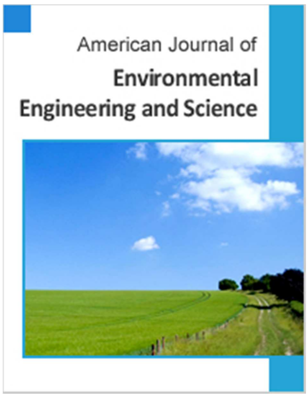
American Journal of Environmental Engineering and Science
2016; 3(1): 33-42
Published online February 24 2016 (http://www.aascit.org/journal/ajees)
ISSN: 2381-1153 (Print); ISSN: 2381-1161 (Online)

American Association for Science and Technology



Utilizing of Geoinformatics for Mapping Land Use/Land Cover Changes in Sohag, Egypt

Abdel-rahman A. Mustafa, Osama E. Negim

Soil & Water Department, Faculty of Agriculture, Sohag University, Sohag, Egypt

Email address
a_mustafa32@yahoo.com (Abdel-rahman A. M.), onegim@yahoo.com (Osama E. N.)

Citation
Abdel-rahman A. Mustafa, Osama E. Negim. Utilizing of Geoinformatics for Mapping Land Use/Land Cover Changes in Sohag, Egypt. *American Journal of Environmental Engineering and Science*. Vol. 3, No. 1, 2016, pp. 33-42.

Keywords
GIS,
Capability Classification,
Urban Sprawl,
DTC,
NDVI,
NDWI,
SBI

Received: January 15, 2016
Revised: January 28, 2016
Accepted: January 30, 2016

Abstract
In this study an attempt was done to assess the change of agricultural land in Sohag province, Egypt between 1987 and 2012. Decision Tree Classifier (DTC) was applied to map land cover changes in the study area. Landsat ETM+ satellite data of three years viz., 1987 and 2012 have been used in the study. Three remote sensing derived indices namely, Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and Soil Brightness Index (SBI) have been used for identifying vegetation, waterbodies and built up area. These derived indices have been incorporated in Decision Tree Classifier (DTC) for delineating and mapping land use / land cover in the study area. Results revealed that there was an increase in built up areas which reflects urban sprawl on old cultivated soils. Also, the activities of soil reclamation were increase during the studied period. On the other hand, there was a decrease in the area of the river Nile. Combining the soil and land capability maps, in one hand, and the Landuse / land cover layers, in another hand under GIS environment, the risk of urban expansion on the expense of the highly capability soil class can be notice. The obtained results cleared that the highest capability soils (S1 and S2 classes) occurred in the old cultivated land which decreased from 292.15 km^2 to 211.70 km^2 and occupied by built up area. Whereas, the lowest capability class (N1) betided in Agricultural Prospective areas which have a coarse texture soils and high calcium carbonate content and many other properties that limit their productivity. Similarly, the coarse texture soil and high calcium carbonate content decrease the capability (S3 class) of the new reclaimed areas. The results of this study are of paramount important for natural resources management and for decision makers for implementing the restricted rules which protect the land from human misusing of natural resources.

1. Introduction

Egypt is one of the lands which suffering from the rapid growth of population, the total population increased ranged from 11 million in year 1907 to 79.88 million in 2011 (Msrintranet. Capmas. gov. eg, 2011). Brikowski and Faid (2006) noticed that the Quaternary River Nile sediments which occupy 5% of the Egypt area support 90% of Egypt's agriculture production. In the last three decades the development of the Egyptian desert has accelerated rapidly for reliving overpopulation pressure in the narrow Nile Valley and Delta which the average annual growth rate is expected to reach 1.75% (FAO, 2006). The successive governments of Egypt adopted policies seeking self-sufficiency in food production through the extension of cultivated land (1.2% per year) and maximization of production of the existing agricultural land (Abdul aziz et al., 2009).

Also the national plan aims at exploiting 25% of the territory of Egypt by the end of the first half of the 21st. Reclamations for agriculture purposes and human settlements have targeted different areas throughout the Egypt and the southern part of the western desert are which the study area lie in it is a part of these areas.

Land use is influenced by economic, cultural, political, historical and land tenure factors at multiple scales. Land use referred to as man's activities and the various uses which are carried on land. Land cover is referred to as natural vegetation, water bodies, rock/soil, artificial cover and others resulting due to land transformation. Since both landuse/land cover are closely related and are not mutually exclusive they are interchangeable as the former is inferred based on the land cover and on their contextual evidence. The lack of spatially detailed data of agricultural landuse change creates a serious problem for modeling and mapping these changes. Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy. Geoinformatics which include remote sensing, GIS and GPS provide efficient methods for analysis of land use issues and tools for not only agricultural land use planning but also for modeling. Urban land cover types and their areal distributions are fundamental data required for a wide range of studies in the physical and social science, as well as by municipalities for land planning purposes.

Elbeih et al. (2013) investigated the impact of urban sprawl on agricultural land through integrating remote sensing and GIS in Gharbia Governorat, Egypt. They concluded that the study area witnessed a severe land cover change as a result of urbanization due to the influence of both population growth and lack of security especially during the beginnings of 2011. A considerable increase in urban settlements has taken place at the expense of the most fertile lands in the governorate. These results coincided with the findings elaborated by Al Tarawneh (2014) who studied the effect of urban sprawl on agricultural land in Shihan Municipality Areas, Jordan. The results showed that Shihan Municipality areas lost much of its agricultural land as a result of urbanization and indiscriminate, like other towns and villages in Jordan. The study concluded the need to ring the alarm bells, to take the urgent necessary steps, to expedite the processing of land use plans that limit urban sprawl, and improve the legislation that prevents constructions in agricultural land; to save what remains of these lands.

