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REMOTE SENSING AND GIS TECHNIQUES FOR URBAN GROWTH MONITORING OF BASARAH CITY

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Abstract. Basarah city has experienced a rapid urban expansion over the last decades due to accelerated economic growth. This paper reports an investigation into the application of the integration of remote sensing and geographic information systems (GIS) for detecting urban built up growth for the period 1973 - 2002, and evaluate its impact on the environmental situation of Basarah city by analyzing the spatial distribution of urban expansion according to land cover types and normalized difference vegetation index (NDVI). The integration of remote sensing and GIS was found to be effective in monitoring and analyzing urban growth patterns and in evaluating urbanization impact on surface conditions of Baghdad area.

Keywords: *Barasah, landsat, remote sensing, temperature, urban*

1. Introduction

In Basarah, land use and land cover patterns have undergone a fundamental change due to accelerated expansion since 1958. Urban growth has been speeded up, and extreme stress to the environment has occurred. This is particularly true in the city where massive agricultural land is disappearing each year, converting to urban or related uses. Evaluating the magnitude and pattern of all Iraq's urban growth is an urgent need. Furthermore, because of the lack of appropriate land use planning and the measures for sustainable development, random urban growth has been creating severe environmental consequences. Thus, there also is a need to assess the environmental impact of the rapid urban expansion.

The integration of remote sensing and GIS has been widely applied and been recognized as a powerful and effective tool in detecting urban land use and land cover change (Ehlers *et al.* 1990, Treitz *et al.* 1992, Harris and Ventura 1995). Satellite remote sensing collects multispectral, multiresolution and multitemporal data, and turns them into information valuable for understanding and monitoring urban land processes and for building urban land cover datasets. GIS technology provides a flexible environment for entering, analyzing and displaying digital data from various sources necessary for urban feature identification, change detection and database development. However, few of the urban growth studies have linked to post-change detection environmental impact analysis. The question of how to develop an operational procedure using the existing techniques of remote sensing and GIS for examining environmental impacts of rapid urban growth remains to be answered.

The main goal of this research is to demonstrate the integrated use of IKONOS satellite data and GIS in evaluate urban growth patterns in the Basarah city.

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2. Data and Methods

The study area is located on AL - Basarah Governorate southern part of Iraq. AL - Basrah is the largest city in southern Iraq, situated on the west bank of Shatt Al-Arab, 55 km from the Arabian Gulf and 545 km from Baghdad (Figure 1). It is the main port of Iraq and its gate to the outside world. Basrah is important in terms of Iraq's and Islam's history, and is surrounded by the largest plantation of datepalms in the world. The canals which crisscross Basrah have led to its being known as the Venice of the East". About 70 km north of Basrah is Qurna at the junction of the Tigris and Euphrates: according to legend, it is the site of the Garden of Eden.

Urban expansion detection of Basarah city for the period 1973 - 2002 was conducted using high resolution Landsat satellite images. Images processing for urban detection as described in Figure 2. Registration of Landsat images using twenty ground control points (GCPs) (mostly road intersections close to Basrah center) were selected, then linear transformation were applied. The root mean square error (RMS_{error}) were equal to 0.5 pixel. Resampling operation for registered images were conducted by nearest neighbor method. ERDAS 8.4 well known image processing software is used for the operation of registration process.

Histogram adjustment have used for minimizing atmospheric effect. This simple method is based primarily on the fact that infrared data are largely free of atmospheric scattering effects, whereas the visible regions are strongly influenced by them. Normally the data collected in visible wavelengths have higher minimum value due to the increased atmosphere scattering taking place in these wavelengths. So if the histogram is shifted to the left so that the effect of atmospheric scattering will be somewhat minimized. This simple algorithm models the first order effect of atmospheric scattering or haze.

