# Mapping of Reclamation Rate in the Egyptian Deserts Using SPOT Satellite Images

by: Dr. Farrag Ali FARRAG [1] and Dr. Mostafa Abdel-Bary EBRAHIM [2]
[1] Assistant Professor & [2] Lecturer
Civil Engineering Dept.
Faculty of Engineering
Assiut University
Assiut, Egypt.
[1]farrag@acc.aun.eun.eg & [2]ebrahim@acc.aun.eun.eg

**KEYWORDS:** Agriculture, Change Detection, Image processing, Remote sensing, SPOT

## ABSTRACT

In this study temporal multispectral SPOT satellite images were examined for accurate mapping of the reclaimed areas under the irrigation and wither conditions in the Egyptian deserts. A combination of image interpretation, image thresholding, vegetation indices and unsupervised classification techniques were applied. Three SPOT images of the same area (captured in 1992, 1995, and 1998) were processed with emphasis on detecting the changes at a small area as a test area where a governmental reclamation project is taking place. The detected increase in the reclaimed area was examined against the actual applied one. The proved processing technique was applied on another area where some scattered reclamation process is carried out by private agencies.
This study proved that the digital analysis of high spatial and spectral resolution SPOT multispectral images, with computer-aided visual approach, is a valuable tool for accurate detecting and locating of the new reclaimed areas. Accordingly, such technique can be applied for regular evaluation of the reclamation rates that taking place nowadays in the Egyptian deserts, such as Toshika project in upper Egypt.

## 1. INTRODUCTION

Reclamation of desert is one of the major tasks nowadays in Egypt. The reclamation is carried out mainly in the desert areas for cultivation purposes in order to fulfil the needs of the high population growth. The reclamation rates need to be measured continuously and to be examined against the original planes. Experience has demonstrated that collection and compilation of data, for such purposes, using traditional techniques is costly and time consuming. The use of high resolution satellite images which is both repeated very frequently and also employs computer processing can be an alternative data capture tool for accurate mapping of the cultivated land and for determining the reclamation rates (see eg, [Evans etl (1992), Austin (1992), and Genong (1996)]). On the other hand applying automatic detection techniques reduce the time needed for obtaining accurate information about reclamation process.

A combination of image interpretation, image thresholding, vegetation indices and unsupervised classification techniques was used for analyzing temporal multispectral SPOT images. The actually applied reclamation in a test area was used as a reference to examine the results obtained by these image processing techniques. The proven processing technique was applied on other area (Wady El-Asuty) where some scattered reclamation processes are applied by private agencies.

## 2. STUDY AREAS AND DATA

The reclamation process was analyzed in two study areas. The first area belongs to Assiut cement factory in the western desert, about 17 km to the west of Assiut City (Egypt). The reclamation in this area was controlled properly, where the information about the reclamation rate is available. This area was considered as test area where the actually applied reclamation in this area was used as a reference to examine the results obtained form SPOT images. The second one is in Wady El-Asuty, about 30 km from Assiut city in the eastern desert. Wady El-Asuty represents about 350 $km^2$ of dry valley that has a special importance for the future planning of Assiut Governorate. In the central part of this area some private agricultural activities and new communities were started and planned to be extended [Farrag (1997)].

Three SPOT multispectral images with 20 m ground resolution were the main data source for this study. The SPOT images correspond to column 113 and row 296 of SPOT Grid Reference System (GRS). The first image was captured by SPOT-1 on 23 July 1992, the second image was captured by SPOT-3 on 25 July 1995, and the third image was captured by SPOT-4 on 11 August 1998. SPOT-1, 2, 3 and 4 are equipped with High-Resolution Visible (HRV) sensor that recording three bands in the multispectral mode with 20 m ground resolution. Band 1 (the green band) covering the spectral band from 500 nm to 590 nm, band 2 (the red band) covering the spectral band from 610 nm to 680 nm , and band 3 (the near infra red band) covering the spectral band from 790 nm to 890 nm [Michele 1981 and SPOT Magazine No 28 ( January 1998)].

**3. METHOD□OLOG□Y**

The process and analysis of SPOT images consisted of four steps. First, the images were geometrically corrected. Second, the data of each of the three bands was examined and analyzed individually. Third vegetation indices were constructed and examined. Fourth, a compost image was constructed and examined visually and unsupervised classification was carried out in order to test the possibility of extracting the reclaimed areas automatically. Geometric correction was applied to the part of the image which cover the two study areas, while the process of examining the information contents of individual image bands, examining vegetation indices, and unsupervised classification were applied to the test area. Then the processing technique which give most accurate results was applied to the second study area.