In the current study, an investigation has been carried out in a Part of Sohag governorate to detect the change in agriculture areas, urban areas, and River Nile during the period from 1987 to 2012 and to emphasize that the urbanization has been occurred on the highest fertile and the most capable soils of the area. The information gleaned from landuse/cover and changes over time can be used in formulating management policies of the national governments and monitoring active agricultural programs.

2. Materials

2.1. Location

Sohag Governorate is located in upper Egypt, 467 km south of Cairo between geo-coordinates 26° 7' 00" to 26° 57' 00" N and 31° 20' 00" to 32° 14'00" E covering about 11,022 km^2. The Governorate is bounded to the north and south by Assuit and Qena Governorates. To the east, it is bounded by the Red-Sea Governorate and the Eastern desert and to the west by the New Valley Governorate and the Western desert (Fig. 1a and b). The length of the River Nile reaches 125 km, and the width of the valley varies from 16 to 20 km. Sohag province consists of 11 central units, 10 cities, 51 local units, 270 mother villages and 1217 small villages. Total population is 3,113,012 capita, 78% of them live in rural areas. The study area covers the middle sector of Sohag province extending between latitude 26° 41' 00" to 26° 23' 00" N and 31° 35' 00" to 31° 55'00" E and bordered from both the east and west by the higher relief Eocene limestone plateau. The false color composite (FCC) of the area is shown in Fig. 2.

2.2. Remote Sensing Data

In the present study the Landsat ETM+ satellite data of two years viz., 1987 and 2012 were used. Sohag Governorate is covered by three images (175Path /42 Row, 176 Path /42 Row and 176 Path /41 Row). The digital data of geo-coded cloud free of three images were downloaded from http://glcf.umd.edu/data/landsat/ (GLCF, 2014). Tables 1 and 2 present the principle specifications of the sensor and data used in the investigation.

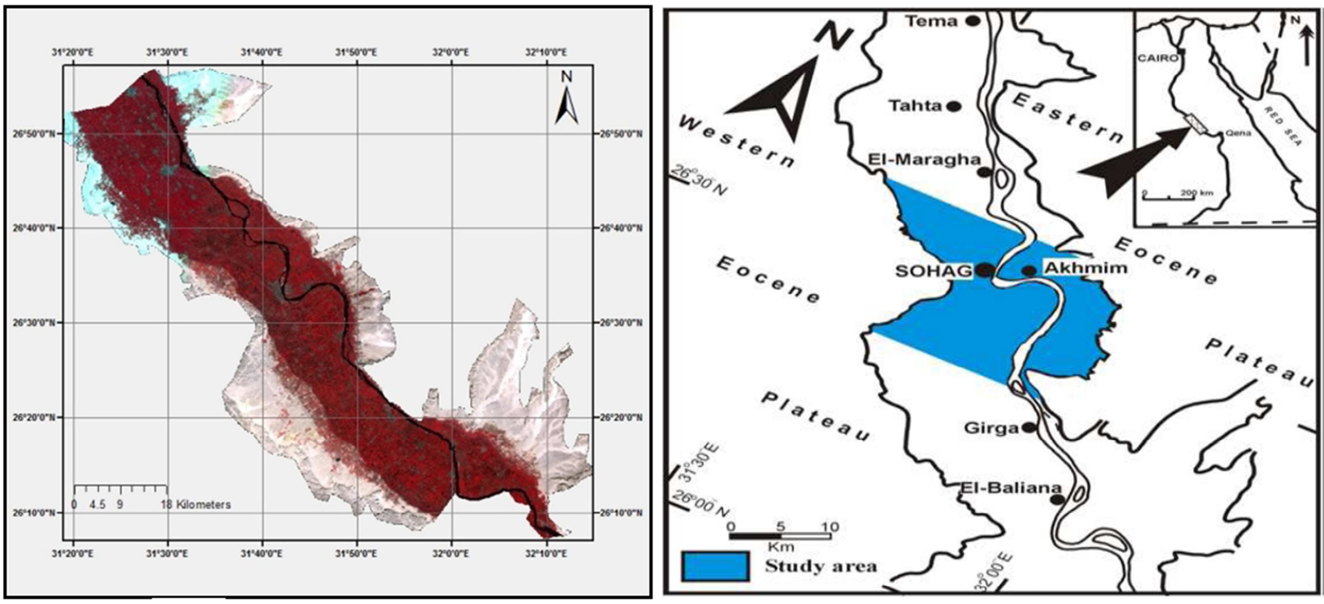
3. Methodology

3.1. Pre-processing of Remote Sensing Data

Essential steps must be done before digital image processing. This includes the generation of false color composite images (FCC), mosaicking of the three images and sub image extraction and masking out using resize module of ENVI software (ver.4.8).

