APPLICATION OF CHANGE DETECION TECHNIQUES IN MARSH AERAS, SOUTH IRAQ

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ABSTRACT

The marshes in the southern part of Iraq are considered as one of the most important water bodies in the world. This is due to their economical and environmental importance, because they include huge water and fishery resources, as well as their historical and tourist importance.

Large environmental changes took place, due to the dryness of the marshes during the nineties of the last century. Therefore, this study is found to be very necessary to record these changes, using remote sensing techniques. The application of change detection techniques aims to discover all types of changes that took place in Al-Huwaiza Marsh during the last 27 years, from 1975 – 2002. This is achieved by using Landsat MSS images, dated in 1977 and Landsat ETM+ dated in 2002. After application geometrical corrections, the desertified areas, development of sabkha, highly saliferous soil and absence of vegetation were clearly determined.

تطبيقات تقنيات كشف التغيرات في مناطق الاهوار، جنوب العراق

مواهب فاضل عبد الجبار

المستخلص

نظرا لأهمية مناطق الأهوار في جنوب العراق حيث تعتبر من المسطحات المائية المهمة في العالم وذلك لأهميتها الاقتصادية والبيئية، لاحتوائها على ثروات مائية وسمكية وكونها مناطق سياحية، وان ما حدث من تغيرات بيئية كبيرة بعد عمليات التجفيف في منتصف التسعينيات من القرن الماضي وتداعيات هذه التغيرات، لذلك من الضروري دراسة ومتابعة هذه التغيرات وآثارها باستخدام تقنيات التحسس النائي بهدف كشف التغيرات الحاصلة على منطقة هور الحويزة خلال فترة 27 سنة الماضية وذلك بمقارنة الصور الفضائية من نوع لاندسات MSS الملتقطة عام 1977 واخرى من نوع لاندسات +ETM الملتقطة عام 2002. حيث تم تطبيق عدد من تقنيات كشف التغير الرقمية بعد إجراء عمليات التصحيح الهندسي ومطابقة الصورتين ومتابعة هده التغيرات. وتم تحديد بعض المتغيرات الحاصلة من تصحر وتكون السباخ والترب الملحية وانحسار في الغطاء النباتي والمسطحات المائية .

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INTRODUCTION

The marshes in the southern part of Iraq are considered as one of the most important water bodies in the world. This is due to their economical and environmental importance, because they include huge water and fishery resources, as well as their historical and tourist importance.

Large environmental changes took place, mostly during the nineties of the last century, such as dryness of the main parts of Hor Al-Hawaiza and the Central Marshes (west of Tigris River). Therefore, the present study is found to be necessary to recover these changes using remote sensing techniques. Change detection techniques are commonly used in delineating the change areas, in the different dates.

In the present study, two landsat images of different dates: Landsat MSS image, Nov. 1977 and Landsat ETM+ image, Sep. 2002 are used to detect and evaluate the changes, in the study area (Fig.1).

Current change detection system uses a variety of image processing tools to make changes visible, but typically rely on manual interpretation by expert analysts to delineate the changed areas. Most systems look for changes between only two images: one before and one after, change detection techniques in common use include:

Difference, subtraction spectral bands between the images, NDVI, and change vector analysis, these differences have been used in: coastal zone, environments, mapping of changes in tropical forests, desertification, urban areas, and analysis of irrigated crops (Salih, 2004).

