Monitoring Land-Cover in the New Reclaimed Area: A Case Study in EL-Nubaria, Egypt

*Abou-Hadid A. F., M.A. A. Abdrabbo, A.A. Khalil and M. K. Hassanein

The Central laboratory for Agricultural Climate, Agricultural Research Centre, Dokki, Giza- Egypt
*abouhadid@arc.sci.eg

Abstract: Agricultural production in Egypt is limited by urban encroachment and soil salinity. On the other hand, continuous reclamation efforts in the desert and coastal regions succeeded in establishing new agricultural communities and increased the area of cultivated land and the amount of final product in the last decade. In the present study a suitable methodology is developed for monitoring land cover in the new reclaimed area EL-Nubaria region by integrating remote sensing and GIS based on land survey approach. Area frame surveys are common approaches together land cover data. In contrast to mapping approaches, area frame sampling is a statistical method. Based on the visual observation of sample geo-referenced points, area estimates are computed and used as a valid generalization without studying the entire area under investigation. The approach has also the important advantage of not involving/disturbing the land owners and the farmers. Digital topographic maps 1:50000, SPOT5, 2,5m resolution satellite images and Ortho-rectified Digital Topographic Maps (DTM) were used. The total area for EL-Nubaria is 5670 km², most of land cover areas are permanent crops 1899 km², cropland 985 km² and desert 845 km². Most of crop area decreased between 1999 and 2009 except the sugar beet and potatoes increased by 6191 and 16245 feddan. The present study proved that integration between remote sensing and GIS is a powerful tool for sustainable land use planning.
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1. Introduction:

Egypt lies in the semi arid and arid zone of Africa. Desertification can often be found in detached areas in arid and semi arid places (Pacheco, 1980). The use of remote sensing in monitoring and identification of the desertification phenomena has been investigated by Abd El-Hamid (1994). TM images covering the eastern boundaries of the Nile River Delta (Figure 1) towards the Suez Canal (covering about 18000 hectares), taken during the summer season (July 2, 1984 and August 9, 1989) were digitally processed at the Earth Data Analysis Center (EDAC) , University of New Mexico, USA. A file for an image containing the major principal components, NDVI and the CH3/CH4 ratio (SI, soil index) was created for applying unsupervised classification which was used in the comparative study. The results obtained showed that unplanted areas were 33.9% in the year 1984 and 47.3% in 1989. This means that the rate of desertification in this part of the country was 2.68% per year.

Reclamation of desert is one of the major tasks nowadays in Egypt. The reclamation is carried out mainly in the desert areas for cultivation purposes in order to fulfill the needs of the high population growth. The reclamation rates need to be measured continuously and to be examined against the original planes. Experience has demonstrated that collection and compilation of data, for such purposes, using traditional techniques is costly and time consuming.

Figure 1: The light colored Areas to the west and east of the Nile Delta in north Egypt is sand covered Land

The use of high resolution satellite images which is both repeated very frequently and also employs computer processing can be an alternative data capture tool for accurate mapping of the cultivated land and for determining the reclamation rates (Austin (1992) and Genong (1996). On the other hand applying automatic detection techniques reduce the time needed for obtaining accurate information about reclamation process. The agricultural expansion outside the old valley is one of the main objects of the Egyptian national plan (Darwish *et al*, 2006). A great attention is directed to the North Western of Egypt (NWE), due to its diverse characteristics. Therefore, studies on management of natural resources in such regions are considered of vital importance (Ali, 2008). Many studies have shown the land cover and land use changes in arid, semi-arid and agricultural productive lands. Ram and Kolarkar (1993) studied land use changes in arid areas in India by visual comparison of satellite imagery, maps and aerial photographs. In Egypt, Sadek (1993) used satellite imagery to highlight agricultural boundaries and monitor reclamation process. In this paper, we have demonstrated that geospatial technologies can offer reliable tools to support analysis, problem solving, planning, decision-making, and management of the processes required to pursue land sustainability analysis. Remote Sensing (RS) & Geographic Information System (GIS) combination creates great possibilities for fast inventory and updating the natural resources status in the new reclaimed area. The objective of this studies monitoring the land cover of EL-Nubaria area during the last ten years.

2. Material and methods

Study Areas

The study area (EL-Nubaria) is located in the North Western of Egypt (NWE), about 47 km South of Alexandria. It lies at longitudes 30° 10' and latitudes 30° 52'. The area of EL-Nubaria region covers a part of four governorates El Beheira 4195 km², Alexandria 70 km², El Monoufia 561 km² and Giza 844 km² (Figure 2).

