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Monitoring Land Use/Land Cover Changes Around Damietta Promontory, Egypt, Using RS/GIS

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Abstract

Land use/land cover (LULC) change is considered one of the most important signals of regional environmental changes. In this study, supervised classification and post-classification change detection techniques were applied to Landsat images acquired in 1987 and 2015 to map LULC changes along the north part of the Nile delta coastal zone specifically, at Damietta promontory. Landsat images were radio-metrically and geometrically corrected, and then, multi-temporal post-classification analysis was performed to detect LULC changes rates of the Nile delta coast around Damietta promontory where the Damietta branch (of the Nile River) meets the Mediterranean Sea.

Four categories including seawater, developed (agriculture and urban), and undeveloped areas were selected to evaluate their temporal changes by comparing the processed images. The objective of this study is to map and assess the rate of changes LULC changes at the study area which can help the decision makers to replan the use of natural resources efficiently.

By applying remote sensing/GIS technique, areas of rapid change are identified and targeted for more detailed monitoring in the field. Changes among different LULC classes were assessed. The results show that the sew water and urban area were increased.

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1. Introduction

Sustainable development at coastal zone is urgent nowadays worldwide.Consequently, monitoring is is required to reach the sustainability, and ecological protection. The LULC changes have become an essential parameter in the recent strategies to achieve the integrateds coastal zone management that have a great impact on economic development and natural resources managment [1]. Similar to other delta as worldwide, the Nile Delta has been experiencing significant coverage due to natural and man-made intervention. It has been changed from an acccreted zone by the action of sediments transported from the Nile river to the coastal zone to an eroded area after building different water control structures along the Nile, from from South at Aswan to North at the lower Delta, i.e, Aswan Low Dam in 1902 and the Aswan High Dam (AHD) in 1964 [2]. The barrages and dams have a marked control on the magnitude of peak discharges from the river and have virtually eliminated sediment delivery to the coast since its construction[3]. Consequently, an observable change in the land cover of the coastal zone has been occurred during last decades.

The Damietta area has been subjected to large landscape changes and reformations at recent decades. The area still under development and is expected to experience some more changes during the next few years. This demonstrates the urgent need for assessment of the present coverage pattern and land-uses of this area. The present study attempts to determine details of LULC information of the Damietta estuary and surrounding area using high resolution remote sensing Images. Land cover types and surface characteristics were described and their areas estimated and mapped using the standard remote sensing methods[4].

Digital change detection is the process of describing changes in land use properties. It is considered one of the recent important tools in acquiring free data for to manage natural resources in various field. Among different field, it has been widely used in coastal area for monitoring and resources management . In addition, Geographical Information System (GIS) has been applied integrally with remote sensing to estimate the evolution and discover the different changes occurred during a certain helping to make decisions [5]. The simple access to various satallite images from various satellite platforms have helped to generate information on varied aspects of the coastal and marine environment. Remote sensing technique has widely been used in environmental change detection studies. In these studies, different tools have been used in an integrated way to formulate a valuable management action plans [6].
For monitoring coastal area, various methods has been used to detect changes via digital images obtained from different satallite platforms. The most familiar change detection techniques include simple band ratio, principal component analysis, vegetation index algorithms, and others. Major data sources include MSS, TM, ETM, System Pour l'Observation de la Terre (SPOT), moderate resolution imaging spectroradiometer (MODIS), advanced very high resolution radiometer (AVHRR), and other sensors [7]. Post classification change detection is a perfect technique applied to address thematic changes in satellite data. The advantage of using this approach is its applicability to data from different sensors with a high degree of confidence [8]. In addition, post-classification statistics proved to be an effective method as it can analyze the coastal processes and develop reliable models to predict shoreline trend represented in eroded and accreted areas, This is because datasets from two or more dates are independently classified, thereby minimizing problems arising from atmospheric correction and/or sensor degradation [9]. Analysis of different remote sensing images, including Landsat MSS, TM, ETM+ and Spot satellite along parts of the Nile Delta has identified areas of erosion followed by beach accretion. Different studies have been carried out to assess the land cover change along Damietta area [3]. For example, a previous study [9] reported that, a severe change has been occured as a result of agricultural and tourist development projects. These changes led to vegetation degradation and water logging that area. Another study [10], found that barren lands at the north of Damietta have poor potentiality for agriculture. These lands could be utilized for other land use, such as residential, industrial or for touristic activities. While those located east of Damietta could be utilized for aquaculture or as bioremediation facilities for biological treatment of agricultural wastewaters. On the other hand, the current study aims to use the RS/GIS to monitor the

changes in land use over the period from t1987 to 2015 to help decision making to set the right policies and take the right decision to protect the area from further unwanted changes.

