Vegetation Change Detection in Abu Dhabi Emirate, United Arab Emirates

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USGS science for a changing world

National Drilling Company

Figure 2 - Khazna study area, April 1996 TM (432 composite)

Figure 3 - Khazna study area, November 2000 TM (432 composite)

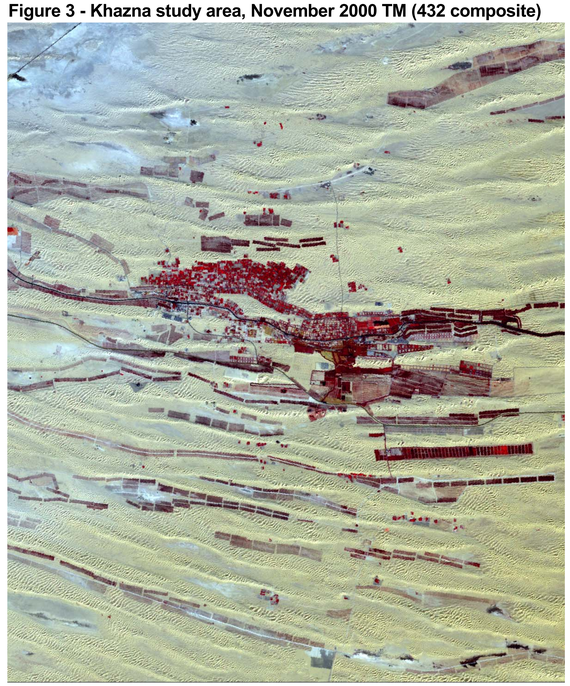


Figure 1
United Arab Emirates Vegetation Change Detection Study Areas

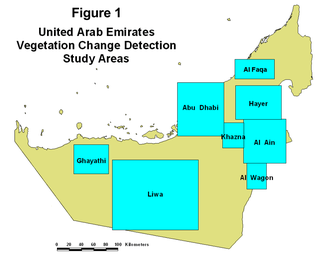


Figure 5 - Grayscale NDVI Image, Khazna Area

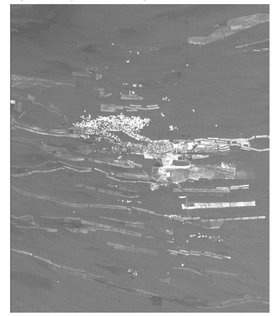
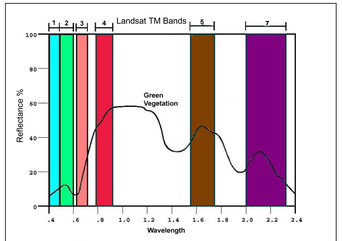


Figure 4 - Normalized Difference Vegetation Index (NDVI)



To help detect vegetation, this project took advantage of the Normalized Difference Vegetation Index, or NDVI. Healthy, green vegetation normally reflects a greater percentage of light in the near infra-red wavelength (band 4) than in the red wavelength (band 3).

NDVI is calculated using the following expression:

NDVI = (NIR - Red) / (NIR + Red)

Where NIR is the Near Infra-red band (TM band 4), and Red is the Red band (TM band 3).

The results range in value from -1 to 1 (and is normally stretched to fit 0 - 255), where the brighter values indicate pixels of green vegetation, and the darker values have little or no vegetation. There are many other vegetation indices, but NDVI is the most commonly used and seemed to work well in this application.

Figure 6 - Binary NDVI image of Khazna Area, 1996

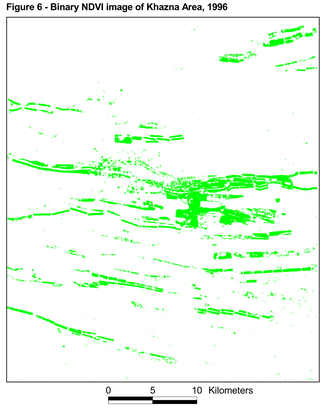


Figure 7 - Binary NDVI Image of Khazna Area, 2000

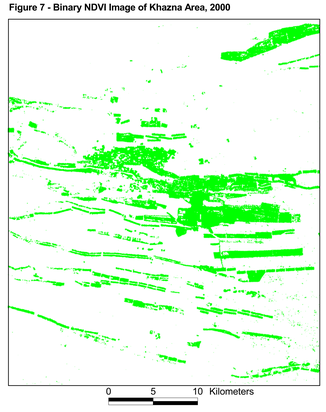
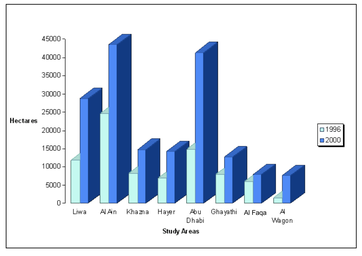


