Monitoring Spatial and Temporal Changes of Urban Growth in Dakahlia Governorate, Egypt, by Using Remote Sensing and GIS Techniques

رصد التغيرات المكانية والزمانية للنمو الحضري في محافظة الدقهلية فى مصر باستخدام تقنيات الإستشعار عن بعد ونظم المعلومات الجغرافية

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الخلاصة:

تعتبر محافظة الدقهلية واحدة من المحافظات الزراعية الهامة في وسط دلتا النيل بمصر. حيث تعانى الاراضي الزراعية الخصبة في دلتا النيل من التدهور المستمر ويرجع ذلك بشكل أساسى إلى التوسع العمرانى. ولقد أثبت كل من الإستشعار عن بعد ونظم المعلومات الجغرافية قدرتهما الكبيرة على إستكشاف مشاكل التوسع العمرانى وتأثيراتها على الأراضي الزراعية. وتتمثل الأهداف الرئيسية لهذه الدراسة فى عمل تقييم دقيق للمناطق الحضرية في محافظة الدقهلية ودراسة تأثير التوسع العمراني على الأراضي الزراعية خلال الفترة من 1984 إلى 2014. وبناءا على ذلك، تم استخدام صور لاندسات TM في عام 1984 و+ETM فى عامى 2002 و 2011 وOLI-TIRS في عام 2014 لدراسة التغيرات المكانية والزمانية في كل من المساحات الحضرية والزراعية في محافظة الدقهلية. كما تم استخدام ثلاثة مؤشرات هى مؤشر التغير في الغطاء النباتي (NDVI)، ومؤشر التغير في الأبنية (NDBI) ومؤشر التغير في الغطاء النباتي والمعدل للتربة (SAVI) فى إستخراج المناطق الحضرية فى مقابل الأراضي الزراعية من صور لاندسات المتعددة الأزمنة. ولقد أوضحت النتائج أن الزيادة السنوية في الأراضي الحضرية كانت حوالي 2.54 كم ^{2} سنويا خلال الفترة 1984-2002 وحوالي 4.01 كم ^{2} سنويا خلال الفترة من 2002 إلى 2011. الا ان هذه النسبة ازدادت بشكل كبير بحوالى 47.99 كم ^{2} سنويا خلال الفترة من 2011 الى 2014. كما لوحظ أن الزيادة في المناطق الحضرية تركزت حول المدن والقرى القديمة قبل 2011 ولكنها اخذت شكل عشوائي بعد عام 2011.وقد بين تقييم دقة المؤشرات المدروسة ان مؤشر التغير في الأبنية (NDBI) هو الأعلى فى الدقة بالمقارنة بالمؤشرات الأخرى المدروسة. وعليه يمكن إستنتاج أن الزحف العمراني على الأراضي الزراعية الخصبة هي العملية الأكثر خطورة والتي تؤدي إلى تدهور الأراضي الخصبة في محافظة الدقهلية.

Abstract

Dakahlia is one of the important agricultural governorates in the Middle of Nile-Delta, Egypt. Fertile agriculture areas in the Nile-Delta of Egypt are constantly deteriorating mainly due to urbanization. Remote sensing and GIS technology have proven their great ability to explore the problems of urbanization and their impacts on agricultural lands. The main objectives of this study were to provide an accurate assessment of urban areas in Dakahlia Governorate and to study the impact of urbanization on agricultural lands during the period from 1984 to 2014. Accordingly, Landsat TM images in 1984 and ETM+ in 2002 and 2011 and OLI-TIRS in 2014 were used to study spatial and temporal changes in both urban and agricultural lands in Dakahlia Governorate. Normalized difference vegetation index (NDVI), Normalized difference built-up index (NDBI) and soil adjusted vegetation index (SAVI) were used to extract urban versus agricultural lands from these multitemporal Landsat images. The results indicated that the annual increase in urban lands was about 2.54 km^2 per year during the period from 1984 to 2002 and about 4.01 km^2 per year during the period from 2002 to 2011. However, the rate was highly increased by about 47.99 km^2 per year during the period from 2011and 2014. It was also observed that the increase in urban areas was clustered around old cities and villages before 2011; however it took a random pattern after 2011. Accuracy assessment of the studied indices indicated that the NDBI

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has the highest accuracy. It could be concluded that urban encroachment over the fertile agricultural lands is the most serious process that result in fertile land degradation in Dakahlia Governorate.

Keywords

Land cover, land use, NDVI, NDBI, SAVI, change detection, urbanization, Remote sensing, GIS.

1. Introduction

Fast economic growth of the countries leads to migration of population from rural to urban and thus increase the number of population in urban areas. These changes are caused by a series of environmental problems such as loss of agricultural land and increased air and water pollution and rising level of diseases, etc. Al-Dakahlia is the important governorate in the Middle of Nile Delta, Egypt. Fertile agriculture areas in the Nile-Delta of Egypt are constantly deteriorating mainly due to urbanization. Remote sensing and GIS technology has proven its great ability to explore the problems of urbanization and overtaking on agricultural land. It can deduce from the above that there is a great relationship between urban growth and environmental problems (**Han et al., 2009).**

RS is considered one of the most important modern techniques that are used in the field of urban growth and monitoring the changes that occur on land cover. It began in 1972 with a series of Landsat satellites that were designed and still working to monitor changes in land cover. The spatial patterns of actual urban infrastructure come only from remote sensing images, and remote sensors record data in a continuous matter, allowing comparisons that get Urbanism during different periods **(Masek et al., 2000).**

