RS and GIS Based Approach for Detecting Land-use Changes and its Impact on the Groundwater Aquifer

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Abstract: The assessment of Land-use changes has an important role on groundwater management. It can give an early warning for planners and developers to protect groundwater aquifer from depletion and preserve its sustainability. The study area can be considered as one of the highest priority regions in Egypt to achieve sustainable development in the future. The present agricultural activities are mainly based on groundwater for irrigation. However, irrigation requirements have become so large that they may cause depletion of the groundwater levels in most of the existing wells. The aims of this work are to accurately characterize land-use changes in the Desert Fringes of Western Nile Delta region over number of years using object-based image classification approach. Study area was divided into three subareas: A, B, and C. Unsupervised followed by supervised classification separately were applied to the acquired satellite images. The classification results were further improved by employing image enhancement and visual interpretation, as well as 150 random points were chosen as ground trothing to calculate and check the accuracy of the classification. The accuracy values obtained were sufficient to meet the monitoring needs of the change detection in the study area. Five land-use categories, cultivation, desert, urban, road and water were identified and mapped. Results indicated that the major change was in the barren land which has changed into agricultural land. The change detection results show that agricultural development increased by 95 % (around 178,850 feddan) throughout the study period (1984-2011). It was also found that the increase in urbanization by about30, 500 feddan during 1984-2011 was predominantly due to encroachment into traditionally cultivated land at the fringes of urban centers. The development of reclaimed land was naturally accompanied with maximum drawdown in groundwater level between 3-13 meters. The overall results demonstrated that using satellite images to produce land-use maps is relatively cheap, accurate and fast. The results also, showed that change detection map can provide a powerful tool for planning, monitoring groundwater development and help to design a suitable exploration plan. Spatial planning should take better account of effects of land-use change on the groundwater system and define mitigating actions for reducing the negative impacts of land-use change.

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1. Introduction

One of the main challenges facing the sustainable development in Egypt is the need for better development and management of its limited fresh water resources. Some of the most important groundwater problems in Egypt are: overexploitation and lowering of its levels in some areas; saltwater intrusion into freshwater aquifers in some of the Nile Delta governorates; water logging and/or salinization (***Elbeih, 2015***). The Nile Delta of Egypt, which is considered as wave dominated (***Coleman et al. 1981***) 2.3% of Egypt's area; however, it supports 63% of the country's agricultural land (***Hereher, 2009***), accommodates about 45% of Egypt's population and includes 25% of the total Mediterranean wetlands (***Sestini, 1992***). In the Western Nile Delta region, groundwater is the main source for domestic, industrial and agriculture use. With the expansion of developing activities in this area, it is essential to develop a groundwater management strategy to avoid any environmental impacts on the aquifer system due to the extensive future abstraction of groundwater. With proper groundwater management plan one could minimize the effect of over extraction and aquifer deterioration (***Dawoud et al., 2005***). Groundwater is quickly depleting with a commensurate effect on overall water quality. To improve the situation, the Government of Egypt has identified the West Delta Water Conservation and Irrigation Rehabilitation Project (WDWCIRP) (***Attia et al., 2007***).

Remote sensing and GIS techniques are very powerful tools for analyzing and manipulating the data for the purpose of water resource development and management. GIS technology provides suitable alternatives for efficient management of large and complex databases. The greatest advantage of using

Remote Sensing data for hydrological modeling and monitoring is its ability to generate information in spatial and temporal domain. Remote sensing and GIS techniques are found efficient to minimize the time, labor and money and are able to make quick decisions for Sustainable water resources management. Remotely sensed data are most useful where they are combined with numerical modeling, geographic information systems, and ground-based information. In short both these techniques play a great role in the field of hydrology for water resources development and management. ***(Gaurav, and Shukla, 2015)***. The advantages of using remote sensing for mapping and inventory of earth resources may include the large ground coverage of satellite images, the multiple spectral information the satellite images can afford, the temporal resolution of satellite data, the digital format of the images and the long time extent of the satellite data archives (about four decades) (***Lu et al., 2004***). Digital change detection is the process of determining and/or describing changes in land-cover and land-use properties based on co-registered multi-temporal remote sensing data. The basic premise in using remote sensing data for change detection is that the process can identify change between two or more dates that is uncharacteristic of normal variation. Numerous researchers have addressed the problem of accurately monitoring land-cover and land-use change in a wide variety of environments (***Singh, 1989, Muchoney and Haack, 1994, and Shalaby and Tateishi, 2007***).

Many studies have reviewed and summarized the various change detection techniques (***Singh, 1989, Mouatet al., 1993, Lu et al., 2004, Jensen, 2005, and Rogan et al., 2007***). ***Bhagawat (2011)*** presented the change analysis based on the statistics extracted from the four land-use/land-cover maps of the Kathmandu Metropolitan by using GIS. According to him, land-use statistics and transition matrices are important information to analyze the changes of land-use. ***Singh et al. (2014)*** have used recent freely available satellite data of Landsat-8 for assessing the land-use pattern and their spatial variation of Orr watershed Ashok Nagar district, M.P., India. ***Rawat and Kumar (2015)*** used Lands at satellite imageries of two different time periods to illustrate the spatio-temporal dynamics of land-use/cover of Hawalbagh block of district Almora, Uttarakhand, India. The results indicate that during the last two decades, from 1990 to 2010, vegetation and built-up land have been increased while agriculture, barren land and water body have decreased. They highlight the importance of digital change detection techniques for nature and location of change of the Hawalbagh block. ***Tran et al. (2015)*** assessed the spatio-temporal dynamics of land-cover/land-use changes in the lower Mekong Delta over the last 40 years with the coastal Tran Van Thoi District of Ca Mau Province, Vietnam as a case study. Land-cover/land-use change dynamics are derived from moderate to high spatial resolution (Landsat and SPOT) satellite imagery in six time intervals ranging from 1973 to 2011.

However, from studies in Egypt ***El Gammal et al. (2010)*** have used several Landsat images of different time periods (1972, 1982, 1987, 2000, 2003 and 2008) and processed these images in ERDAS and ARC-GIS software to analyze the changes in the shores of the Lake Nasser, Egypt and in its water volume which is the world's biggest artificial lake. ***El-Asmar et al. (2013)*** have applied remote sensing indices, i.e., normalized difference water index (NDWI) and the modified normalized difference water index (MNDWI) in the Burullus Lagoon, North of the Nile Delta, Egypt for quantifying the change in the water body area of the lagoonduring 1973 to 2011. ***Shalaby and Moghanm (2015)*** used land satellite images to study the urban sprawl and its impact on agricultural land in Qalubiya Governorate. Collected ground truth, during several field trips conducted between 2003 and 2008, and topographic map of 1991 were used to assess the accuracy of the classification results. He performed Post classification change detection technique to produce change image through cross-tabulation.

The aims of this work are to accurately characterize land-use changes in the study area during following periods: of 1984-1999, 1999-2011 and 1984-2011 using object-based image classification approach. Specific objectives are to: produce accurate and reliable results regarding land-use maps in the study area during specific period and define the main land-use/ land-cover as five classes (desert, cultivated, urban, roads and water); get an accuracy as high as possible for the classified image using 150 points at the year 2011as field checkpoints (ground truth data); determine the causes of the changes through spatial comparison of the land-use maps produced; and identify impact of land reclamation activities on the groundwater aquifer.

2. Materials and Method

2.1 Study Area Location

The area concerned in this study occupies the South West of the Nile Delta region. It is bounded by Longitudes $30° 27^{\backslash} 33^{\backslash\backslash}$ to $31° 00^{\backslash} 04^{\backslash\backslash}$ East, and Latitudes $30° 04^{\backslash}25^{\backslash\backslash}$ to $30° 35^{\backslash} 23^{\backslash\backslash}$ North as shown in **figure 1**. It is located in the Western Delta region occupying the area between Cairo and Alexandria, west of Rosetta Branch, and extends westward to the desert area west of Wadi El Natrun up to the eastern edge of the Qattara Depression. It is characterized by rapid development based on surface water and groundwater during the period from 1987 to 2000. Local area of interest which depends mainly on groundwater only extends from Rosetta branch east to Wadi El-Natrun north-west, El Tahrir north, Dina and wadi El Farigh south.

