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INVESTIGATION OF LANDUSE/LANDCOVER CHANGES IN EASTERN SAUDI ARABIA

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I. ABSTRACT

Temporal Landsat Data has been employed to investigate Landuse/Landcover changes in an area of 80x60 km^2 in the Eastern Province of Saudi Arabia. The images were registered to a UTM 50 M Grid with an accuracy of less than two pixels. The Registered images were used to create difference images, for three different dates. The difference images were thresholded and color coded to highlight the areas of change. The threshold criteria was determined from the difference histograms and familiarity with the area. In-situ investigations were used to confirm and occasionally modify the results of initial image analysis. The overall results show that almost 30% of the land area under investigation has changed in the 1972-1981 period, with most of the change occuring after 1978.

II. INTRODUCTION

The past several years have seen the Kingdom of Saudi Arabia undergo a phase of relatively rapid development, primarily concentrating on providing a basic infrastructure for subsequent growth. The main emphasis has been on the selection of sites for industrial areas and utilities, expansion of cities, construction of roads, highways and airports, and establishment of basic industries. As a result of these activities there have been considerable changes in the Landuse/ Landcover patterns around population centers.

Temporal Landsat imagery has been employed to detect the changes in Landuse/Landcover patterns in an area of about 80x60 km^2 in the Eastern Province of the Kingdom. Three Landsat CCT's of the area (Path 176 Row 42) were processed in the Image Processing Laboratory of the UPM Research Institute. The Imagery dates were September 04, 1972, October 06, 1978, and April 20, 1981.

The main objective of this study was to isolate the areas that are likely to have changed and to identify the nature of Landuse/Landcover changes.

The study area is shown in Figure 1. It is located in the oil producing Eastern Province of the Kingdom of Saudi Arabia and includes the urban areas of Dammam, Al-Khobar, Dhahran and Qatif. The Qatif oasis has historically formed an island of dense green palm groves in a land area primarily composed of sand sheets, sand dunes, sabkha and occasional rock outcrops.

III. PROCESSING OF IMAGES

The images of the study area were in the form of raw CCT's. The initial examination of the images revealed that 1972 was of good quality whereas the 1978 and 1981 images had almost all the land areas saturated in bands 4 and 5 due to the high setting of the satellite's MSS. This effectively reduced the latter images to one band since bands 6 and 7 were highly correlated.

Following a debanding process, the images were registered to a 1:100,000 map of cultural and land features using a first order polynominal transformation, and cubic convolution resampling. The registered images were resamples over a 50 m UTM grid. The registration accuracy was of the order of 1-2 pixels. It has not been possible to achieve better registration because of the lack of stable ground features on the images to be used as ground control points.

Figure 2 shows the geometrically uncorrected 1972 Band 7 image of the study area. Figures 3 and 4 show the geometrically corrected Band 7 images of the area for 1972 and 1981 respectively. The brightness range has been stretched to cover the entire brightness scale of 0 to 255, in all the photo productions.

Since band 7 was the only good band for all the three years, this was used to create difference images among the three years. The difference images were mapped to a brightness range from 0-255.

IV. DISUCSSION AND RESULTS

There is a variety of change detection approaches which can be implemented digitally[1,2,3]. These include analysis of change vectors, analysis of data differences, comparison of classification from two dates and direct classification of multi-date data.

In this case, there was only one good band of data for each of the three years, therefore analysis of data differences approach was chosen to detect and identify the changes in landuse/ landcover.

The histograms of the difference images are given in figures 5 and 6. The central peaks correspond to areas with little or no change, whereas pixels closer to the tails indicate areas where major changes have occured.

The initial thresholds for the difference images were selected using the histograms, available maps and personal familarity with the area. The changed and unchanged areas were highlighted interactively by different colors and photographically reproduced. In-situ investigations were used to change the thresholds and modify the results of initial image analysis, in the identification of the areas of change. The thresholded images were produced in color, but due to publication limitations the black and white versions of the color images are given here.

Figure 7 is the 1978-1972 difference image which has been thresholded. Black represents areas with little or no change, whereas grey and white represent areas of change. The grey color represents those areas where reflectance in band 7 has decreased in 1978 as compared to 1972. This group of pixels represents two types of areas: one showing changes from sand or rock to either urban expansion or to agriculturally reclaimed land; and the other showing the intertidal zone.

