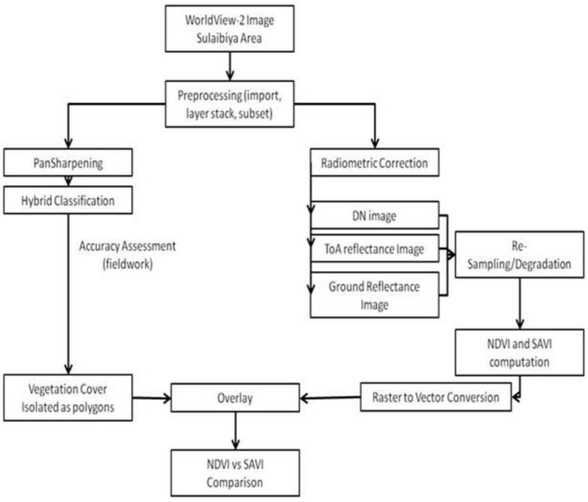
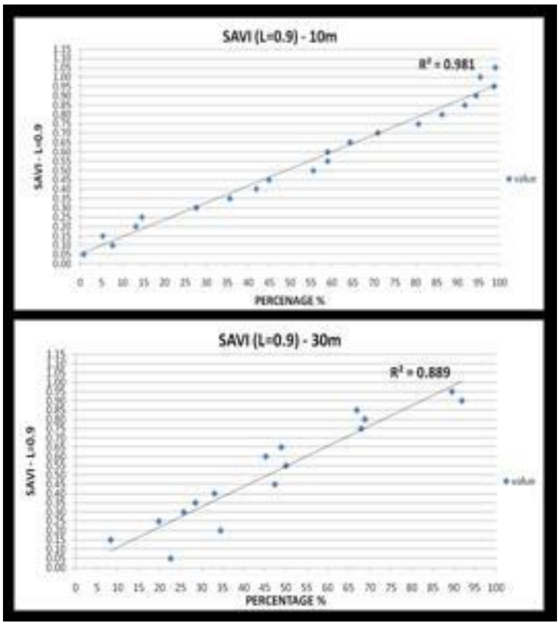


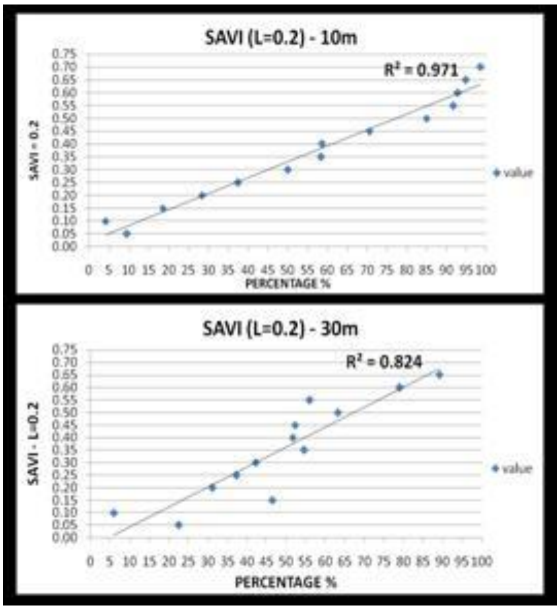
Figure 2: General Methodology Flowchart

In this study, PCI Geomatica 2013, and ERDAS imagine 2011 were used as commercial packages for raster image processing; while ArcGIS10 was used for vector overlay.

RESULTS AND DISCUSSION

Figures 3a and 3b depict the results obtained for the NDVI and SAVI comparison using DN and Spatial resolution of 10 and 30 m. These parameters were used among the 84 possibilities to match most common available SPOT and Landsat imagery. It turns that at 10 m pixel size, both vegetation indices (NDVI and SAVI) are highly correlated with the percentage of pixel's area covered by vegetation' values of R2 are stable around 0.97. However, when spatial resolution is 30 m NDVI scored the less correlation with an R2 of 0.66 only. On the other hand, the spatial resolution of 10 meters affected negatively the SAVI score but the lowest value obtained is R2 = 0.82 for soil factor parameter L of 0.2. Also for SAVI as the soil factor increase (L=0.5 and L=0.9) the R2 remains strong with values of 0.83 and 0.88 respectively. From a different aspect, it is clear that SAVI index is more sensitive to presence of vegetation when the spatial resolution is 30 m. In fact, the lowest percentage of vegetation cover detected using SAVI, at this resolution, is 7%, and while the NDVI is start to reacts only when there is 15% of the pixel covered by vegetation. It means that for a pixel of 900 m2 there is only 63 m2 covered with vegetation the SAVI may Detect it (L=0.9), but using NDVI the minimum vegetation area should be 135 m2 nearly the double. Even though SAVI uses atmospheric corrected reflectance for Red and NIR bands but it still gives satisfactory results at 30 m using DN. To illustrate the role of atmospheric correction on SAVI performance, figure 4 shows the R2 for SAVI (L=0.9) using ToA reflectance and ground reflectance. The values were respectively 0.97 and 0.98 with a sensitivity surface of 5% for both (45 m2). Hence the radiometric correction has a significant role to get valuable information using SAVI index.