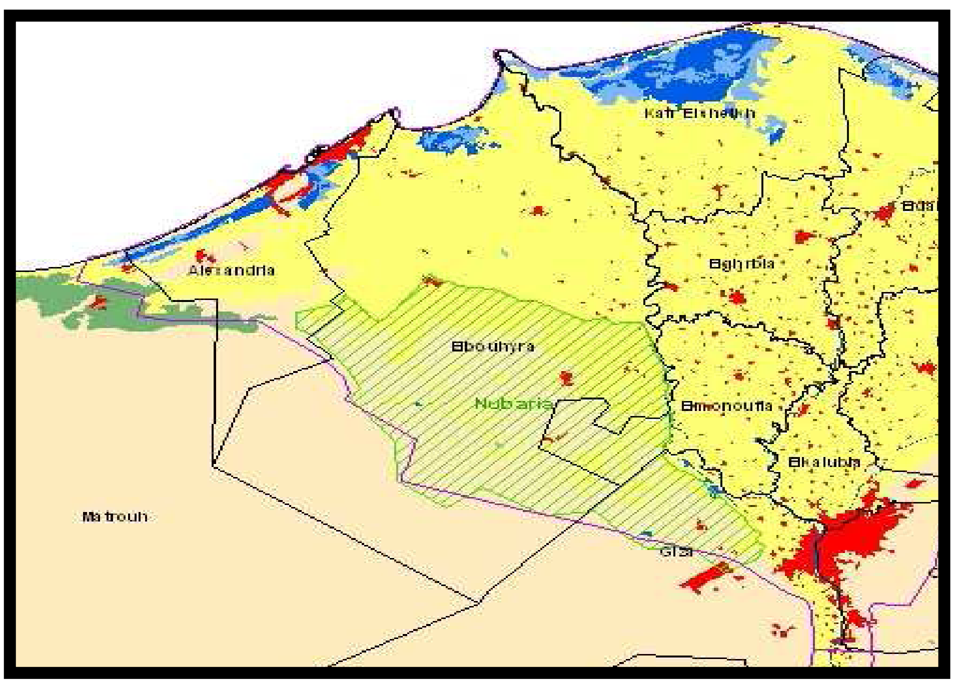

Figure 2: The area of agricultural EL-Nubaria region covers a part of four governorates (El Beheira, 74% Alexandria 1 %, El Monoufia 10 % and Giza 15 %)

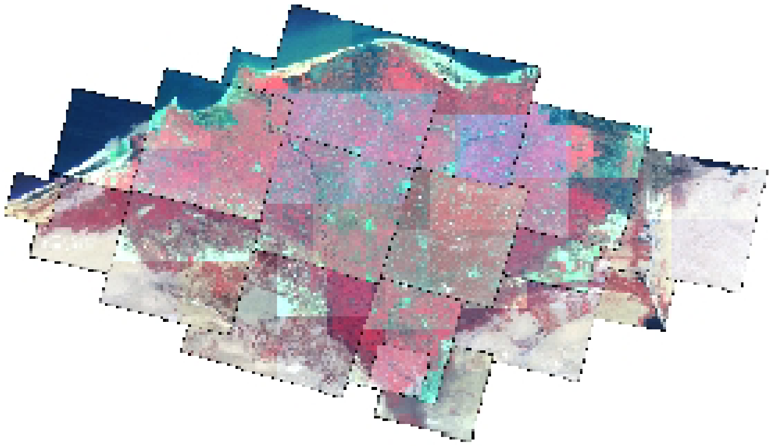

Figure 3: Satellite images covered the Nile delta, *Red color: mean high chlorophyll activities such as crops, * Light blue: Urban and Light grey: Bare soil