2. Materials and Methods

2.1. Study area

The study area of the Damietta Promontory area lies on the north-eastern Nile delta coast and extends about 11.0 km east, 11.0 km west, 5.0 km north, and 12.0 km south referenced to the tip of the promontory,(Figure 1). gThe promontory is one of the most vulnerable areas as it suffers from a continous erosionIt is considered a vital area as it used for transportation, agriculture, and fishing activities. It suffers from different coastal problems represented in accretion inside the inlet, and shoreline erosion that began after the construction of the Aswan High Dam [11].

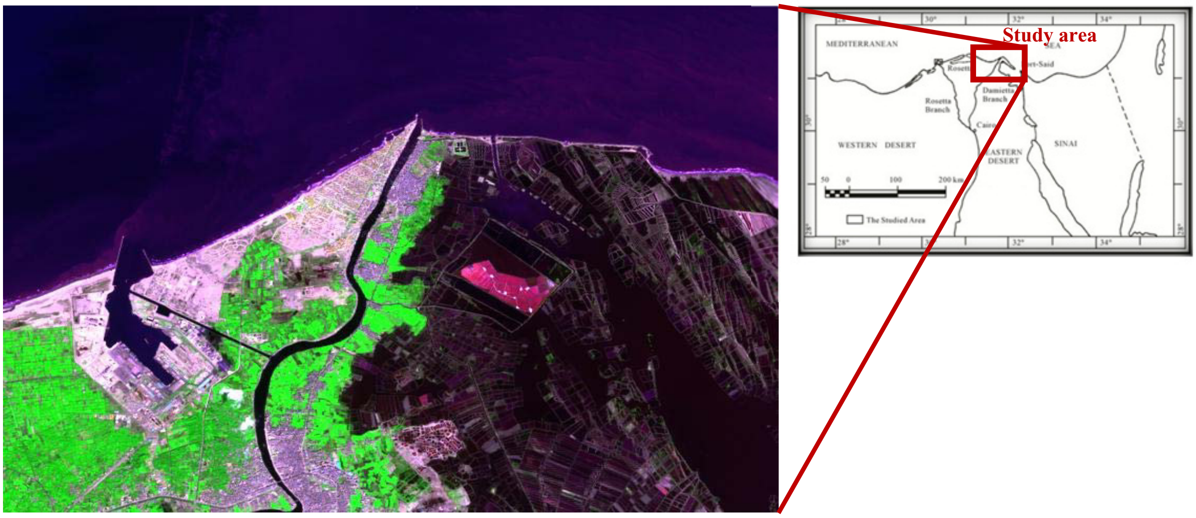

Fig. 1. Study Area, Damietta Promontory area at the terminal of Damietta Branch, Land-sat image, 2015.

2.2. Datasat

The image data was obtained at unequal intervals between 1987 and 2015, covering a time span of 28 years. The images have been acquired in summer season and in good quality, with no effective clouds. Four sets of satellite images were used as presented in Table 1: two from the Landsat TM (30 m spatial resolution) acquired in 1987 and 1999; two Landsat ETM (30 m spatial resolution) acquired in 2003 and 2015.

Table 1. Landsat images used in this research.

Acquired Date	SpaceraftID/Sensor	Path/Row	Pixel Size (m)	Coordinate System/Datum	Zone
Apr 22, 1987	Landsat_5/TM	176/38	30	UTM/WG84	36
Sep 06, 1999	Landsat_7/TM	176/38	30	UTM/WG84	36
Feb 05, 2003	Landsat_7/ETM	176/38	30	UTM/WG84	36
Nov 29, 2015	Landsat_8/ETM	176/38	30	UTM/WG84	36

2.3. Image Pre-Processing

A first step in the pre-processing is to check all images any defects such as striping. Then, all images were clipped to focus on our study area. After that, all images were corrected geometrically and radiometrically. At last, all images were stacked and classified. Image processing has been implemented using ENVI software version 4.8.

2.3.1 Geometric Correction

Geometric correction of the different satallite images is of great importance for change detection since the potential exists for registration errors to be interpreted as LULC change, leading to an overestimation of actual change[12]. Based on the metadata documentation, the TM, and ETM+ images used in the present investigation are ortho-rectified products. They are indeed in the World Geodetic System (WGS84) datum and the Universal Transverse Mercator (UTM) projection system[3] .

Using ENVI 4.8 software, the Satellite map from Google earth software (figure.2) was used as a base map to geo-reference the Landsat image acquired in 2015 through image to map referencing. Then, the Landsat TM image in 2015 was considered as the master image that was utilized to register the other images through image-to-image registration. To accurately register each image, about 20 ground control points (GCP) was examined and matched with all images. These points includedthe most distinguished geomorphologic features. the calculated route mean square error (RMSE) was found about 0.43 pixels, that ensures a good geo-referencing of the images.