3.2. Visual Interpretation of Remote Sensing Data

Visual interpretation is the identification of features based on their some interpretation keys such as shape, size, pattern, tone, texture, color, shadow and other associated relationships within the imagery. To visually interpret digital data such as satellite images, individual spectral bands must be displayed simultaneously in the form of a color composite.



a b

Fig. 1. *FCC (a) and Map (b) of Sohag Governorate.*

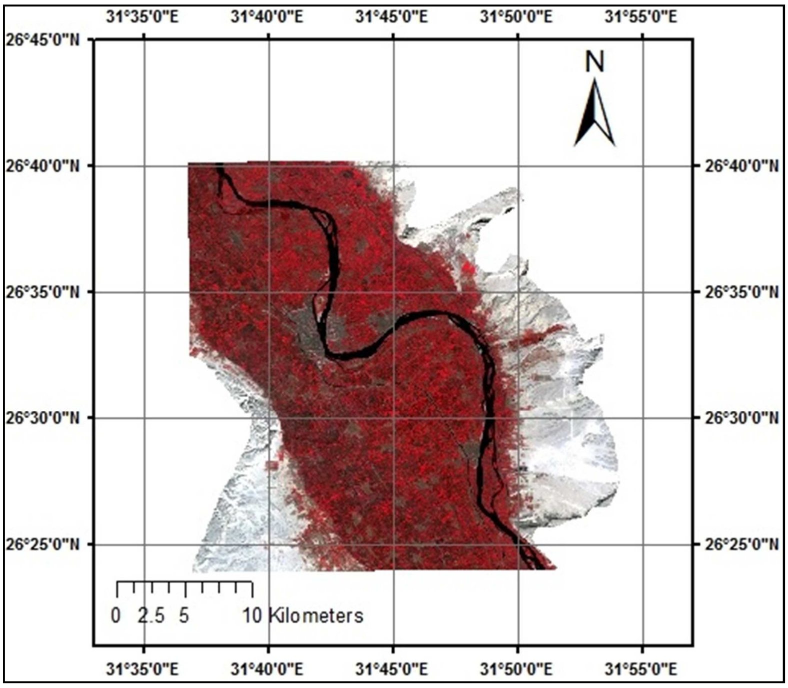


Fig. 2. *FCC of the study area.*

Table 1. *Satellite and sensor specifications.*

Bands		Spatial resolution (m)	Spectral resolution (µm)
1	Blue	30	0.414 – 0.514
2	Green	30	0.519 - 0.601
3	Red	30	0.631 – 0.692
4	NIR	30	0.772 – 0.898
5	SWIR-1	30	1.547 – 1.749
6	TIR	60	10.31 – 12.36
7	SWIR-2	30	2.064 – 2.345
8	Pan	15	0.515 – 0.896

Table 2. *Remote sensing data specifications.*

Scene	(Path / Row)	Date (year)
1	175 / 42	
2	176 / 42	1987 & 2012
3	176 / 41	

3.3. Spectral Indices

To map land use/land cover, appropriate spectral indices were calculated. Spectral index is a mathematical expression of number of bands to enhance the variation and to recognize vegetation and/or soil conditions. The main indices used in the present study are given hereunder.

3.3.1. Normalized Difference Vegetation Index (NDVI)

The NDVI, being a potential indicator for crop growth and vigor, was used in the study. Rouse et al., (1974) suggested a formula which is given by equation 1.

$$NDVI = \frac{(NIR - R)}{(NIR + R)} = \frac{(B4 - B3)}{(B4 + B3)} \quad (1)$$

Where: NIR: Near infrared band (B4), R: Red band (B3).

3.3.2. Normalized Difference Water Index (NDWI)

The water bodies (such as the River Nile) were identified using normalized difference water index (NDWI) given by Mcfeeters, (1996). Equation 2 gives the expression of NDWI.

$$NDWI = \frac{(Green - NIR)}{(Green + NIR)} = \frac{(B2 - B4)}{(B2 + B4)} \quad (2)$$

Where: Green (B2), NIR: Near infrared band (B4)

3.3.3. Soil Brightness Index (SBI)

This index enhances the bare soil reflectance and makes better visual contrast between soils and vegetation boundaries (Kauth and Thomas, 1976). Also, it is found useful for identifying built up areas. SBI is given by the equation 3.

SBI = 0.4328 (Green) + 0.6490 (Red) + 0.4607 (NIR) (3)

3.4. Classification Approach

Classification is a method by which labels or class identifiers are attached to the pixels making up a remotely sensed image on the basis of their characteristics. These characteristics are measurements of their spectral response in different wavebands. They may also include other attributes (e.g. color, tone, texture, pattern, size, shape and association) or temporal signatures. Many types of classification methods are extensively used in remote sensing such as supervised, unsupervised and decision tree classifier.

The decision tree classifier (DTC) is a hierarchically based classifier i.e. a data set containing (ω) themes are classified into successive levels of lesser complexity, till each class is separated (Fig. 3).

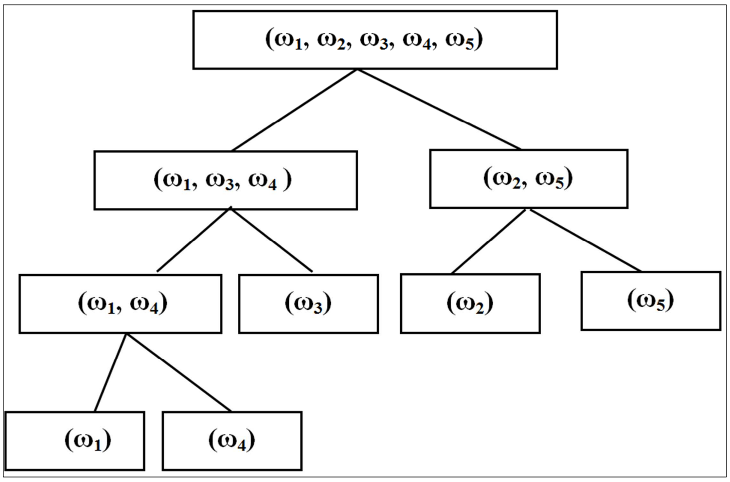


Fig. 3. *Example of binary tree (ω: specific class).*

Thirty training sites identified (Fig. 4) and five different land cover classes were considered, namely water body (i.e the River Nile), Old cultivate lands, New reclaimed lands, Prospective agricultural lands and built up areas.

