MONITORING OF AGRICULTURAL AREA TREND IN EASTERN NILE DELTA IN EGYPT USING LANDSAT ETM+ DATA

Mohamed ABOELGHAR*
Ryutaro TATEISHI**

*Center for Environmental Remote Sensing CEReS
Chiba University
1-33 Yayoi-cho, Inage-ku, Chiba, 263-8522
Tel 81-43-290-2964 Fax 81-43-290-3857
E-mail: ghar@ceres.cr.chiba-u.ac.jp

**Center for Environmental Remote Sensing CEReS
Chiba University
1-33 Yayoi-cho, Inage-ku, Chiba, 263-8522
Tel 81-43-290-2964 Fax 81-43-290-3857
E-mail: ghar@ceres.cr.chiba-u.ac.jp

KEY WORDS Land Cover Changes, Remote sensing, Landsat ETM+

ABSTRACT Agricultural production in Egypt is limited by urban encroachement 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 two decades. In this study, a 2001 Landsat Enhanced Thematic Mapper image was classified into four main landcover classes namely agricultural, water, urban and desert areas. These, together with previous studies in 1988 and 1994, were used to map the landcover changes. Generally, the results show a noticeable increase in area on both agriculture and urban areas with decrease in desert lands. The rate of changes from 1988 to 1994 is higher than the rate from 1994 to 2001 for agriculture and lower for both urban and desert. Agricultural land increased by 36% from 1988 to 1994 and by 23% from 1994 to 2001. The urban settlements increased by 45% from 1988 to 1994 and by 363% from 1994 to 2001. The desert area decreased by 24 % from 1988 to 1994 and by 29 % from 1994 to 2001. This work could be used to model present and future landscape changes in one of the most important agricultural areas in Egypt.

Introduction

Urban encroachment, soil salinity and reclamation of desert to be cultivated represent three main circumstances, which negatively or positively affect the total cultivated area in Egypt. Agriculture is the core and the main goal for any development strategies and increasing the total agricultural product by improving the quality and increasing the area of the cultivated land is the national target of Egypt in the last two decades. In the same time, deserts represent vast lands from the whole country area. These require continuous public and private reclamation efforts to change these lands from desert to productive lands. Urbanization is an inevitable process due to progress and development however the encroachments of urban settlements onto previously agricultural lands may pose dire consequences. Therefore, determining the trend and the rate of land cover conversion is very necessary for development planners in order to build up the best land use policy. For this purpose, the temporal dynamics of remote sensing data can play a very important role in monitoring and assessing land cover changes.

Many studies have shown the land cover and land use changes in arid, semi-arid and agricultural productive land. Lenney et al. (1996) assessed land cover changes in Egypt using field calibrated, multi-temporal NDVI features derived from 10 Landsat TM images dating from 1984 to 1993. High rate of reclamation was identified from the period between 1986 and 1993, with low rate of conversion from agricultural productive land to new urban areas between 1984 to1990. 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. Lambin and Ehrlich (1997) used ten – years data of NOAA-AVHRR to assess and analyze land cover changes in the African continent from 1982 to 1991. The study showed

that continuous unidirectional change process affected less than 4% of Sub - Saharan regions during the study period. Rembold et al. (2000) studied land cover changes in lake regions of central/ south Ethiopia using aerial photographs dated 1972 and 1994 Landsat TM image. Mendoza and Etter (2002) combined black and white aerial photographs with fieldwork and GIS to monitor land cover changes covering 56 years (1940-1996) in parts of Bogota, Colombia.

The objectives of this work is to have general view about land cover changes in the last thirteen years, to study the interaction among the different land cover types, provide recent and accurate information about the area of the different land cover classes in the study area and predict/ forecast the land cover changing for the next period.

Study area

The study area is located in Eastern Nile Delta between 31^{o} $10^{\backslash}$ to 32^{o} $20^{\backslash}$ East and 30^{o} to 31^{o} $30^{\backslash}$ North. The area belongs to Mediterranean climate with two main seasons; hot dry summer and cool winter, with 20.7^{o}C average air temperature and 38 mm total precipitations for the whole year. The area contains different types of land cover and land use; 1) old agricultural lands with traditional irrigation system cultivated with annual crops, fruits and vegetables following two main agricultural calendars. The main soil type in this area is Vertisols Abdulla et al. (1997); 2) New reclaimed areas with recent circular irrigation system (PAVOT) cultivated with different agricultural types. 3) Old reclaimed areas that are totally cultivated by traditional irrigation methods. The major soil type in the newly reclaimed areas is Aridisols Abdulla et al. (1997); 4) Water bodies and wet lands; 5) Desert that have not been included in any reclamation effort. The study area is located in El-Sharkya governorate, which is one of the most important agricultural areas in Egypt. The total cultivated area in this governorate is 3203.63 km^2. This governorate represents 9.73% from the whole national cultivated land. Area about 559 km^2 from El-Sharkya is ready to be included in the reclamation effort. Because of the recent efforts to convert the desert to agricultural lands and establish new urban communities, this area is considered as one of the highly areas of land cover changes in Egypt

Method

One Landsat TM image dated 19 March 2001 with almost cloud - free conditions was selected in this study. The image was georeferenced by nearest neighbor resampling algorithm with RMS error less than one pixel. All channels of TM data were used except the thermal band channel 6. Generation of recent land cover map for the study area was extracted using a supervised maximum likelihood classification. (Fig1). Similar previous work carried out using two Landsat TM and MSS in April 1994 and July 1988 respectively. Different land cover maps and other ground truth data were selected to assess land cover changes. A comparison between the maximum likelihood classified image and different land cover maps was carried out. The overall classification accuracy is 86.97% as showed in (table1).