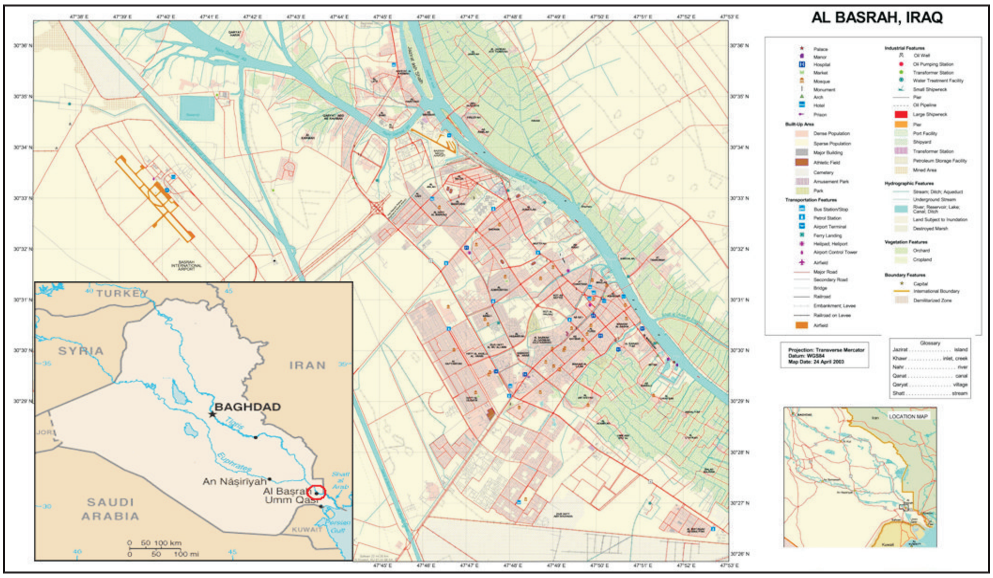

Figure 1. Study Area Map.

Land cover patterns were mapped by un-supervised classification method. ISODATA un-supervised classification algorithm used to classify the Landsat images using bands 2 (green), 3 (red) and 4 (near-infrared).

GIS raster overlay process is applied as urban expansion detection method for Basarah city at the period 1973 - 2002 by using ArcVIiew 3.3. visual screen digitization technique was used for calculation of Basarah areas in 1973, 1990 and 2002 .The urban built up areas were identified as polygons as it shown in Figure 3.

For the surface temperature estimation, the radiation emitted from the target on the surface is measured by using thermal infrared region (10.4-12.5 μm) of Landsat images. Land surface temperature of wide areas can be extracted under assumption that satellite sensor should have proximity to the black body. In this study we estimated the surface temperature using NASA model.

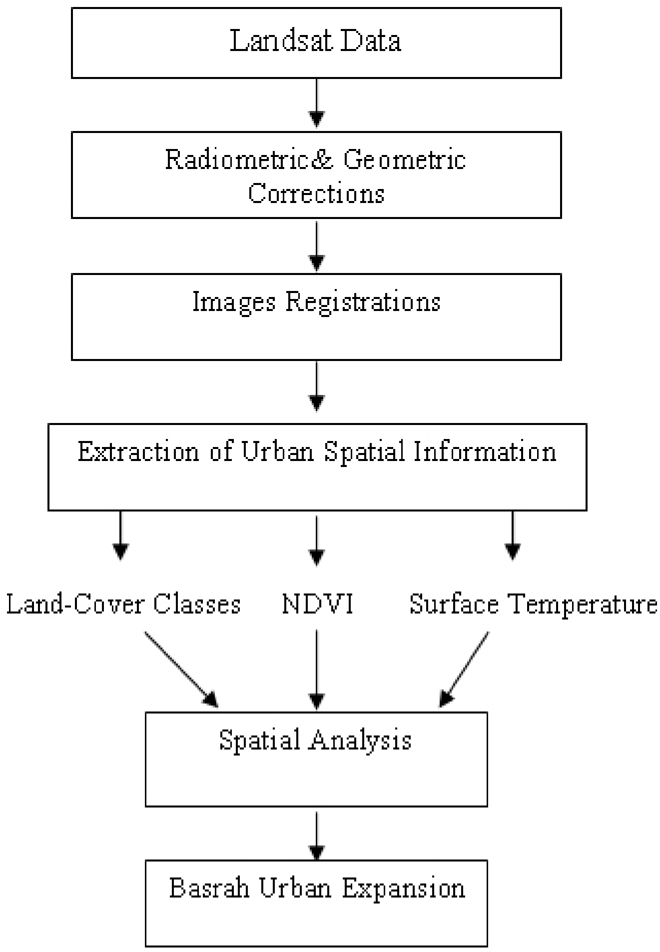

Figure 2. Image processing and analysis for urban expansion of Basarah City

The digital numbers were transformed into absolute radiance (Schott & Volchock, 1985); Using:

$L(\Omega)$= GAIN * DN +OFFSET. (1)

Which can also be expressed as:

$L\Omega$= (Lmax - Lmin)/255 * DN + Lmin (2)

where: $L\Omega$ is the spectral radiance, Lmin and Lmax [$mW.cm^{-2}sr^{-1}\mu m^{-1}$] are spectral radiances for each band at digital numbers 0 and 255 respectively. For TM5 the values of Lmin and Lmax are 0.124 and 1.560 [$mW.cm^{-2}sr^{-1}\mu m^{-1}$] respectively. For ETM+ 7 the following reference values are given:

Low Gain: Lmin - 0.0 Lmax - 17.04 watts/(meter squared * ster * µm)

High Gain: Lmin - 3.2 Lmax - 12.65 watts/(meter squared * ster * µm)

The spectral radiances ($L\Omega$) were converted into effective at-satellite temperatures T by:

T= K2 / ln(K1 / Ll +1) (3)

where: K1, K2 are calibration constants. For Landsat 5 TM the constant K1= 60.776 $w*m^{-2}*sr^{-1}*\mu m^{-1}$ and K2= 1260.56. For Landsat 7 ETM+ the constant K1 = 666,09 $w*m^{-2}*sr^{-1}*\mu m^{-1}$ and K2 = 1282.71 K respectively.

Then, corrections for emissivity (ε) were applied to the radiant temperatures according to the nature of land cover. In general, vegetated areas were given a value of 0.95 and non-vegetated areas 0.92 (Nichol, 1994). The emissivity corrected surface temperature can be computed as follows (Artis and Carnahan, 1982):

Ts =T(K)/ (1+(lT(K)/a) ln e (4)

where Ω=wavelength of emitted radiance (for which the peak response and the average of the limiting wavelengths (Ω=11.5 µm) (Markham and Barker, 1985) will be used, α =hc/K (1.438×10^{-2} m.K), K=Stefan Boltzmann's constant ($1.38\times10^{-23}J.K^{-1}$), h=Planck's constant ($6.26\times10^{-34}$J s), and c = velocity of light (2.998×10^{8} m s^{-1}).

NDVI image was computed from visible (0.63–0.69 µm) and near-infrared (0.77–0.90 µm) data of the Landsat TM and ETM+ images, using the following formula:

NDVI=TM4 TM3/TM4 +TM 3 (5)

The original NDVI has the values between -1 to +1, but we transformed NDVI values into image of 8 bit (0-255) value.

3. Result and Discussion

3.1. Basarah Urban Change Detection

We can notice from Figure 3. that there was randomly growth (expansion) in all direction of the city. The major expansion was in north and west of the city. Shatt Al-Arab Shitt River in the east and date palms in the south east of Basarah limited the expansion in these directions, they works as natural boundary for the city. It was found that the increasing percentage of city area were about 80% and 124% for 1990 and 2003 respectively than 1973 area. While for the period 1990 – 2002 there was 26% percentage increasing in the area of the city.

3.2. Land Cover Classification

Land cover of Basarah area was classified to five classes (Figure 4). These classes representing five major features in the study area (orchards, water, barren land (dry and wet soil),

The accuracy of the classifications was verified by comparing the results obtained by classification with existing land use and cover maps that have been field-checked. From Figure 4 and Table 1, barren land (dry and wet soil) occupied major area of study region which about more than of 65% of total area, while 25-30% of total area for other land cover pattern (water, orchards, Urban area areas). It is clear that there was a considerable increasing in urban area and decreasing in other classes areas with fluctuation in wet soil area through the period of study.

