Landsat Digital Data Processing of Land Use Land Cover Classification of East Nile Delta, Egypt

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Abstract

Satellite image Landsat-5 Thematic Mapper data acquired in July 1984 and covering most of the eastern part of Nile Delta, Egypt, were interpreted. Land use and land cover features were mapped using a false colour composite image (FCC, bands 7, 4, 3 and 5) at scale of 1:100,000.

Digital image processing includes: contrast enhancement, rationing method, and supervised classification using the parallelepiped classifier technique, were performed. The main land use and land cover categories were determined. The statistical analysis of the classified image reveals that the desert areas represent about 25%, fallow land 19%, agriculture 14%, sabkhas 10%, shallow water 8% and settlement / infrastructure 4%.

1. Introduction

The land surface of Egypt (1,000,000 km^2) consists of about 96% desert, and about 4% of its total area is the traditional agricultural land of the Nile Delta and Nile Valley. Therefore, there is a severe pressure and demand dictated by the growing population on this limited area of agricultural land. ABDEL-HADY (1984) stated that about 3 000 acres of agricultural land being converted to urban use each year.

EL KHATTIB and HAWELA (1991) applied digital image processing for studying the spectral signatures of the main crops under Egyptian conditions. The same technique was used by ABDEL-HADY *et al.* (1983) to measure and to classify the cultivated land in Egypt.

AL CIBAHY (1992) applied different techniques of digital image processing to explore the potential of remote sensing in detecting vegetation and in assessing vegetation attribute such as the vegetation ratio of agroecosystems of Northern Egypt.

Satellite data, with the aid of computer categorization and classification and supplemented by ground truth data proved to be a valuable tool in providing up to date information on regional land use patterns, (YOUNES *et al.*, 1993, ABDEL RAHMAN *et al.*, 1992, and ABDEL RAHMAN and SADEK, 1993).

2. Procedures

Visual interpretation of TM data of East Nile Delta scene (Table 1), was carried out in order to explore the relationship between satellite derived multispectral data and different features on the ground.

The digital image processing includes; the production of false colour composite (FCC) and ratio images (RI). By comparison between different ratios, the most suitable band ratios were selected for land cover classification. Furthermore, Principle Component Analysis (PCA) and supervised classification techniques using parallelepiped classifier were applied to this study.

Table 1. Satellite image characteristics.

Satellite	Sensor	Path	Row	Date	Data format
Landsat-5	Thematic mapper	176	39	02 July 198	Computer Compatible Tape (CCT)

3. General characteristics of the study area

The study area is located in the eastern part of the Nile Delta, between latitudes 30°30' and 30°50' and between longitudes 31°30' and 32°00' (Fig. 1). The area covers about 0.5 million acres. The western part of the studied area is a part of the old cultivated land of Sharkiya and Dakahliya Governates. The soils are nonsaline, slightly calcareous and well drained clay deposits. The Northern part is mostly covered with swamps and marshes of El-Manzala lake, while the southern part is newly reclaimed desert land. Gypsiferous and saline soils are the dominant soil types in the eastern part of the study area.

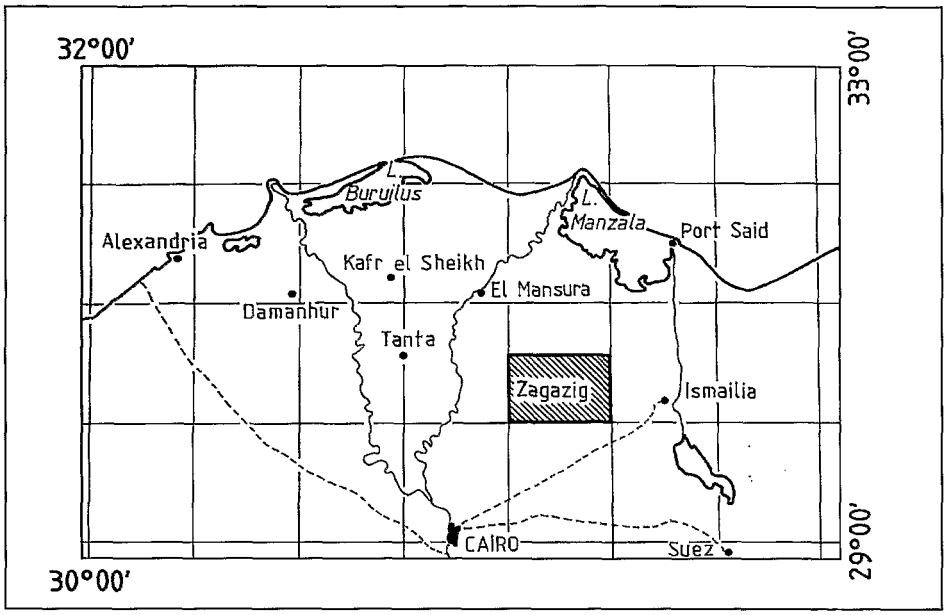

Figure 1. Location of the study area.