Vegetation indices (VIs) have been widely used for assessing vegetation condition, cover, phenology, and processes such as evapotranspiration (ET), climate and land use change detection and drought monitoring. VIs are robust satellite data products computed the same way across all pixels in time and space, regardless of surface conditions. As ratios, they can be easily cross-calibrated across sensor systems, ensuring continuity of data sets for long term monitoring of the land surface and climate related processes. The ability to compare pixel values this way would be useful for interpretation through the historical record and between different vegetation cover, assuming that seasonal effects are considered and data were atmospherically corrected **(Rawat et al., 2013).**

Change detection also, is the process of identifying and describing the changes in land cover and land use characteristics based on RS data recorded in multiple time periods. Numerous researchers have addressed the problem of accurately monitoring land cover and land use change in a wide variety of environments using remotely sensed data **(Kasereka, 2010).** Of the various requirements of preprocessing for change detection, multitemporal image registration and radiometric and atmospheric corrections are the most important. The importance of accurate spatial registration of multi-temporal imagery is obvious because largely spurious results of change detection will be produced if there is misregistration **(LU et al., 2004).**

The objectives of this work were to monitor the spatial and temporal changes in urban and agricultural lands in Dakahlia Governorate of Egypt using RS and GIS techniques and to provide an accurate assessment of these areas during the period from 1984 to 2014.

2. Study Area and Data

2.1 Study Area

Dakahlia governorate is located in the northeast of Nile-Delta in Egypt as shown in **(Fig. 1)**. It is located between these coordinates 30.5 ° - 31.5 ° N, and 30 ° - 32 ° E, with a total area of about 3,895 km^2. It has a population of about 5,834,023 people in 2014 (Central Agency for Public Mobilization and Statistics). Surface elevation varied from 0 to 39 m above the sea level, with an average value of 4m. Slope gradient varied from 0 to 15 %, with an average value of 0.79%, this mean that the majority of this area is leveled.

Maximum temperature in the studied area varies from 35.3 C^o in summer to 20.1 C^o in winter. Minimum temperature ranges between 20.2 C^o in summer and 7.5 C^o in winter. Total precipitation varies from 29.2 to 72.3 mm. Geology of the studied area includes Nile-deposits, sabkha-deposits, and sand dunes **(CONOCO, 1989).** Vegetation varies from major field-crops growing in the summer season such as rice, cotton, maize to vegetables such as tomato, potato, and cucumber.

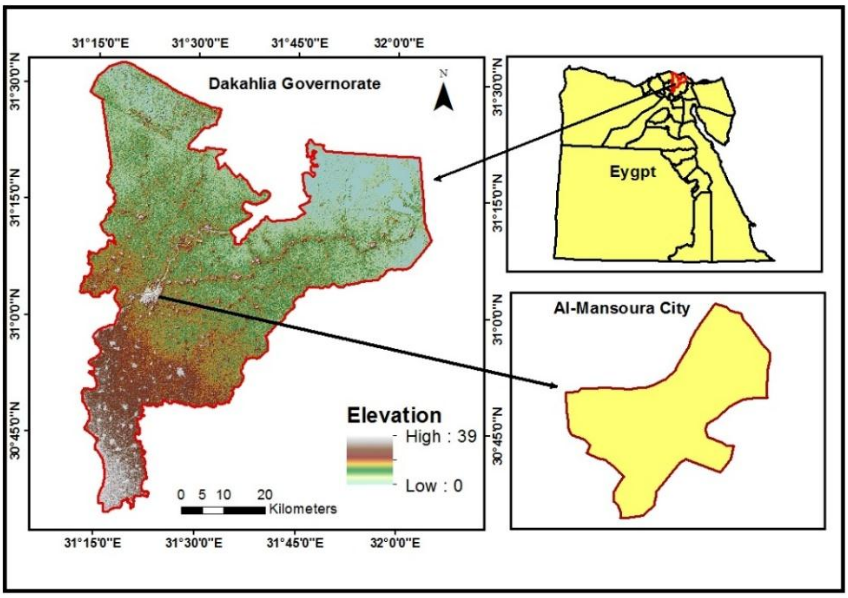


Figure 1. Location map of the study area in Egypt.

2.2. Landsat Data

Studied area is covered by two Landsat images (path 176, rows 38 and 39) as shown in **(Fig. 2)**. A total of eight Landsat images were used to study the spatial and temporal changes in urban and agricultural lands in the Dakahlia governorate and Al-Mansoura city during the period from 1984 to 2014. The acquisition dates for these images are represented in **Table 1**, where each year was represented by two images. Agricultural lands in the Nile valley and delta in Egypt are intensively cultivated, which assures a presence of vegetation cover all over the year. However, all the studied images were acquired during the summer season to guarantee that the vegetation cover is at its maximum peak. All the obtained images were cloud. Landsat images were downloaded from the earth explorer website developed by the United States Geological Survey (USGS): http://earthexplorer.usgs.gov/.

Table 1. Acquisition dates of the studied Landsat images.