3.5. Accuracy Assessment

Accuracy is the degree of closeness of results to the true values. The expected accuracy and the level of confidences obtained from a particular accuracy assessment approach depends primary on the number of samples of each class and the quality of reference data set involved in the analysis. The classified thematic maps are produced for a wide variety of resources and these maps are not useful without quantitative statements about their accuracy. Generally, classification accuracy refers to the extent of correspondence between the remotely sensed data and reference information (Jensen, 2004). The accuracy of digital land cover classifications can be expressed quantitatively by building and interpreting a classification error matrix. An error matrix compares information from a classified image or land cover map to known reference (truth) sites for a number of sample points.

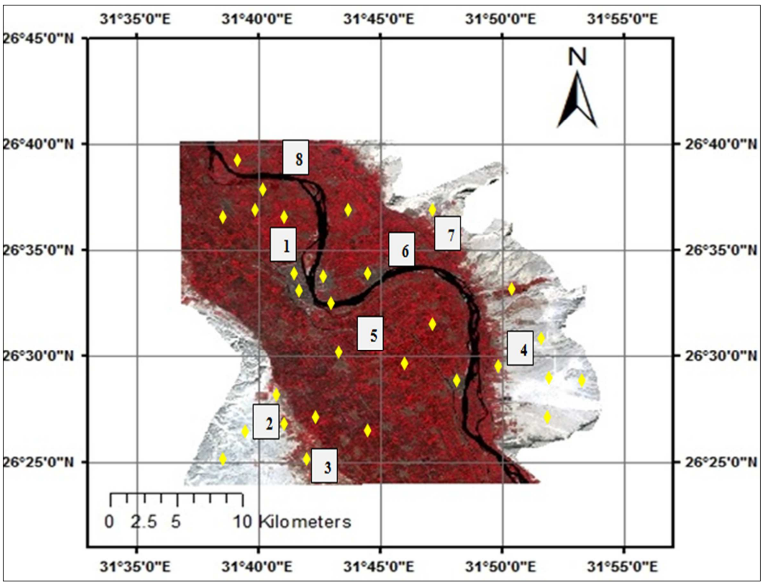


Fig. 4. *Soil profiles and training sites in the study area.*

The accuracy assessment of the land cover maps extracted from Landsat data include the generation of random references (truth points) for each land cover map. Accuracy assessment of the land cover maps after the post-classification refinement and the results were recorded in a confusion matrix. Two important information can be derived from the matrix the first is errors of omission (producer's accuracy) and the second one is errors commission (user's accuracy) (Lillesand and Kiefer, 1994; Congalton and Green, 1999; Campbell, 2002).

Kappa analysis technique is based on K statistics and it has been recommended (Fung and Ledrew, 1988) as suitable measures of accuracy in thematic classification because it takes into account the whole error matrix instead of only the diagonal elements, as the overall accuracy does. The Kappa coefficient is given as in equation 4:

$$K = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} (x_{i+} * x_{+i})}{N^2 - \sum_{i=1}^{r} (x_{i+} * x_{+i})} \quad (4)$$

r = number of rows in the error matrix

x_{ii} = number of observations in row *i* and column *i* (on the major diagonal)

x_{i+} = total number of observations for row *i*

x_{+i} = total number of observations for column *i*

N = total number of observations in error matrix

Kappa is a real dimensionless number between -1 and 1, the value close to 1 includes the maximum agreement while value of -1 can be interpreted as a total disagreement.

3.6. Soil Samples Collection and Analysis

A number of 8 soil profiles represented the different soils occurred in the study area were chosen and dug for collecting soil samples. A total number of 30 horizon wise samples were collected, air dried and prepared for chemical and physical analysis (i.e. soil texture, $CaCO_3$ content, CEC, EC, ESP, pH, and organic carbon content) according to (Black, 1982). The resulted data have been compiled in the database and incorporated into the attribute tables of the soil maps. Land capability techniques were done using the rating tables suggested by Sys and Verheye, (1978); FAO, (1976 and 1983) and Sys et al., (1991) according to the equation 5:

$$\mathrm{Ci} = \mathrm{t} \times \frac{\mathrm{W}}{100} \times \frac{\mathrm{S1}}{100} \times \frac{\mathrm{S2}}{100}\frac{\mathrm{S3}}{100} \times \frac{\mathrm{n}}{100} \quad (5)$$

Where:

Ci = Capability index (%)

t = Slope (t)

w = Drainage conditions (w)

s1 = Texture (x)

s2 = Soil depth (d)

s3 = $CaCO_3$ content (k)

n = Salinity and alkalinity (n)

4. Results and Discussion

4.1. Landuse/Land Cover Changes

The land use categories such as water bodies, old cultivated lands, built up area and agricultural prospective areas have been identified and mapped from Landsat TM for the year 1987. Regarding to the image of 2012, one more category has been identified i.e. new reclaimed areas. The landuse/land cover of 1987 and 2012 images are presented in figures 5 & 6 and the represented FCC images in Figures 7 & 8. The results indicated that there was a decrease in the area of the River Nile as it decreased from 25.4 km^2 in 1987 to 20.9 in 2012 (Fig. 9 & 10). The decrease of River Nile may be due to the increase of deposition of sediments, and formation of new islands (Ahmed and Fawzi, 2011).

Whereas there was an increase of the areas occupied by built up land during 1987 and 2012 and the magnitude of this increase was 86.1 km^2. As a result, about 80.5 km^2 of old cultivated lands were lost. This is due to shifting of old agricultural land to build up (Table 3).