4. Results and discussion

4.1. Interpretation of remote sensing data

The interpretation of the produced FCC image (band 7, 4, 3: plate 10a) as well as of the single B/W band was carried out following the land use and land cover classification system, ANDERSON *et al.* (1976). The produced land use and land cover map of the area (Fig. 2), shows that the area consists of the following categories:

- a: Agricultural land,
- b: Urban,
- c: Water bodies,
- d: Wet land,
- e: Barren land.

The mapped land use and land cover units were similar to those mapped by ABDEL RAHMAN *et al.* (1992) in their studies on water table levels of the same region.

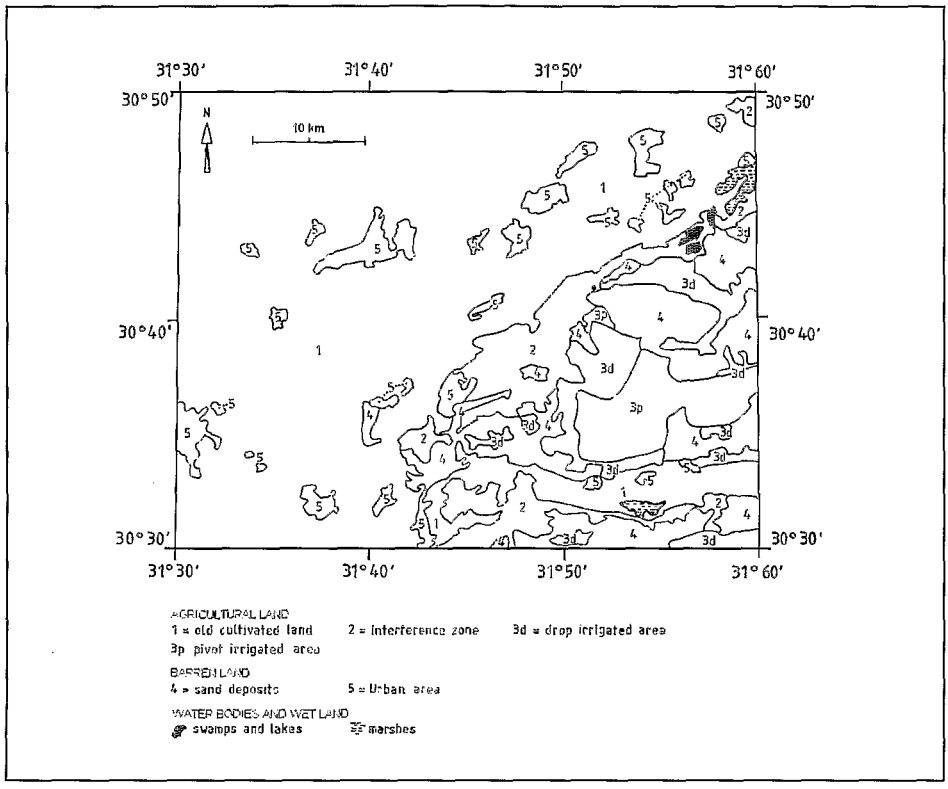

Figure 2. Land use / land cover map of east part of Nile Delta, Egypt.

4.2. Digital Image Processing

Digital Image Processing methods are grouped into three functional categories namely; image restoration, image enhancement, and information extraction, SABINS (1978). The original image data of the area were subjected to the routine processing (radiometric and geometric corrections) applied to all Landsat data passing through the Gadderd image processing facility in the receiving stations. Image processing has been carried out on a part of the study scene (subscene, 61,844 pixels).

Contrast enhancement techniques were used for the seven available bands. The image statistics are shown in table 2. Minimum-Maximum, visual and 4% truncation methods were applied for each band in order to have the best possible enhancement of the image. Plate 10b shows the subscene marked in plate 10a after enhancement.