Image Year	**Sensor Type**	**Acquisition Date**
1984	Landsat 5 (TM)	30/9/1984
2000	Landsat 5 (TM)	23/8/2000
2011	Landsat 7 (ETM+)	21/7/2011
2014	Landsat 8 (OLI-TIRS)	6/8/2014

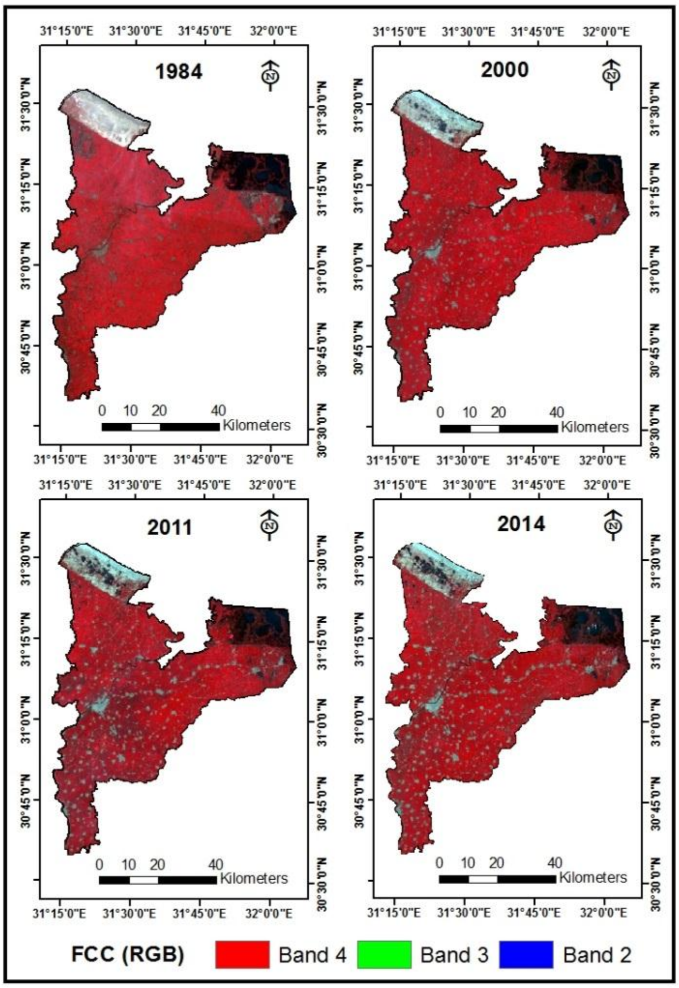


Figure 2. False Color Composite (FCC) of the studied Landsat images acquires in 1984, 2000, 2011 and 2014.

3. Digital image processing

3.1. Atmospheric and radiometric corrections

Studied images were atmospherically and radiometrically corrected to eliminate the atmospheric interferences (dust, haze, smoke, etc.) by using the dark-object subtraction method in the Envi software package. The data were converted from DN values to reflectance. The two images for each year were mosaicked to form a single image using a histogram matching and stitching processes. Each mosaiced image for each date was subsetted to cover the eastern of Nile-Delta and its outer edges.

3.2 Geometric correction

All the studied images were geometrically corrected using 20 of the ground control points. The RMS error was very low (less than 0.3 of the pixel). All images were projected to have the same projection (UTM, Zone 36N, Datum WGS 1984) and the same pixel size 30 m.

3.3 Gap-filling

On May 31, 2003 the Landsat 7 Enhanced Thematic Mapper (ETM) sensor had a Scan Line Corrector (SLC) failure. Since that time all Landsat ETM images have had wedge-shaped gaps on both sides of each scene, resulting in approximately 22% data loss. These images are available for free download from the USGS website and are found under the L7 SLC-off collection. **Scaramuzza et al. (2004)** have developed a technique which can be used to fill gaps in one scene with data from another Landsat scene. A linear transform is applied to the "filling" image to adjust it based on the standard deviation and mean values of each band, of each scene. They developed a plug-in called "**landsat_gapfill.sav"**, which works under ENVI software package. This technique was used to fill the gaps in the ETM+ images acquired 2011.

3.4 Studied indices

Normalized Difference Vegetation Index (NDVI) was calculated using the following equation (Rouse *et al.* in 1973):

$$\mathbf{NDVI = (NIR - Red) / (NIR + Red)}$$

Where, NIR is the reflectance in the near infrared portion of spectrum and Red is the reflectance in the red portion of spectrum. NDVI values range between -1.0 and +1.0, where positive values indicate healthy green vegetation and near zero or negative values represent non-vegetated land-covers such as urban areas, deserts and water bodies.

Normalized difference built-up index (NDBI) was calculated using the following equation as described by **(Zha et al., 2003):**

$$\mathbf{NDBI = (MIR - NIR) / (MIR + NIR)}$$

Where, MIR is the reflectance in the middle infrared portion of spectrum and NIR is the reflectance in the near infrared portion of spectrum. NDBI values range between -1.0 and +1.0, the same as the NDVI. Although, positive values indicate urban areas and near zero or negative values represent vegetated land.

Soil adjusted vegetation index (SAVI) was calculated using the following equation as described by **(Huete, 1988):**

$$\mathbf{SAVI = (NIR - Red) \times (1 + L) / (NIR + Red + L)}$$

Where, NIR is the reflectance in the near infrared portion of spectrum and Red is the reflectance in the red portion of spectrum and L is a correction factor ranging from 0 for very high plant densities to 1 for very low plant densities. The difference between SAVI and NDVI is the SAVI is more sensitive than the NDVI in detecting vegetation in the low-plant covered areas such as urban areas. The SAVI can work in the area with plant cover as low as 15%, while the NDVI can only work effectively in the area with plant cover above 30% **(Xu, 2008)**.

Certain areas which represent open water, fish pools, lakes, sabkhas, bare lands and low intensity vegetated areas were excluded from this study. These areas were given a value of zero. The NDVI, NDBI and SAVI algorithms were applied to the mosaics of 1984, 2000, 2011 and 2014 reflectance images. Image processing techniques were carried out using both ERDAS Imagine 2013 and Envi 5.1 Software packages.