The white color represents the areas where band 7 reflectance in 1978 has increased as compared to 1972. The Landuse/Landcover classes belonging to this category are clearing of green areas for construction, land fill sites and quarrying of rim rock for construction.

Figure 8 shows the 1981-1972 thresholded difference image the grey tone scheme is the same as for figure 7. A comparison of Figures 7 and 8 show that the activities which started change in the Landuse/Landcover pattern in the period 1972-1978 have accelerated in the 1978-1981 period.

An examination of figures 7 and 8 show the details of changes. The urban centers of Dammam, Dhahran and Al-Khobar have expanded which is indicated by the increase of grey around them. The other patches of grey in the triangle between these cities is due to the construction of industrial sites, roads and new housing projects on previously desert land.

The grey area in Southwest of Qatif is the result of irrigation and other agricultural land reclamation activities which can also be seen in other parts of the image in small patches.

The other major activity which has been contributing to the change is the surface stripping and refilling. The white patch around Dhahran represents surface stripping of the Dammam Dome. This area is full of lime stone quarries with lime stone dust spreading around, once the fragile top soil and surface vegetation are removed.

The three big white patches in the North of Dammam represent land reclaimed by filling of Arabian Gulf. It has been calculated that areas affected by surface stripping and land filling amount to 145 km^2 in the 1972-1978 period and 392 km^2 in the 1972-1981 period on the other hand urban and agricultural land expansion total 197 km^2 in the 1972-1978 period, and 277 km^2 in the 1972-1981 period.

V. CONCLUSION

Landsat data provides a very useful tool for the detection and identification of landuse/ landcover changes on regional basis. The overall results show a very high rate of change. Almost 30% of the land area under investigation has undergone change in the 1972-1981 period with more than half of that occuring after 1978.

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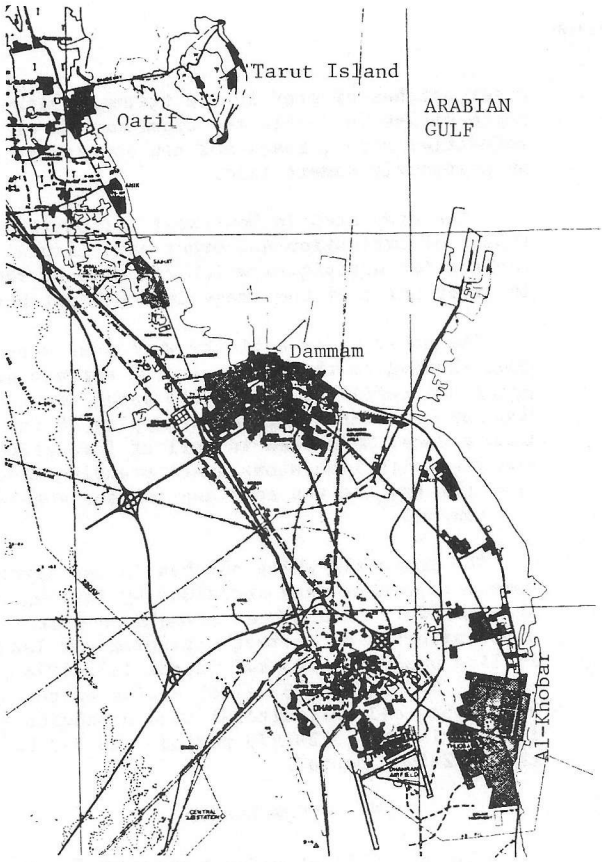

Figure 1: Map of the Study Area

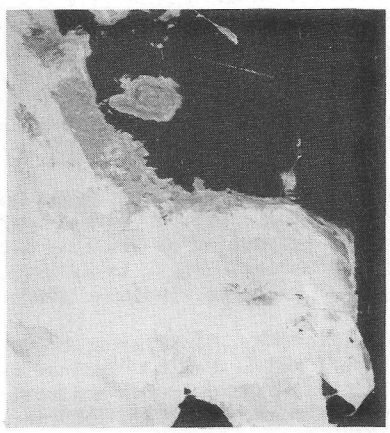

Figure 2: Uncorrected 1972 Landsat Image of the study area.