Ratio images are prepared by dividing the digital number (DN) in one band by the corresponding DN in another band for each pixel, stretching the resulting value, and plotting the new values as an image. This technique was used to find out the proper combinations between the available bands to extract maximum amount of information from

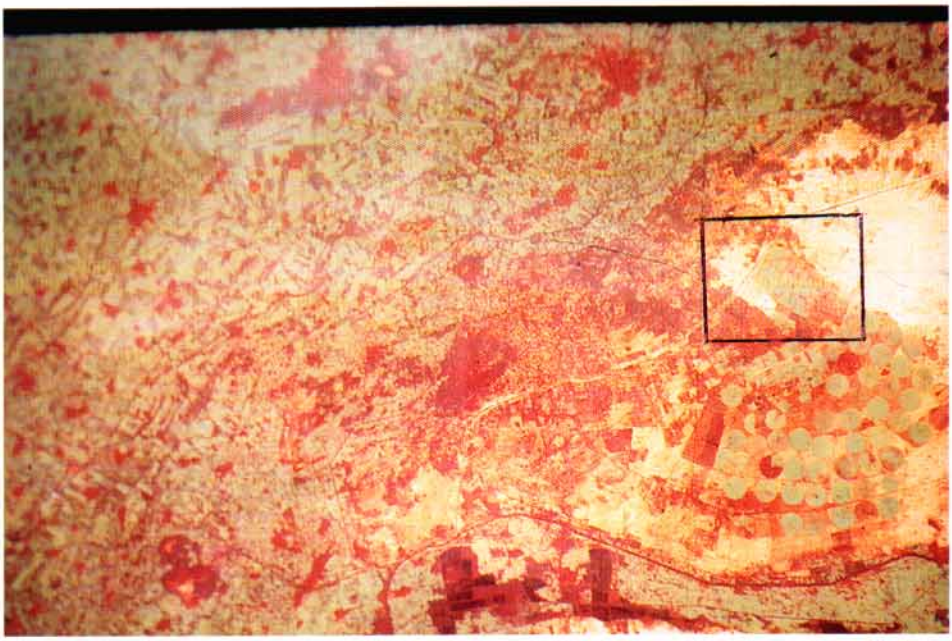

Plate 10a. FCC (bands 7,4,3), the selected subscene is marked in the eastern part of the image (p. 383).

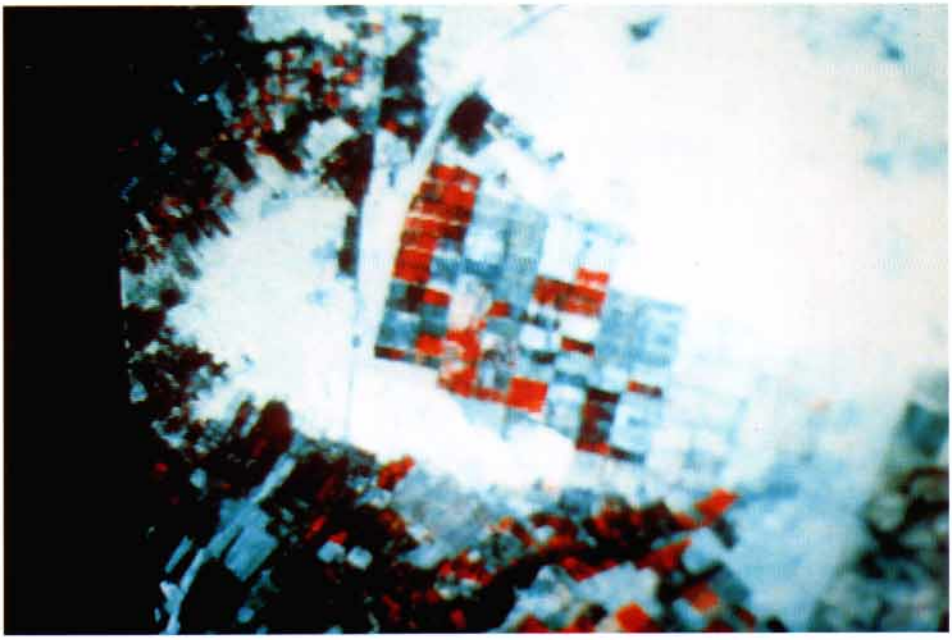

Plate 10b. Enhanced Landsat image (subscene) using contrast enhancement technique (p. 384).

the Landsat data. Some of these ratio images were useful (4/3, 4/2, 4/1, 3/1), while some others were not suitable. Table 3 shows the statistical data of these ratio images, which were generated from the visible and near infrared TM bands. A total of ten ratio images from the original seven bands was displayed and investigated after processing.

Table 2. Image statistical of the available bands.

Band	Min.	Max.	Mean	Variance
1	89.0	187.0	141.2	500.56
2	36.0	115.0	81.4	388.78
3	33.0	167.0	109.0	1170.26
4	27.0	156.0	115.3	343.87
5	11.0	255.0	180.7	2649.95
6	130.0	162.0	151.4	22.76
7	6.0	176.0	106.9	1587.56

The spectral differences between phenomena in the studied scene were more apparent in ratio images (band 4/band 1 and band 4/band 3) than in the individual bands. In these ratio images (4/1, 4/3; table 3), the differentiation was possible between agricultural areas and desert, and between cultivated fields and fallow fields. Infrastructural features and water bodies were very clear.