3.5 Accuracy Assessment

Accuracy Assessment was carried out on the obtained binary imaged from the three studied indices in 1984, 2000, 2011, and 2014 to determine how well each index accomplish the land use classification task. The classified image was compared with a variety of data such as aerial photographs, topographic maps (scale 1:50000), high resolution images and ground truth data for the 2014 images). This task was accomplished by compiling an error matrix. An error matrix is a table of values that compares the value assigned to each land use during the classification process (urban= 1 and Agriculture= 2) to the actual land use from the above mentioned sources of data. These were compared on a point-by-point basis, where a random set of about 210 points were generated throughout the studied area. Then using the aerial photos and the other resources of data, the land use for each point was identified. Then, these same random points were used to identify each point's known land use in the classified image. The error matrix table was completed by comparing these two values.

An important component of accuracy assessment, Cohen's kappa co-efficient was also calculated from the error matrix. Kappa tells us how well the classification process performed as compared to randomly assigning values **(Campbell and Wynne, 2011).**

3.6 Change Detection of Urban lands

Change detection was developed by subtracting the NDBI binary image for each two successive years. We have got six types of change, which are: 1. Urban to excluded areas; 2. Excluded to urban; 3. Agricultural to excluded areas (fish pools); 4. Excluded to agricultural areas; 5. Agricultural to urban; and 6. No change. The objective of applying change detection was to locate areas of urban encroachment and area of land reclamation and cultivation projects in Dakahlia Governorate.

4. Results and discussions

4.1 Spatial Distribution of Urban viz. Agricultural Lands in Dakahlia Governorate based on the NDVI index:

Spatial distribution of urban viz. agricultural lands in Dakahlia governorate based on the NDVI index in 1984, 2000, 2011 and 2014 is represented in **(Fig. 3)**. Data in **Table 2** show estimated urban lands were about 257.3, 311.8, 296.2 and 449.6 km^2 in 1984, 2000 2011 and 2014, respectively and their percentages were about 6.61, 8.00, 7.60 and 11.54%, respectively. On the other hand, areas of agricultural lands were about 2700.8, 2912.5, 2949.8 and 2795.9 km^2 in 1984, 2000 2011 and 2014, respectively and their percentages were about 69.34, 74.77, 75.73 and 71.78, respectively. The excluded areas were about 937.4, 671.3, 649.6 km^2 and 650.0, respectively and their percentages were about 24.07, 17.23, 16.68 and 16.69%, respectively. These results indicate that urban areas in Dakahlia governorate were significantly increased during the period from 2011 to 2014. This could be attributed to the loss of governmental control over that period of time. That increase in urban areas was on the account of agricultural areas, which were significantly decreased

4.2 Spatial Distribution of Urban viz. Agricultural Lands in Dakahlia Governorate based on the NDBI index:

Figure 4 illustrates the spatial distribution of urban viz. agricultural lands in Dakahlia governorate based on the NDBI index in 1984, 2000, 2011 and 2014. **Table 3** show estimated urban lands were about Urban areas were about 242.0, 282.7, 326.8 and 470.8 km^2 in 1984, 2000 2011 and 2014, respectively and their percentages were about 6.21, 7.26, 8.39

Table 2. Areas of urban viz. agricultural lands and their percentage in Dakahlia governorate from 1984 to 2014 based on the NDVI index.

Land use/cover categories	1984		2000		2011		2014	
	Area km^2	%	Area km^2	%	Area km^2	%	Area km^2	%
Urban	257.3	6.61	311.8	8.00	296.2	7.60	449.6	11.54
Agric. lands	2700.8	69.34	2912.5	74.77	2949.8	75.73	2795.9	71.78
Excluded areas	937.4	24.07	671.3	17.23	649.6	16.68	650.0	16.69
Total	3895.5	100	3895.5	100	3895.5	100	3895.5	100

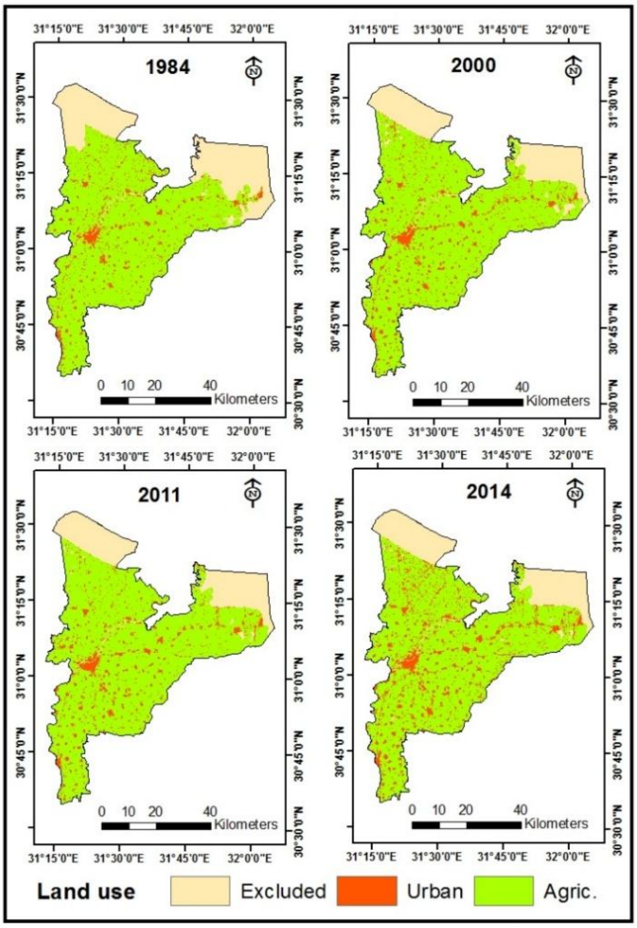


Figure 3. Spatial distribution of land use in Dakahlia Governorate obtained from the NDVI index in 1984, 2000, 2011 and 2014.

and 12.09%, respectively. However, agricultural areas were about 2716.1, 2941.6, 2919.1 and 2774.7 km^2 in 1984, 2000 2011 and 2014, respectively and their percentages were about 69.73, 75.52, 74.94 and 71.23 %, respectively. The excluded areas and their percentages were the same as that with the NDVI index. These obtained results indicate that urban areas in Dakahlia governorate were increased during the studied period of time, however the significant increase was observed after 2011. Agricultural areas were significantly decreased.