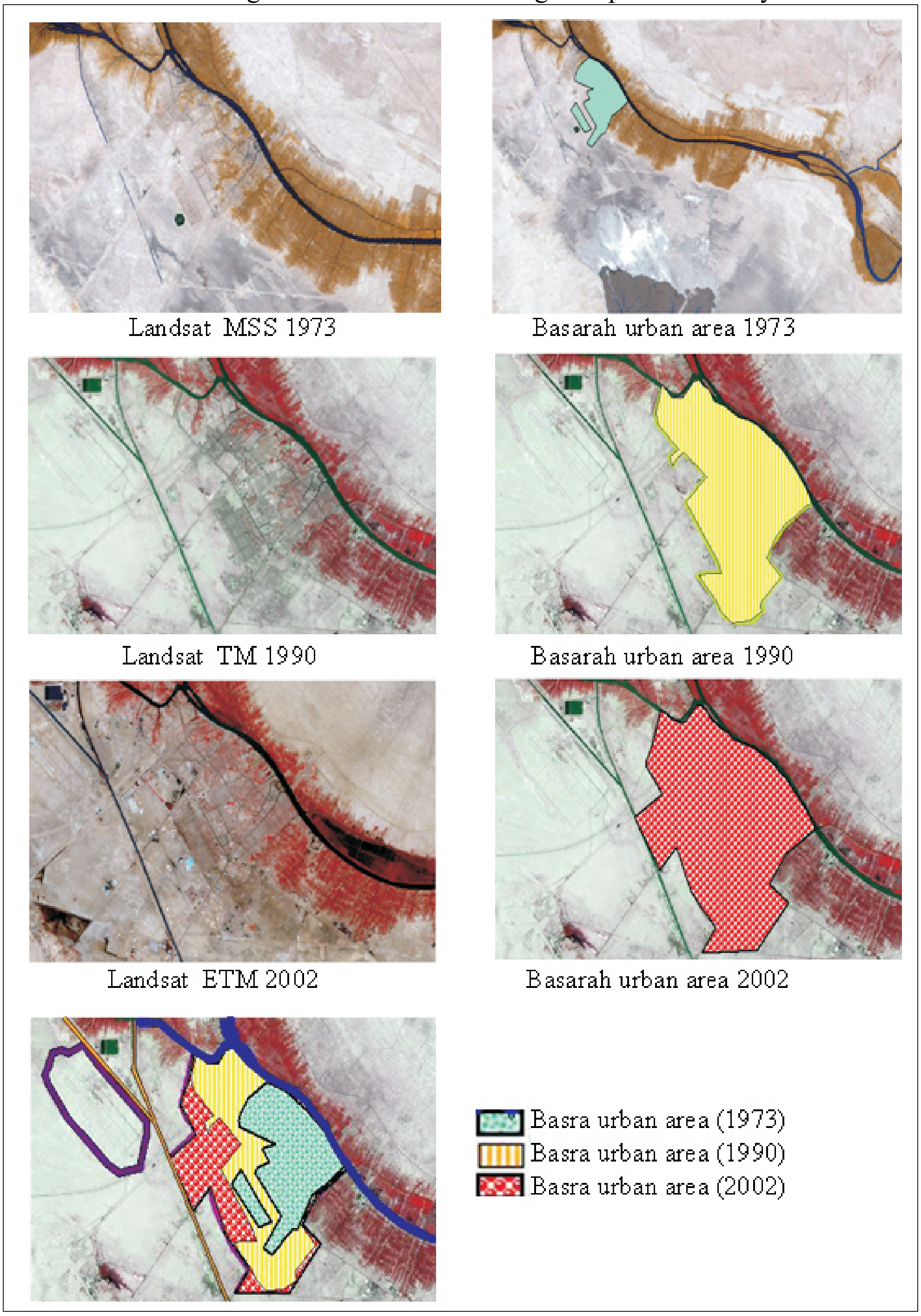

Figure 3. Basarah Urban Expansion 1973-2002 from false composite of Landsat images

