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Research Article

Effect of Land-Use Changes on Agricultural Soil at Northern Part of Suez Canal Region

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Abstract

This paper presents the changes in land use/land cover (LULC) in northeast delta in order to assess the loss of fertile soils due to the urban encroachment. To increase the accuracy of LULC classification, the visual interpretation (using on screen digitizing) was integrated with the supervised classification. This was applied for monitoring changes in LULC using different dates and different satellite images (LNADSAT19984, 1990, 2000, and ASTER 2005). The results show that large area of the fertile soils in the old delta was converted to urban during the period of 1984 to 2005 because of urban sprawl. Urban expansion is a dominant human induce land degradation processes in the region. The overall accuracy of classified LULC results of 1984 and 2005 is 90.6% and 85.4%, respectively. This accuracy clearly made the obtained results reasonably, high dependably and sufficient for detection of urban growth rate. Urban expansion in the region was 48.8% (7032.3 hectare) during the period 1984 to 2005. The increase in urban expansion area was at the expense of agricultural land by 30.9% of old cultivated land. Also, it was noted an increment of new reclaimed soil. This study is emphasized the importance of archiving digital maps in the geographic information systems to evaluate the dynamic changes of LULC. This empirical case considered the application of remotely sensed data as very effective materials could be used for monitoring environmental changes.

Keywords: Land Use/Land Cover; Remote Sensing; GIS; Digital Change Detection Technique

Introduction

UN-Habitat [1] reported that the world urbanization increment rate is expected to by 60% in 2030. This process will have profound influences on food security and environment. Bettencourt., *et al.* [2] stated that world cities are occupying only 0.3% of the total land area, while 3% is taking up by arable land. The rapid loss of farmland under uncontrolled urban sprawl is causing alarm for Egyptian government with respect to food security [3-5]. Egypt's urban population is expected to increase by 30 million in the next three decades, and the urbanization by 40% in 2030 (Afify., *et al.* 2008). Thus, seeking for a balance between urbanization and farmland preservation to protect food security is a major challenge.

According to Korotayev., *et al.* [6], Egypt is third-most populous country in the Middle East and the Africa continental. It came after Ethiopia and Nigeria. About 95% of the population in Egypt lives around the banks of the Nile River in the valley, the Delta and the Suez Canal area. This makes the region as one of the most densely populated in the world. Comparing to 181 persons per sq. mi. for the country as a whole it contains an average of over 3,820 persons per square mile (1,540 per km^2). As a means of trying to compensate for the loss of old agricultural land the government has attempted a mixed success to encourage migration to newly reclaimed irrigated land in the desert. However, the loss rate of the old agricultural land is highly increased [5].

According to Abdou., *et al.* [7] the migration to large cities in Egypt together with the high population growth leads to creation of several unplanned urban squatter settlements and formation of unregulated slum areas. These areas constitute a nationwide problem, being unplanned, illegally constructed and under-served. They tend to be the least well served in terms of infrastructure and public services and the settlers suffer from poverty, unemployment, poor housing and sanitation, lack of clean water, poor accessibility and high levels of overcrowding [8].

The investigated area is located in the North eastern part of Nile Delta occupying an area of about 134977 hectare. Great part of this area is under reclamation and suffering from land degradation [5].

An attempt is made in this study to map out the status of land use/cover to detect the land consumption rate and the changes that has taken place during the study period using geospatial techniques [9].

Materials and Methods

To estimate LULC changes during the selected periods, advanced tools such as Remote Sensing (RS) and Geographic Information System (GIS) techniques have to be used.

Digital image processing techniques are basically ways to change and alter the original raw spectral data to increase the information availability, and to provide the best possible product for analysis and interpretation. It is convenient to consider and group the image processing techniques into four general areas; radiometric correction, geometric corrections and image geo-referencing, and image enhancement to increase the accuracy of Information extraction using supervised classification [10-12].

