Exploration of Misrsat-1 Data in Different Change Detection Applications

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Abstract: - Misrsat-1 is the first Egyptian earth observation satellite which was successfully put in orbit on 17/04/2007. It is a micro-satellite technology built in cooperation with the Ukraine. It is expected to play a vital role as a source of information for the remote sensing and GIS communities. During the last decades, detecting and measuring changes has been given a significant boost with the advent of remotely sensed data. Various satellite data of different dates were normally used to form multitemporal classification for change detection. The aim of the present study is to explore and demonstrate Misrsat-1 capability in detecting the changes with the archived SPOT-2 data for different application purposes including; urban areas, agricultural areas, land use, and water bodies. Four satellite scenes were processed, two Misrsat-1 scenes acquired on 23-7-2007 and 24-7-2007 and two SPOT-2 scenes acquired on 30-12-1995 and 9-8-1997 respectively. Since adequate processing and proper classification of multitemporal images are essential, therefore these data have been geometrically corrected and radiometrically balanced. The direct multidate classification approach was carried out to generate the change maps. The location and extent of the changed areas could be easily detected and their statistics could be accurately calculated as well.

Key-Words: - Misrsat-1, change detection, geometric correction, radiometric balancing, multitemporal data

1 Introduction

With the launch of the early remote sensing Satellites, the technological capability for detecting the changes of the earth's surface and monitoring the local, regional and global environmental resources from space was initiated. The technological developments have gone very rapidly and resulted in new sensors with higher spatial and spectral resolutions and images being available over shorter time intervals than ever before [1]. The use of series of remotely sensed images is widely practiced to analyze spatial and temporal patterns of environmental elements and impact of human activities. Therefore, temporal differences of the same objects at different times can be discovered. It requires adequate processing of multi-temporal data, proper geo-referencing, classification and analysis for change detection.

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times [2]. Locating, characterizing and quantifying areas of significant change is one of the important applications of remote sensing as well as land use/ land cover change analysis, monitoring of shifting cultivation, urban area expansion, assessment of deforestation, water bodies delineation, damage assessment, disaster monitoring and development of accurate change detection maps. This may be undertaken at a substantially reduced cost and time when compared with traditional field-based land cover survey techniques. There are different techniques and computer algorithms that can be applied for muli-temporal change detection. The most popular techniques are based on algebraic operations, transformations, classification, neural networks, etc. Many papers, classified from different viewpoints, [2, 3, 4, 5, 6, 7, 8, 9, 10, 11] have summarized the current methods of change detection of remote sensing.

In the present study, we attempt to assess the utilization of Misrsat-1 data and explore its capability in detecting the changes with the archived (SPOT-2) images currently available at NARSS. Various dates spanning the last 12 years are used to produce maps of change of several application purposes including: urban areas, agricultural areas, land use, and water bodies in different parts of Egypt.

2 Data Acquisition

Remote sensing imagery offer unique possibilities for spatial and temporal characterization of the changes. The basic requirement is the availability of different dates of imagery which permits continuous monitoring of change and environmental developments over time. Change detection can be performed by restricting the analysis to a single sensor series or by using different satellite data sets. In this study, we used different satellite (Misrsat-1 and SPOT-2) data sets. Misrsat-1 satellite captures both multi-spectral and panchromatic images. The characteristics of its data are as follows:

- The spatial resolutions of the Multi-spectral and the panchromatic bands are 7.8 meter.

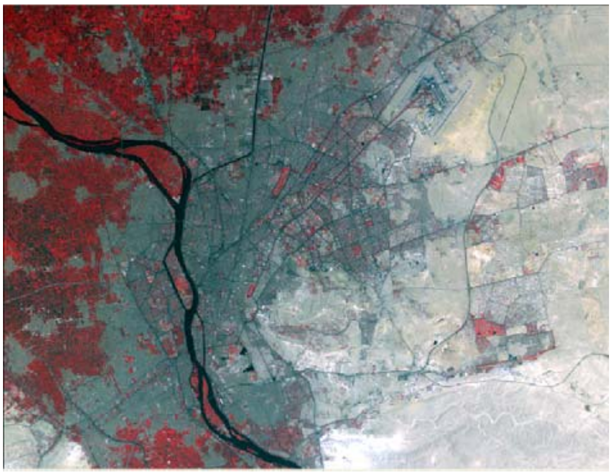
- The spatial resolution of the Mid-Infrared band is 39.5 meter.