It covers an area of approximately 3,000 km2 (300,000 ha). The study area is characterized by a Mediterranean semi-arid climate. The warmest summer month (August) has a mean temperature of 31.9^{o}C, and coldest winter month (January) has mean 7.8^{o}C, Short rainstorms sometimes occur, mainly in winter. Climatic records also show that the area receives 5.5 mm precipitation per year, most of which falls during January, February, and March. The summer months are usually dry.

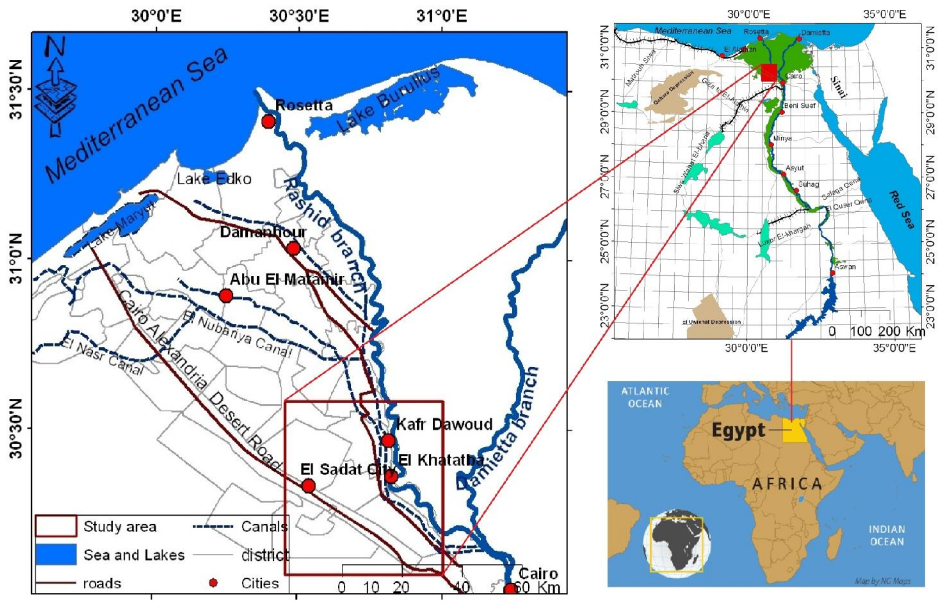

Figure 1. Key map of the study area.

2.2. Geological setting

The Nile Delta and its shelf represent a complex sedimentation system (***Mikhailova, 2001***). The vertical section of the delta is composed of a thick (5–17 m) layer of clay overlying sands with an undulate surface (***Popov, 1958***). The western Nile Delta is generally characterized by low relief and mild topography with elevation varying from zero to +100 m. The land features have been developed through the interaction of the geologic structures, the geomorphologic processes and the climatic condition, which affects the scenery in the different province.

The Western Nile Delta has a thick sedimentary succession that ranges in age from the Late Cretaceous to Quaternary. The rocks of Miocene, Pliocene, and Quaternary times are the most outcropping sediments dominating the investigated area and its vicinities as clarified in **figure 2.** In Wadi El Natrun, the sedimentary section is greater than 4 km in thickness and ranges in age from Triassic to Pliocene. The water-bearing formations belong to Oligocene, Miocene, Pliocene and Quaternary.

2.3. Hydrogeological setting

The available water resources include surface water (Rosetta branch and its irrigation channels) and relatively shallow groundwater that is mainly recharged from the Nile. Groundwater is the main source for domestic, industrial and agriculture use in the western Nile Delta region (***Dawoud et al., 2005***).

The surface water system includes El Rayah El Beheri, El Rayah El Naseri, and El Nubaria canal, and El Nasr Canal. These canals behind Rosetta branch, as well as surface drainage system play an important role in the water systems mainly cut through sands. Therefore, a direct connection between surface water and groundwater exists. Groundwater flow to the westward direction, the flow rates is low (10 to 20 m/yr). According to stratigraphic sequence of water-bearing formations with other geological and hydrological conditions of the study area, groundwater aquifers can be classified into 5 aquifers: The Nile Delta aquifer (Quaternary aquifer), Pliocene aquifer, Miocene aquifer, Oligocene aquifer and Mediterranean coastal aquifer as shown in **figure 3**. The depth to the ground water table in the Quaternary aquifer ranges between 1–2m in the North, 3–4m in the Middle and 5m in the South as reported by (***RIGW, 2002***) and (***Morsy, 2009***). ***Sharaky et al. (2007)*** studied the hydro geochemistry of groundwater in western Nile Delta aquifers to obtain additional information on the possible contamination with major elements, nutrients and trace elements. They concluded that the fresh water in the study area is mainly concentrated in the central-eastern part and most of the groundwater is located in the high salinity and low sodium hazard zone.

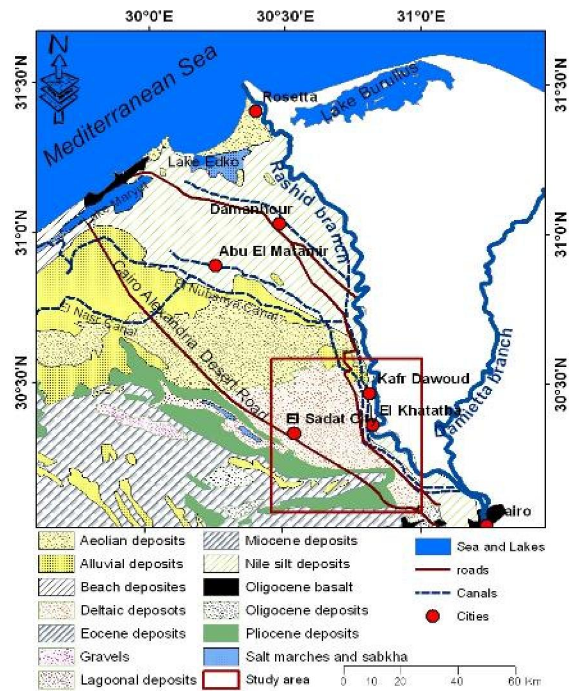

Figure 2. Geologic map of the Western Nile Delta Region (After CONCO, 1987).

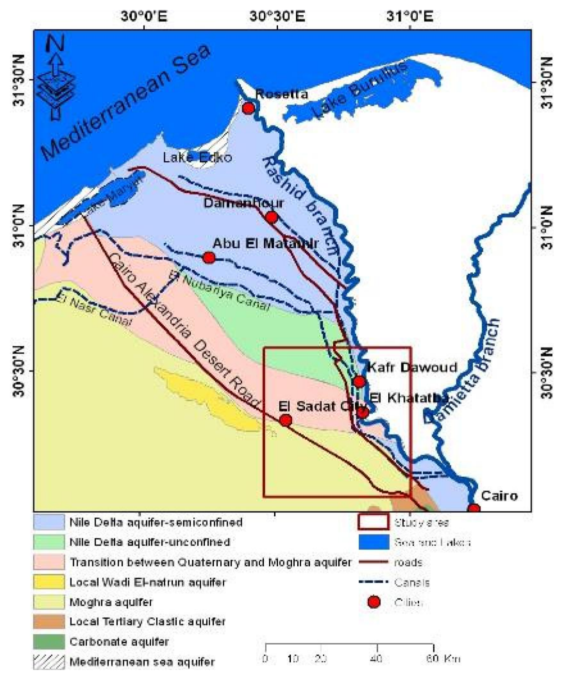

Figure 3. The main groundwater aquifers in the Western Nile Delta Region (Modified by Morsy, 2009).