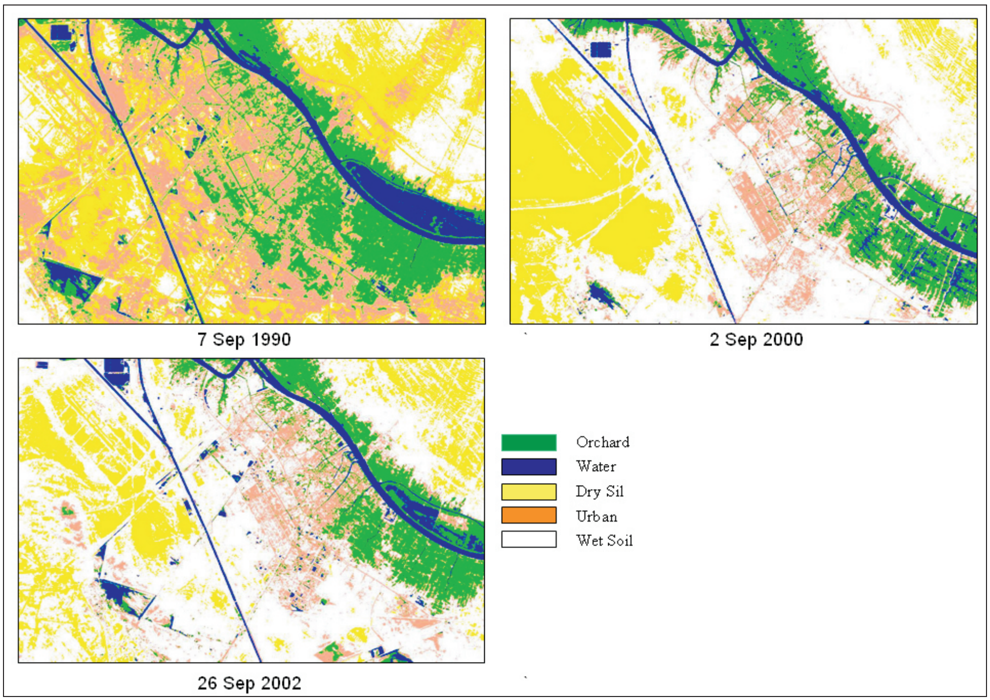

Figure 4. Multi – Temporal land cover classification

Table 1. Change in land type area based on Landsat images (negative values indicate a decrease)

Land use/ Cover	Land Area (Pixels)			Rate of land use change		
	1990	2000	2002	2000-1990	2002-2000	2002-1990
Orchard	71820	66863	64683	-4957	-2180	-7137
Water	29646	35029	27287	5383	-7742	-2359
Dry Soil	115480	104271	89831	-11209	-14440	-25649
Urban	78202	80175	81148	1973	973	2946
Wet Soil	306453	290489	338652	-15964	48163	32199

3.3. Surface Temperature

Surface temperature is an important parameter in understanding the exchange of energy between the earth surface and the environment. The surface temperatures were derived from the thermal band radiance values of TM and ETM+ sensor (Figure 5).

Surface temperatures distributions of area of studies are shown in Figures 6. The mean surface temperatures for the study area were found to be 32.83 ^{0}C, 28.02^{0}C and 29.91^{0}C for the years 1990, 2000 and 2002 respectively. From the figures, it is clear for all the studied years that barren land (dry and wet soil) exhibits highest surface temperature followed by urban, vegetated (orchards) and water areas. The lowest radiant temperature is found in water bodies.