## 3.1 Geometric Correction

Geometric correction of SPOT images was essential in order to be able to take measurements from the images and to carry out quantitative analysis. The images were rectified to the Universal Transverse Mercator (UTM) coordinate system using a second order polynomial transformation. Each of the three bands of each image was individually geometrically corrected using the same set of control points. The measurement of the ground coordinates of the control points was carried out in the field applying Differential Global Positioning System (DGPS). The residual Root Mean Square (RMS) error was 20.1 m (about one pixel). The resampling process of each band was carried out using nearest neighbor method (in order to avoid any smoothing to the original image data).

## 3.2 Image Stretching

In this step major emphasis was made on the examining the sensitivity of each of the three bands of SPOT image to detect the new reclaimed area. The identification and delineation of new reclaimed areas were based on the information contents of individual bands.
The image of each of the three bands was processed separately and the obtained results were compared. Image processing includes linear stretching and slicing images to a number of levels. The process of linear stretching involves identification of two brightness values (DNs) as minimum and maximum values in the resulting stretched image. These minimum and maximum values represent the limits of the feature of interest (the new reclaimed area in our case). Then the image data between the two limits was sliced to a number of levels, to be interpreted as different classes of reclaimed areas. The determination of the minimum and maximum values that corresponding to the reclaimed land in the test area was carried out by displaying the image of each band on the screen and testing the pixels that corresponding to the well defined reclaimed areas (the test area). The identified values are given in Table 1.

In general, it realized that band 3 (the near infrared band) of SPOT images is the most sensitive band to reclaimed and vegetated areas. In order to include the information that can be obtained from the other two bands, composite images were constructed from the stretched bands and given for the test area in Plates 1, 2, and 3 for the images of 92, 95, and 98 respectively.

| Image date | 1992 | | | 1995 | | | 1998 | | |
|---|---|---|---|---|---|---|---|---|---|
| Band | B1 | B2 | B3 | B1 | B2 | B3 | B1 | B2 | B3 |
| Min. value | 55 | 60 | 40 | 65 | 60 | 50 | 40 | 30 | 30 |
| Max. value | 135 | 130 | 100 | 140 | 150 | 130 | 85 | 105 | 80 |

Table 1. The minimum and maximum values used for stretching image bands

### 3.3 Vegetation Indices

The ratio of near infrared and the red band of space imagery is sometimes referred to as the Simple Vegetation Index (SVI). The Normalized Difference Vegetation Indices (NDVI) is given by:
NDVI=(IR-R)/(IR+R)
In which:
IR is the brightness of pixels in the near-infrared band (band 3 of SPOT XS, 7 of Lansat MSS and 4 of TM).
R is the brightness of pixels in the near band (band 2 of SPOT XS, 5 of Lansat MSS and 3 of TM).

Vegetated areas will generally yield high values for either index, because of their relatively high near-infrared reflectance and low visible reflectance. Rock and bare soil areas have larger visible reflectance than the near-infrared reflectance and result in vegetation indices less than zero or near zero. The NDVI is preferred to the SVI for global vegetation monitoring because it helps compensate for changing illumination conditions, surface slop, aspects and other extraneous factors [Lillesan& Kiefer (1994)]. In this study the NDVI is constructed and the resulting pixels with values greater than zero were considered as vegetated areas. The obtained images of NDVI are given for the test area in Plates 4, 5, and 6 for the images of 92, 95, and 98 respectively.

### 3.4 Image Classification

In this step major emphasis was made on the identification and delineation of the new reclaimed areas using the information contents of the composite images. For visual interpretation, composite images were constructed and displayed in pseudo natural color, where band 2 was assigned to red, band 3 was assigned to green and band 1 was assigned to blue. Visual interpretation was carried out to give an indication of number of classes that can be discriminated on the image and possibility of distinguishing the reclaimed areas. Several tests were carried out in order to choose the optimum number of classes in the classified image. It found that 10 classes give reasonable results. The unsupervised classification was carried out to test the possibility of automatic discrimination of the new reclaimed areas. The obtained unsupervised classified images are given for the test area in Plates 7, 8, and 9 for the images of 92, 95, and 98 respectively.