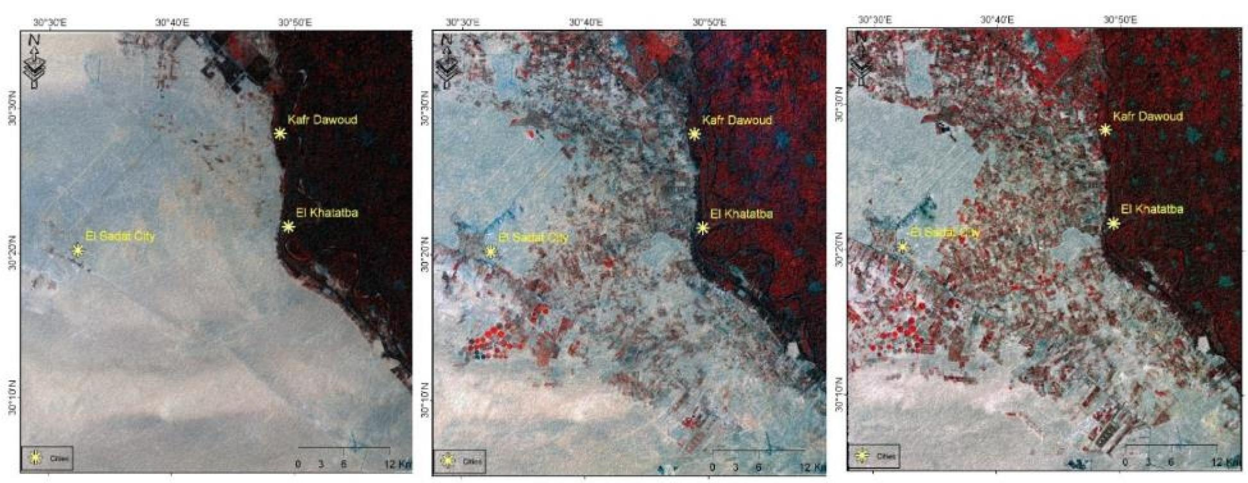

Figure 4.False color composite of the selected Landsat images with band combinations of 4,2,1 for (1984, 1999) images and 3,2,1 for (2011) image.

2.4 Source of Data

1. The base images used in the classification were Landsat Thematic Mapper (TM) acquired September, 11th 1984, Enhanced Thematic Mapper (ETM+) dated 11 July, 1999 with 30m resolution and Spot4 image dated 2011 (a mosaic of three images from 31 March, 2 July and 12 August) with 20m resolution.

The landsat data images are available from the Global Land-Cover Facility (http://glcf.umiacs.umd.edu/index.shtml). The Spot images were obtained from National Authority for Remote Sensing and Space Sciences (NARSS). All visible and infrared bands (except for the thermal infrared band) were included in the analysis as shown in **figure 4**.

2. The Digital Elevation Model (DEM) used in this study is the Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) version 2. The ASTER DEM was downloaded from NASA's Earth Observing System Data and Information System using the Reverb tool (http://asterweb.jpl.nasa.gov/gdem.asp). The ASTER DEM is available in WGS84 Geoid reference datum, geographic coordinates and one arc-second elevation grid with 30m resolution.

The ASTER DEM data were converted to a hill shade terrain map using Global Mapper 12 (TM) as in **figure 5**. From the hill shade surface lineaments were observed by a drop in elevation for a short distance. This Dem Map for the Nile Delta identifies topographic position; classify the quantitative description of landform.

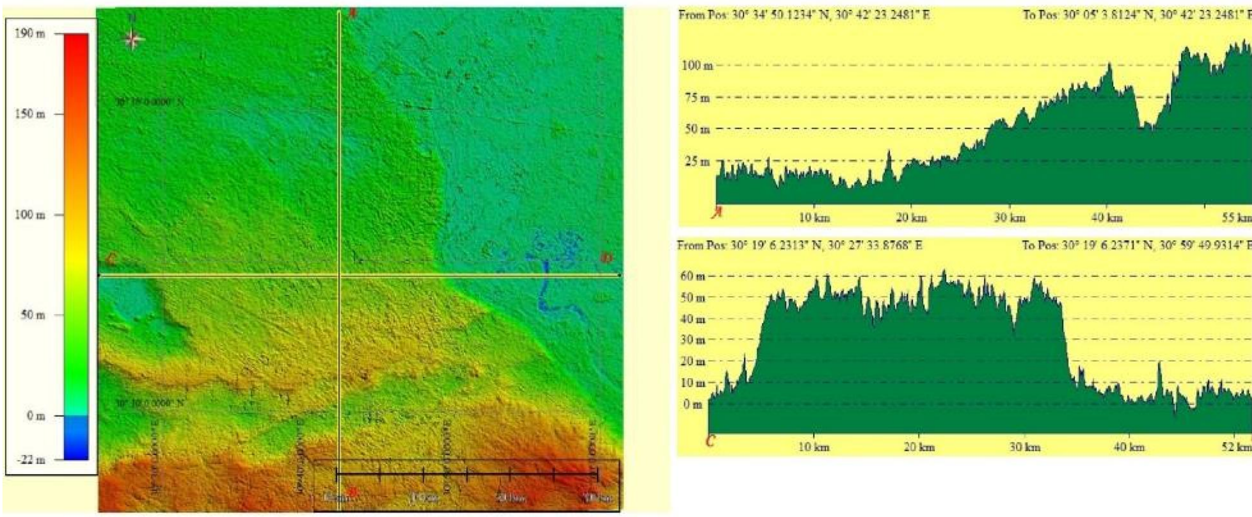

Figure 5. A Shaded-Relief Representation for the study area- DEM with vertical and horizontal path profile lines across the study area DEM.

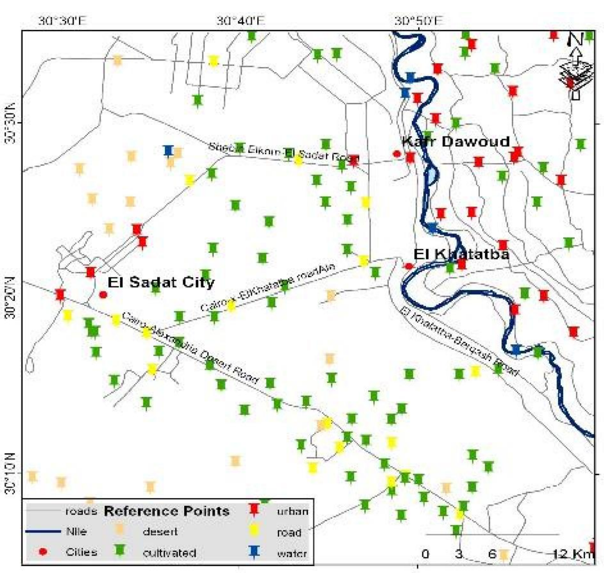

Figure 6. Reference points checked in study area.

3. A total of 150 ground truth points were collected from the study area in March, 2012. The archived data, old sketch maps, and ground truth points were used mainly as reference data for image classification and accuracy assessment. The coordinates of these points were determined in the field using Global Positioning Systems (GPS). The class type of these random points in the classified image was compared with the reference points from the field observation (**Figure 6**).

2.5 Methodology

In this research different programs were utilized, ERDAS Imagine 9.2 for preprocessing and doing classification for the satellite image, Global Mapper 12 for contour maps and digital elevation model (DEM) of study area, Arc GIS 10 for the purpose of analyzing and processing of digital images and obtaining a dedicated maps and measurements.

All of the satellite images (Landsat, SPOT) were used for land-cover/land-use classification along the period of 1984 to 2011. For older time periods, existing land-use maps, topographic maps (scale 1:50,000), hydrologic maps (scale 1:00,000) ***(RIGW /IWACO, 1992)*** were scanned and geometrically registered. Google Earth imagery, were used to select unambiguous training sites and correct the satellite images. Experience gained through visual interpretation of recent images helped to select the most representative training sites for these older dates.