- The spectral resolutions are as shown in table (1):

Table (1) The Spectral Resolutions (Wavelength-μm) of the Misrsat-1 and the SPOT-2 Data

Bands	Description	Misrsat-1	SPOT-2
band 1	Green	0.51-0.59	0.51-0.59
band 2	Red	0.61-0.68	0.61-0.68
band 3	Near Infrared	0.80-0.89	0.78-0.89
band 4	Panchromatic	0.50-0.89	0.51-0.73
band 5	Mid Infrared	1.10-1.70	-----------

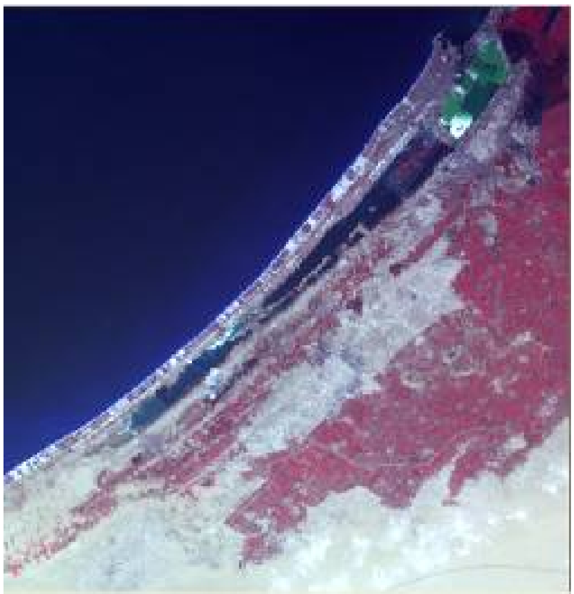
Two different areas covered by Misrsat-1 and SPOT-2 satellites are used in this study; Cairo and Alexandria cities. Subscenes covering (4758 column, 3650 row) and (4742 column, 3633 row) are shown in Fig. (1, 2) respectively. Parts of these areas were used in our processing to depict the changes for the different applications.



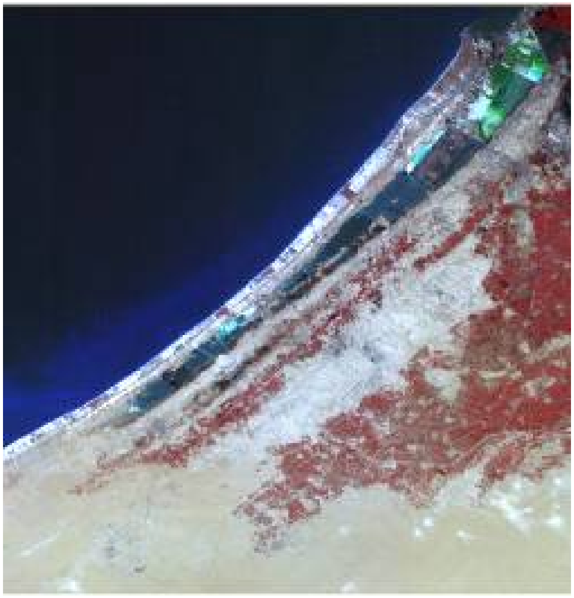
a) Misrsat-1 Data (23-7-2007)

b) SPOT-2 Data (30-12-1995)

Fig. 1: The first study area, Cairo



a) Misrsat-1 Data (24-7-2007)



b) SPOT-2 Data (9-8-1997)
Fig. 2: The second study area, Alexandria

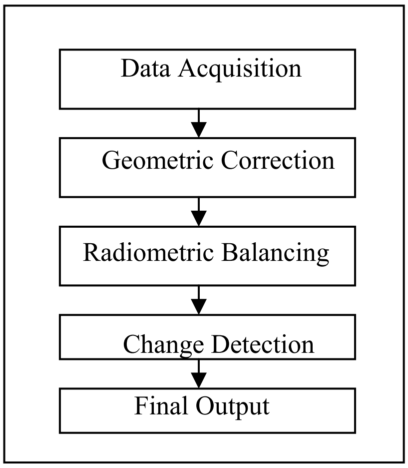


Fig. 3: General flow chart for change detection procedures.