Fig. 2. Points Used in Geometric Correction, Satellite Image
Image (Google earth), 2015.

2.3.2 Radiometric Correction

Firstly, the dark-object subtraction method to correct the atmospheric scattering caused by haze, dust or smoke [3]. Then, the current radiometric correction was implemented in one step using radiometric correction tool in ENVI software, which combines the sun and view angle effects, and the sensor calibration with the atmospheric correction. Image Classification

2.4. Image Classification

The overall objective of the image classification procedure is to automatically categorize all pixels in an image into LULC classes or themes. One of the most important applications of satellite remote sensing is to detect changes in land use to discern those areas on digital images that change features of interest between two or more dates [1][3].

The LULC classes are typically mapped from digital remotely sensed data. The spectral signatures of land and water in the region was used to identify each class that already familiar from the different previous studies.

The classification process has been implemented using all spectral bands in the Landsat images (1987, 1999, 2003 and 2015) except the thermal bands .

Based on many trials , supervised classification using support vector machine technique has been implemented to the four images . Four LULC classes have been selected as follows; seawater, agriculture, urban and undeveloped areas. The classified images were then refined using 5×5 majority/minority analysis to remove odd pixels in the classified matrix and reduce noise in the output maps.

Table 2. Points and RMS error used in geometric correction.

Points	Map (x, y)		Image (x, y)		Predict (x, y)		RMS Error
	x	y	x	y	X	y	
P1	362290.9500	3478062.1400	1417.5000	5046.2500	1417.7800	5046.1200	0.31
P2	382800.8900	3482750.1200	2101.8700	4889.5300	2101.6300	4889.6300	0.26
P3	367061.0300	3464814.8300	1576.5000	5486.7500	1576.5400	5486.9000	0.15
P4	392070.7900	3485032.2900	2410.7400	4813.4100	2410.7600	4813.3700	0.04
P5	393515.0000	3483967.0000	2458.5000	4849.0000	2458.8700	4848.8300	0.41
P6	393254.0400	3482173.3100	2450.1000	4908.5700	2450.1000	4908.5900	0.02
P7	393756.9300	3480116.6000	2466.7500	4977.0000	2466.7900	4977.1000	0.11
P8	393381.2500	3476172.3300	2454.3100	5108.5800	2454.1200	5108.5200	0.20
P9	398002.6800	3476394.7400	2608.4400	5101.0000	2608.1800	5101.0400	0.26
P10	410761.4500	3469354.7200	3032.9500	5335.4800	3033.1400	5335.5700	0.21
P11	408214.2500	3471106.8500	2948.3100	5277.1700	2948.3300	5277.1700	0.02
P12	399040.0400	3474578.9200	2642.7200	5161.5300	2642.6900	5161.5400	0.04
P13	395598.2000	3466524.2600	2527.7100	5429.9900	2527.6500	5429.9600	0.07
P14	391126.7600	3470625.7900	2378.7800	5293.3500	2378.7700	5293.3300	0.02
P15	380994.3100	3465868.9700	2040.6700	5452.0000	2040.9100	5451.8100	0.31
P16	376812.6600	3466287.6800	1901.7200	5438.0000	1901.5600	5437.8700	0.20
P17	373324.0500	3467204.3100	1785.2300	5407.3100	1785.3200	5407.3600	0.10
P18	366358.4900	3466435.8800	1553.0000	5433.0000	1553.1500	5432.9500	0.16
P19	370731.3500	3474875.2800	1699.1400	5151.8800	1699.0800	5152.0400	0.17
P20	369593.5600	3471396.6500	1661.5000	5267.7500	1661.0800	5267.8400	0.43

3. Results and Discussions

Support vector machine algorithm techniques among the other supervised calssification techniques gives a good overall accuracy ranged from 0.97 to 1.0 . The areas were computed for the land cover types in each of the classified images shown table 2 in square kilometres. Table 2 presents the descriptions for the land cover types used for the analysis of the study area.

It is clear from the figure 3. that, seawater area has increased from 240.289 km^2 in 1987 to 248.017 km^2 in 2015. This means that the eroded land during this period is about the difference between the two areas. In addition, the urban area increased by 1.466%, which led to a decrease in the agriculture area through advancing towards the sea. On the other hand, the undeveloped areas cover decreased due to the urban extension on both sides of the Damietta promontory, and also due to the construction of the coastal protection measures in front of the promontory.

Damietta harbour, also, have some changed in water area as increase on basin to serve the commercial demands. Land area also was changed whereas urban areas in harbour part were increase.

Table 3. Area and percentage of change of different land cover classes of 1984 and 2014 classified images.