The flow chart depicting the study methodology is illustrated in **figure 7**.

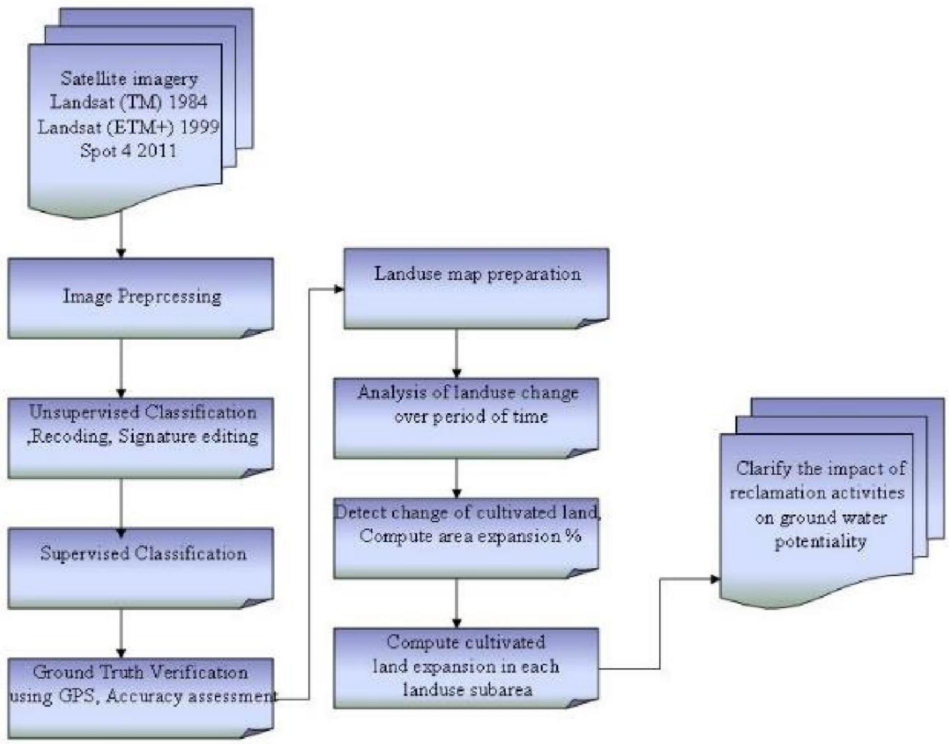

Figure 7. Flowchart depicting the change detection method.

2.5.1 Image pre-processing

The methodology adopted for this study took into consideration various image pre-processing operations, including geometric correction, rectification, image enhancement and interpretation. All visible and infrared bands (except for the thermal infrared band) were included in the analysis. Geometric correction was applied to raw sensors data to correct errors of perspective due to the Earth's curvature and sensor motion. In this research Nearest Neighborhood method was used to resample the images of the study area to 30m because it is suitable for change detection application (***Imagine, 1997***).

Pre-processing of satellite images prior to change detection is essential and has the unique goal of establishing a more direct linkage between the data and biophysical phenomena (***Coppin et al., 2004***). Georeferencing refers to the process of assigning map coordinates to image data. Image mask process is used to reduce consumed time during processing and the storage capacity of processed images (***El-Sayed, 2010***). The satellite images (Landsat, SPOT) in this case study were geometrically corrected to the Universal Transverse Mercator grid (UTM), zone 36, WGS84 ellipsoid and datum, using nearest neighbor resembling method. Twenty GCPs were used for geometric correction of the image mosaic at province scale in 2011 (3 SPOT scenes). All the images were georegistered to the map with a root mean square (RMS) error of less than 0.5 pixels.

2.5.2 Classification

This paper describes the development of a land-cover classification which is based on carrying out unsupervised classification followed by supervised one with the help of ERDAS IMAGINE 9.2 to improve the overall accuracy of the final classification as determined by means of an accuracy assessment.

In the unsupervised classification stage and for more accurate results, the number of classes should be more than the desired class numbers, in this study there were 20 unsupervised classes. Output file was saved as signature file to be used as input file in supervised classification.

Supervised classification involves the classification of pixels of unknown identity by means of a classification algorithm using the spectral characteristics of pixels of known informational class (referred to as training areas) identified in the signature files. Maximum likelihood decision rule was the more accurate method for running supervised classification (***Shaker, 1998***). ***Bikashand Anthony, (2015)*** applied a systematic supervised classification to the composite Landsatimagery to obtain land-cover thematic maps with overall accuracies of 90% and higher.

2.5.3 Accuracy assessment

Classification accuracy refers to the degree of correspondence between the classification from remote sensing data and the reference information (***Congalton, 1991***). A classification accuracy assessment was performed based on 150 random points that were identified and located using a stratified random method in ERDAS software to represent the different land-use classes of the area.

The producer's accuracy represents the measure of omission errors that corresponds to those pixels belonging to the class of interest that the classifier has failed to recognize. The user's accuracy, on the other hand, refers to the measure of commission errors that correspond to those pixels from other classes that the classifier has labeled as belonging to the class of interest (***Richards, and Jia, 1999***). The overall accuracy is the percentage of correctly classified samples. The Kappa coefficient expresses the proportionate reduction in error generated by a classification process. Kappa accounts for all elements of the confusion matrix and excludes agreement that occurs by chance. Consequently, it provides a more rigorous assessment of classification accuracy (***Congalton, 1991***).

The randomly selected points within the classified image list two sets of class. The first set of class values represents the actual land-cover type. The second set of class values are known as reference values. The ground truthing of reference values are possible through field visit, comparing base maps, aerial photos, previously tested maps or other data (***ERDAS IMAGINE, 2006***). The 150 points of 2011 used in our study represented field checkpoints (ground truth data); while 1999's points (178 points) were represented by field checkpoints (***Monem, 2002***), archived data, old sketch maps, and topographic maps as reference data. The reference data and the classification results were compared and statistically analyzed using error matrices as shown in **table 1**.

2.5.4 Change detection of Land-Use

Detecting and analyzing Use-Cover over large geographic areas as well as over regional areas have been highlighted both in a manner of discrete long-time span and in sequential time series with high temporal resolution remote sensing satellites through a process commonly called 'change detection' (***Coppin, and Bauer, 1996***). Numerous change detection methods have been developed to assess variations in the land-cover using satellite data including image differencing, principal component method and post-classification comparisons. Among these techniques the post-classification comparison is preferable. The accuracy of this technique to detect the dynamic changes depends mainly on the accuracy of the individual classification of each land-cover unit (***Esam et. al., 2012***).

The vegetation change detection process divided in to pre-processing, selecting the appropriate technique and accuracy assessment (***Çilsever et al., 2012***). ***El Gammal et al. (2010)*** used several landsat images, acquired at different times (1972, 1982, 1987, 2000, 2003 and 2008), have been processed by using the ERDAS and ARC-GIS software to follow changes in the shores of lake Nasser and in its water content. According to (***Esam et al., 2012***), the post-classification change detection analysis was used to detect the change in the agriculture, urban areas and the change in the River Nile during the period between 1987 and 2009 using landsat images. ***Dewidar (2004)*** applied Maximum Likelihood Supervised Classification and Post-classification Change Detection Techniques to Landsat images for mapping and monitoring land cover and land use changes in the North-western coastal zone of Egypt.

3. Results and Discussion

Based upon the final classification, there are five primary land-use classes found within the study area, as illustrated in **figure 8**. The result of the process is the creation of 5 separate classes: cultivated area, water, urban, roads, and desert. However, the classification technique still incurred a great deal of error. Most of this error occurred due to an inability to differentiate between urban structures and roads.