The spectral bands of used remote sensed data were corresponding to the VNIR and Mid-IR while the thermal bands were not included. The minimum digital number (DN) value were applied to performed Atmospheric corrections for selected bands according to (Vairinho and Woldai, 2000). Geometric correction as shown in figure 1 was processed using ground control points sampling because of its easiest for images due to higher spatial resolution (IIASES,1997).

Before rectification After rectification

Figure 1: Geometric correction.

Geo-coding or re-sampling was performed to solve the geometric distortions and the created new pixels were arranged in geometry with a resolution of equal the master. The pixels sizes were re-sampled to 15 m for ASTER and to 30 m for the Landsat images.

Image enhancement means modification of subjective features of the image, that were poorly expressed, emphasizing certain information and improving the detectability of the targets of interest by amplifying the slight differences to make them readily observable. The current work includes spectral enhancement, Gaussian stretch, histogram equalization, density slicing, edge enhancement; Gaussian stretch is shown in figure 2 meanwhile spatial enhancement and filtering as shown in figure 3 for ETM image and figure 4 for ASTER image.

Figure 2: Gaussian Stretch Methods.

Figure 3: ETM image before (a) and after (b) enhancement.

Figure 4: ASTER image before (a) and after (b) enhancement.

To assure redundancy in the contained spectral information, the non-normalized individual of Landsat images performed to be highly correlated with each other and coefficients was close to 1.

The principal components for the sum-normalized bands were calculated using ILWIS software, to identify the eroded areas which could be retrieved from selected bands. Then generate a color composite for visual interpretation to help increasing the accuracy of classification.

The less correlated of Sum normalized bands was for bands 1, 5 and 4 while bands 1, 2 and 3 were presented high correlation. Also, bands 5 and 7 shows a high correlation. In this study, the best results were obtained from less correlated sum normalized bands (1, 4 and 5) which means it was best combination of suggested statistics.

The overall spectral variability of bands 451 in red, green and blue (RGB), is presented in figure 5 for ETM image and figure 6 for ASTER image. Green vegetation was identified using the peak presented in the near infrared region.

Figure 5: Color composite of sum normalized Landsat image in 1984, Bands 451 in RGB, respectively.

Figure 6: False color composite of ASTER image in 2005, Bands 321 in RGB, respectively.

Results and Discussion

The goal of image classification is to automatically classify all pixels of multi spectral image into one or several classes or themes. The spectral reflectance characteristics of different features manifest different combination of digital values (commonly known as spectral signatures). Based on these spectral signatures, a new output image is created having specific number of categories or clusters. These categories data may then be used to produce thematic maps. The two general types of classification, which have the following distinctions, have been executed for the investigated area. Image classification included two types unsupervised and supervised classification.

Supervised classification has been executed for the studied area showing land use/ land cover of the investigated area as shown in table 1 and figure 7-12.

Feature in study area in	1984	1990	2000	2005
Agriculture	33.95	36.00	44.95	57.75
Desert and bare soil	38.77	37.33	33.67	23.58
Lake Manzala	21.44	19.26	12.25	11.62
Lake Temsah	0.11	0.11	0.11	0.11
Suez Canal	0.58	0.64	0.67	0.68
Urban	1.59	1.77	2.54	2.80
Water Bodes and Fish bonds	3.56	4.89	5.80	3.46

Table 1: The result of applying supervised of image 1984, 1990, 2000, and 2005.

Figure 7: Land use land cover in 1984.

Figure 8: Land use land cover in 1990.

Figure 9: Land use land cover in 2000.

Figure 10: Land use land cover in 2005.

Figure 11: Urban expansion in, 1984 - 2005.

Figure 12: Change in lake manzala between 1984 and 2005.