3 Processing Methodology

The basic premise in using remotely sensed data for change detection is that changes in the object of interest will result in changes in radiance values or local texture that are separable from changes caused by other factors, such as differences in atmospheric conditions, illumination and viewing angle, soil moisture, etc. [4]. Accuracy of change detection is strongly dependent on the preprocessing procedure so that, before conducting any digital change detection several special concerns should be addressed.

3.1 Change Detection Procedures

The first step of the change detection procedures, Fig. 3, involves data acquisition and a number of initial preprocessing steps prior to data analysis. For instance, when acquiring imagery it is always necessary to preview the digital data to evaluate cloud cover conditions and data quality. In addition, the study area must be subset to conform to the outer boundaries of the area of interest [12].

Geometric distortions are normally introduced to satellite data during acquisition. These deficiencies may result from several sources including platform attitude (roll, pitch, and yaw), Earth's rotation, scan skew and panoramic distortions. Therefore, accurate geometric correction is particularly important for change detection analysis. The simultaneous analysis of multispectral data necessitates accurate spatial orientation of the input data sets. Because analysis is performed on a pixel-by-pixel basis, any mis-registration greater than one pixel will provide a false result (spurious changes) for that pixel. To overcome this problem, the co-registration error between any two dates should not exceed 1 pixel. This is typically accomplished on the basis of uniformly well-distributed ground control points located on both the images and the maps. The digital Misrsat-1 (image) coordinates of each point were compared to their corresponding geographic (map) coordinates (scale 1:50000) to determine a polynomial equation for adjustment between them. The affine transformation model was applied. The image was thus rectified according to the Universal Transverse Mercator (UTM) projection, and resampled at 8 meter resolution using the nearest neighbor technique. Then, it was used as a reference image to rectify the SPOT-2 image which has been also resampled at 8 meter resolution. Visual inspection was used to assess the accuracy of co-registration of the used images.

Radiometric balancing between Misrsat-1 and Spot-2 data is performed to produce a homogenous radiometric set of data. So that, false changes are not introduced by factors such as: modification of the spectral distribution due to atmospheric conditions, different path radiance and seen angle variation. Ideally, all images would be calibrated to standard reflectance units. However, when comparing images to detect change, it is sufficient to convert raw digital counts to be consistent with a chosen reference image [13]. Histograms were generated in order to identify the suitable contrast stretching level to optimize the balance for both images. It was applied to the SPOT-2 data in order to match the radiometric condition of the Misrsat-1 data prior to make their composite. The lower resolution imagery

(SPOT-2) was combined with the higher resolution Misrsat-1 imagery after being resampled.

In the change detection process, when images of different types are comprised, with different spatial and spectral resolution, the number of difficulties increases. Different spatial resolution and differences in spectral resolution necessitate a different classification process for each, possibly with the result that comparison of their categories can not be expected to yield high accuracies [1]. Therefore, the direct multi-date classification is used, since it bypasses the difficulties associated with the analysis of images acquired by different sensors. The main limitations are the higher dimensionality compared to the other approaches and the requirements of many classes.

3.2 Direct Multi-date Classification

This method, sometimes called spectral-temporal classification or composite analysis, is considered among the earliest semi-automated computer assisted approaches used to generate change maps, where explicit categorical changes are detected directly. It is based upon a single analysis (one classifier) of a combined or superimposed data set of multiple dates simultaneously. It may use standard pattern recognition or spectral classification techniques to identify land cover change areas. The superimposed output image may be classified by supervised or unsupervised method to generate a product containing a set of classes (locations) where no change occurred between dates and a set of change classes, which when properly labeled, yield a change image. In either case, these change classes are expected to present significantly different statistics from no-change classes [14] and thus can be identified.

4 Results and Discussion

The results of conducting optimal co-registration and radiometric balancing were essential for implementing the multi-date change detection procedures. The analysis was performed by first merging the two three-band data sets (i.e. one each, green, red and near infrared) into a composite of six-band data set followed by the application of unsupervised classification algorithm. It could successfully detect and identify the areas that have experienced change within the 12 years period. To investigate the spatial characteristics of the changes and to have an overall impression of their patterns, the production of color theme print was undertaken, as shown in Fig. 4.