Table 3. Areas of urban viz. agricultural lands and their percentage in Dakahlia governorate from 1984 to 2014 based on the NDBI index.

Land use/cover Categories	1984		2000		2011		2014	
	Area km^2	%	Area km^2	%	Area km^2	%	Area km^2	%
Urban	242.0	6.21	282.7	7.26	326.8	8.39	470.8	12.09
Agric. lands	2716.1	69.73	2941.6	75.52	2919.1	74.94	2774.7	71.23
Excluded Areas	937.4	24.07	671.3	17.23	649.6	16.68	650.0	16.69
Total	3895.5	100	3895.5	100	3895.5	100	3895.5	100

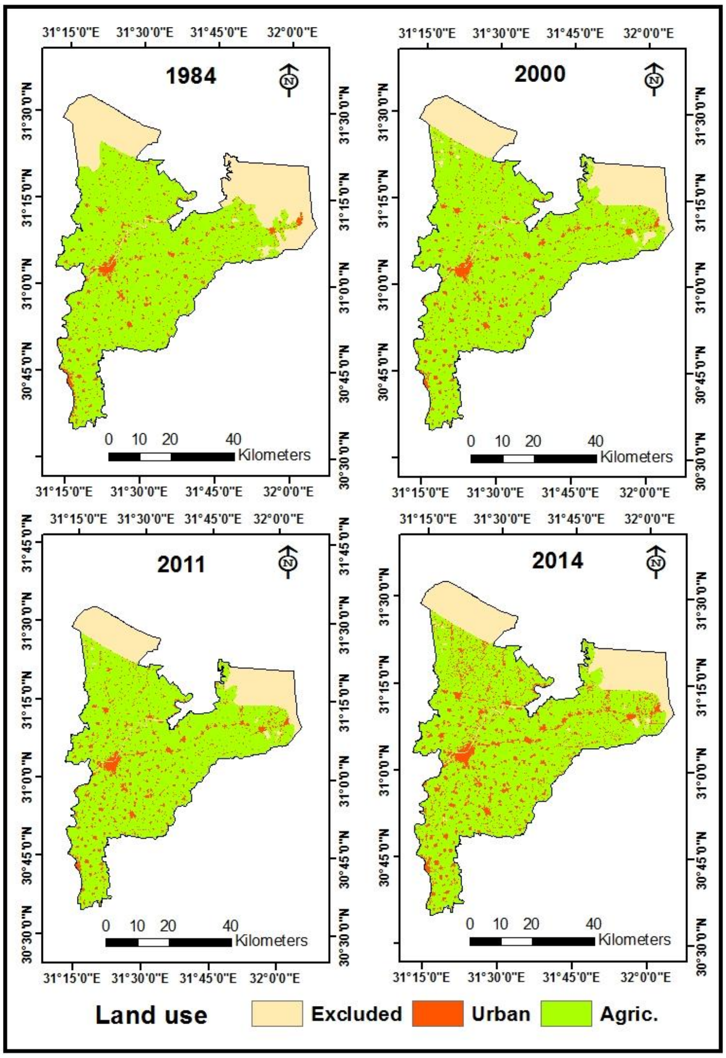


Figure 4. Spatial distribution of land use in Dakahlia Governorate obtained from the NDBI index in 1984, 2000, 2011 and 2014.

4.3 Spatial Distribution of Urban viz. Agricultural Lands in Dakahlia Governorate Based on the SAVI index:

Spatial distribution of urban viz. agricultural lands in Dakahlia governorate based on the SAVI index in 1984, 2000, 2011 and 2014 is demonstrated in **(Fig. 5)**. Urban areas were about 257.3, 311.8, 296.2 and 449.6 km^2 in 1984, 2000 2011 and 2014, respectively and their percentages were about 6.61, 8.00, 7.60 and 11.54%, respectively. Agricultural areas were about 2700.8, 2912.5, 2949.8 and 2795.9 km^2 in 1984, 2000 2011 and 2014, respectively and their percentages were about 69.34, 74.77, 75.73 and 71.78, respectively as shown in **table 4**. Similar trends were observed with the SAVI to that with both the NDVI and the NDBI. It was also observed that the increase in urban areas was clustered around old cities and villages in 1984, 2000, and 2011, however after 2011 these areas were randomly distributed in the studied area.

Table 4. Areas of urban viz. agricultural lands and their percentage in Dakahlia governorate from 1984 to 2014 based on the SAVI index.