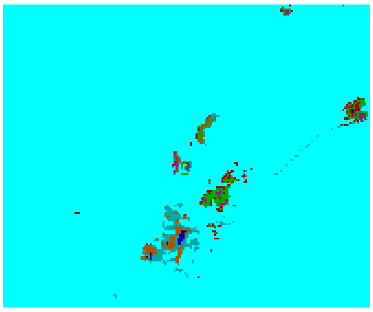

Plate 1

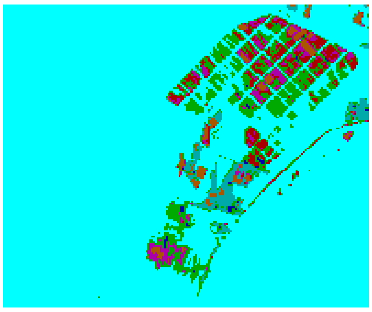

Plate 2

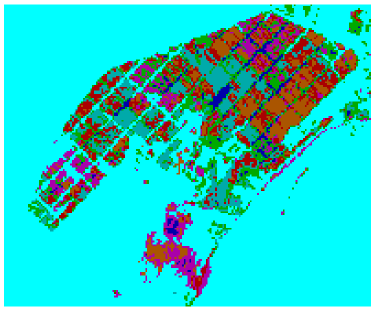

Plate 3

Plates 1, 2, and 3 Composite images from streatched bands

Background (the other classes represent the reclaimed areas)

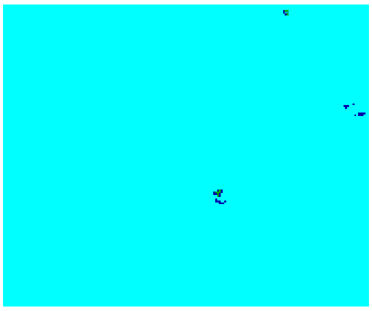

Plate 4

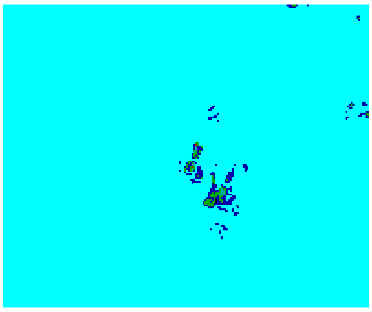

Plate 5

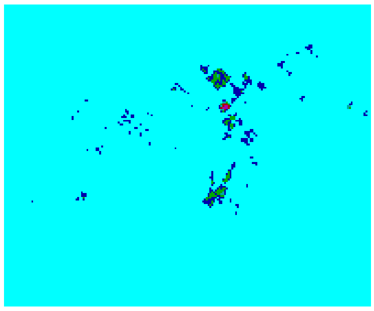

Plate 6

Plates 4, 5, and 6 Images of NDVI

Background (the other classes represent the reclaimed areas)

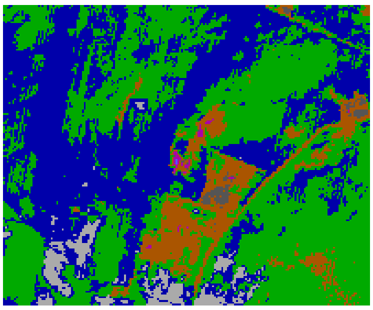

Plate 7

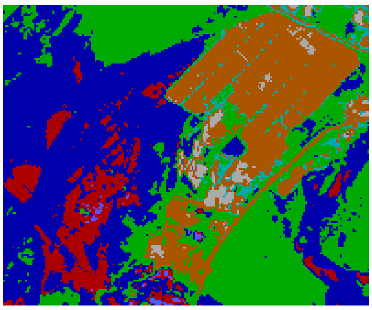

Plate 8

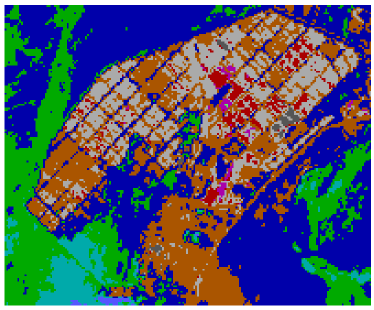

Plate 9

Plates 7, 8, and 9 Unsopervised classified images

Classes of the reclaimed areas

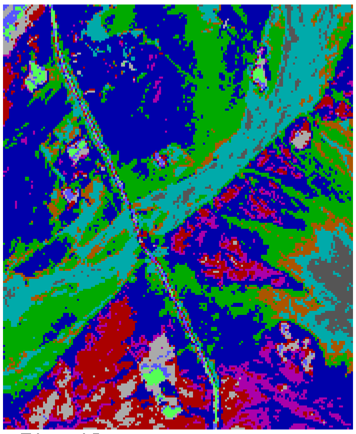
Plate 10

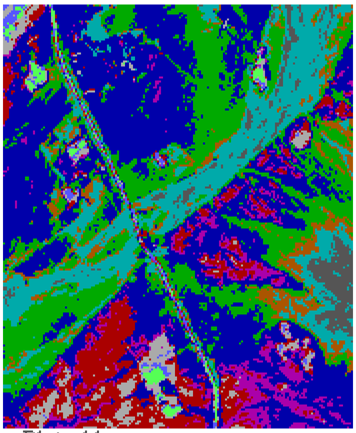
Plate 11

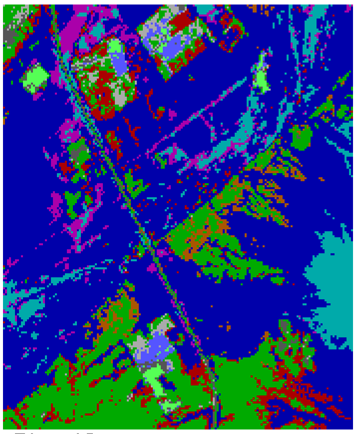
Plate 12

Plates 10, 11, 12 Composite of the second test area (1992, 1995 and 1998)