Figure 8 - Comparison of total vegetation (1996/2000)



Introduction

The landscape of the United Arab Emirates is undergoing significant change. Through the use of irrigation and agricultural programs over the last 20 years, the country has transformed large expanses of sand desert into areas of green vegetation and forests. While providing vegetables, animal fodder, and forest habitat for the country, this "greening" of the country is also having an affect on the ground water resources of the region. These effects include draw-down of the water table, infiltration of brackish/saline water, contamination of the ground water by agri-chemicals, and land surface subsidence.

The Ground Water Research Program (GWRP) is a joint effort between the National Drilling Company (NDC) of the Abu Dhabi Emirate and the U.S. Geological Survey. Its mission is to identify and monitor potential ground water sources for agricultural and municipal use within the Abu Dhabi Emirate. Knowledge of the location, extent and character of the irrigated lands will allow hydrologists to better understand and model factors affecting ground water. Better estimates can be made of ground water usage based on the nature of the vegetation for example, fodder fields have an average comsumptive-use rate over 6 times that of forested areas. This project was initiated to help delineate new vegetated areas over time, and to help categorize the kinds of vegetation using relatively inexpensive satellite data and image processing tools.

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Objective and Methodology

The primary objective was to delineate areas of vegetation using Landsat 7 ETM+ satellite imagery acquired in 2000, and make comparisons to the 1996 Landsat imagery (the date of the most recent vegetation analysis). A secondary objective was to perform a land cover classification of the vegetation. Proposed categories include palm trees, vegetable plots, fodder fields, and forests.

The region was divided into 8 study areas that cover nearly all of the irrigated vegetation in the Emirate (figure 1). Landsat 7 ETM+ satellite imagery was acquired for the region. Portions of three scenes (160-43, 160-44, and 161-44), taken in November and December 2000, were used for the vegetation analysis (figures 2 and 3). Vegetation was delineated using the Landsat 7 imagery by creating a Normalized Difference Vegetation Index (NDVI) image (figure 5). The NDVI algorithm is described in figure 4. A threshold value was interactively selected for each NDVI image to create a binary image depicting vegetation and non-vegetation. The binary images were then filtered using a majority 3 by 3 filter to remove isolated "noise" pixels (figures 6 and 7). Total areas of vegetation (in hectares) were then tabulated for each study area and year.

Both supervised and unsupervised classifications were performed. A supervised classification was performed on the Al Ain study area because we had more knowledge of the actual land cover. Unsupervised classifications were performed on the other study areas. An NDVI mask was used to exclude non-vegetated areas from the classification.

Results

The chart in figure 8 presents the results of the area calculations. The total area of vegetation measured from the 1996 imagery was 77,200 hectares. The total area of vegetation measured from the 2000 imagery was 162,700 hectares - more than double the 1996 amount. The Liwa, Hayer, and Abu Dhabi study areas had at least a doubling in area of measured vegetation. The Al Ain, Khazna, and Ghayathi study areas had at least a 1.5 times increase. The Al Wagon area had an increase of over 4 times the vegetation measured in 1996. It should be noted, this technique of vegetation assessment is sensitive to actual green organic surface cover. It does not indicate areas where irrigation fields have been prepared and vegetation is not yet visible. Also, fields with young, widely spaced plants will tend to not be included in the areas of measured vegetation because the surface area of plant material is small compared to the surrounding sand and soil.

A ground-based accuracy assesssment has been initiated. Random points are selected and the predicted land cover type is compared to that observed in the field. Factors affecting the accuracy include the density and maturity of tree farms and the relative small size and heterogeneous nature of the farm plots. The typical farm field is about 190 meters square, containing 3.5 hectares. Approximately 36 pixels would cover a typical field. With edge effects, clear distinction between crops and trees is difficult. Future work will take advantage of the higher spatial resolution (15 meter) pan imagery and will examine texture and pattern characteristics.

The results presented are preliminary and have not been reviewed.

Irrigated vegetation on sand dunes (Liwa Area)

Date palms and grass (Al Ain area)

References

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