Digital change detection techniques by using spatio-temporal dynamics of land use/cover helps in understanding landscape dynamics. Supervised classification methodology has been employed using maximum likelihood technique in ENVI Software. The images of the study area were categorized into five different classes namely Agriculture, Desert and bare soil, Lake Manzala, Lake Temsah, Suez Canal, Urban, and Water Bodes and Fish bonds. The results indicate that during the study periods, Agriculture and Urban land and Suez Canal area have been increased by 23.8%, 1.2% and 0.1% while Desert and bare soil, Lake Manzala and Water Bodes and Fish bonds areas have decreased by 15.2%, 9.82%, and %, 0.1% respectively. Lake Temsah has recorded a negligible decrease. The paper highlights the importance of digital change detection techniques for nature and location of change of the Suez Canal region. The confusion matrix of the area in m^2 is appeared in table 2.

The overall accuracy of the land use/cover map for 1984 and 2005 were determined to be 90.57% and 85.43%, clearly, these data have reasonably high accuracy, and thus are sufficient for urban growth detection. The monitoring East Delta, from 1984 to 2005 indicated that the urban area was changed from 28110 to 44854 hectares by increasing rate about 48.79%, while, the decreasing rate in old vegetated was 30,9%. The overall accuracy of the land use/land cover maps for 1984 and 2005 was 90.57% and 85.43% respectively. It is clearly that, these data have reasonably high accuracy, and thus are sufficient for urban growth detection.

Feature in study area	**1984**	**1990**	**2000**	**2005**
Agriculture	601690.68	614253.74	796611.61	1023479.69
Desert and bare soil	687111.94	85786.77	596694.50	417817.69
Lake Manzala	379954.64	341291.03	217136.85	205919.98
Lake Temsah	1967.94	1967.94	1967.94	1924.55
Suez Canal	10308.92	11353.70	11901.32	12129.75
Urban	28110.44	31299.70	45015.20	49615.99
Water Bodes and Fish bonds	63039.05	86688.79	102856.20	61295.97
Feature in study area	**1984-1990**	**2000-1990**	**2005-2000**	**2005-1984**
Agriculture	12563.0600	182357.8700	0.0000	421789.0100
Desert and bare soil	-601325.1700	510907.7300	0.0000	-269294.2500
Lake Manzala	-38663.6200	-124154.1800	-6694.1800	-174034.6600
Lake Temsah	0.0000	0.0000	-40.2900	-43.3900
Suez Canal	1044.7800	547.6200	228.4200	1820.8200
Urban	3189.2700	13715.5000	219.8400	21505.5500
Water Bodes and Fish bonds	23649.7400	16167.4000	6286.2100	-1743.0900

Table 2: Land use/land cover supervised classification of the studied between 1984, 1990, 2000, and 2005.

It is clear from the tables 1 and 2 that urban sprawl is taking place upon the old Nile delta which is a fertile soil and although the agricultural areas increased doesn't compensate the valuable loosed soil from the old delta.

Equation of Normalized Difference Vegetation Index (NDVI) was applied and the results of NDVI classification used to distinguish between Agricultural and non-Agricultural areas.

Conclusion

The results revealed are consistent with the change detection techniques applied for study area. These techniques were studied independently with available images of the Landsat TM and the ASTER of two dates. This has been done to understand, analyze and evaluate the different change detection that has been appeared.

Over the past four decades, farmland loss problem in the face of rapid urbanization has become a topic of increasing concern in the study area.

This research work demonstrates the ability of GIS and Remote Sensing in capturing spatial-temporal data. Attempt was made to capture as accurate as possible five land use/land cover classes as they change through time.

The overall accuracy of the land use/land cover map for 1984 and 2005 were determined to be 90.57% and 85.43%, clearly, these data have reasonably high accuracy, and thus are sufficient for urban growth detection.

The land use and land cover change matrix for the different types of the East Delta area from 1984 to 2005. Urban expansion in the East Delta, from 1984 to 2005 was 48.79%, increase in urban or built-up land, and decreased in old vegetation area (30.91%). Also, the agriculture land was increased upon desert land and bare soil through the reclamation process. Most of the dried Manzlah bed lake moved to agriculture class and minor part to fish ponds.

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