Integration Study of Vegetation Cover in Babil Governorate By Using Remote Sensing Data and GIS

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ABSTRACT:
This project examines the use of GIS and Remote Sensing in mapping vegetation Cover in Babil governorate between 1976 and 2010 so as to detect the changes that has taken place in this status between these periods ..

The remotely sensed data used in this study were NDVI images created from ETM+ , TM , MSS sensors on board Landsat Satellites.

The results produced from these NDVI images gave good indicators of vegetation degradation through the period 1986 – 1992 in the form of image maps. The final result was the image map gives an assessment for desertification, which gives good indication of areas desertified and those under risk of desertification.

The remote sensing and geographic information system techniques were used to assessment and mapping of desertification over large areas of Babil governorate in the center of Iraq.

1. Introduction
Babil governorate lays in the middle part of Iraq distance from Baghdad the capital about 100 Km considered as one of the middle Euphrates governorates surrounded by Baghdad from the North and from west and southern west by Al-Anabar and Karbala , and from southern west and south two governorates Al-Najaf and Al-Diwanya , (Fig. 1) shows the location map of the study area.

The study area (Babil) is situated between longitudes 44o 00’ – 45o 00’ E and latitudes 32o 00’ – 33o 15’ N. Its total area is equal to 6793 Km2.

It’s lands raise up about 35 m to the south over the sea level . The climate is semi-arid with a mean annual rainfall ranging from less than 50 mm to about 200 mm .The temperature in summer can reach as high as 50 °C during day time. Dominate warm winter.

Satellites give unique possibilities to study variations in vegetation cover and growth. The Normalized Difference Vegetation Index (NDVI , a satellite based measure of vegetation activity and mass) computed from data of satellite sensors has been used for assessing green vegetation cover and the correlation between average NDVI and green biomass has been well established (Tucker et al., 1985; Eklundh, 1996).

Fig. 1: Location map of the study area
2. Objective

This study includes vegetation measurements estimations and interviews in Babel governorate and satellite and precipitation data analyses. It tries to answer if and why any changes in vegetation have occurred. Investigating the differences in terms of vegetation and land use for areas with a significant NDVI increase and for areas without a significant NDVI increase is the western part of the study area. Specific objectives include testing of the following hypotheses:

1. Are the vegetation changes in areas with a significant NDVI increase = vegetation changes in areas with no significant NDVI increase?
2. Are the vegetation changes in areas with a significant NDVI increase ≠ vegetation changes in areas with no significant NDVI increase?

3. Remote sensing

Remote sensing can be defined as the science of collection, processing and interpretation of images and related data, obtained from aircraft and satellites, which record the interaction between matter and electromagnetic radiation (Jensen, 2000). Remote sensing means measuring at a distance without physical contact. When the sun’s electromagnetic energy reaches the earth’s surface, it will be reflected, absorbed or transmitted. The radiation that is used to identify objects with different remote sensing techniques are either the reflected or the emitted energy. The proportions accounted for by each process depend on the nature of the surface, the wavelength of the energy and the angle of illumination (Campbell, 2002). Remote sensing uses the knowledge that the radiation intensity within different wavelengths often is typical for different objects. Different objects have different spectral signatures (Lillisand and kiefer, 2000). For example, at certain wavelengths, sand reflects more energy than green vegetation while at other wavelengths it absorbs more (reflects less) energy. Therefore, these spectral signatures can be used to distinguish one thing from another or to obtain information about shape, size and other physical and chemical properties (Figure 2 (Levin, 1999). When the radiation passes through the atmosphere it will be affected aerosols and clouds that scattering it. This may lead to error in the data (Levin, 1999).

4. Satellite sensors used in this study

Three cloud free Landsat MSS, TM and ETM+ scenes covering the study area were selected for analysis. MSS image consists of four bands. The characteristics of this image compared to the others are low in terms of spatial ground resolution and band widths (Figures 3a, 3b, 3c, 3d, 3e and Table 1) (al kahry 2007). Multispectral...
sensors collect data in a few spectral bands which cover important regions of the reflected solar spectrum (about 350 to 2500μm). Because these sensors provide data in multiple bands, the ground resolution is degraded and total number of pixels per line for these sensors is less than that of panchromatic sensors. This is due to both the decreased light energy available in each band as well as bandwidths. Therefore, the spectral resolution for spaceborne multispectral sensors is usually poorer than for panchromatic sensors. Multispectral sensors have been used effectively in studies of land degradation in arid and semi-arid lands.

Firstly, both the MSS and TM data cover a broad spatial extent. Each individual scene of Landsat sensors covers an IFOV on an area of approximately 185*185 kilometres. Furthermore, since the launch of Landsat 1 in 1972, the terrestrial surface of the earth between 81° N and 81° S latitudes has been subject to image acquisition (Campbell, 1996). Secondly, the data archive covers a relatively long temporal sequence of more than 25 years. For example, MSS technology began in 1972 and after 10 years later TM started. Although this cumulative period may be short in terms of the history of humanity, the time period covers a temporal range to capture a variety of the man-induced changes in arid lands. Thirdly, the MSS and Landsat instruments provide a reasonably high degree of spectral resolution when compared.