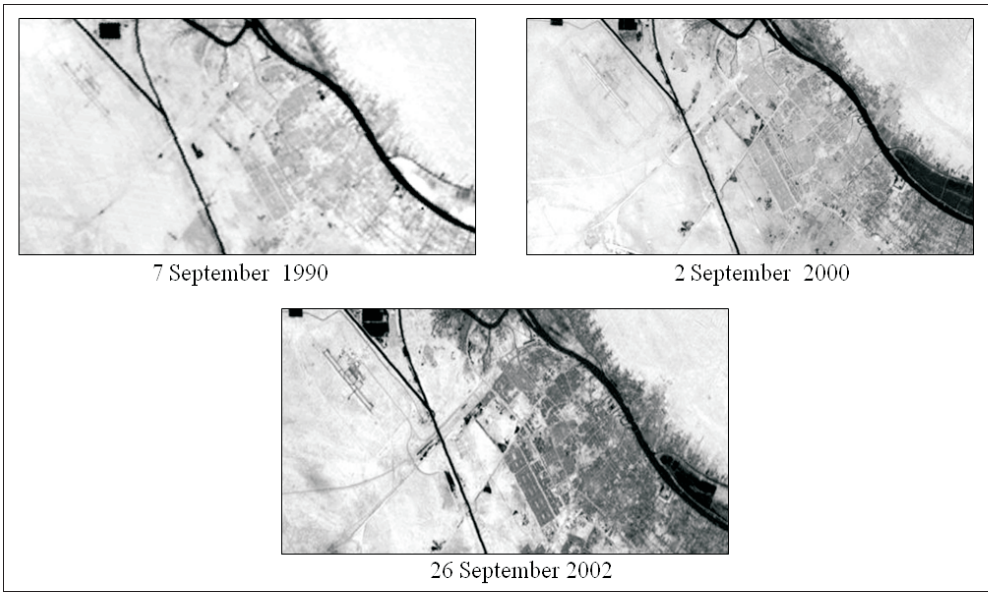

Figure 5. Multi-temporal thermal (band 6) of Landsat for study area

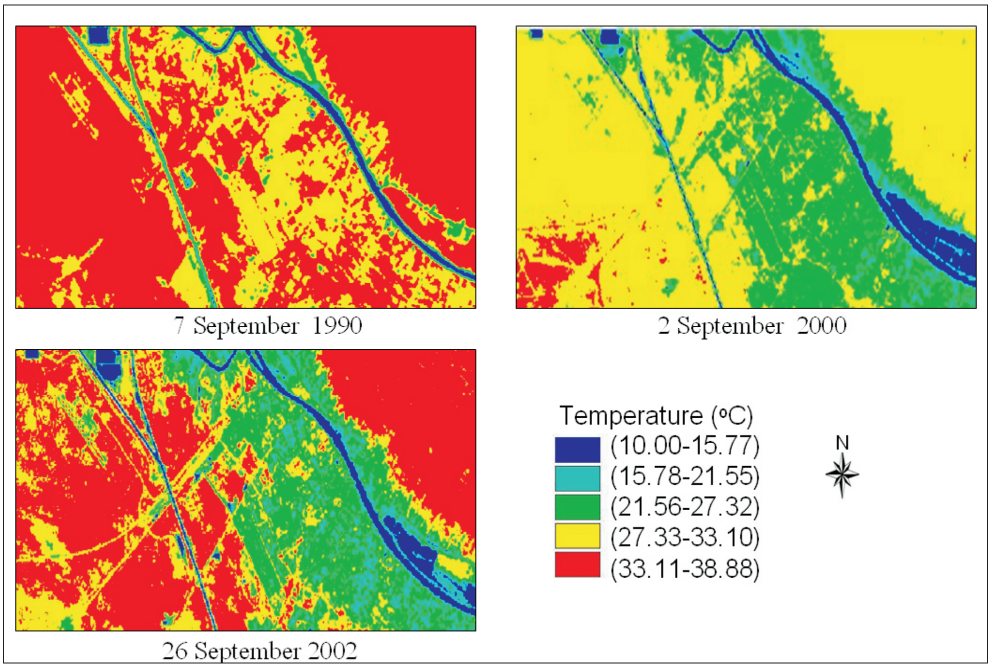

Figure 6. Distribution of the surface temperature (1990, 2000 and 2002)

3.4. The NDVI

The NDVI (Figure 7) can be used as an indicator of relative biomass and greenness (Rouse *et al.* 1974). It has been found that NDVI be a good indicator of surface radiant temperature (Nemani and Running, 1989; Gallo *et al.* 1993b; Gillies and Carlson, 1995; Lo *et al.* 1997). The resultant NDVI image was correlated with the land use/cover change and surface temperature map extracted from Landsat image to study how all these changes have interacted.

The mean value of NDVI the study area were found to be 0.027, 0.143 and 0.221 for the years 1990, 2000 and 2002 respectively. The average NDVI value per and cover patterns then is given shown in Figure (8)