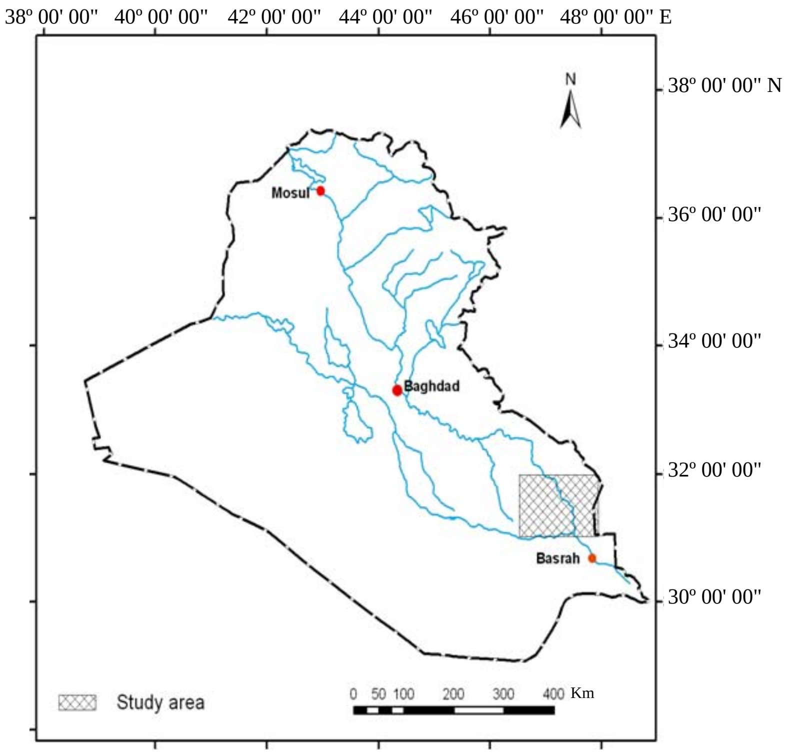


Fig.1: Location map of the study area

PREVIOUS WORKS

Since the last century, many studies concerning different purposes like geology, history, oil exploration, and agriculture were curried out within the marshes region of Southern Mesopotamian Plain, the studies which are related with our study are given hereinafter:

The regional geological survey of the Mesopotamian Plain (Yacoub, 1993) represents the most comprehensive geological study in area under consideration. The geological survey revealed that the study area is covered completely by Quaternary sediments, which are mainly of fluvial and lacustrine origins and partly of aeolian. The essential types of sediments are:

- **Sheet run-off sediments,** which occupy the northeastern corner of the study area. These sediments represent a distal part of big alluvial fan originated at the foothill region (further to the north of the study area).
- **Deltaic flood plain sediments of Tigris River**, which occupy the northwestern and central parts of the study area.
- **Marsh lake sediments**, which occupy the southern half part of the study area, in addition to scattered shallow depressions and sabkhas in the flood plain region.
- **Scattered patches of aeolian sediments**

The aforementioned sediments reflect the recent sedimentary environments and geomorphologic features, which are well visible on the satellite images. Thus, the visual interpretation in the present study and determination of the main classes of land cover depends on the data and maps obtained after the regional geological survey.

Salih (2004) used the application of digital change detection methods in evaluating and detecting the changes of the landcover and land use in Hor Al-Hamar and Shatt Al-Arab areas, using two Landsat images MSS, 1975 and ETM+ 2002, the final results of his study conicide with the results of the present study.

The alluvial plains of Iraq occupy a structural trough, which is linked to active subduction related to orogenic processes in the Zagros Mountains of Iran. The bedrock in the region close to the confluence of Tigris and Euphrates Rivers consists of recent delta-plain and delta-front sediments of the Mesopotamian Plain, in which there were numerous marshes and permanent lakes until the recent destruction of the marshlands. It is estimated that the recent sediments of the Tigris and Euphrates Rivers flood plains were deposited in the last 5000 years, during which (130 – 150) Km of seaward progradation has taken place (Sharad and Tseshaie, 2004).

Master and Woldai (2004) interpreted a circular lake, named Umm Al-Binni structure in Al-Amara marshes of southern Iraq, it is possibly a late Holocene meteoritic impact crater, based on its morphology and this conclusion is achieved after the visual interpretation of Landstat MSS and recent Landsat TM and ASTER satellite imagery. However, the authors recommended further field investigation, including gravity and magnetic profiles as wells series of auger drillings could be done in order to confirm their postulation.

METHODOLOGY

Change detection is a remote sensing method applied in environmental studies to determine if any change had occurred or not, in a particular area. At least, two satellite images, not necessarily to be of the same type, but belong to different dates, would serve the purpose. After some digital image processing is applied, the resultant image is obtained in black and white tones.

Landsat multispectral data provides the longest duration archive of moderately high spatial resolution satellite image data for monitoring the types and rates of land surface changes, imposed by human activities. The derivation of change information from Landsat data generally consists of registering the data of two or more images of the same area acquired at different times. Adjusting the radiometric properties of the data to normalize for various observation and atmospheric conditions.

The procedure of image change production can also be implemented on multiple data sets of non-similar data characteristics, allowing combination of Landsat MSS data with data from other sensors, such as Landsat Thematic Mapper ETM+.

Five change detection techniques are used in this study to compare land cover changes, these techniques include:

- Simple change detection study between the two images
- Image Subtraction
- NDVI (Normalized Difference Vegetation Index)
- Tasseled Cap Transformation (vegetation, soil, water)
- Temporal Classification Comparison

▪ **Simple change detection between the two images**

- Image Difference: To produce a gray scale image composed of single band continuous data. This image is the direct result of subtraction of the Before Image from the After Image, since change detection calculates changes in brightness values over time (Figs.2 and 3).