Before using the classification results from satellite images for change detection, their validity should be assessed by testing the results against the reference data or ground truth data. An error matrix was generated to evaluate the produced land-use maps resulting from the integration of visual interpretation with the classification results (**Table 1**). An error matrix was prepared for each resulting thematic map. The matrix provided the correspondence between the predicted and the actual classes of membership for an independent testing dataset. It made it possible to derive range of quantitative measures of classification accuracy. Four measures (producer's, users, overall accuracy, and Kappa statistic) of accuracy assessment were computed to evaluate the accuracy of the thematic maps.

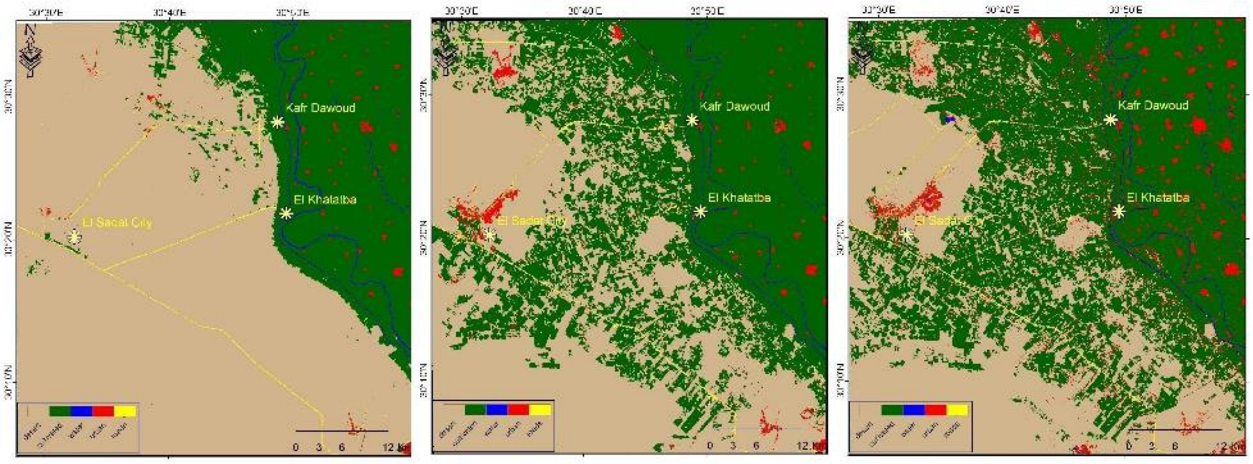

Figure 8. Land-use maps for study area at 1984, 1999 and 2011 respectively.

Table 1. Error matrices and total classification accuracy for the classified images (1999 and 2011).

Land-use classes		Reference data					Classification accuracy (%)		Kappa statistics
		Desert	Cultivated	Urban	Road	Water	Producer's accuracy	User's accuracy	(K^)
1999 Classified data	Desert	46	11	2	2	0	92	75.41	0.658
	Cultivated	4	87	3	1	0	87.88	91.58	0.8103
	Urban	0	0	9	2	0	52.94	81.82	0.799
	Road	0	1	3	3	0	37.5	42.86	0.4017
	Water	0	0	0	0	4	100	100	1
Total accuracy							83.71		0.7279
2011 Classified data	Desert	15	14	1	2	0	88.24	46.88	
	Cultivated	0	61	1	3	0	79.22	93.85	0.4008
	Urban	1	1	22	4	0	84.62	78.57	0.8736
	Road	1	0	2	16	0	64	84.21	0.7408
	Water	0	1	0	0	5	100	83.33	0.8105
Total accuracy							79.33	0.7042	0.8276

Land-use classification maps of the study area for 1984, 1999, and 2011 were produced in **figure 8**. The results reveal that the total accuracies of the land-use classification maps were 83.71% and 79.33% for 1999 and 2011 respectively, and the Kappa coefficients for these years were 0.7279 and 0.7042, respectively. Generally, the accuracy is sufficient to meet the monitoring needs of the land-use cover in the study area.

In the time series, the land-use change during the period of 1984–2011 was markedly characterized by the expansion of the cultivated area and changes in the urban pattern. The urban area expanded into much of the agricultural land, and the agricultural land expanded into the desert land. Other land-use types did not display such intuitive and obvious changes and appeared to be occupied by agricultural land. As **figure 9** showed, it was observed a lot of changes in groundwater cultivated areas during the period from 1984 to 2011.

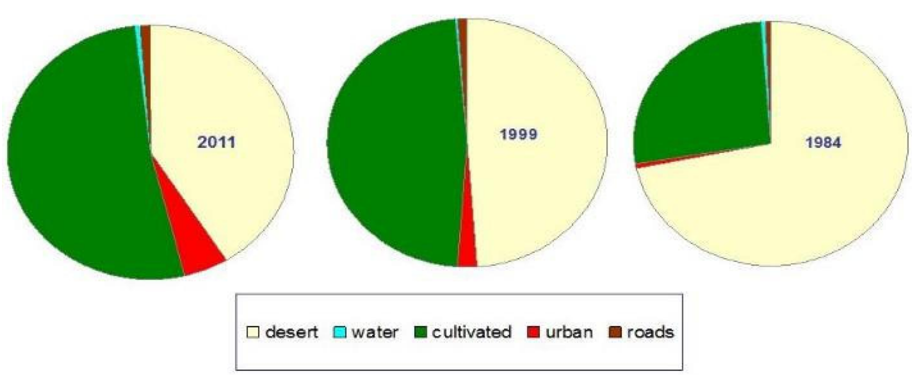

Figure 9. Piechart showing the land-use change in the study region during the year from 1984, 1999 and 2011.

Depending on the results from the different image classification, land-use change was calculated using post classification technique and results presented in **table 2** and maps illustrated on **figure 8**. From **table 2**, about 145,939 Feddan of land changed to cultivated land-use from non-cultivated between the years 1984 to 1999 compared to the value of about 32,910 Feddan between the years 1999 to 2011.

Table 2. Area of each land-use class resulting from the classified images.

Years	Area (Feddan)				
	Desert	**Cultivated**	**Urban**	**Roads**	**Water**
1984	501,721	187,306	4,510	3,603	4,040
1999	343,167	333,245	14,447	6,958	3,322
2011	288,892	366,155	35,012	7,029	4,072

Table 3. The percentages of changed areas in each class.

Land-use classes	Percentage change % (trend)	
	1984-1999	**1999-2011**
Desert	-32	-16
Cultivated	78	10
Urban	22	142
Road	93	1
Water	-18	22

Determination of the trend and rate of land-cover conversion is required for the development of a rational land-use policy (***Shalaby and Tateishi, 2007***). Satellite remote sensing offers the opportunity to assess the effects of these processes and provide the data needed for the development of national agricultural strategies (***PaxLenney, 1996*****).** The ratio of increasing to these cultivated areas reached to about 95.5% as calculated in the **table 3** and presented in **figure 10**. Desert showed continuous decrease from 1984 to 1999 and 1999 to 2011 with about -32% and -16 losses, respectively on the other side, there were significant increases in the urban and road classes with percentage of 220% and 142%, respectively for urban and 93% from 1984 to 19999 for roads and a minor change from 1999 to 2011 evaluated by 1%.

In this research, post classification comparison (PCC) was applied to compare and analyze the land-use maps resulting from the integration of the results of visual interpretation and supervised classification. PCC was employed to detect the differences between each pair of land-use maps (i.e., 1984-1999, 1999-2011, and 1984-2011). Three change maps were compiled to display the specific nature of the changes between the classified images. Post classification comparison was applied using Arc GIS10 according to the following steps:

- Preparing the final classified image (land-use map) for the study area at the three different dates (1984, 1999, and 2011) which have the same classes.

-Convert raster dataset to polygon features.

-Export each class in a separate shape file, especially the agriculture class.

- Subtract land-use map at date 1984 from the other land-use map at date 1999 through the Arc GIS program and subtract land-use map of date 1999 from 2011 land-use map. Each layer of the two classified images subtracted from each other, to give different changes of any class.

- The resulted change detection map illustrates different changes in classes during this period of time.