Table 3. Statistical data of some ratio image.

	4/1	2/3	3/1	4/3	2/4	4/1
Min. Pixel Value	0	0	0	0	0	0
Max. Pixel Value	255	255	255	255	255	255
Mean Pixel Value	123	107.6	106.8	123	139.0	123
Sample variance x60	2678	155.4	637.9	2679	265.7	2678
Standard deviation	51.8	12.5	25.3	51.8	51.5	51.8

Unlike band rationing, which requires a careful choice of band combinations to emphasize specific spectral characteristics, the principle components transform (PCT) requires not a priori information and thus can be applied in a less directed fashion.

The statistical technique of principle components analysis (PCA) aims to replace the original TM bands, which describe the data, with new orthogonal axes that better describe the particular scene under study. The statistics of (PCA) of the four ratios (4/3, 3/1, 2/4 and 4/1) is presented in table 4.

Table 4. Statistical data of some ratio image.

Band	Min.	Max.	Mean	Variance
1	223	78	106.75	208.7
2	135	28	48.63	92.1
3	182	23	55.07	250.2
4	169	11	67.37	332.4

4.3. Image classification

The basis for the classification of the cover type is the correlation of different categories of interest with statistically separable groups of data as defined by their spectral properties in the multidimensional space (SHORT, 1982).

In this study, four channels (band 1, 2, 3 and 4) each of them representing a ratio bands were used in a supervised classification of TM data. A false colour composit (bands 3 green, 4 blue and 2 red) with 4% contrast enhancement was used for this study.

Based on visual interpretation of Landsat TM image of the area and many field observations, seven training sites were selected namely: desert, culture, vegetation, water, fallow land, sabkhas and shallow water. Spectral signatures are then developed from the brightness values of the pixels in each signature. For each signature, between 2 to 3 training sites were used in calculation with the parallelepiped classifier technique (WIGTON, 1976). Table 5 shows the statistical analysis of the classified image.

The number of pixels and the percentage of the area covered by each signature are presented in table 6. The percentage of unclassified pixels was also calculated and presented in the same table.

Table 5. Summary of the statistical spectral reflectance of the main categorical groups.

No	Signature name	Channel 1		Channel 2		Channel 3		Channel 4		Sum	
		X	SD	X	SD	X	SD	X	SD	X	SD
1	Settlement	0.31	0.012	0.189	0.001	0.260	0.006	0.240	0.007	1526	20.70
2	Agriculture	0.03	0.017	0.164	0.012	0.180	0.038	0.330	0.047	345	67.14
3	Water bodies	0.44	0.006	0.233	0.006	0.190	0.004	0.140	0.008	221	9.47
4	Fallow land	0.32	0.010	0.182	0.005	0.250	0.010	0.250	0.008	459	49.00
5	Sabkhas	0.35	0.016	0.187	0.009	0.230	0.012	0.240	0.021	373	49.00
6	Shallow water	0.36	0.017	0.165	0.007	0.180	0.025	0.300	0.081	284	67.90

Table 6. Classification of different signatures in the studied area.

No.	Signature name	No. of pixel	% of total	% of unclassified
1	Desert	16,632	25.28	29.39
2	Settlement	2,846	4.33	5.03
3	Agriculture	9,008	13.69	15.92
4	Fallow land	116	6.02	0.20
5	Sabkhas	12,380	18.82	21.87
6	Shallow water	6,278	9.54	11.09
7	Unclassified	5,489	8.34	9.69
8		9,195	13.98	-

The obtained data reveal that most of the classified area was covered with desert, followed by fallow land, which is located mainly in the newly reclaimed area. The vegetative areas include; old cultivated land planted with field crops and newly reclaimed lands, where sprinkler and drip irrigation systems are applied, covering about 14% of the area. Culture includes; roads, airports, settlement and urban areas, representing about 4% of the whole region. The rest of the study area was covered with sabkhas, shallow water and water bodies and unclassified area.

5. Conclusion

The conventional visual interpretation and digital image processing analysis of Landsat-5 TM data were very useful tools for mapping and classifying the land cover and land use features of the eastern part of the Nile Delta. Distinction between the various cultivation systems in the newly reclaimed areas was possible through the interpretation of the enhanced Landsat image. However, roads, urban areas, settlements and other culture features could be mapped using the ratio technique.

The study reveals that the main land use and land cover features in the studied area were desert (25.28%), settlement/infrastructure (4.33%), agriculture (13.69%), water bodies (6.02%), fallow land (18.82%), sabkhas (9.54%), shallow water (8.34%) and unclassified pixels (13.98%). It could be concluded also that supervised classification, using parallelepiped classifier, was a very powerful technique for mapping land use and land cover features in such arid conditions.

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