LANDSAT MSS, 1977 LANDSAT ETM+, 2002

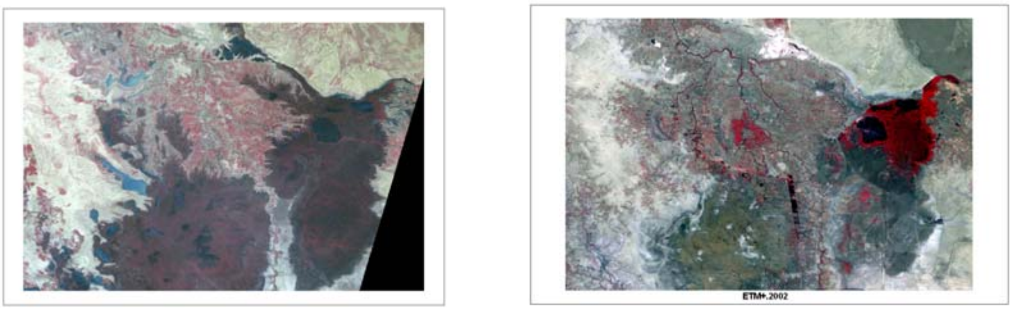


Fig.2: Two Landsat images of different dates

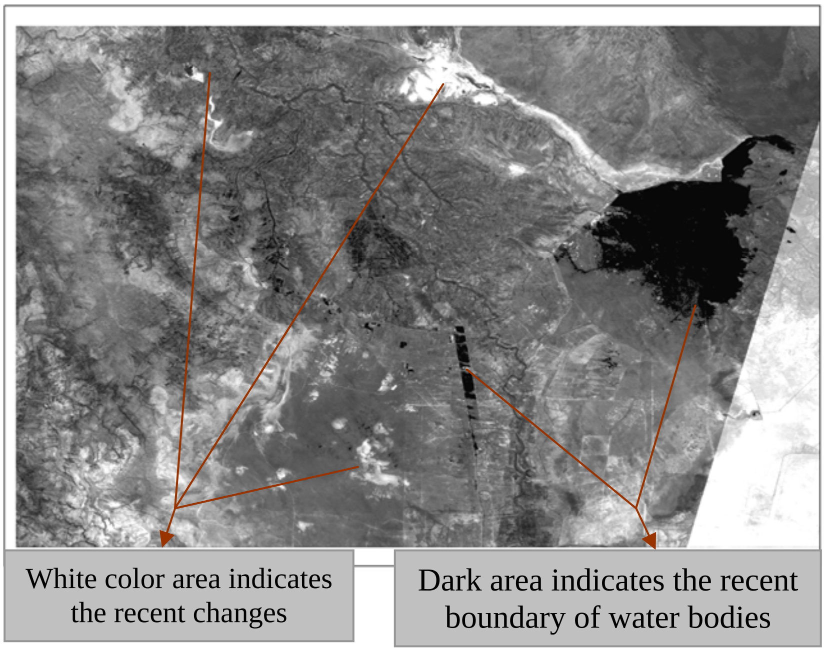


Fig.3: The resultant image in gray scale

- Highlight Change: The Highlight Change Image is divided into the two class thematic images, Decreased and Increased (Fig.4).