Table 3. *The lands cover changes in (km2) in 1987 and 2012 years.*

Class	1987	2012	Total change
River	25.36	20.92	- 4.44
Built up area	123.10	209.20	+ 86.10
Old cultivated land	292.15	211.70	- 80.45
New reclaimed land	---	6.60	+6.60
Agricultural prospective area	246.53	238.72	- 7.81
Total	687.15		

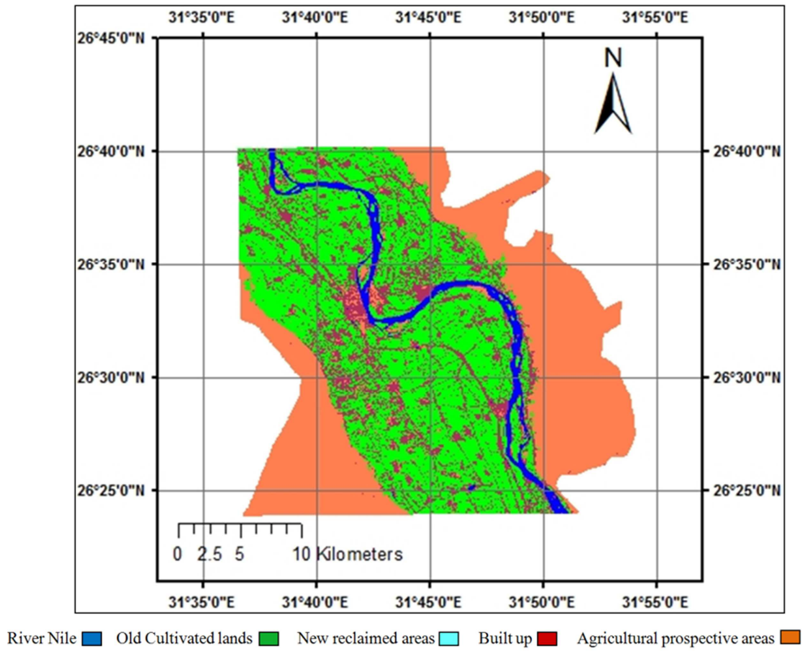


Fig. 5. *Landuse/land cover map for the year 1987.*

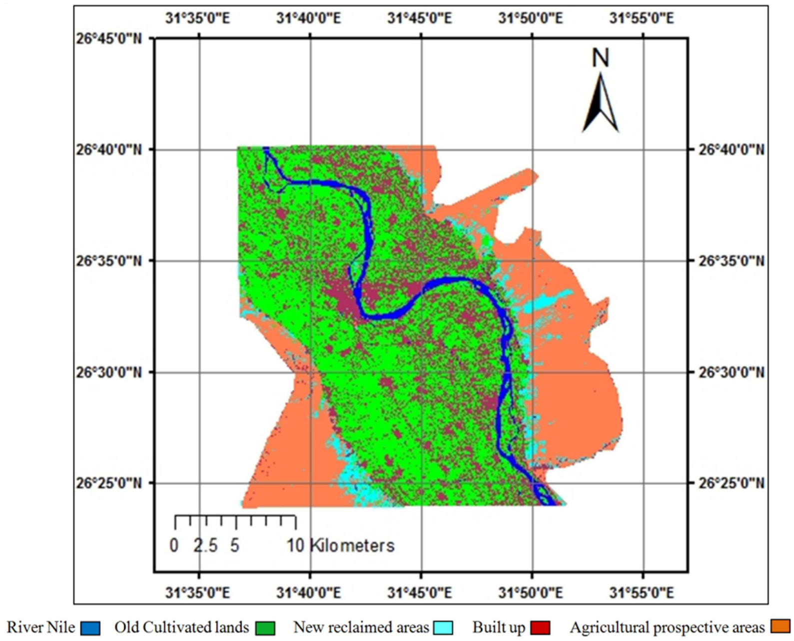


Fig. 6. *Landuse/land cover map for the year 2012.*

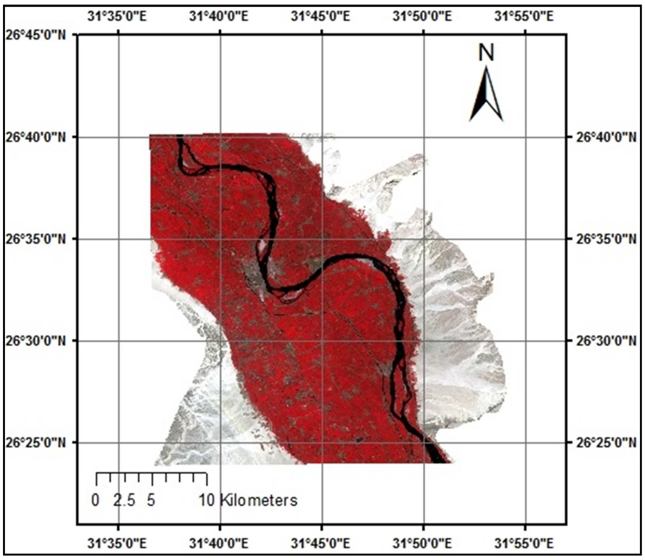


Fig. 7. FCC of 1987 image.