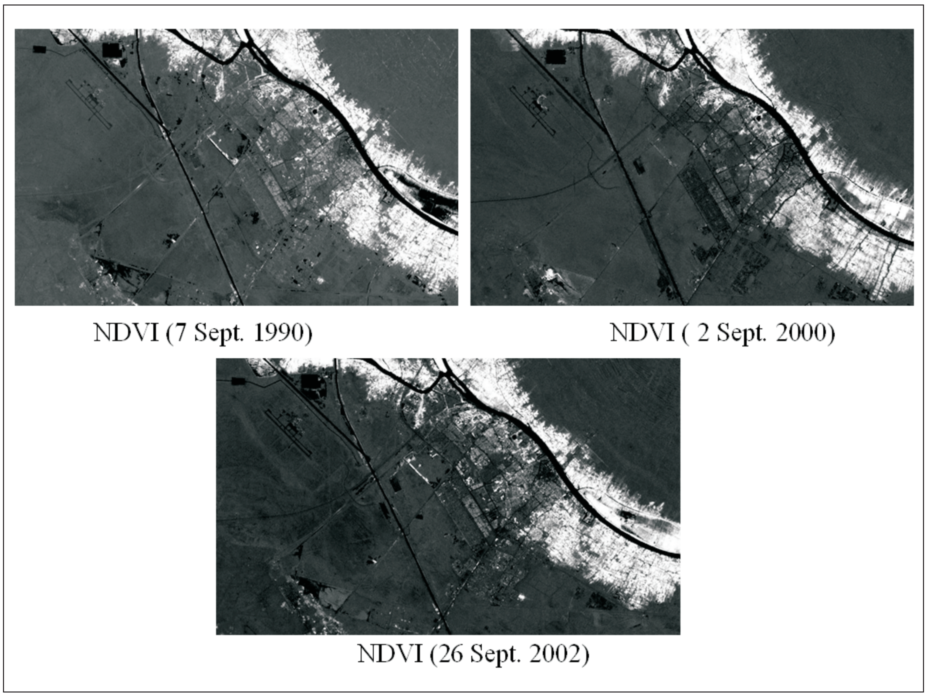

Figure 7. NDVI for study area

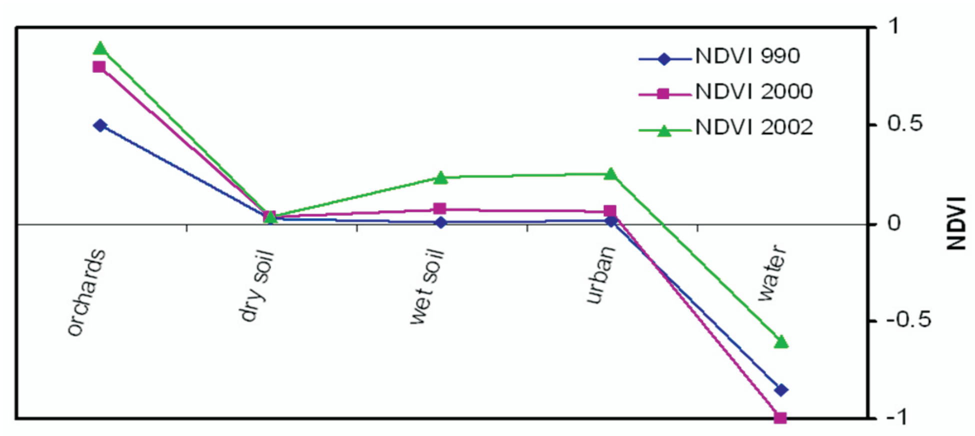

Figure 8. NDVI values by land cover type for 1990 , 2000 and 2002

5. Correlation Analysis of Surface Temperature and NDVI

NDVI is negative correlated with surface radiant temperature (Lo *et al.*, 1997). The relationship between surface radiance temperature and NDVI was investigated foetr each land cover type through correlation analysis. Table 2 shows the analysis between surface temperature and NDVI for the years of study. It is apparent from the table that surface temperature values tend to negatively correlate with NDVI values for all years and land cover types.

Figures (9 and 10) shows the relationship between the land surface temperature and NDVI values on the change of land use/cover types in the Basra region. It is clear from the two figures that the results of the correlation and regression analysis between land surface temperature and NDVI for different land use/cover types possessed negative (-) correlation for different image dates The highest negative correlation was found in agriculture field, while the lowest correlation was observed in barren land area. The results also revealed that agricultural areas show the lowest surface temperature and the highest NDVI;this could be attributed to the fact that the increase in green biomass is often associated with a reduction in surface resistance to evapotranspiration, greater transpiration and larger latent heat transfer resulting in lower surface temperature.

Table 2. Correlation analysis of Temporal Surface temperature vs. NDVI.

YEARS	Regression Equation	r	r^2
1990	Y=0.918x+0.871	-0.306	-0.553
2000	Y=0.873x+0.106	-0.894	-0.799
2002	Y=0.848x+0.123	-0.974	-0.965