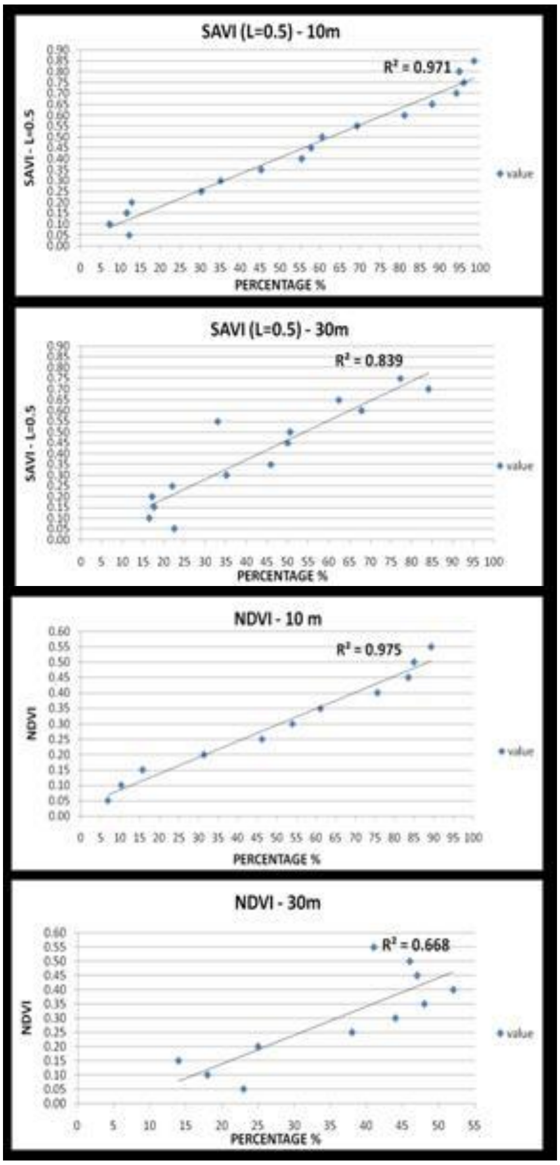


Figure 3a: 6 graphs showing comparison of NDVI vs SAVI at 10 and 30 m spatial resolution using DN

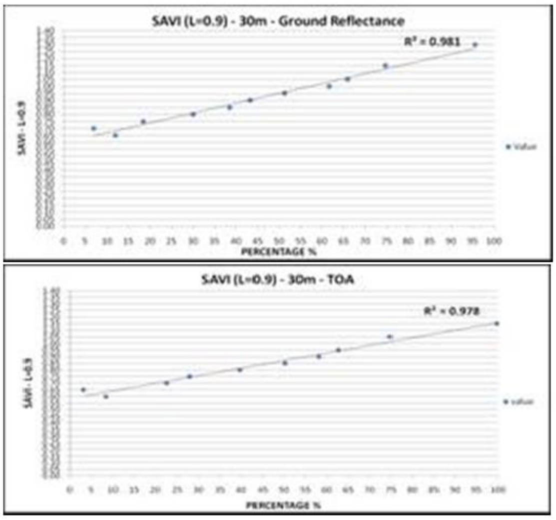


Figure 3b: Comparison of SAVI at 30 m spatial resolution using ToA Reflectance vs Ground Reflectance

CONCLUSIONS

This study confirmed the adequacy of SAVI vegetation index over the more popular NDVI in arid and semiarid zones especially in medium spatial resolution. The methodology adopted in this study shows quantitatively that at 10 m spatial resolution both SAVI and NDVI have comparable performance to detect vegetation cover. However, as the spatial resolution is lower, the SAVI with a soil factor of 0.9 is more robust. NDVI is still correlated to percentage of vegetation area in a pixel but with much lower accuracy than SAVI. It has been shown also that despite the fact that SAVI is a vegetation index requiring atmospheric correction before being computed but it still gives good results even with DN. However, with atmospheric correction it is much more accurate. Hence, it is recommended to use SAVI index to produce vegetation maps for the State of Kuwait and it is reliable even for historical remote sensing data with lower spatial resolution.

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