Areas which converted from desert to cultivated land are mostly concentrated in this research. Change detection map of **figure 10** illustrates amount of changes in development areas during the period from 1984 to 1999 and 1999 to 2011, two vector layers represent main water resources (river, canals) and main roads were also added as reference for the map.

Impact of Reclamation Activities on the Groundwater Aquifer

According to the groundwater development plan (RIGW, 1991), the study area was divided into a number of subareas, based on groundwater in irrigation (A-Kafr Dawud and Sadat City, B-Desert road, Khatatba road and South Khatatba, C-Dina farm and East Wadi el-Farigh) as shown in **figure 11**. The boundaries of these areas were presented as GIS vector layer (by using arc/info software), this vector layer was produced by (GIS of RIGW) and it also contains roads, canals and drains. Through this vector layer, total area of each class for each subarea was calculated. **Table 4** displays the amount of cultivated areas for areas at 1990 and the proposed cultivated areas at 2000 according the groundwater development plan.

The land-use and change detection maps show a great usefulness in planning of groundwater management and development. According to **figure 12**, a lot of changes observed in groundwater development cultivated areas Kafir Dawoud, Desert road, Khatatba Road, Dina Farm, South Khatatba, Sadat City and East Wadi el-Farigh (subareas A,B and C). Accordingly, it was decided to select and focus on those areas for detailed assessment, to evaluate the impact of these rapid changes on groundwater aquifer.

As illustrated in **table 5**, it was observed that several areas were being developed. The areas along the Cairo-Alexandria desert road, Khatatba road, South Khatatba (subarea B) and East Wadi el Farigh, continuously new wells are implemented and new farms were established during the period 1990-2000. Those areas exceed the contingent of groundwater development plan 1990. Subarea C showed the most significant increase in cultivated areas from the year 1984 to 2011 as the area expanded from about 9 feddan (as shown in figure 8 at 1984) to 25,802 feddan. Where, subarea B increased from about 3,015 feddan in 1984 to 81,594 feddan in 2011 and subarea A has an increase from about 8,241 feddan in 1984 to 5,686 feddan in 2011.

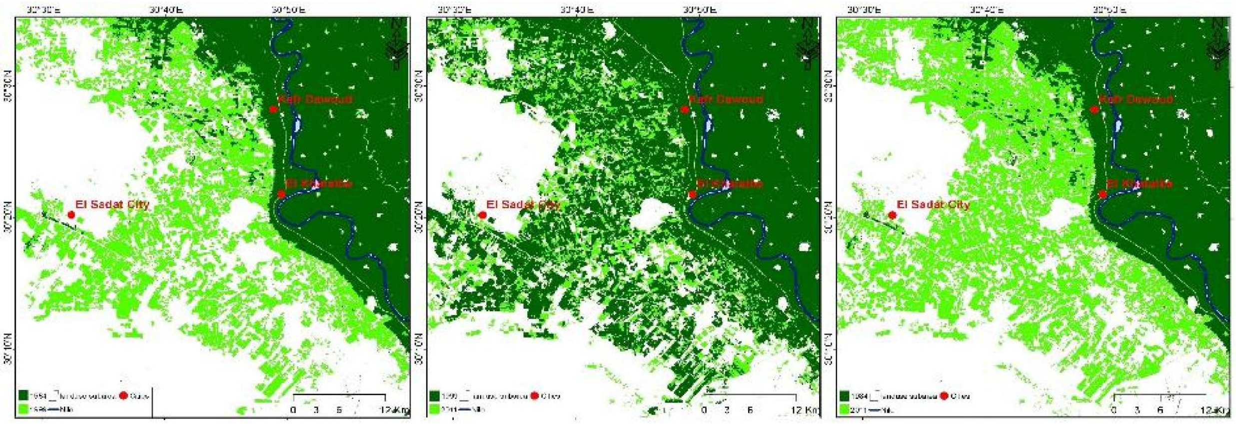

Figure 10. Cultivated areas change detection maps for study area at (1984-1999), (1999-2011) and (1984-2011), respectively.

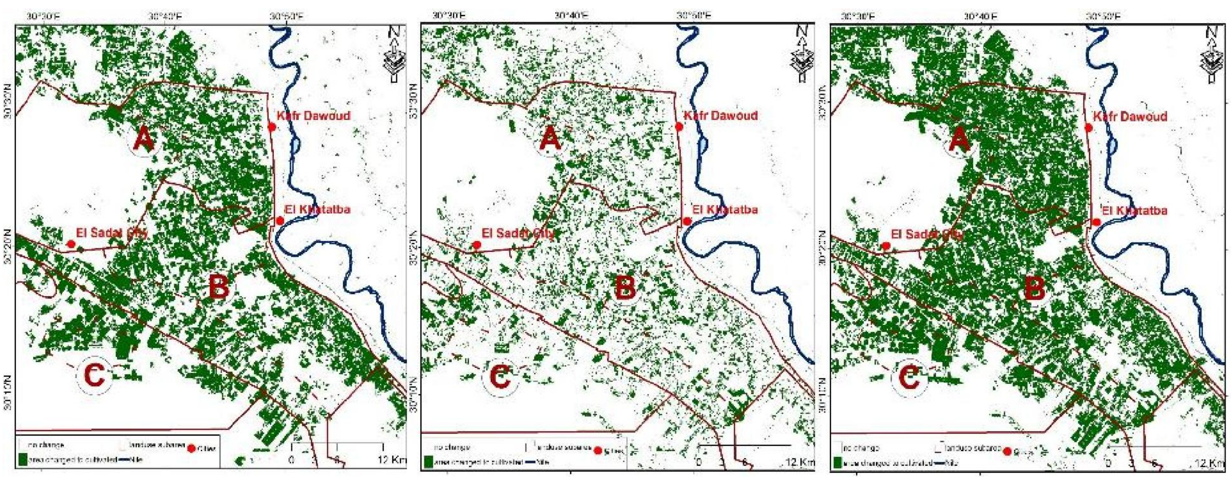

Figure 11. Extraction of Cultivated land expansion in each subarea during the period (1984-1999) (1999-2011) and (1984-2011), respectively.

Table 4. Groundwater development plan according to (RIGW, 1990)

Development area	Area available for cultivation (Feddan)	Cultivated area (Feddan)	
		1990	2000
KafrDawoud and Sadat City (A)	90,000	28,200	36,000
Khatatba Road, South Khatatba and Desert road (B)	100,000	16,500	38,000
East Wadi el Farighand Dina Farm (C)	80,000	13,350	21,000

Table 5. Amount of cultivated area during the period 1984- 2011 at different subareas.

Land-use Subarea	Area/Feddan		
	1984	1999	2011
A	8,421	43,378	56,586
B	3,015	67,222	81,594
C	9	20,021	25,802