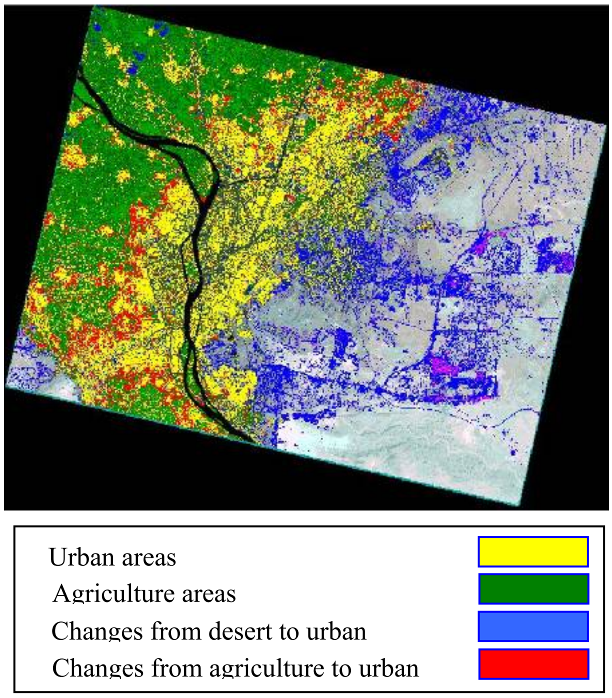


Fig. 4: Change detection image of the Cairo area

4.1 Changes of Urban Areas

Throughout the last 12 years, urban expansion was sufficiently widespread to be readily recorded by Misrsat-1 satellite. All pixels, which belong to encroachment of urban areas over desert, were coded blue. While pixels belonging to encroachment of urban areas over agricultural practices and vegetation, were coded red. Whereas, the yellow and green indicate no change areas for urban and agriculture, respectively. In this way, the location and extent of the changed urban areas could be easily identified. It was also possible to generate its statistical measurements, as shown in table (2).

Table (2) Statistical Measurements of the Changed Urban Areas

Type of Change (encroachments)	No. of changed pixels	Changed area in km^2
Urban over Desert	1725188	110.41
Urban over Agriculture	869000	55.62
Total	2594188	166.03

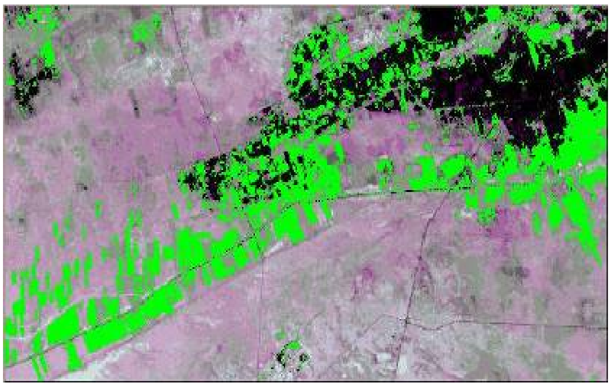
From table (2), one can observe that the total area of urban change encompasses (2594188) pixels equivalent to 166.03 km^2. Out of this total area, 110.41 km^2 represent urban encroachments over desert areas and 55.62 km^2 represent urban encroachments over agricultural areas. The evaluation of the result has been accomplished based on visual interpretation. Consequently, care has been taken when interpreting the detected changes.

4.2 Changes of Agricultural Areas

Throughout the 10 years period between the two coverages over the Alixandria area, the agriculture and vegetation were increased. Subsets of the same area from both scenes were used to depict these changes as shown in Fig. 5. In the output change detection image, all pixels which represent changes from bare land to agriculture were coded green, see Fig. 6. Whereas, the rest of the colors represent no change areas. Table (3) shows noticeable increase in agricultural areas. The total area of change encompasses (358478) pixels equivalent to 22.94 km^2.

a) Subset of Misrsat-1 Data (24-7-2007)

b) Subset of SPOT-2 Data (9-8-1997)
Fig. 5: Subsets of the second study area, Alexandria



Changes from bare land to agriculture

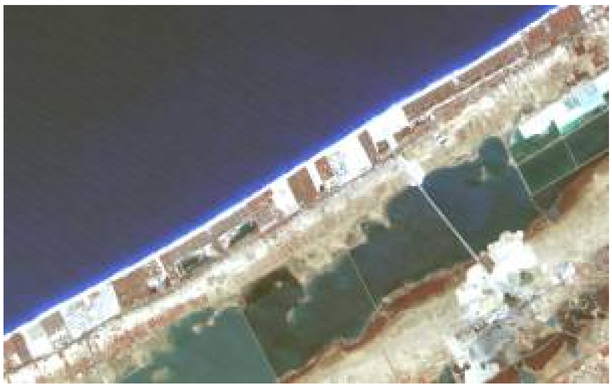
Fig. 6: Change detection image of the agriculture areas