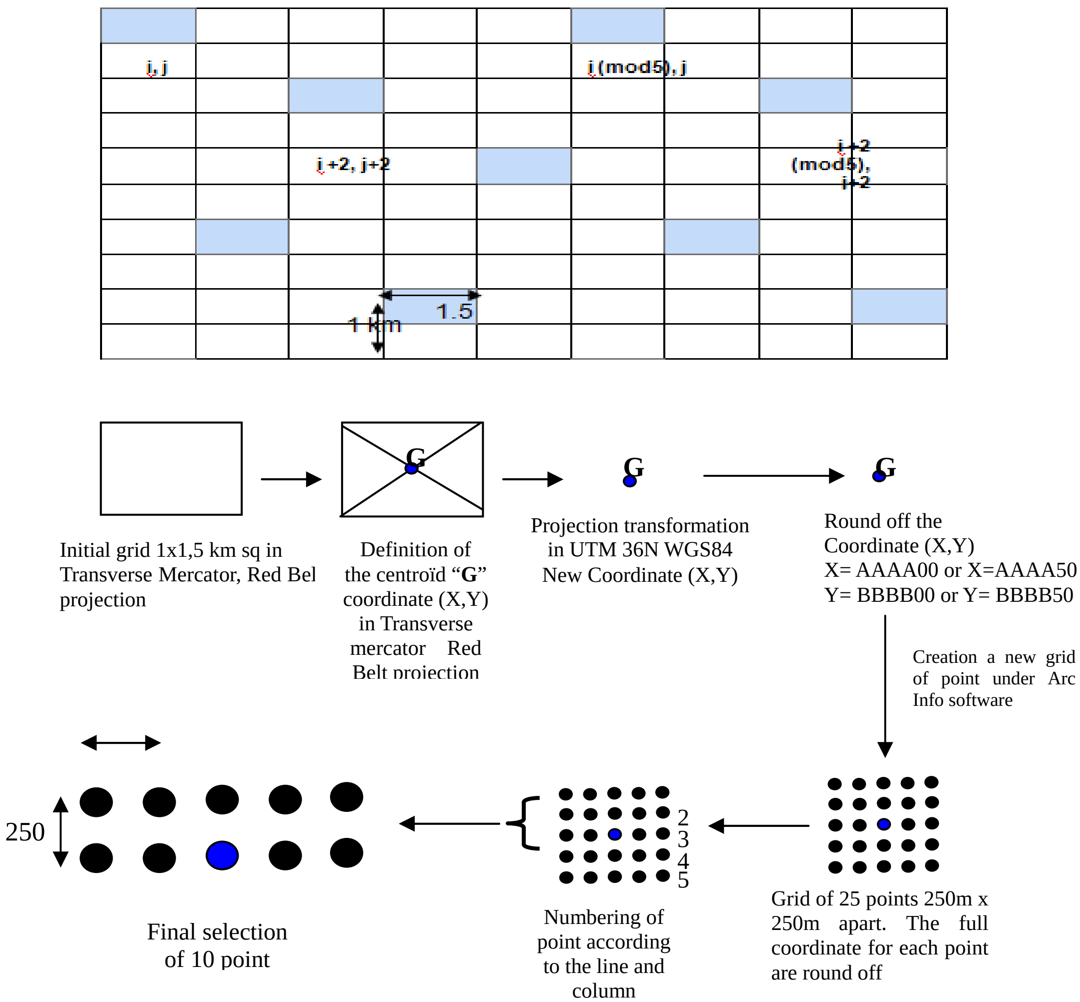

Figure 4: Methodology of selection the sub-sites

Suitable methodology is developed for estimating crop area by integrating RS and GIS based on survey approach. Area frame surveys are common approaches to gather land cover data. In contrast to mapping approaches, area frame sampling is a statistical method. Based on the visual observation of sample geo-referenced points, area estimates are computed and used as a valid generalization without studying the entire area under investigation. The approach has also the important advantage of not involving/disturbing the land owners and the farmers. Ninety surveyors visited about 1600 sites in the Nile Delta during winter of 2008/2009 and summer season of 2009 year to record the visual observation of land cover (Abou Hadid, 2010). Digital topographic maps 1:50000 and SPOT5 satellite images were used, 2,5m resolution, (Figure 3)Ortho-rectified (DTM). The survey used the WGS84 (World Geographic System 84), Universal Transverse Mercator 36 N, which parameter are given hereafter particular sites were visited during the winter and summer surveys, the sample could be constituted of a sub-set of these sites and one point will be designed in each of the selected sites. The sub sample is defined as points of observation, 250m x 250m apart; there are 10 points of observation, which are called points. They are located in two lines East-West of 5 points (Figure 4).