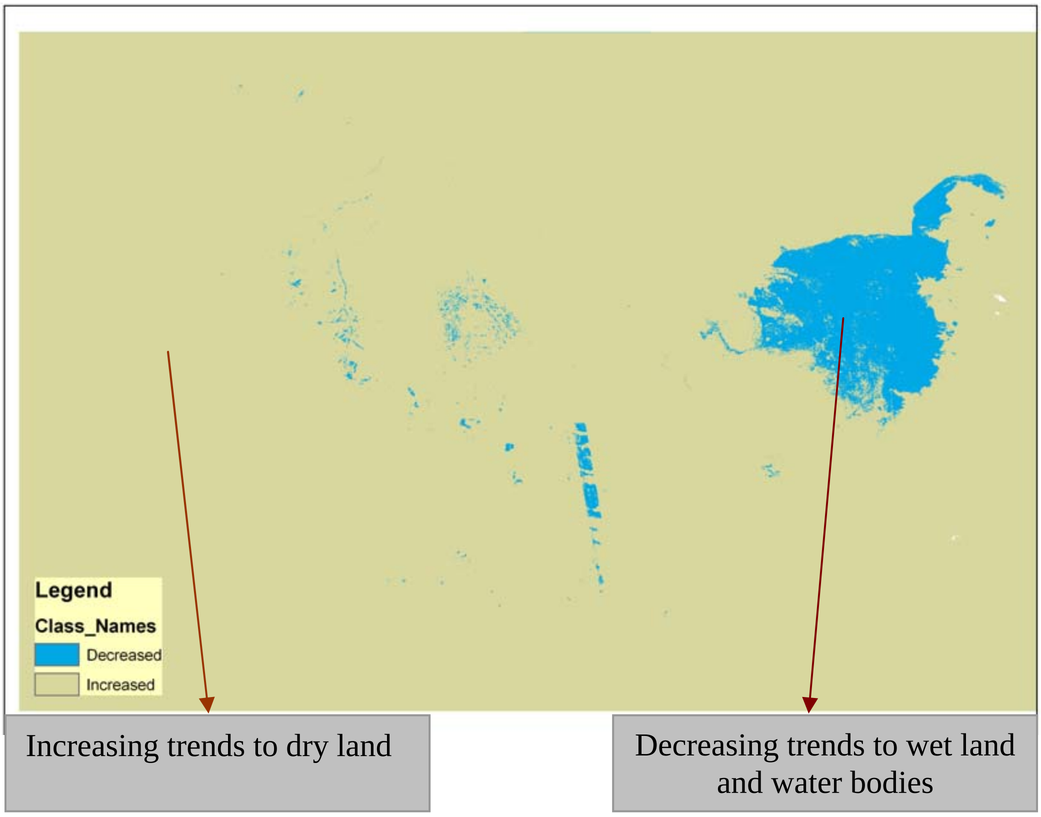


Fig.4: The resultant image (Highlight Changes)

▪ **Image Subtraction**

The main logic that lies behind this method is to calibrate both images spectrally, which were rectified perfectly to each other, and to select some points in dark and bright that remain unchanged on both images (Fig.5), then to subtract them from each other.

BVref = a*BVsub+b

BVref = 0.44893*BVsub+2.69313

Description	Reference	Subject
dark	1	6
dark	2	7
dark	45	11
bright	108	44
bright	111	58
bright	118	63

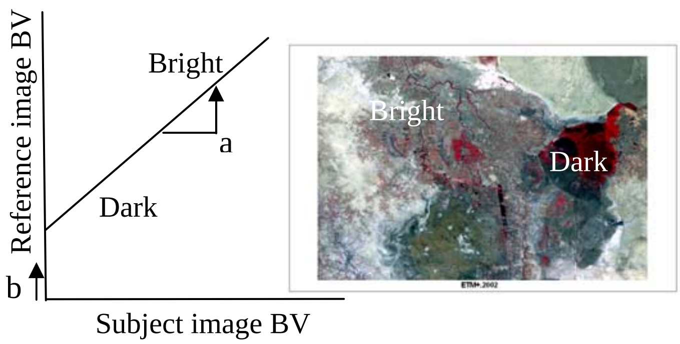
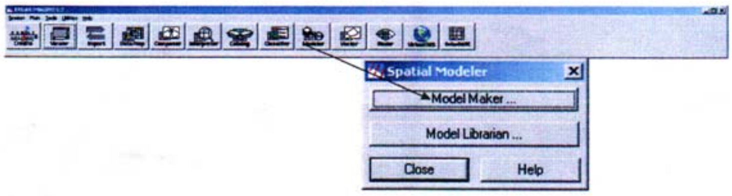
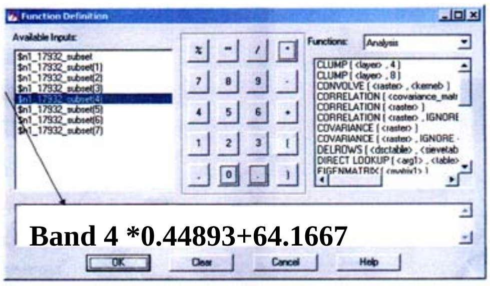


Fig.5: Scatter plot by Excel (after Taner, 2007)