Table (3) Statistical Measurements of the Agriculture Changed Areas

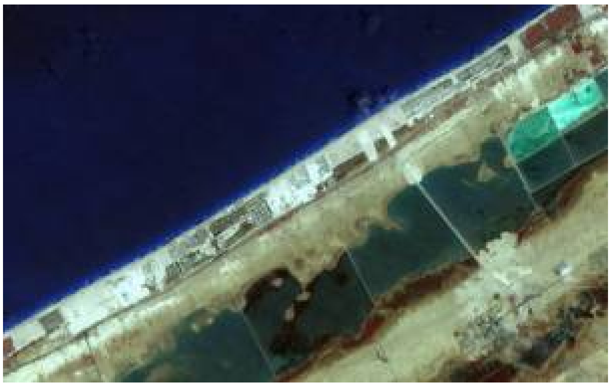
Type of Change	No. of changed pixels	Changed area in km^2
Bare land to Agriculture	358478	22.94

4.3 Changes of Land use Areas

Land use change is a complicated process; several factors have influences on this process, including both physical and human aspects. Land use in Alexandria was substantially changed within the last 10 years. These developments may be attributed to the complex interaction between natural environment and human activities such as, the rapid expansion of tourist villages and related activities, among others. Two other subsets of the same coastal area from both scenes were used to illustrate these changes as shown in Fig. 7.



a) Subset of Misrsat-1 Data (24-7-2007)



b) Subset of SPOT-2 Data (9-8-1997)
Fig. 7: Subsets of the coastal area, Alexandria

In the output change detection image, Fig. 8, the red color represents the newly created resorts and tourist villages, while the blue is indicative of the developments of the resorts areas. The green color shows the changes form bare land to agriculture practices and vegetation areas, whereas, the yellow depicts the filling over water bodies and wet lands. Statistics have been also generated giving their areas in square kilometers as shown in table (4).

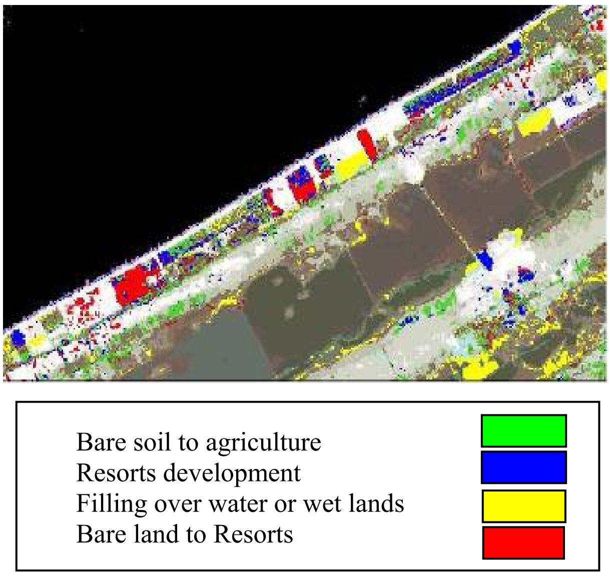


Fig. 8: Change detection image of the land use areas

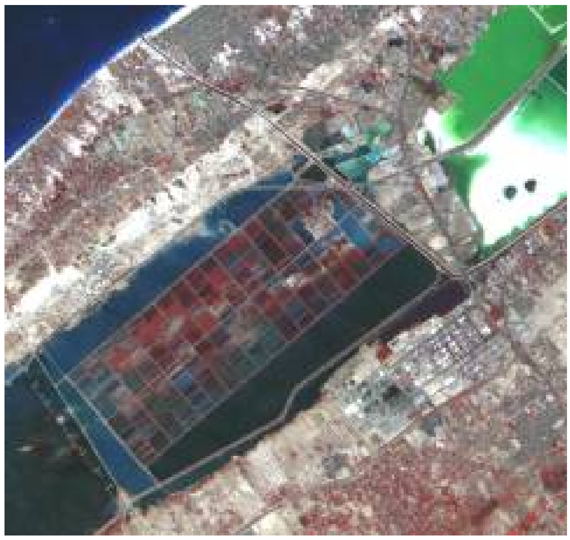
Table (4) Statistical Measurements of the Land Use Changed Areas