Land use/cover categories	**1984**		**2000**		**2011**		**2014**	
	Area km^2	**%**	**Area km^2**	**%**	**Area km^2**	**%**	**Area km^2**	**%**
Urban	**442.7**	**11.36**	**284.0**	**7.29**	**296.0**	**7.60**	**580.4**	**14.90**
Agric. lands	**2515.4**	**64.58**	**2940.3**	**75.49**	**2949.9**	**75.73**	**2665.1**	**68.42**
Excluded Areas	**937.4**	**24.07**	**671.2**	**17.23**	**649.6**	**16.68**	**650.0**	**16.69**
Total	**3895.5**	**100**	**3895.5**	**100**	**3895.5**	**100**	**3895.5**	**100**

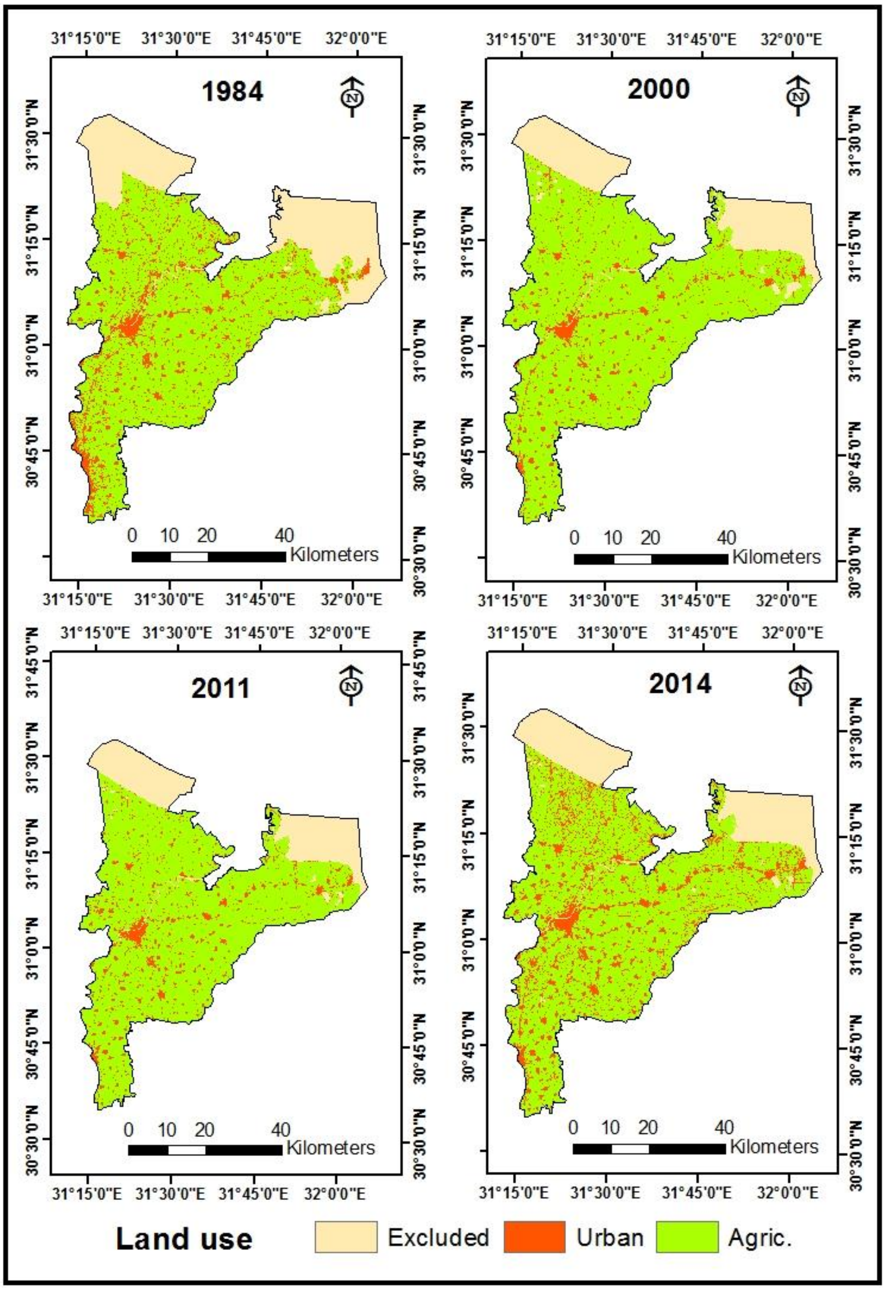


Figure 5. Spatial distribution of land use in Dakahlia Governorate obtained from the SAVI index in 1984, 2000, 2011 and 2014.

4.4 Accuracy assessment of the studied indices:

Accuracy Assessment was performed on the obtained binary imaged from the three studied indices (NDVI, NDBI, and SAVI) in 1984, 2000, 2011, and 2014 to evaluate the efficiency of each index in accomplishing the land use classification process. In this process the classified images were compared with the actual land use for each year. The confusion matrix contained three types of accuracy, which are producer's, user's and overall accuracy as represented in **Table 5**. This also includes Cohen's kappa coefficient value for each index. It was observed that land use in the studied area was classified with high accuracy using the three studied indices.

Data in Table 5 show that the lowest Producer's Accuracy for urban areas was 84.38% in 1984 with the SAVI, whereas the highest was 98.25% in 2011 with the NDVI. The average values for Producer's Accuracy of urban areas were 94.15, 94.56 and 91.72% for the NDVI, NDBI and the SAVI, respectively. The lowest Producer's Accuracy for agricultural areas was 94.19% in 2011 and the highest was 100% in 1984 and 2000. The average values for Producer's Accuracy of agricultural areas were 97.17, 97.98 and 97.32% for the NDVI, NDBI and the SAVI, respectively.

The lowest User's Accuracy for urban areas was 85.94% in 2011, whereas the highest was 100% in 1984 and 2000. The average values for User's Accuracy of urban areas were 93.52, 95.51 and 93.95% for the NDVI, NDBI and the SAVI, respectively. The lowest User's Accuracy for agricultural areas was 93.42% in 1984 and the highest was 99.32% in 2011. The average values for User's Accuracy of agricultural areas were 97.67, 97.85 and 96.49% for the NDVI, NDBI and the SAVI, respectively.