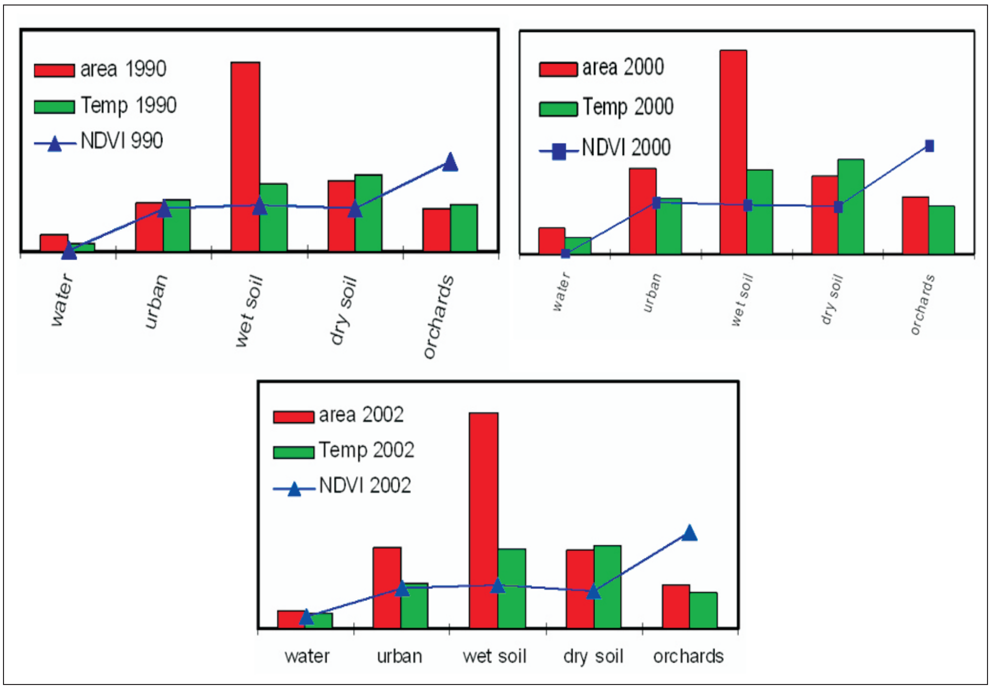

Figure 9. The change of surface temperatures and NDVI on the change of land cover

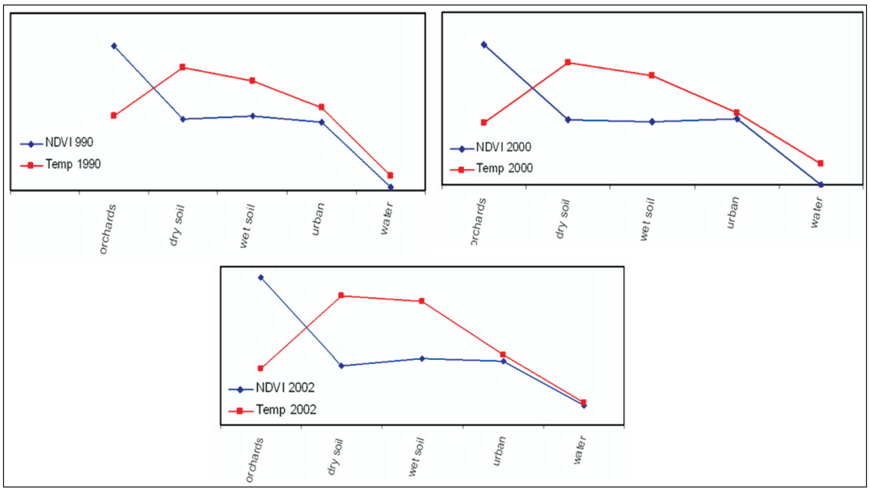

Figure 10. Relationship between surface temperature and NDVI

6. Conclusions

An integrated approach of remote sensing and GIS was applied for evaluation of rapid urban expansion of Baghdad city for the period (1973 - 2002) and its impact on the environment of Basarah city. The results are summarized as follows:

A rapid urban expansion of Basrah city noticed by remote sensing and GIS over the last decades due to accelerated economic growth. The major expansion was in north and west of the city. Shatt Al-Arab Shitt River in the east and date palms in the south of Basarah city limited the expansion in these directions.

There are noticeable changes in the environmental of the study area during the period 1990-2002. There was decreasing in water and agriculture (vegetation and orchards) area with increase in urban area. These changes have direct effects on NDVI and land surface temperature in the region.

The results of the correlation analysis between land surface temperature and NDVI show negative (-) correlation for all land use types. The analysis indicated that water and agricultural field scored the lowest surface temperature followed by urban and barren land (dry and wet soil). It is important to mention that the relationship between land surface temperature and NDVI was determined largely by vegetation and environmental conditions and was thus related to the partitioning of the energy fluxes.

The statistical analysis of thermal information and vegetation indices confirms that each of them contains independent information which should be used for the analysis of environment. The change of surface temperature during the year is dependent on surface cover and NDVI which is shown in this work. The emissivity of different land use cover is therefore dependent on NDVI, and because of this, of the vegetation.

The methodology employed in this study provides an alternative to the traditional empirical observation and analysis using in situ data for environmental studies. This methodology should be possible to apply to other regions.

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