Figure 3: Geometrically corrected 1972 image

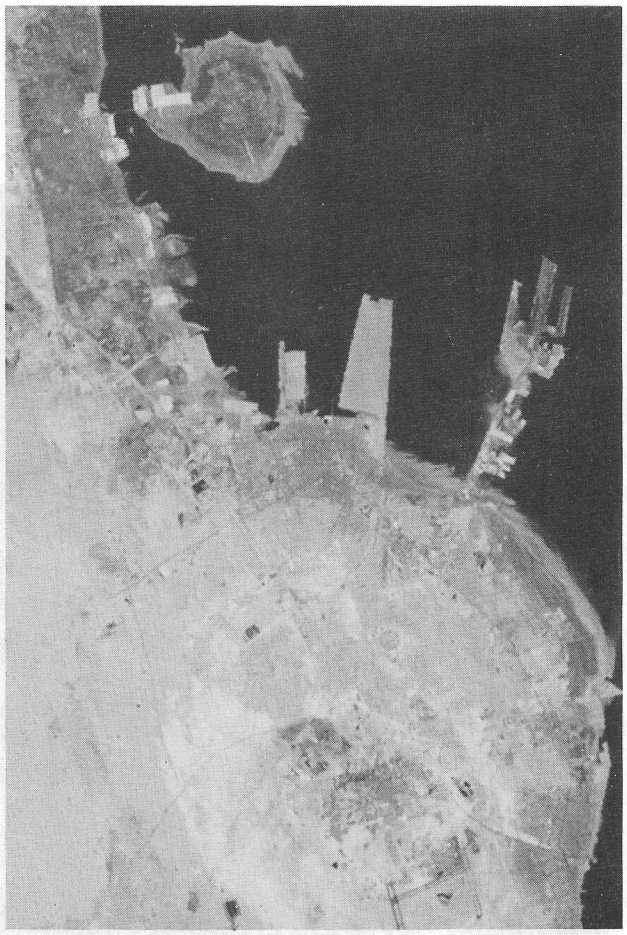

Figure 4: Geometrically corrected 1981 image

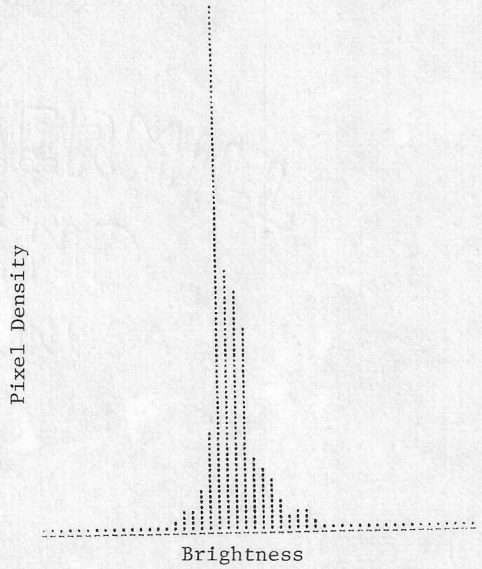

Figure 5: 1978-1972 Difference Image Histogram

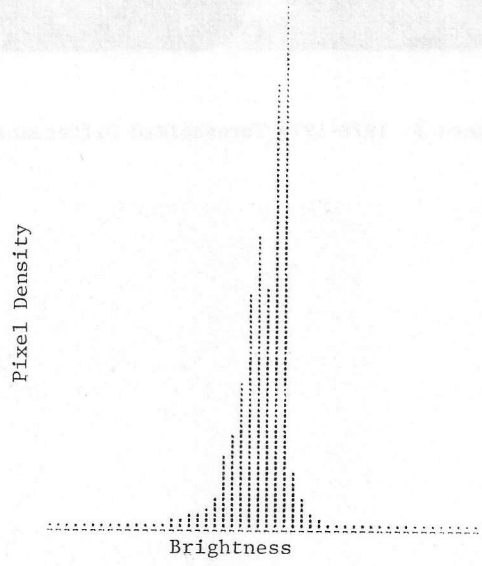