Area or point sampling

The decision to sub sample the segment area through a grid of points is straight forward when looking to the structure of variance (variance between segments and variance between points within segments). In all our sampling simulation, the component of variance related to the second stage rarely reached 5% of the total variance. The sampling plan adopted consists of one systematic square grid 2 (1x1.5Km) and rectangular segments of 2x5 points 250 m apart. This imposes due to the absence of replicates-an approximate estimation of variance through the differences between neighboring sampling units (Cochran, 1977). Area frame surveys are common approaches to gather land cover data. In contrast to mapping approaches, area frame sampling is a statistical method. Based on the visual observation of sample geo-referenced points, area estimates are computed and used as a valid generalization without studying the entire area under investigation. The survey was started at January, 15, 2009 for survey the winter crop and at June, 15, 2009 for summer crops. A supervisor will cover a regional zone and should manage about ten or twelve surveyors.These ratios are globally maintained in 2009.

Field survey sites determination

The sampling plan is systematic and has two levels (Figure 4) Primary Sampling Unit (PSU) and Secondary Sampling Unit (SSU). The primary sampling unit is based on a regular grid 1x 1,5km coming from the Egyptian cadastral maps 1x1.5 km (Figure 4).The cadastral maps were elaborated by the Egyptian Survey Authority (ESA). They have been then updated by the Ministry of Agriculture using aerial photographs in the year 1985. The PSU represents an area of around 1.5 km². The index grid of the maps has been drawn over the full Egyptian territory. The systematic random has been carried out in chosen then one out of ten sheets according to the following algorithm.

Sx,y = Ith (modulo 5) column on the jth row, and (i+2)th (mod 5) column on the (j+2)th row

The following examples show the geo-referenced Grid 1x1, 5km covering the entire Delta and Nile Valley including around a buffer zone in order to take into account a potential agriculture extension over the desert. The coordinate system used for all geographic data were download on GPS devices to every surveyor (100 surveyor covered all Nile delta and Nile valley. The survey used the WGS84, Universal Transverse Mercator 36 N, which parameter are given hereafter.

Determination of sub site (Points)

The SSU's are defined as points of observation, 250m x 250m apart; there are 10 points of observation, which are called points. They are located in two lines East-West of 5 points (Figure 4). From the previous grid of selected site coming from the previous project some steps was implemented in order to obtain the final grid of 10 point sed for field survey.

Nomenclature

The design of the nomenclature is based on “Classification system for land cover and land use” (Eurostat, 2001). Various existing national and international classification systems have been analyzed to establish best practice for the construction of a classification system to be used in the framework of land use in agriculture system.

The main points which were the object of analysis and choices were:

1. The definition of land (extended to inland water), of land cover (above the earth's surface)

2. The observation unit: a circle of 3m of diameter except in case of heterogeneous areas or permanent crops,
3. The separate registration of multiple use/cover in order to avoid mixed classes,
4. The documentation of the classes in terms of definition, list of inclusions and exclusions, compatibility between land cover and land use,
5. The correspondence with existing national or international classification systems.

Comparison between land cover at 1999 and 2009

Agricultural statistics data from Ministry of Agriculture and Land Reclamation (MALR) was used to compare the land cover at last ten years with the data obtained by the GIS and field survey.

3. Results and Discussion:

EL-Nubaria area has been affected by many natural and human activities. Results obtained from field survey are prepared in Table (1).Total area for EL-Nubaria was 1349999 feddan (5670 km²). EL-Nubaria classified in to sixteen types, Towns and villages 288 km^2, greenhouses 120 km^2, roads and tracks 306 km^2, canals and ditches 66 km^2, cropland 985 km^2, permanent crops 1899 km^2, agricultural bare land 776 km^2, woodland and hedge 52 km^2, shrubland and steppe 89 km^2, grassland 33 km^2, desert 845 km^2, other bare land 163 km^2, wetland 2 km^2, lakes and water ponds 10 km^2, Nile River 8 km^2 and fish farming 28 km^2.The highest activities (land cover) areas in EL-Nubaria were for permanent crops and cropland 1899 km^2 and 985 km^2 (234504 and 452095 feddan), respectively (Figure 5). The lowest land cover area in EL-Nubaria was for wetland 408 feddan. The desert area still takes high area in EL-Nubaria 845 km^2 under winter and summer surveys. Percentage of land cover area was illustrated in figure 6. The highest land cover frequency was by permanent crops 33.5 %. The crop land come in the second class by 17.4% and the third class was for desert 14.9 %.