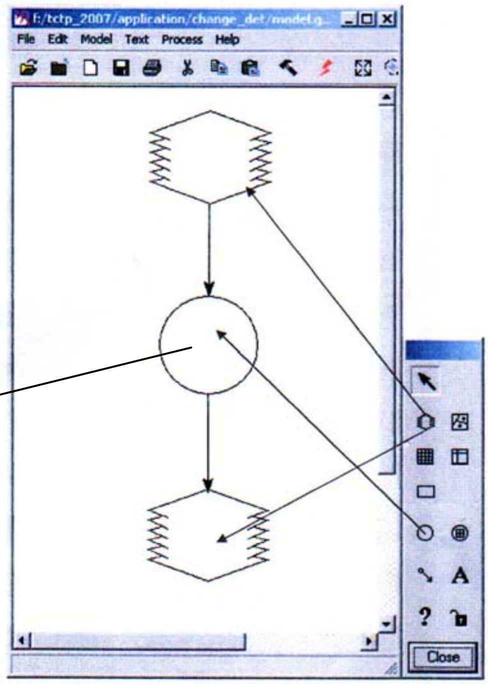
From the graph of Fig.(5), the constants a and b can be obtained. Then the following procedure is applied (using ERDAS IMAGINE software) starting from spatial modeler, through model marker.



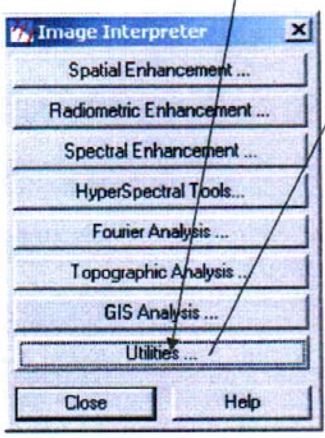
Automatically, a new window is opened and using model maker tool place two input files and one algebra icon are opened.

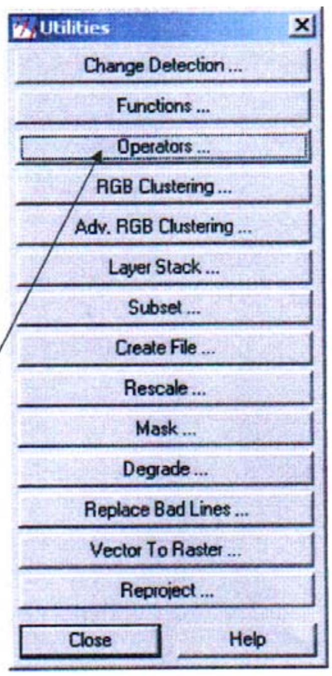


Then click on algebra icon to enter the constants, select the band 4 multiply and add by constants obtained in scatter plot by excel, then click OK.

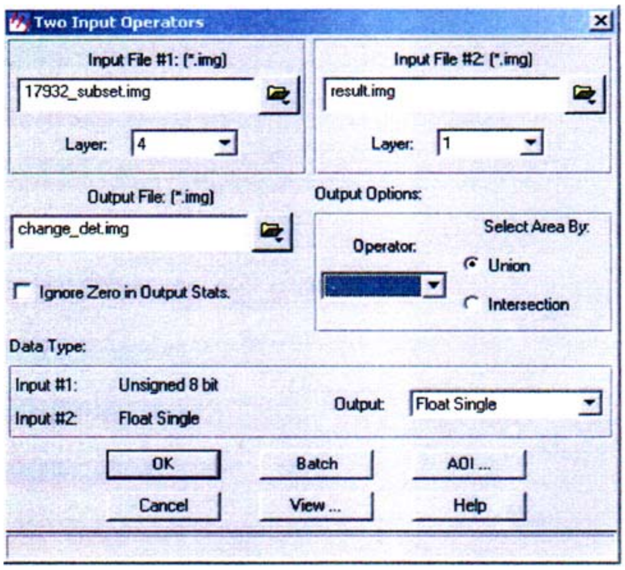


Last step is to use the calibrated image in subtracting process.





Click on the interpreter icon, then on utilities, then on operators, the following window will be opened.



A new window is opened; enter the name of both files that will be applied for subtraction. Then enter the output file name. Select operator type as (-) then click OK (TCTP, 2007). The final resultant will appear as the image in Fig. (6).