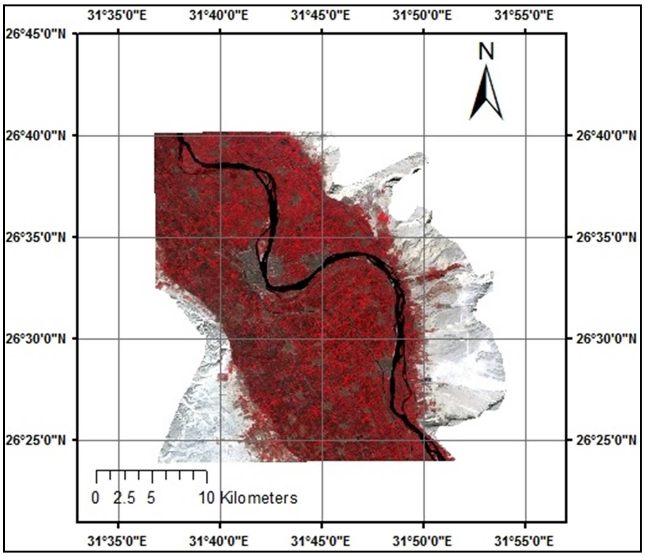


Fig. 8. FCC of 2012 image.

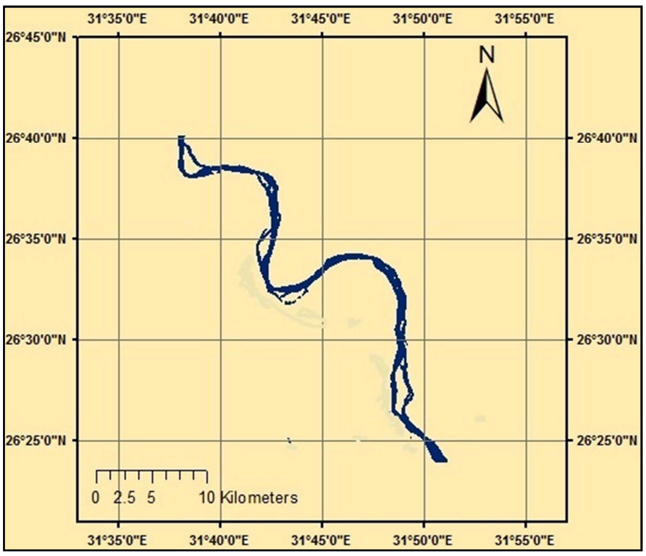


Fig. 9. The River Nile in the year of 1987.

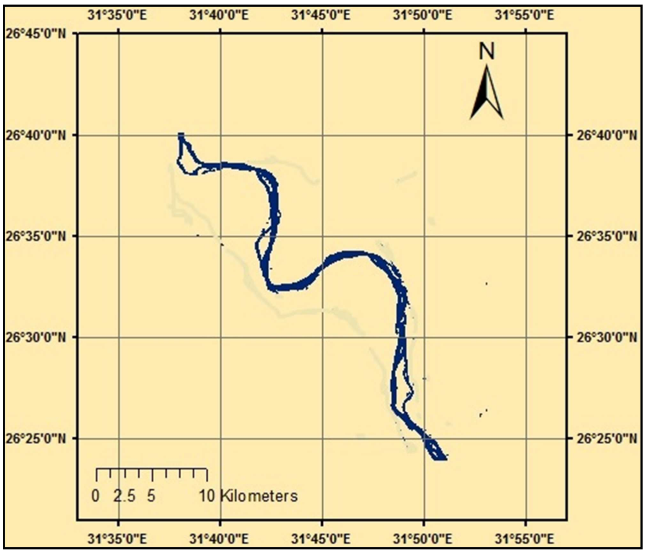


Fig. 10. *The River Nile in the year of 2012.*

4.2. Accuracy Assessment

The assessment is based on stratified random sampling approach. The classification outputs were subjected to post classification accuracy assessment. Accuracy assessment matrix of DTC was generated for both images (Tables 4 and 5). A close look at tabulated figures reveals that classification approach was effective. The overall accuracy of DTC along with remote sensing derived indices was 99.5% and 95.6% for 1987 and 2012 images respectively.

Table 4. *The Error Matrix of decision tree classifier for 1987 image.*

Classification data	Training site data (pixels)				
	Water bodies	**Old cultivated lands**	**Built up areas**	**Agricultural Prospective areas**	**Row total**
Water bodies	754	0	0	0	754
Old cultivated lands	0	1670	10	7	1687
Built up areas	0	6	1865	6	1877
Agricultural Prospective areas	0	0	0	1335	1335
Column total	754	1676	1875	1348	5653
Overall accuracy = 99.5% Kappa coefficient = 0.99					

Table 5. *The Error Matrix of decision tree classifier for 2012 image.*

Classification data	Training site data (pixels)					
	Water bodies	**Old cultivated lands**	**Built up areas**	**Agricultural Prospective areas**	**New Reclaimed Areas**	**Row total**
Water bodies	637	0	25	0	0	662
Old cultivated lands	0	1568	43	12	21	1644
Built up areas	30	32	2347	21	7	2437
Agricultural Prospective areas	0	24	39	1254	13	1330
New Reclaimed Areas	0	13	23	14	934	984
Column total	667	1637	2477	1301	975	7057
Overall accuracy = 95.6% Kappa coefficient =0.94						

4.3. Capability Assessment of Soils

Studying the urban expansion from 1987 to 2012 revealed that urbanization mainly occurs on the account of most fertile soils of Sohag city. This can be proved by assess the capability of soils of the study area. It is clear from the obtained results of capability assessment (Tables 6, 7 and 8) that the highest capability soils (S1 and S2 classes) occurred in the old cultivated land which decreased from 292.15 km^2 to 211.70 km^2 and occupied by built up area. Whereas, the lowest capability class (N1) betided in Agricultural Prospective areas which have a coarse texture soils and high calcium carbonate content. Similarly, the coarse texture soil and high calcium carbonate content decrease the capability (S3 class) of the new reclaimed areas. It is noticed that urban encroachment over the high capable soils is great.