Table 1: Aggregated lands cover nomenclature in EL-Nubaria region

Classes	Definition	Area (km^2)	Frequency (%)	Total area(Feddan)
A11	Towns, villages	288	5.1	68633
A13	Greenhouses	120	2.1	28669
A22	Roads, tracks	306	5.4	72902
A24	Canals, ditches	66	1.2	15716
B1	Cropland	985	17.4	234504
B5	Permanent crops	1899	33.5	452095
B7	Agricultural bare land	776	13.7	184645
C	Woodland, hedge	52	0.9	12353
D	Shrub land, steppe	89	1.6	21101
E	Grassland	33	0.6	7904
F6	Desert	845	14.9	201270
F7	Other bare land	163	2.9	38797
G	Wetland	2	0	408
H1	Lakes, water ponds	10	0.2	2450
H2	Nile river	8	0.1	1816
H4	Fish farming	28	0.5	6736
Total		**5670**	**100.1**	**1349999**

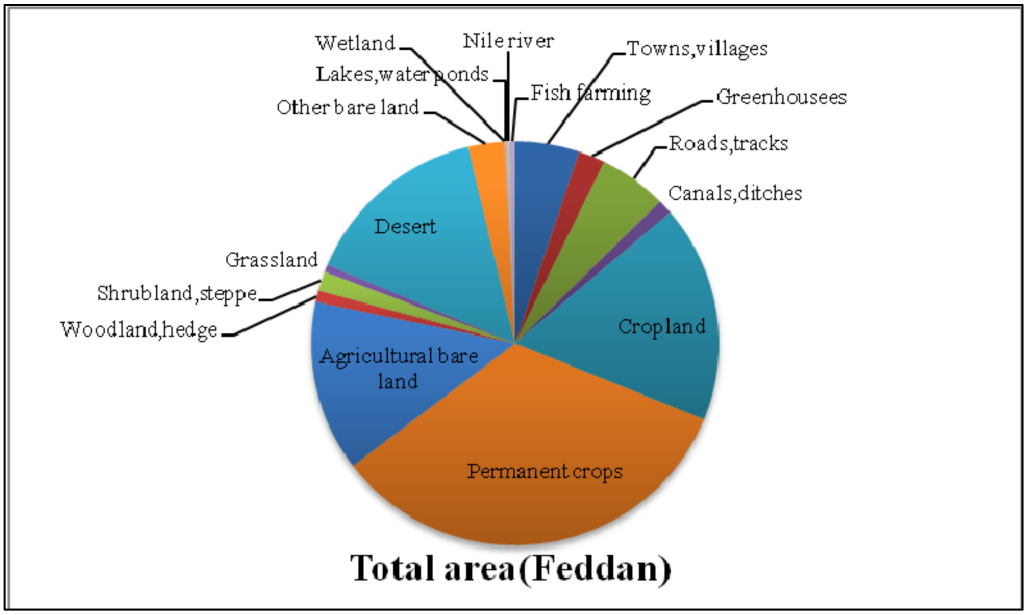

Figure 5: The classification of land cover in EL-Nubaria during the field survey

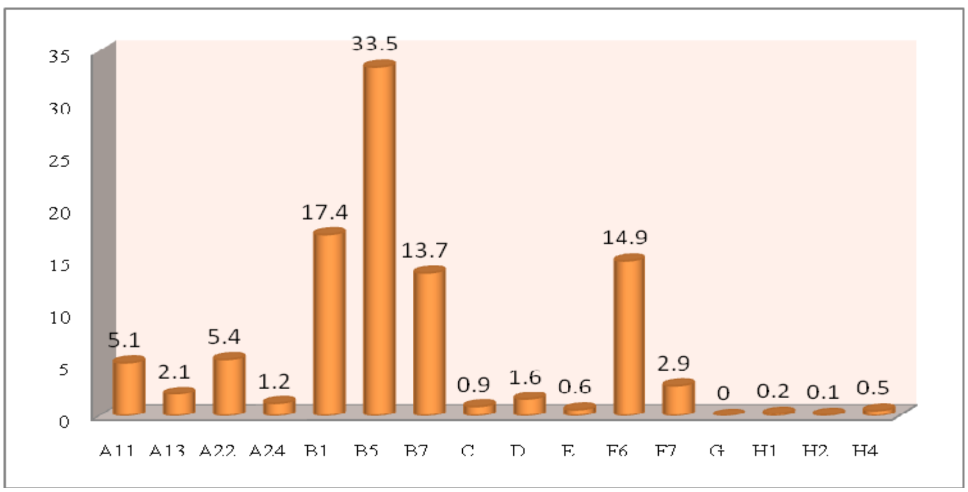

Figure 6: Frequency of land cover representation in EL-Nubaria

Land covers change in EL-Nubaria

Data on crop area for 1999 were obtained from Agricultural Statistics to compare land cover change between the two periods 1999 and 2009. Eight crops selected for this comparison (bersim, wheat, barley, bean, sugar beet, potatoes, tomatoes and other vegetables). The land cover change results for the eight selected crops between (1999 and 2009) are showed in (Table2) and discussed in details as following, total area of eight crops in 2009 decreased by 151951 feddan in comparison with 1999. The cultivated land in the study area increased from 1999 to 2009 by 6191 and 16245 feddan for only two crops sugar beet and potatoes, respectively. Total area for six other crops (bersim, wheat, barley, bean, tomatoes and other vegetables) decreased during the study period. The highest land cover decrease was for wheat and bersim area by -74030 and -48117 feddan respectively (Figure 7). The lowest land cover decrease was for tomatoes and barley by -8880 and -9261 feddan.