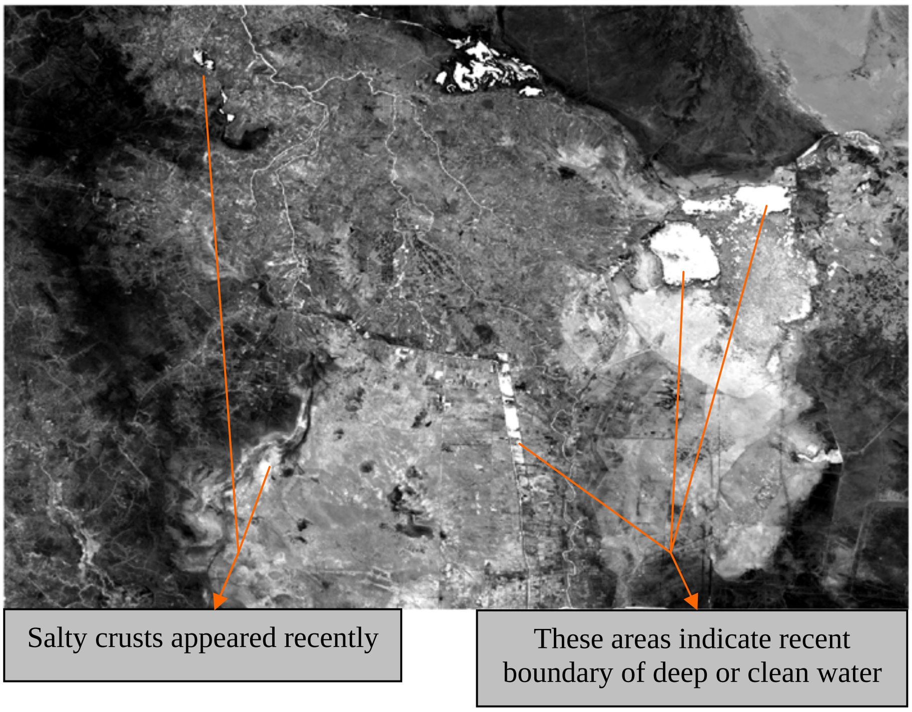


Fig.6: The resultant image shows the change in white color

- **The Normalized Difference Vegetation Index (NDVI)**

The NDVI is a non-linear transformation of the visible (red) and near-infrared bands of satellite information.

NDVI is defined as the difference between the visible (red) and near-infrared (NIR) bands, over their sum. The NDVI is an alternation measure of vegetation amount and condition; it is associated with vegetation canopy characteristic such as biomass, leaf area index and percentage of vegetation cover (TCTP, 2007).

The NDVI is also calculated from Landsat information by using the combinations of band 3 and 4 (Figs.7 and 8).

The standard Landsat NDVI function:
NDVI = (band 4 – band 3)/ (band 4 + band 3)

Fig.7: NDVI for Landsat ETM image, 2002

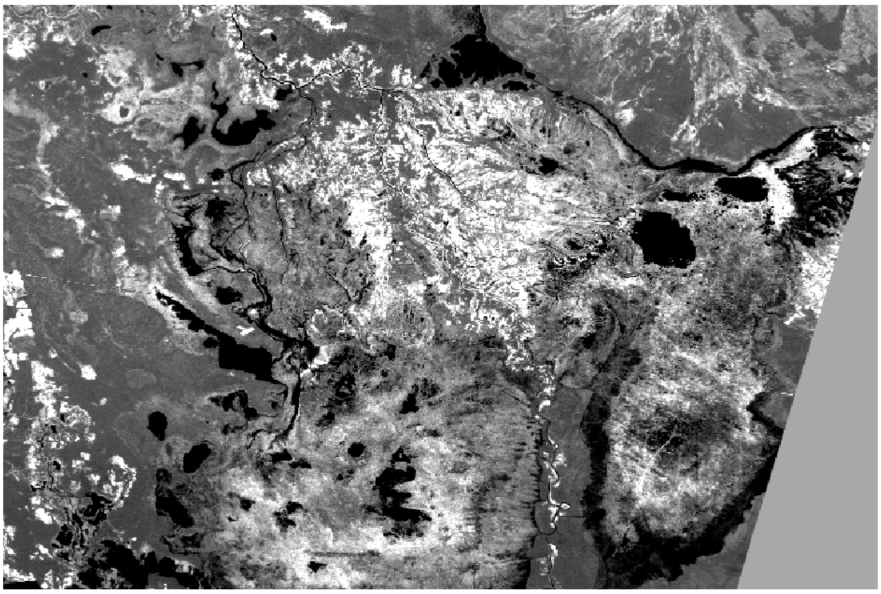


Fig.8: NDVI for Landsat MSS image, 1977

▪ **Tasseled Cap Transformation**

The Tasseled Cap Transformation (TCT) is used to enhance separation between soils and vegetation through the determination of three indices namely; soil brightness, greenness and a third feature associated with soil moisture.