Type of Change	No. of changed pixels	Changed area in km^2
Filling over water or wet lands	40636	2.60
Bare soil to agriculture practices	48844	3.13
Bare land to Resorts	23719	1.52
Resorts Development	30924	1.98
Total	144123	9.23

From table (4), one can observe that the total area of land use changes encompasses (144123) pixels equivalent to 9.23 km^2. Out of this total area, 3.5 km^2 represent newly created resorts and resorts developments. Thus, classification is required for management and planning of these various resources.

4.4 Changes of Water Bodies

Some of the water bodies in Alexandria were changed within the last 10 years. Subsets of the same water body areas were used to depict these changes as shown in Fig. 9.



a) Subset of Misrsat-1 Data (24-7-2007)

b) Subset of SPOT-2 Data (9-8-1997)
Fig. 9: Subsets of some water bodies, Alexandria

In Fig. 10, the red color represents changes from salty water to clear one, whereas, the yellow color indicates filling over water by land. Orange and Cyan represent changes in water from one type to another inversely. Finally blue illustrates water inundation. It was also possible to generate their statistical measurements, as shown in table (5).

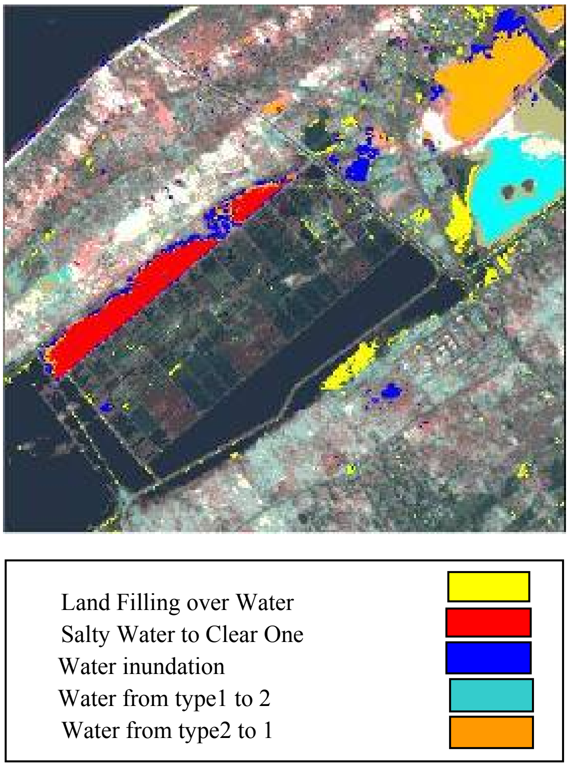


Fig. 10: Change detection image of the water bodies areas

Table (5) Statistical Measurements of the water Bodies Changed Areas

Type of Change	No. of changed pixels	Changed area in km^2
Land Filling over Water	27452	1.76
Water Inundation	25594	1.64
Salty Water to Clear One	31772	2.03
Water from type-2 to 1	39863	2.55
Water from type-1 to 2	29324	1.88
Total	154005	9.86

From table (5), one can observe that the total area of water bodies changes encompasses (154005) pixels equivalent to 9.86 km2. Accordingly, the study on changes improves our understanding of the interrelationships among natural environment and human activities [9] and thus provides an important scientific basis for the sustainable development of our country.

5 Conclusions

The aim of this study is to use the bi-temporal, new multispectral sensor Misrsat-1 with the archived SPOT-2 images currently available at NARSS in change detection of different applications. Close inspection of the results reveals that, the Misrsat-1 spectral and spatial resolution superimposed with SPOT-2 data was a good combination that enables precise change detection of major urban areas, agricultural areas, land use, and water bodies. The changes that happened to different objects between the various dates were obtained and accurately delineated (mapped).

The performance of the direct multi-date classification technique showed effectiveness in differentiating areas that changed from those that did not, as well as detecting different types of changes. Therefore, clear potential exists by using Misrsat-1 data for detection mapping, quantification of changes and monitoring different environments using multi-sensor/temporal remotely sensed data.

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