Classes	Area %		Area (km^2)		Area Change %
	1987	2015	1987	2015	(1987-2015)
Sea Water	68.407%	71.437%	240.289	248.017	3.030%

Agriculture	15.926%	13.000%	55.940	45.135	-2.926%
Undeveloped	05.936%	04.365%	20.851	15.154	-1.571%
Urban	09.731%	11.197%	34.182	38.875	1.466%

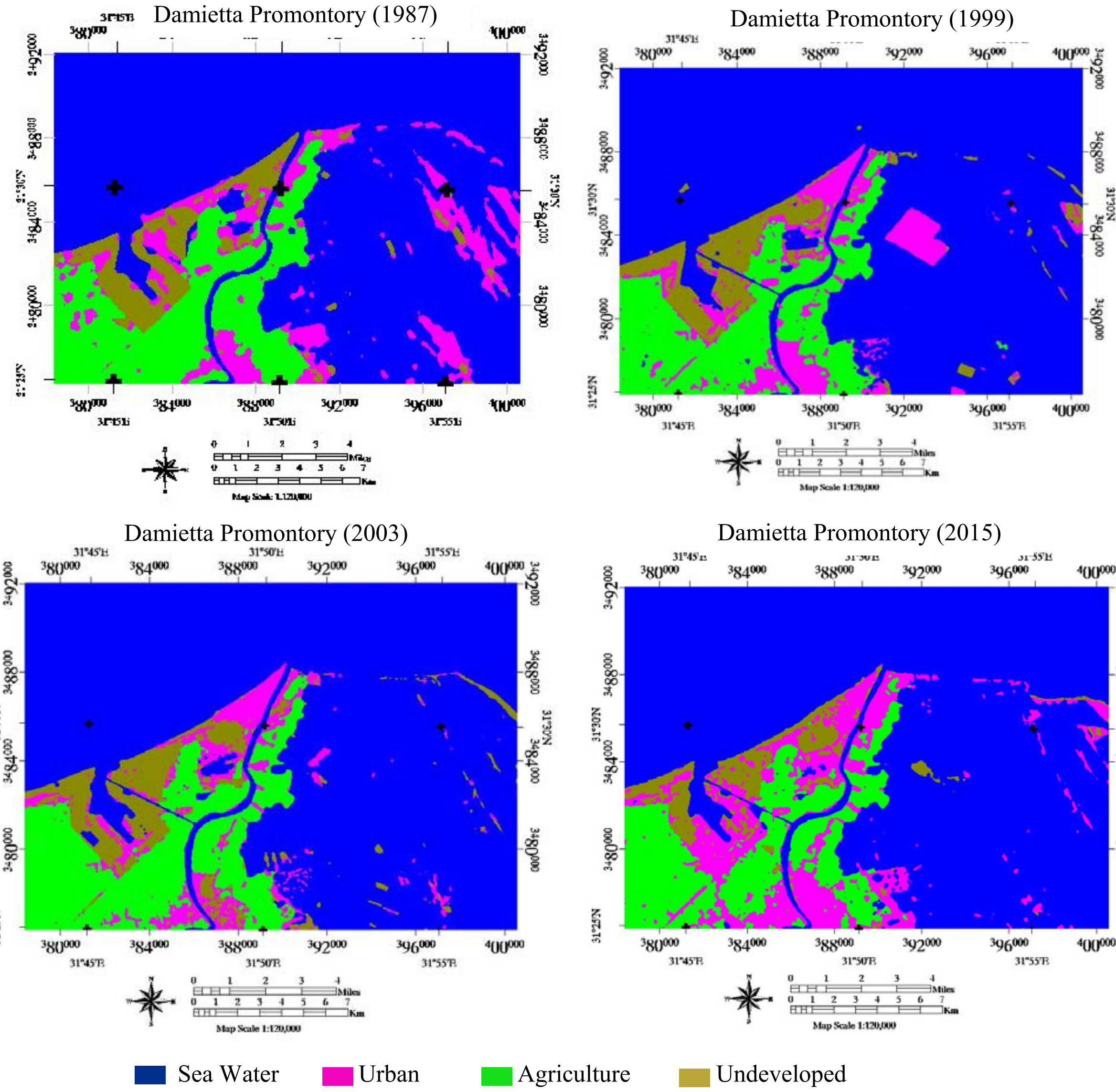

Fig. 3. Land-use supervised-classification for the different Landsat images 1987, 1999 and 2015.

4. Conclusions

Land cover changes have been investigated at Damietta Promontory using Landsat images spacing of 28 years period, acquired in 1987, 1999, 2003, and 2015. These data was geo-referenced using a satellite image, and then corrected geometrically, and radio-metrically. Changes in land cover were detected through supervised classification.

It was found that within the last 28 years, 3.030% of the coastal area at the promontory has been eroded. A considerable increase in urban settlements has taken place by.1.466% was developed. The agriculture areas have been decreased to 2.926%. Damietta harbour was sophisticated and undeveloped areas were decreased.

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