TCT is an orthogonal transformation where the first index is a weighted sum of all bands in the direction of principle variation in soil reflectance that includes more soil reflectance or brightness information. The second index is the greenness axis that describes the contrast between the near infrared and the visible bands, whereas the third component is the contrasts mid infrared reflectance with visible and near infrared reflectance and is important in confirming the separation of areas into vegetated and bare soil units (Kariuki *et al.*, 2004). The changes are clearly observed between the two images (Figs.9 and 10).

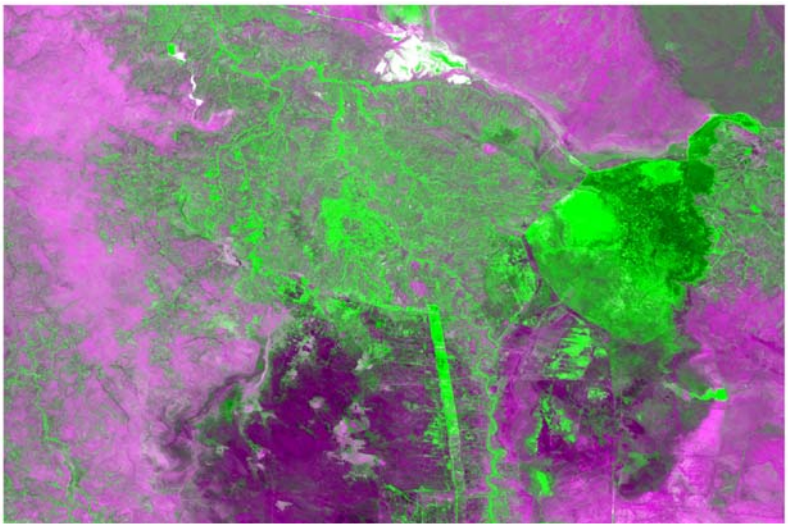


Fig.9: Tasseled Cap of Landsat ETM image, 2002

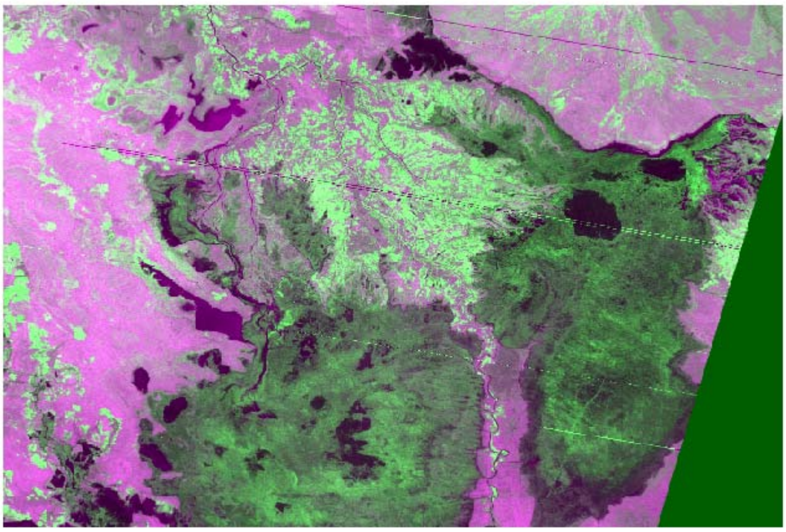


Fig.10: Tasseled Cap of Landsat MSS image, 1977

* Layer 1 (red) brightness indicates soil (purple color), Layer 2 (green) indicates vegetation (green color), Layer 3 (blue) the wetness component indicates water or moisture (dark color).

▪ **Temporal Classification Comparisons**

The used change detection procedure has involved classified images for both dates (Fig.2). Hence the output image greatly depends upon the accuracy of the classified images, a supervised classification, for the images of each date, was curried out using minimum distance method. The selection of the training samples was based on land cover and terrain, taking into consideration the results obtained from the aforementioned methods. Four different land cover classes were selected including deep water, shallow water with reed, dry land and wet land (Figs.11 and 12 and Table 1). This method also shows clear variation in the extension of the four classes, as being numerically indicated in table (1).