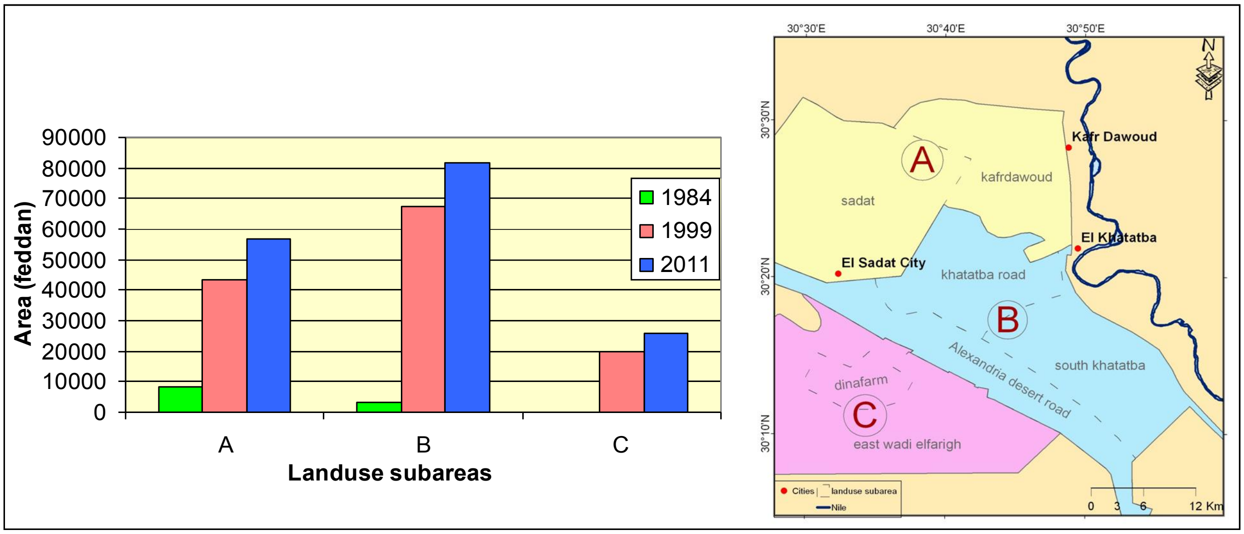

Figure 12. Area chart showing area cultivated in each subarea at different years, where (A-KafrDawudand Sadat City, B-Desert road, Khatatba road and South Khatatba, C-Dina farm and East Wadi el-Farigh).

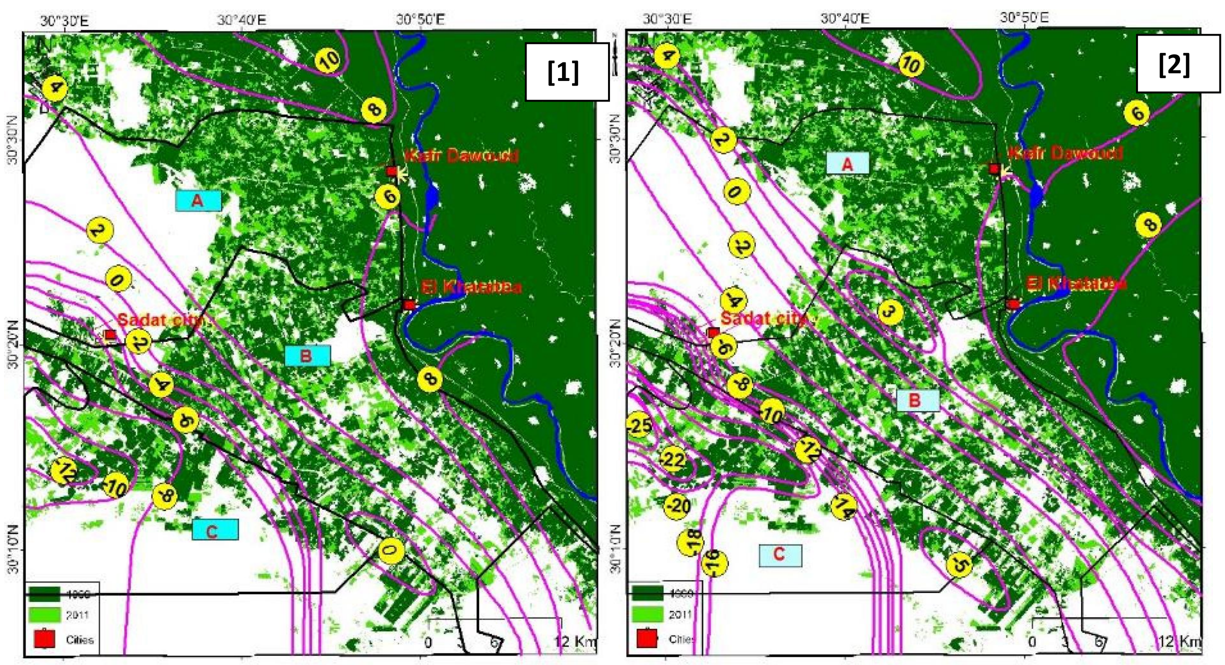

Figure 13. IsoPiezometric heads in meters for studied area in the years [1] 1999 and [2] 2011, respectively.

The Percent of increasing cultivated area in subareas A, B, and C through the period (1999 to 2011) were 30.44%, 21.38%, and 28.87%, respectively. Development of reclaimed land in subareas A, B, and C were accompanied with maximum draw down in groundwater level of 3, 5, and 13 meters **(Figure 13)**. Subarea C was solely dependent on groundwater for irrigation while subarea A and B were irrigated by conjunctive use of surface water and groundwater. It was obvious that the change in the hydrological condition was due to the change in the land-use which causes various adverse effects, e.g. lowering or increasing of water levels.

Planning and monitoring of this extension were needed in order to control its side effects and to assure the feasibility of land reclamation projects in the medium and long term. So, the proper management of the groundwater is an important issue for the sustainable safety of the aquifer systems. Presently, strategies for groundwater protection should be attempted by controlling the groundwater extraction and introduction of new techniques in irrigation. The present study deals mainly with the impacts of agricultural activities on water and soil in the study area.

4. Conclusion and Recommendations

This research shows that remote sensing is an invaluable tool for monitoring spatial and temporal land-use change, particularly when other sources are prohibitive. The study utilized three Landsat and Spot images at 1984, 1999 and 2011. The five dominant classes of land-cover in the study area were desert, roads, water bodies, urban, and agriculture. Results of the accuracy assessment were 83.71% and 79.33% for 1999 and 2011 land-use maps respectively. Based on a post-classification approach, the percentage of agricultural increasing reached 95.5% from 1984 to 2011. This development of agriculture areas were also accompanied with maximum draw down in groundwater level from 3 to 13 meters during the period 1999-2011. The area of East wadi el Farighand South Dina farm (subarea C) represented the highest rate of increasing cultivated areas mainly depend on groundwater in irrigation reached to 25801.48 fed in 2011, with great difference from 1984 which was recorded by 9 fed.

Though, problems in these areas have been studied many times. Serious actions need to be taken order to preserve the precious and limited agricultural land and increase food production. Meanwhile, it is important to install an extensive monitoring program using remote sensing and GIS in both qualitative and quantitative terms. In addition, the National Water Policy for 2016 should be monitored and checked periodically for short term to correct deviations of the existing water policy.