The lowest overall accuracy for the NDVI was 94.31% in 2014 and the highest was 97.63% in 2000, with an average value of 96.31%. The lowest Overall accuracy for the NDBI was 95.73% in 2014 and the highest was 98.10% in 2000, with an average value of 97.02%. Also, the lowest overall accuracy for the SAVI was 93.84% in 2014 and the highest was 98.10% in 2000, with an average value of 95.59%.

The obtained results also indicate that the lowest Kappa coefficient for the NDVI was 0.87 in 2014 and the highest was 0.94 in both 1984 and 2000, with an average value of 0.91. The lowest Kappa coefficient for the NDBI was 0.90 in 2014 and the highest was 0.95 in 2000, with an average value of 0.93. Also, the lowest Kappa coefficient for the SAVI was 0.86 in 2014 and the highest was 0.95 in 2000, with an average value of 0.89.

It could be concluded from the accuracy assessment results that land uses in the studied area were classified with high accuracy. However, the NDBI index had the highest accuracy when compared with the two other indices.

4.5 Changes in Urban viz. Agricultural Lands in Dakahlia Governorate from 1984 to 2014 Based on the NDBI index:

Data in **Table 6 and Figures 6, 7** show the changes in land use in Dakahlia governorate between 1984 and 2014 based on the NDBI index. The most obvious change in land use between 1984 and 2000 was from excluded areas to agricultural lands by about 248.54 km^2 (about 6.38% of the studied area). As mentioned before excluded areas include open water, fish pools, lakes, sabkhas, bare lands and low intensity vegetated areas. The obtained results indicate that part of these areas was reclaimed and added to the agricultural sector. These areas can be noticed in the north eastern parts (close to El-Manzala Lake) and the north western (North of Billkas District) parts of the studied area. Little changes were observed from agriculture to urban areas (0.57% of the area). There were also little changes from the excluded areas into urban (0.48%).

Table 5. Accuracy assessment of the NDVI, NDBI and SAVI during the studied period from 1984 to 2014.

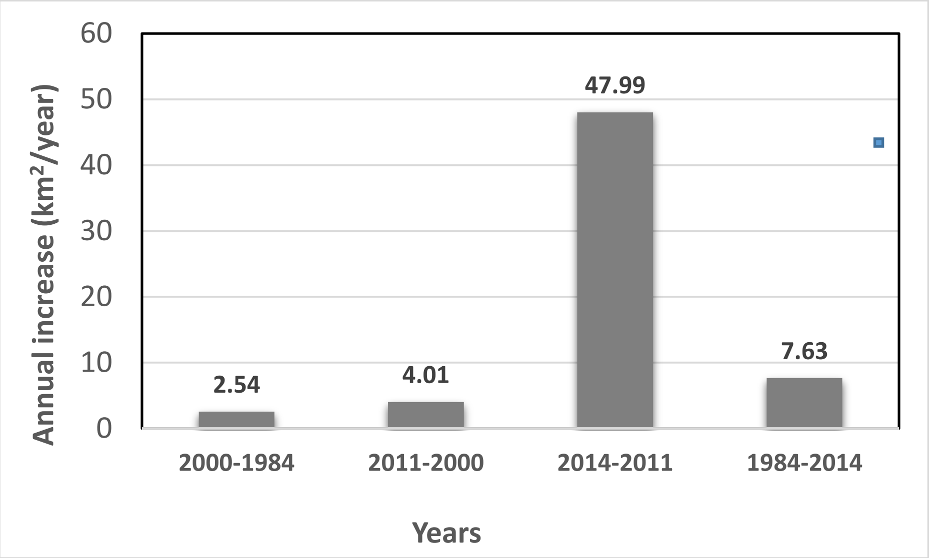
Year	Indices	Type	Producer's Accuracy	User's Accuracy	Overall Accuracy	Kappa
1984	**NDVI**	**Urban**	**92.98**	**98.15**	**97.57**	**0.94**
		Agric.	**99.33**	**97.37**		
	NDBI	**Urban**	**91.53**	**100.00**	**97.57**	**0.94**
		Agric.	**100.00**	**96.71**		
	SAVI	**Urban**	**84.38**	**100.00**	**95.15**	**0.88**
		Agric.	**100.00**	**93.42**		
2000	**NDVI**	**Urban**	**91.53**	**100.00**	**97.63**	**0.94**
		Agric.	**100.00**	**96.82**		
	NDBI	**Urban**	**93.10**	**100.00**	**98.10**	**0.95**
		Agric.	**100.00**	**97.45**		
	SAVI	**Urban**	**93.10**	**100.00**	**98.10**	**0.95**
		Agric.	**100.00**	**97.45**		
2011	**NDVI**	**Urban**	**98.25**	**87.50**	**95.73**	**0.90**
		Agric.	**94.81**	**99.32**		
	NDBI	**Urban**	**96.72**	**92.19**	**96.68**	**0.92**
		Agric.	**96.67**	**98.64**		
	SAVI	**Urban**	**98.21**	**85.94**	**95.26**	**0.88**
		Agric.	**94.19**	**99.32**		
2014	**NDVI**	**Urban**	**93.85**	**88.41**	**94.31**	**0.87**
		Agric.	**94.52**	**97.18**		
	NDBI	**Urban**	**96.88**	**89.86**	**95.73**	**0.90**
		Agric.	**95.24**	**98.59**		
	SAVI	**Urban**	**91.18**	**89.86**	**93.84**	**0.86**
		Agric.	**95.10**	**95.77**		

Between 2000 and 2011 the changes from agriculture to urban (about 1.08%) were increased over the changes into agricultural lands (about 0.51%). This could be attributed to the increase in population over that period of time. The most significant change in urban areas was observed between 2011 and 2014. About 143.84 km^2 (3.69% of the studied area) of agricultural land were converted into urban areas. This could be attributed to the loss of governmental control over the situation during that time. Many of the civilians took advantage of that situation and randomly built new buildings over agricultural lands. This type of change in most of the cases is irreversible. In other words it is difficult to return an agricultural area back to agricultural activities after putting concrete on it. The total changes in land use during the studied period of time from 1984 to 2014 indicted that 259.66 km^2 (6.67% of the studied area) were added to the agricultural lands, however 198.72 km^2 (5.10% of the studied area) were converted from Agricultural to urban areas.