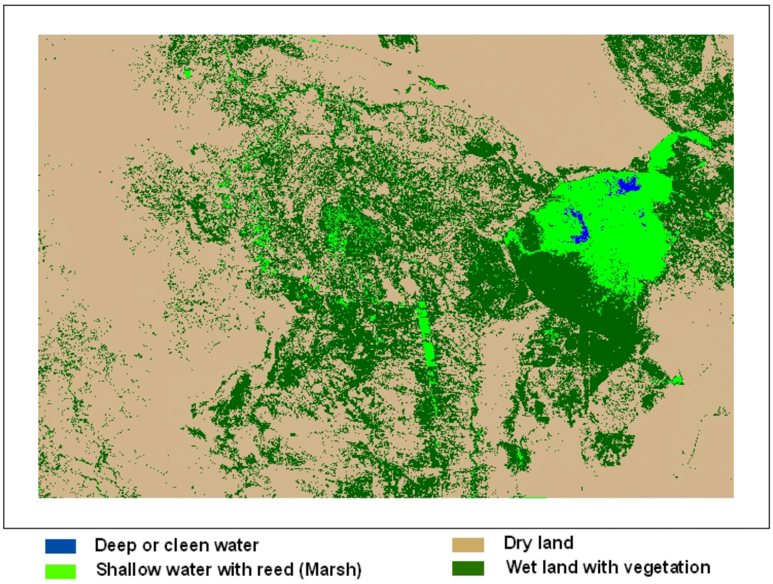


Fig.11: Supervised classification of Landsat ETM+ image, 2002

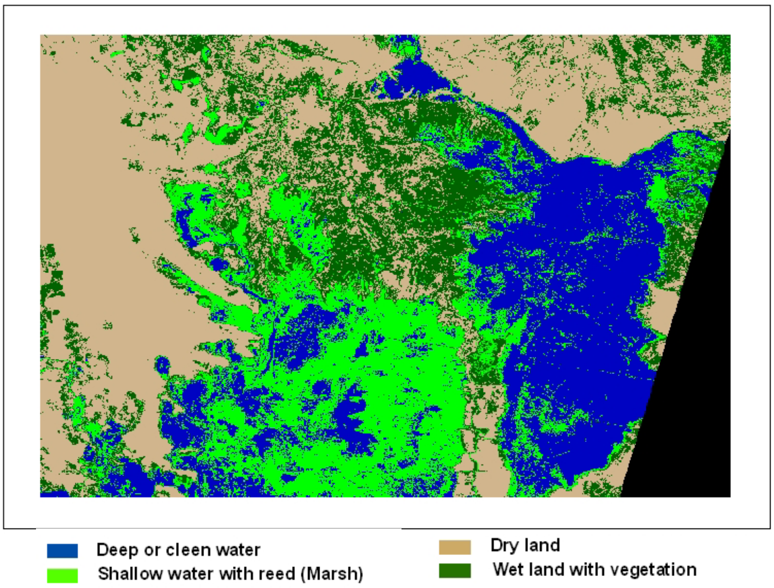


Fig.12: Supervised classification of Landsat MSS image, 1977

Table 1: Supervised classification statistic summary report for ETM+, 2002 and MSS, 1977 images

Classes	Color Class	Landsat MSS, 1977		Landsat ETM +, 2002	
		Area (PIXEL)	Percent	Area (PIXEL)	Percent
Deep water		1178043	21.3674	168175	0.20841
Shallow water with reed		1073723	19.47542	3938249	4.88057
Wet land with vegetation		917552	16.6426	22132260	27.42795
Dry land		1985720	36.0171	54453651	67.48305

RESULTS AND DISCUSSION

By using Landsat images for different years, MSS, 1977 and ETM+, 2002 false color composite image (Fig.2), the dramatic changes can be monitored in water and vegetation areas in different phases of drying and pre drying of the marshes. It can be noticed, by visual interpretation, that the dense marsh vegetation appears as red patches in 1977 image, but in 2002 image most of the marsh land had dried out. It appears as olive to grayish – brown patches indicating low vegetation cover on moist to dry ground. The very light to grey patches are areas of exposed ground with no vegetation, which may be salt flats that can not be used for agriculture.

The application of different techniques of change detection used in the present study and their output figures revealed that there are considerable changes in areas of land cover classes between 1977 and 2002 images and generally these are increasing trends to dry land and decreasing trend to wet land and water bodies. Thus, the dryness of marshes has caused important environmental changes in the study area, which needs urgent solutions and following-up. However, during the last four years, new irrigation works started, aiming to rejuvenate the marshes. Consequently, further remote sensing studies, using modern sets of satellite data are recommended in order to follow-up the recent changes in the marsh areas, for indicating the new boundaries of the reclimated marsh areas.

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