Table 6. *The main soil characteristics of the soil profiles.*

Profile No.	Category	Depth (cm)	Sand %	Silt %	Clay %	Texture class	CEC Cmol+/kg	ESP %	O. C %	EC dS/m	pH	$CaCO_3$ %
1	Old cultivated lands	0-20	31	34	35	cl	12.5	19.5	1.1	4.1	8.4	5.7
		20-45	39	28	33	cl	12.7	22.3	0.7	3.8	8.6	5.4
		45-80	41	20	39	cl	10.2	13.6	0.5	3.5	7.6	4.8
		80-120	42	31	27	L	9.5	12.4	0.2	2.6	7.5	3.1
2	Agricultural Prospective areas	0-25	50	20	30	scl	7.3	5.6	1.8	0.61	8.3	16
		25-45	88	9	3	S	2.1	7.8	0.2	0.56	8.6	19
		45-60	87	11	2	S	1.9	6.8	0.17	0.53	7.7	21
		60-80	90	8	2	S	1.3	8.3	0.07	0.36	7.5	23.5
		80-110	93	5	2	S	1.3	7.2	0.05	0.33	8.1	23.6
3	New Reclaimed Areas	0-35	85	5	10	LS	8.3	8.3	1.6	2.1	7.8	15.5
		35-75	93	5	2	S	1.4	7.2	0.1	2.4	7.5	18.8
		75-130	89	3	8	LS	1.8	8.3	0.03	1.7	7.7	21.4
		130-150	85	10	5	LS	1.1	9.4	0.02	1.4	7.9	20.1
4	Agricultural Prospective areas	0-35	93	2	5	S	3.1	7.4	0.13	1.82	8.4	30.2
		35-60	90	3	7	S	1.7	7.4	0.04	1.09	8.5	33.0
		60-95	87	9	5	LS	1.25	6.8	0.04	0.55	7.6	28.1
		95-115	93	4	4	S	1.4	6.4	0.02	0.62	7.7	32.5
5	Old cultivated lands	0-20	33	20	47	c	17	43	1.4	1.34	7.8	4.5
		20-45	20	38	42	c	15.7	43	0.3	0.77	7.4	5.1
		45-70	27	24	49	c	19.5	54	0.2	0.65	7.7	5.2
6	Old cultivated lands	0-30	25	20	55	c	18	35	1.2	0.41	7.9	3.6
		30-60	33	19	48	c	17.5	47	0.78	0.53	8.1	3.1
		60-112	30	24	46	c	18.4	39	0.55	0.56	7.5	2.6
7	New Reclaimed Areas	0-30	92	2	6	S	2.1	8.3	0.1	1.34	8.3	27.4
		30-55	89	3	8	LS	1.3	9.4	0.03	0.77	8.5	29.5
		55-70	85	10	5	LS	1.4	8.1	0.01	0.65	7.6	27.4
		70-110	93	4	3	S	1.5	8.5	0.01	0.84	7.7	30.1
8	Old cultivated lands	0-30	54	11	35	scl	7.8	11.6	0.7	0.9	7.7	4.6
		30-60	21	46	33	cl	7.5	17.9	0.45	0.6	7.8	3.13
		60-110	22	51	27	sil	5.2	14.7	0.33	0.6	7.5	3.6

Table 7. *The weighted mean of soil characteristics of the Soil profiles.*

Profile No.	Sand %	Silt %	Clay %	Texture class	CEC Cmol+/kg	ESP %	O. C %	EC dS/m	pH	$CaCO_3$ %
1	39.25	27.67	33.08	cl	10.87	16.00	0.54	3.36	7.91	4.51
2	80.95	10.50	8.55	s	2.89	7.09	0.50	0.47	8.07	20.66
3	88.60	4.93	6.47	s	3.12	8.15	0.41	1.94	7.70	19.16
4	90.28	4.61	5.11	s	1.94	7.04	0.06	1.07	8.02	30.55
5	26.21	27.86	45.93	c	17.43	46.93	0.58	0.89	7.62	4.96
6	29.46	21.59	48.95	c	18.05	40.07	0.79	0.51	7.77	3.00
7	90.73	4.05	5.23	s	1.60	8.60	0.04	0.93	8.03	28.86
8	30.45	38.73	30.82	cl	6.54	14.73	0.46	0.68	7.64	3.74

Table 8. *Capability assessment of the soil profiles.*

Profile No.	Slope	Drainage	Soil Characteristics (s)				Capability Index (CI) %	Class	Subclass
			Texture (x)	Depth (d)	$CaCO_3$ (k)	Salinity and Alkalinity, ^#(n)			
1	100.00	100.00	100.00	100.00	95.00	100.00	95.00	S2	S2k
2	100.00	100.00	30.00	100.00	100.00	100.00	30.00	N1	N1x
3	100.00	100.00	55.00	100.00	100.00	100.00	55.00	S3	S3x
4	100.00	100.00	30.00	100.00	90.00	100.00	27.00	N1	N1xk
5	100.00	100.00	100.00	80.00	95.00	100.00	76.00	S2	S2dk
6	100.00	100.00	100.00	100.00	95.00	100.00	95.00	S1	S1k
7	100.00	100.00	55.00	100.00	90.00	100.00	49.50	S3	S3xk
8	100.00	100.00	95.00	100.00	95.00	100.00	90.25	S1	S1xk

5. Conclusion

The objective of this study was to detect the change in agriculture areas, urban areas, and River Nile during the period from 1987 to 2012 of the area under investigation. This area is known for extensive development of urban growth activity in recent years and to examine the capabilities of integrating remote sensing derived indices such as NDVI, NDWI and SBI with DTC in mapping landuse/land cover changes under the studied period. DTC classification was effective with high overall accuracy of 99.5% and 95.6% for 1987 and 2012 images respectively. A Considerable increase in urban settlements has taken place on the expense of the most fertile land in the study area and consequently the food production will be decreased. Integrating remote sensing provided valuable information on the nature of land cover changes especially the area and spatial distribution of different land cover changes. The main causes of urbanization is the rapid population growth and this problem needs to be seriously studied, through multi-dimensional fields including socioeconomic, in order to preserve the precious and limited agricultural land and increase food production.