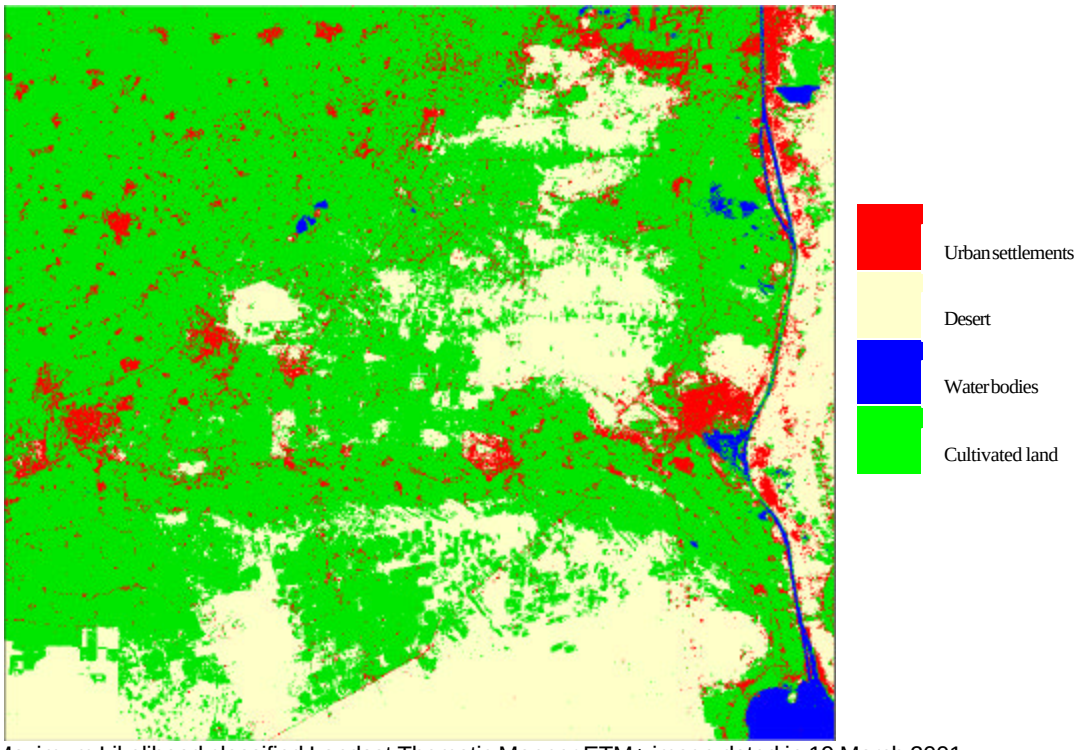


Fig 1 Maximum Likelihood classified Landsat Thematic Mapper ETM+ image dated in 19 March 2001

		Reference map				
Classified image		Desert	Urban	Water	Cultiv.	Total
	Desert	59	5	----	7	71
	Urban	2	52	3	5	62
	Water	----	----	43	5	48
	Cultiv.	4	----	3	73	80
	Total	65	57	49	90	261

Table 1 Accuracy assessment of classified 19 March 2001 Landsat Thematic Mapper ETM+

Regarding to this table, the Standard Percentage Error is 4.34% and the final accuracy is 86.97 $\pm$ 4.34 %. Comparison between the classified image with the similar previous work was carried out. Land cover changes were studied based on the four main land cover classes in this study area; desert , cultivated land, water bodies and built- up areas .

Results and discussion

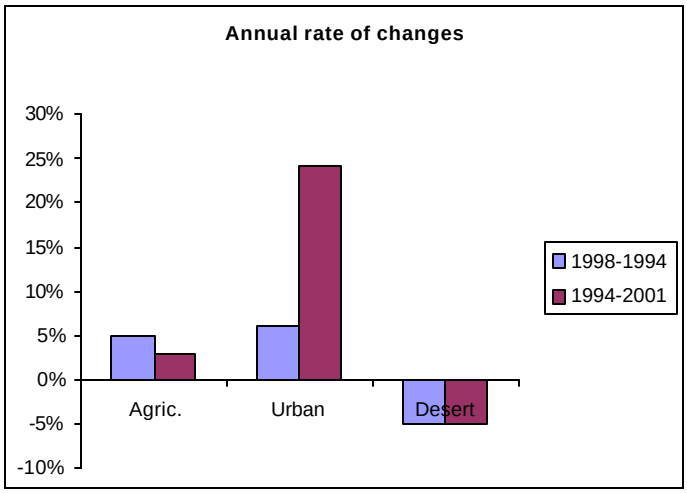
Eastern Nile Delta is one of the most dynamic and highly- changing areas in Egypt for the last two decades. The area has been affected by many natural and human activities. Results obtained from current and previous land cover studies basically summarize the main factors responsible for these changes, which are: a) increase in the total cultivated areas; b) changes in the irrigation system for many parts, from circular irrigation system PAVOT to the traditional irrigation system after reclamation; c) decreasing the total desert area; d) active urbanization processes. The amounts of changes in the main land cover classes over time are shown in (Table2) and discussed in details as following:

	1988	**1994**	**2001**
Cultivated land	1342.95	1821.2	2247.29
Urban	44.3	64.1	296.76
Desert	1918	1452.3	1038.16

Table 2 Changes in the land cover areas by Km^2

The cultivated land in the study area increased by 904.34 km^2 from 1988 to 2001, 478.25 km^2 from 1988 to 1994 and by 426.09 km^2 from 1994 to 2001. The rate of changes is 36% in the first period and 23% in

the second one. The annual change per year is 5% from 1988 to 1994 and 3% from 1994 to 2001 as shown in Figure 2.



Only 19 Km^2 increase in urban settlements was found from the period between 1988 and 1994. Very active urbanization processes were observed from 1994 to 2001, which appeared as 232.66km^2 increase in the whole urban area. The increasing rates were 45% and 363% from the periods between 1988-1994 and between 1994- 2001 respectively. The rate of change per year is 6% from 1988 to 1994 and 24% from 1994 to 2001. The total desert area, which has been changed to urban or cultivated land, is 879.84 km^2. This total amount of changing could be separated into 465.7 km^2 in the first period and 414.14 km^2 in the second period. The annual change per year for the desert land is 5% during the whole period.

Desert and unoccupied lands represent vast areas of the total Egyptian territories. However, the majority of the population and the different human activities are concentrated around the River Nile. This unbalanced distribution caused many serious problems in both social and economical aspects. Therefore, from 1980s, Egyptian government started plans to adjust the human distribution by establishing new urban communities near the borders of the desert areas and far from the main stream of the River Nile. This effort aims to protect the old and highly productive agricultural lands; decrease the human density in the main cities; decrease the pollution sources by building up new specific industrial areas far from dense population centers. Because of the above reasons, there is an urgent need for recent and up to date land cover studies, which would help planners and decision makers to frame the suitable national strategies. Also, to better manage and control the interaction among the different land covers.

The results obtained from this study explained different forms of land cover changes, which have occurred in Eastern Nile Delta of Egypt during the study period (1988-2001). Basically, the most active form of land cover change is the urbanization process. The total and annual rate of the urbanization process increased significantly during the last few years. This increase in urban settlements did not diminish the total cultivated area, which is a clear success indicator for the governmental policies to protect the cultivated lands. The rate of reclamation of deserts for agricultural purposes decreased in the last few years. This should be taken into consideration because the reclamation effort is very necessary to establish complete new communities depending on different kinds of human activities. Also, it is important factor to encourage the domestic immigration to these new communities. The results indicate that the rate of change for the deserts is almost stable during the study period. This requires more effort to activate the reclamation process in the desert areas to be used in a suitable useful activity in order to increase the final gross domestic production.

Conclusion

The land cover changes in the Eastern Nile Delta of Egypt could be summarized as; a) the urban settlements increased considerably with high rate of annual increase every year; b) slight increase in the total cultivated area while the annual rate of agricultural reclamation decreased significantly in the last few years; c) 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.

Reference

Abdulla, A., Yonius, H., Yehia, A. and Abdelrahman, S., 1997. Studying of soil degradation in the East of Nile Delta using remote sensing and GIS technology. Report National Au thority for Remote Sensing and Space Sciences, Cairo, Egypt, pp.1-37.

Lambin, E.F., and Elrlich, D.,1997. Land – cover changes in Sub- Saharan Africa (1982-1991): Application of a change index based on remotely sensed surface temperature and vegetation indices at a continental scale. Remote Sens. Environ., 61(2), pp.181-200.

Lenney, M.P., 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 Sens. Environ., 56, pp.8-20.

Mendoza, J.E., and Etter, R., 2002. Multitemporal analysis (1940-1996) of land cover changes in the southwestern Bogota highplain (Colombia). Landscape and urban planning, 59(3), pp.147- 158.

Ram, B., and Kolarkar. A.S., 1993. Remote sensing application in monitoring land-use changes in arid Rajasthan. Int .J. Remote Sens., 14(17), pp.3191-3220.

Rembold, F., Carnicelli, S., Nori, M., and A Ferrari, G., 2000. Use of aerial photographs, Landsat TM imagery and multidisciplinary field survey for land-cover change analysis in the lakes region (Ethiopia). Int .J. Appli. Earth Observation and Geoinformation, 2(3-4), pp.181- 189.

Sadek, S.H.A., 1993. Use of landsat imagery for monitoring agricultural expansion of East and West Nile Delta, Egypt. Egyptian J. Soil Sci., 33(1), pp.23-24.