Plate 13


Plate 14


Plate 15

Plates 13, 14, 15 Composite from streatched bands (1992, 1995 and 1998)

## 4. QUANTITATIVE ANALYSIS OF RESULTS

In order to be able to obtain quantitative numerical results, and to be able to judge about the accuracy of results that obtained by the different processing techniques, the extracted reclaimed areas by each technique were compared with the actually applied one in the test area. The results of this step are given in Table 2.

| Information source | The identified reclaimed area (square meters) | | |
|---|---|---|---|
| | 1992 | 1995 | 1998 |
| Field reports | 348600 | 1680000 | 4200000 |
| Composite image from stretched bands | 390000 | 1926800 | 3953600 |
| Normalized Difference Vegetation Index | 17200 | 154000 | 222000 |
| Unsupervised classified image | 458400 | 2762400 | 5060800 |

Table 2, The identified reclaimed area by different techniques

From Table 2 it can be realized that the information obtained from composite image that constructed from the stretched bands give the most accurate results (about 88 %). The accuracy of the results that obtained by unsupervised classification is about 61 %, due to the interference of other classes (desert areas) with the reclaimed areas. As a result of visual interpretation, one can realize that the results obtained by NDVI represent the vegetated areas only while the other method represent the vegetated areas in addition to the prepared land for cultivation (N. B. The data obtained from field reports include such land). The percentage of actually vegetated ground to the total prepared land for reclamation can be determined by from the ratio of area given by NDVI to the area given by composite image from stretched bands (or that give by unsupervised classification).

The technique of constructing composite images from the stretched bands was applied to the second study area which contain scattered reclaimed land. The composite images of this are given in Plates 10, 11, and 12 for the images of 92, 95, and 98 respectively, and the composite images that constructed from the stretched bands are given in Plates 13, 14, and 15 for the images of 92, 95, and 98 respectively. The extracted reclaimed areas are listed in Table 3.

| Year | 1992 | 1995 | 1998 |
|---|---|---|---|
| Reclaimed area (square m) | 6000 | 21600 | 47600 |

Table 3, The identified reclaimed land in the second test area

## 5. CONCLUSION

This study proved that the digital analysis of high spatial and spectral resolution SPOT multispectral images, with computer-aided visual approach, is a valuable tool for accurate detecting and locating of the new reclaimed areas. Unsupervised classification and simple thresholding of the image bands were found suitable for this purpose, under the irrigation and wither conditions in the Egyptian deserts.. According to the obtained results one can conclude that, SPOT satellite multispectral image proved to be one of the most important tools for regular evaluation of the reclamation projects that taking place nowadays in the Egyptian deserts.

## 6. REFERENCES

Austin, S., 1992. Application of Remote Sensing to Forest Assessment, Forest Land Cover Inventory and Change Detection., Remote Sensing & Natural Resource Management, Proceedings of the Fourth Forest Service Remote Sensing Applications Conference, Florida, April 6-11, 1992.

Evans, D., etl 1992. Landsat Thematic Mapper Data for Development and Interpretation of Vegetation Information on the Kisatchie National Forest, Forest Land Cover Inventory and Change Detection., Remote Sensing & Natural Resource Management, Proceedings of the Fourth Forest Service Remote Sensing Applications Conference, Florida, April 6-11, 1992.

Farrag, A., etl, 1997. Complementary Groundwater and Soil Studies on Wadi El-Assiuti by The Help of Satellite Images and Gis Techniques (Civil Engineering Dept. Al-Azhar University, Egypt), Volume (19) No. (8) pp. 1185-1205.

Genong, Yu. 1996. Agricultural Land Investigation and Change Detection by Incorporating GIS and Satellite Remote Sensing, Case Studies in Sichuan Province, China, IAPRS Volume XXXI part B7 (Vienna, Austria 1996).

Lillesand, and Kiefer (1994): Remote sensing and image interpretation (third edition) Johan Wiley & Sons, Inc. New York. Chichester. Brisbane. Toromto. Singapore, pp 506.

Michele Chevrel, etl, 1981. The SPOT Satellite Remote Sensing Mission, Photogrammetric Engineering and Remote sensing, August 1981, pp. 1163-1171