Table 6: Changes in land use in Dakhalia governorate between 1984 to 2014**.**

Change in Land use	**1984 - 2000**		**2000 - 2011**		**2011 - 2014**		**1984 - 2014**	
	km^2	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**
Urban to excluded	**0.00**	**0.00**	**0.05**	**0.001**	**0.10**	**0.002**	**0.05**	**0.001**
Excluded to urban	**18.67**	**0.48**	**2.27**	**0.06**	**0.23**	**0.01**	**30.12**	**0.77**
Agric. to excluded	**1.08**	**0.03**	**0.47**	**0.012**	**2.71**	**0.07**	**2.37**	**0.06**
Excluded to agric.	**248.54**	**6.38**	**19.93**	**0.51**	**2.14**	**0.06**	**259.66**	**6.67**
Agric. to urban	**22.04**	**0.57**	**41.90**	**1.08**	**143.84**	**3.69**	**198.72**	**5.10**
No change	**3605.2**	**92.55**	**3830.9**	**98.34**	**3746.5**	**96.18**	**3404.6**	**87.40**
Total	**3895.5**	**100**	**3895.5**	**100**	**3895.5**	**100**	**3895.5**	**100**

Figure (6): Annual increase of urban area in Dakhalia governorate from 1984 to 2014 based on the NDBI index.



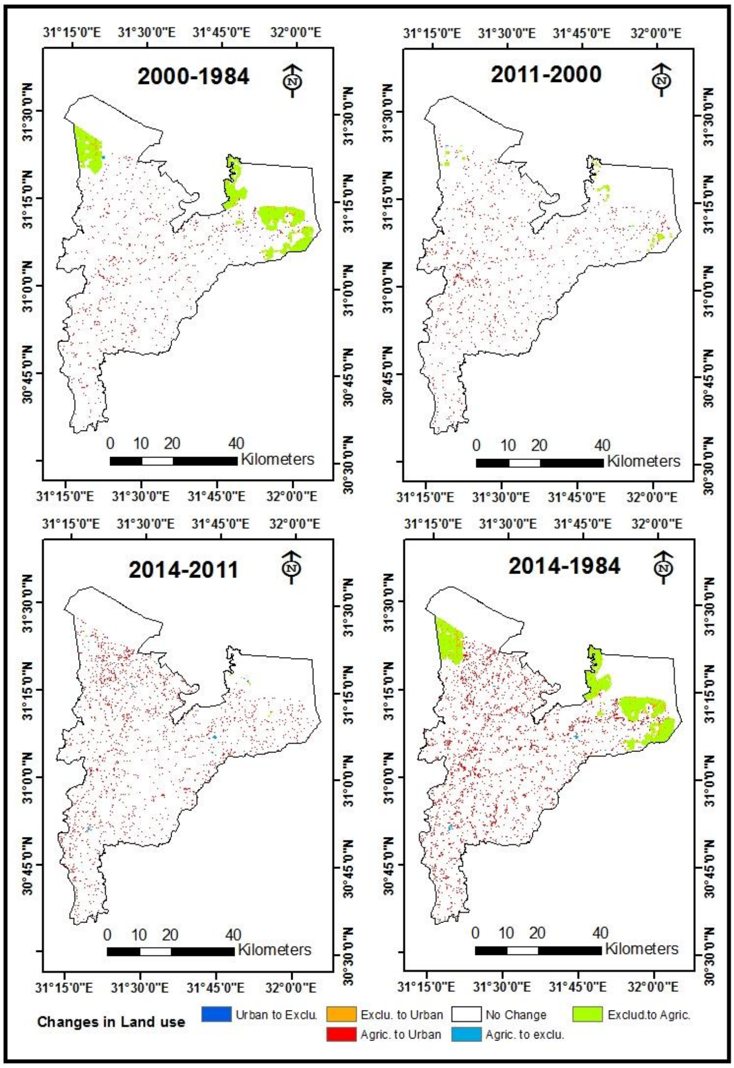


Figure (7): Changes of urban, agricultural and excluded areas in Dakhalia governorate from 1984 to 2014 based on the NDBI index

5. Conclusion

It could be concluded that remote sensing data and techniques could provide more accurate, time-wise, effective and less expensive tools for detecting changes in land use over time. Land use in Dakahlia governorate was classified with high accuracy using the three studied indices (NDVI, NDBI and SAVI); however the NDBI index had the highest accuracy. This study on the Dakahlia governorate, which is one of the major agricultural governorates in Egypt, indicated a significant deterioration in agricultural areas due to urbanization. The decrease in agricultural lands was evident after 2011, which could be attributed to the loss of governmental control over the situation during that time. On the other hand, there was an increase in agricultural lands especially in the north eastern parts (close to El-Manzala Lake) and the north western (North of Billkas District) parts due to land reclamation projects. However, this increase in agricultural lands could not overcome the decrease in old cultivated agricultural land due to urban encroachment. It was also observed that the increase in urban areas was clustered around old cities and villages before 2011; however after 2011 it took a random pattern. This type of change in land use from agricultural to urban is kind of irreversible in most of the cases.

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