Figure 6: 1981-1972 Difference Image Histogram

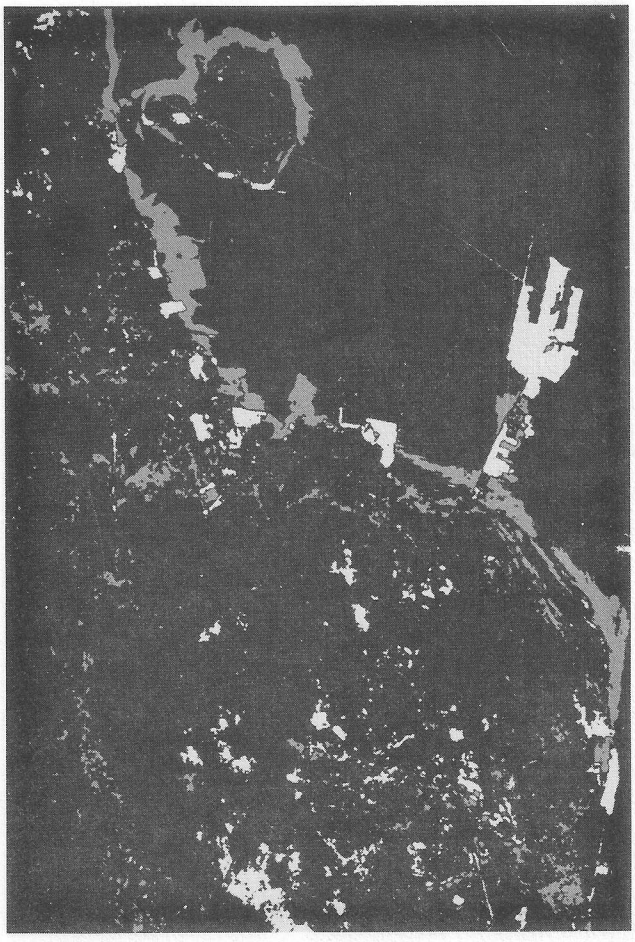

Figure 7: 1978-1972 Thresholded Difference Image

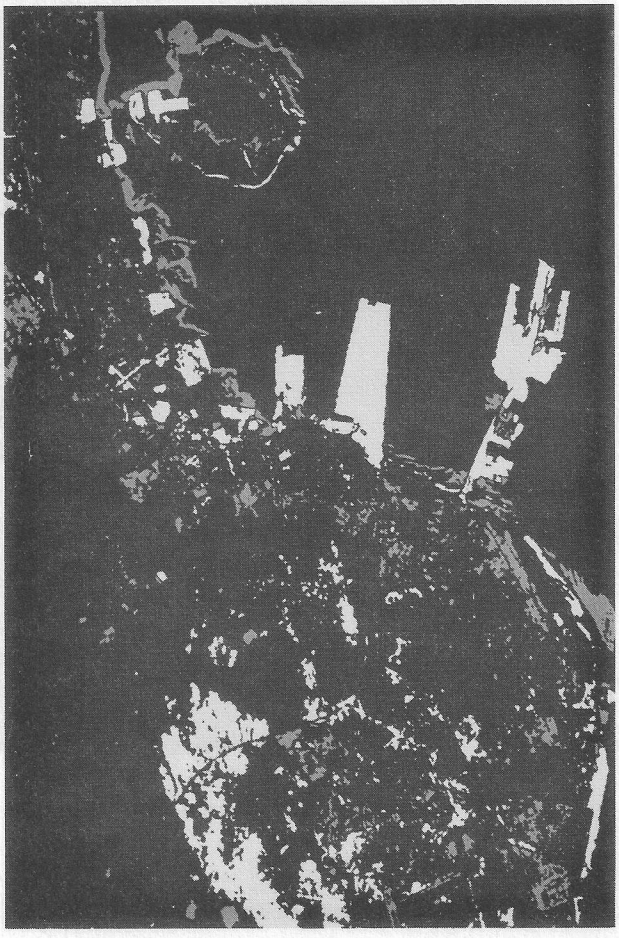

Figure 8: 1981-1972 Thresholded Difference Image