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References

1. Abd El Kawy, O. R., Rød, J. K., Ismail, H. A. and Suliman, A. S. (2011). Land-use and land-cover change detection in the western Nile Delta of Egypt using remote sensing data. *Applied Geography*, 31(2), 483-494. doi:10.1016/j.apgeog.2010.10.012.
2. Attia, F. A., Fahmy, H., Eid, M. (2007). Hoevenaars, Jan (ed.); Slootweg, Roel. *Main Report*. Washington, DC: World Bank.
3. Bhagawat, R. (2011). Application of remote sensing and GIS, land-use/land cover change in Kathmandu metropolitan city. Nepal J. Theor. *Applied Information Technology*, 23 (2), 80–86.
4. Bikash, B. and Anthony, V. (2015). Tracking Landuse/Land cover dynamics in Cloud Prone Areas using moderate resolution satellite data: A Case Study in Central Africa. *Remote Sensing*, *7*(6), 6683. doi:10.3390/rs70606683.
5. Çilsever, M. and Ünsalan, C. (2012). Two-dimensional change detection methods. 76.
6. Coleman, J.M., Robert, H.H., Murray, S.P, and Salama, M. (1981). Morphology and dynamic sedimentology of the eastern Nile delta shelf. *Marine Geology*, 42, 301–312.
7. Congalton, R. G. (1991). A review of assessing the accuracy of classifications of remotely sensed data. *Remote Sensing of Environment*, 37, 35-46.
8. Coppin, P.R. and Bauer, M.E. (1996). Digital change detection in forest ecosystems with remote sensing imagery. *Remote Sensing Reviews*, 13(3-4), 207-234.
9. Coppin, P., Jonckheere, I., Nackaerts, K., Muys, B. and Lambin, E. (2004). Review Article Digital change detection methods in ecosystem monitoring: a review. *Remote Sensing*, 25(9), 1565-1596. doi: 10.1080/0143116031000101675.
10. Dawoud, M., Darwish, M. and El-Kady, M. (2005). GIS-Based Groundwater management model for Western Nile Delta. water resources management, 19(5), 585-604. doi: 10.1007/s11269-005-5603-z.
11. Deer, P. (1995). Digital Change Detection Techniques in Remote Sensing. DTIC Document.
12. Dewidar, K. M. (2004). Detection of land-use/land cover changes for the northern part of the Nile delta (Burullus region), Egypt. *Remote Sensing*, 25(20), 4079-4089. doi: 10.1080/01431160410001688312.
13. Elbeih, S. F. (2015). An overview of integrated remote sensing and GIS for groundwater mapping in Egypt. Ain Shams Engineering, 6(1), 1-15.
14. El Gammal, E. A., Salem, M. S. and El Gammal, A. A. (2010). Change detection studies on the world's biggest artificial lake (Lake Nasser, Egypt). *Egyptian Journal of Remote Sensing and Space Science*, 13(2), 89-99.
15. El-Asmar, H.M., Hereher, M.E., El Kafrawy, S.B. (2013). Surface area change detection of the Burullus Lagoon, North of the Nile delta, Egypt, using water indices: a remote sensing approach. *Egyptian Journal of Remote Sensing and Space Science*, 16, 119-123.
16. El-Sayed, H. (2010). Environmental Investigation on Lake Maryut, West of Alexandria, Egypt: Geochemical, Geophysical and Remote Sensing Study. M.Sc. Thesis, Alexandria University, Egypt.
17. Esam, I., Faid, A. and Erich, N. (2012). Land-Use and Land-Cover Changes of West Tahta Region, Sohag Governorate, Upper Egypt. *Geographic Information System*. doi: 10.4236/jgis.2012.46053.
18. Gaurav, T., and. Shukla, J. P. (2015). A Review on Remote Sensing and GIS Techniques in Water Resource Development and Management with Special Reference to Groundwater. *International Journal of Remote Sensing and Geoscience*. Volume 4, Issue 1,

Jan. 2015, ISSN No: 2319-3484. www.ijrsg.com.

19. Imagine (1997). Photogrammetric Processing, Enhancement, Field Guide. ERDAS Imagine Cooperation, Atlanta, Georgia, USA.
20. Jensen, J.R. (2005). An introductory digital image processing: a remote sensing perspective. Prentice Hall, New Jersey, p 526.
21. Hereher, M. E. (2009). Inventory of agricultural land area of Egypt using MODIS data. *Egyptian Journal of remote sensing and Space Science*. 12, 179–184.
22. Kuemmerle, T., Radeloff, V. C., Perzanowski, K. and Hostert, P. (2006). Cross-border comparison of land cover and landscape pattern in Eastern Europe using a hybrid classification technique. *Remote Sensing of Environment*, 103(4), 449-464. doi:10.1016/j.rse.2006.04.015.
23. Lu, D., Mausel, P., Brondízio, E. and Moran, E. (2004). Change detection techniques. *Remote Sensing*, 25(12), 2365-2401. doi: 10.1080/0143116031000139863.
24. Mikhailova, M. V. (2001). Hydrological Regime of the Nile Delta and Dynamics of Its Coastline. *Water Resources*, 28(5), 477-490. doi: 10.1023/a:1012320920434.
25. Monem, M.A. (2002). Study of groundwater development in the Western Delta Using the Remote Sensing and GIS. M.Sc. Thesis, Faculty of Engineering, Ain Shams University, Egypt.
26. Morsy, W. S. (2003). GIS utilization in groundwater modeling and pollution risk assessment. M.Sc. Thesis, Faculty of Engineering, Cairo University, Egypt.
27. Morsy, W. S. (2009). Environmental management of ground water resources in the Nile Delta Region. PhD. Thesis, Faculty of Engineering, Cairo University, Egypt.
28. Mouat, D. A., Mahin, G. G., and Lancaster, J. (1993). Remote sensing techniques in the analysis of change detection. *Geocarto International*, 8(2), 39-50. doi: 10.1080/10106049309354407.
29. Muchoney, D.M. and Haack, B. (1994). Change detection for monitoring forest defoliation. *Photogrammetric Engineering and Remote Sensing*, 60, 1243–1251.
30. PaxLenney, M., Woodcock, C. E., Collins, J. B. and Hamdi, H. (1996). The status of agricultural lands in Egypt: the use of multi temporal NDVI features derived from Landsat TM. *Remote Sensing of Environment*, 56(1), 8-20.
31. Pelorosso, R., Leone, A. and Boccia, L. (2009). Land cover and land use change in the Italian central Apennines: A comparison of assessment methods. *Applied Geography*, 29(1), 35-48. doi:10.1016/j.apgeog.2008.07.003.
32. Popov, I.V. (1958). Reka Nil (The Nile River), Leningrad: Gidrometeoizdat.
33. Rawat, J. S., and Kumar, M. (2015). Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh block, district Almora, Uttarakhand, India. The Egyptian Journal of Remote Sensing and Space Science, 18(1), 77-84. doi:http://dx.doi.org/10.1016/j.ejrs.2015.02.002

Richards, J. A. and Jia, X. (1999). Remote sensing digital image analysis. Berlin: Springer.

34. RIGW, Research Institute for Groundwater. (1992a). Hydrogeological Map of Nile Delta, Scale1: 500,000, 1st Edn., Nile Delta.
35. RIGW, (2002) Nile Delta groundwater modeling report. Research Inst. for Groundwater, Kanater El-Khairia, Egypt.
36. RIGW/IWACO. (1992). Hydrogeological Map for Abu El-Matamer Scale 1:100000.
37. RIGW/IWACO. (1992). Hydrogeological Map for Wadi El-Natrun, Scale 1:100000.
38. RIGW/IWACO. (1992). Hydrogeological Map for Menuf, Scale 1:100000.
39. RIGW/IWACO. (1992). Hydrogeological Map for West Tanta, Scale 1:100000.
40. Rogan, J. and Chen, D. (2004). Remote sensing technology for mapping and monitoring land-cover and land-use change. *Progress in Planning*, 61(4), 301-325. doi:10.1016/S0305-9006(03)00066-7.
41. Sestini, G. (1992). Implications of climatic changes for the Nile Delta. In: Jeftic L, Milliman D, Sestini G (eds) Climatic change and the Mediterranean. Edward Arnold, London, p.p. 535–601.
42. Shalaby, A. and Moghanm, F. S. (2015). Assessment of urban sprawl on agricultural soil of Northern Nile Delta of Egypt using RS and GIS. *Chinese Geographical Science*, 25(3), 274-282. doi: 10.1007/s11769-015-0748-z.
43. Shalaby, A. and Tateishi, R. (2007). Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt. *Applied Geography*, 27(1), 28-41.
44. Sharaky, A. M., Atta, S. A., El Hassanein, A. S. and Khallaf, K. M. (2007). Hydrogeochemistry of Groundwater in The Western Nile Delta Aquifers, Egypt. Paper presented at the 2nd International Conference on the Geology of Tethys, Cairo University, Egypt.
45. Singh, A. (1989). Review Article Digital change detection techniques using remotely-sensed data. *Remote Sensing*, 10(6), 989-1003. doi:10.1080/01431168908903939.
46. Tran, H., Tran, T. and Kervyn, M. (2015). Dynamics of Land Cover/Land Use Changes in the Mekong Delta, 1973–2011: A Remote Sensing Analysis of the Tran Van Thoi District, Ca Mau Province, Vietnam. [Article]. *Remote Sensing, 7*(3), 2899-2925. doi:10.3390/rs70302899.
47. Weng, Q. (2001). A remote sensing-GIS evaluation of urban expansion and its impact on surface temperature in the Zh.

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