4. Conclusion:

Remote sensing technology and GIS was utilized to monitor land cover in the new land area of Egypt. The land cover changes in the EL-Nubaria could be summarized as;1) slight increase in the total cultivated area while the annual rate of agricultural reclamation decreased significantly in the period 1999 and 2009;2) the rate of change for desert areas is stable. There is an urgent need to activate the agricultural reclamation effort to run in parallel with the urbanization processes in this area. Future work with more satellite images and ground truth data may help to map the land cover changes with maximum level of accuracy. Finally, the present study proved that integration between satellite images and GIS is a powerful tool for sustainable land use planning, with computer-aided visual approach, is a valuable tool for accurate detecting and locating of the new reclaimed areas. Accordingly, such technique can be applied for regular evaluation of the reclamation rates that taking place nowadays in the Egyptian deserts

Table 2: Comparison between crop area during 1999 and 2009

Type	**Total area(Feddan)**		
	1999		**1999**
Bersim	84673	36556	-48117
Wheat	139365	65335	-74030
Barley	11205	1944	-9261
Bean	43017	27223	-15794
Sugar Beet	420	6611	6191
Potatoes	14867	31112	16245
Tomatoes	16269	7389	-8880
Other vegertables	71195	52890	-18305

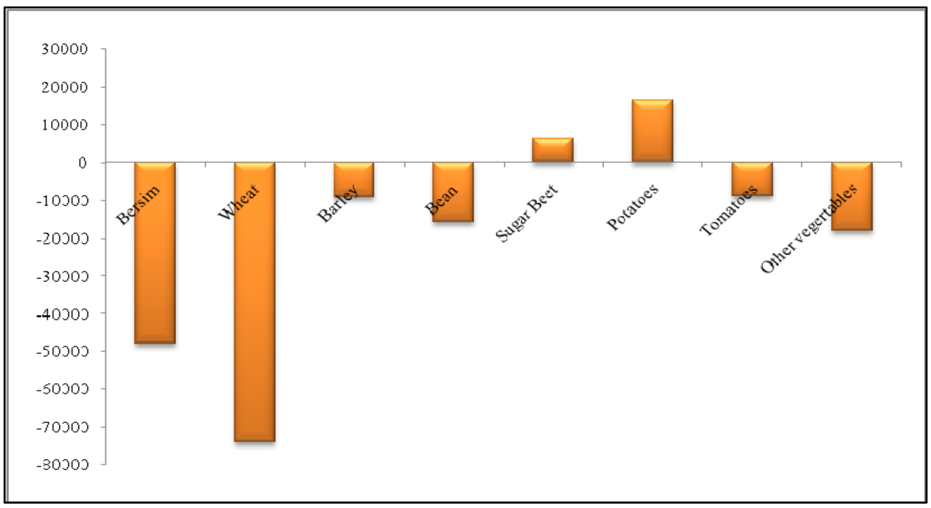

Figure 7: difference between land cover area during 1999 and 2009

Corresponding author:
Abou-Hadid A. F
The Central laboratory for Agricultural Climate, Agricultural Research Centre, Dokki, Giza- Egypt
abouhadid@arc.sci.eg

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