References

[1] ABDUL AZIZ, A. M.; HURTADO, J. M. and AL-DOURI, R. 2009. Application of Multitemporal Landsat Data to Monitor Land Cover Changes in the Eastern Nile Delta Region, Egypt. Int. J. Remote Sens., 30: 2977-2996.

[2] AHMED, A. A. and FAWZI, A. 2011. Meandering and bank erosion of the River Nile and its environmental impact on the area between Sohag and El-Minia, Egypt. Arab J. Geosci., 4: 1-11.

[3] Al TARAWNEH, W. M. 2014. Urban Sprawl on Agricultural Land (Literature Survey of Causes, Effects, Relationship with Land Use Planning and Environment) A Case Study from Jordan (Shihan Municipality Areas). J. of Envir. and Earth Sci.,(4), 20: 97-124.

[4] BLACK, C. A. 1982. Methods of soil analysis. 2nd edition. Chemical and microbiological properties. Agronomy series no. 9, ASA, SSSA, Madison, Wis., USA.

[5] BRIKOWSKI, T. H. and FAID, A. M. 2006. Pathline-Calibrated Groundwater Flow Models of NileValley Aquifers, Esna, Upper Egypt. J. of Hydrology, 324: 195-209.

[6] CAMPBELL, J. B. 2002. Introduction to Remote Sensing. 3rd Edition, the Guilford Press, New York.

[7] CONGALTON, R. G. and GREEN, K. 1999. Assessing the Accuracy of Remotely Sensed Data: Principles and Practices. Lewis Publishers, Boca Raton.

[8] DWIVEDI, R. S., SREENIVAS K. and RAMANA, K. V. 2003. Comparison of classifiers of remote sensing data for land-use/ land-cover mapping. Curr. Sci., 86: 328-335.

[9] ELBEIH, S. F.; SHALABY A. A. and BAHY EL DEEN A. M. 2013. Water Management Problems Associated with Urban Sprawl in Gharbia Governorate, Egypt Using Remote Sensing and GIS. Inter. J. of Advanced Remote Sensing and GIS, (2), 1: 243-259.

[10] FAO. 1976. A framework for land evaluation. FAO Soils bulletin 32. Rome, Italy.

[11] FAO. 1983. Guidelines: Land evaluation for rainfed agriculture, Bulletin 52, Food and Agriculture Organization of the United Nations, Rome, Italy.

[12] FAO. 2006. Food and Agriculture Organization of the United Nations, FAO Statistical Year Books 2005-2006, Issue 2.

[13] FUNG, T. and LEDREW, E. 1988. The determination of optimal threshold levels for change detection using various accuracy indices. Photogramm. Eng. Remote Sens., 54: 1449-1454.

[14] GONCALVES, R. P., ASSIS, L. C. and VIERIA, C. A. O. 2007. Comparison of sampling methods to classification of remotely sensed images. IV International Symposium in Precision in Agriculture, 23-25 October, Vicosa, Brazile.

[15] JENSEN, J. R. 2004. Digital Change Detection, (In: Introductory Digital Image Processing A Remote Sensing Perspective). Pearson Prentice Hall, Upper Saddle River.

[16] KAUTH, R. J. and THOMAS, G. S. 1976. The tasseled cap- A graphic description of the spectral temporal development of agricultural crops as seen by landsat; Proc. of the Symposium on Machine processing of Remotely Sensed Data, Purdue University, West Lafayette, Indiana.

[17] LILLESAND, T. M. and KIEFER, R. W. 1994. Remote Sensing and Image Interpretation. 4th Edition, John Wiley & Sons, New York.

[18] MCFEETERS, S. K. 1996. The use of Normalized Difference Water Index (NDWI) in the delineation of open water features. Int. J. Remote Sens., 17: 1425-1432.

[19] MSRINTRANET, 2011. "Central Agency for Population Mobilisation and Statistics - Population Clock," http://www.msrintranet.capmas.gov.eg/pls/fdl/tst12e?action= &lname.

[20] ROUSE, JR., HAAS, R. H., DEERING, D. W., SCHELL, J. A. and HARLAN, J. C. 1974. Monitoring the Vernal Advancement and Retrogradation (Green Wave Effect) of Natural Vegetation, NASA/GSFC Type III Final Report, Greenbelt, MD. 371p.

[21] SKIDMORE, A. K. 1999. Accuracy assessment of spatial information. In: A. Sten et al. (ed). Spatial Statistics for Remote Sensing. Netherlands, Kluwer academic publishers. Pp 197-200.

[22] SYS, C. and W. VERHEYE, 1978. An attempt to the evaluation of physical land characteristics for irrigation according to the FAO framework for land evaluation. ITC Post-Graduate Lecture Note. Ghent, Belgium

[23] SYS, C.; VAN RANT, E. and DEBAVEYE, J. 1991. Land Evaluation, part II: Methods in land evaluation. Agricultural publication. No. 7, General Administration for Development Cooperation, Brussels. 247pp.