Landsat 4, carrying the first Thematic Mapper (TM) sensor was launched in 1982. The TM sensor is an upgrade of the Multi Spectral Scanner (MSS) subsystem on which efforts were made to incorporate improvements into a new instrument. The TM instrument is thus based on the same technical principal as the MSS but with a more complex design as it provides finer spatial resolution, improved geometric reliability, greater radiometric detail and more detailed spectral information. The MSS has only four broadly defined spectral regions whereas the TM has seven spectral bands, customized to record radiation of interest to specific scientific investigations (Campbell, 1996).

The Landsat Enhanced Thematic Mapper Plus (ETM+) sensor, launched in 1999, is a development of the TM sensor. The Landsat 7 ETM+ sensor offers several enhancements over the Landsat 4 and 5 Thematic Mapper sensors, including increased spectral information content, improved geodetic accuracy, reduced noise, reliable calibration, the addition of a panchromatic band and improved spatial resolution of the thermal band (Masek et al., 2001). The Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) bands 3 and 4 provide red (R) and near infrared (NIR) measurements and can therefore be used to generate NDVI data sets in the following way (Canada Center for Remote Sensing, 2007):

\[
NDVI = \frac{NIR - R}{NIR + R}
\]

......... (Equation 1)

Table 1 : Image characteristics for Landsat scenes
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<table>
<thead>
<tr>
<th>Instrument</th>
<th>Mss</th>
<th>TM</th>
<th>ETM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat</td>
<td>Landsat 2</td>
<td>Landsat 5</td>
<td>Landsat 7</td>
</tr>
<tr>
<td>Acquisition date</td>
<td>1976/10/03</td>
<td>1986/01/05</td>
<td>2010/01/03</td>
</tr>
<tr>
<td>Path / row no</td>
<td>168/37</td>
<td>168/38</td>
<td>168/38</td>
</tr>
<tr>
<td>Spectral bands (μm)</td>
<td>4 bands</td>
<td>7 bands</td>
<td>9 bands</td>
</tr>
<tr>
<td>1- 0.5-0.6 (green)</td>
<td>1- 0.45-0.52 (blue)</td>
<td>Same as TM, With Panchromatic band And two thermal bands</td>
<td></td>
</tr>
<tr>
<td>2- 0.6-0.7 (red)</td>
<td>2- 0.52-0.60 (green)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3- 0.7-0.8 (near-infrared)</td>
<td>3- 0.63-0.69 (red)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4- 0.8-1.1 (near-infrared)</td>
<td>4- 0.76-0.90 (near-infrared)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5- 1.55-1.75 (mid-infrared)</td>
<td>5- 1.55-1.75 (mid-infrared)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6- 10.4-12.5 (thermal)</td>
<td>6- 10.4-12.5 (thermal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7- 2.08-2.35 (mid-infrared)</td>
<td>7- 2.08-2.35 (mid-infrared)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground resolution</td>
<td>57m*57m</td>
<td>28.5m*28.5m</td>
<td>30m*30m</td>
</tr>
<tr>
<td>Dynamic range (bit)</td>
<td>8 bit</td>
<td>8 bit</td>
<td>8 bit</td>
</tr>
</tbody>
</table>

Fig 3a: Landsat 1 Multispectral Scanner MSS
5. Software used in this study:

During this study two different software packages are used since there is not single software that will process all steps in the analyses. These are ERDAS
IMAGING (version 9.0) and ArcGIS (version 9.3). ERDAS Imagine 9.0 is used for analyzing images and layout the results by using ArcGIS 9.1 program.

6. The Normalized Difference Vegetation Index (NDVI)

Tucker first suggested NDVI in 1979 as an index of vegetation health and density (Thenkabail and Gamage et al. 2004). Many natural surfaces are about equally as bright in the red and near-infrared part of the spectrum with the notable exception of green vegetation (Figure 2). Red light is strongly absorbed by photosynthetic pigments (such as chlorophyll) found in green leaves, while near-infrared light either passes through or is reflected by live leaf tissues (mesophyll structures and water content), regardless of their color. This means that areas of bare soil that have little or no green plant material will appear similar in both the red and near-infrared wavelengths, while areas with green vegetation will appear bright in the near infrared and very dark in the red part of the spectrum. By using these wavelengths different vegetation indices can be produced. The NDVI is the most widely used vegetation index and many studies have demonstrated its ability to describe vegetation phenology (Hinderson, 2004).

NDVI is calculated from atmospherically corrected reflectance from the visible and near infrared channels as:

$$\text{NDVI} = \frac{\text{NIR} - \text{R}}{\text{NIR} + \text{R}} \quad \text{(Equation 1)}$$

The resulting index value is sensitive to the presence of vegetation on the Earth’s land surface and can be used to address issues of vegetation type, amount, and condition. Equation 1 normalizes the difference between the channels in order to produce values in the range of -1.0 to 1.0, where vegetated areas will have values greater than zero and negative values indicate non-vegetated surface features such as water, bare soil, or clouds.

The Agricultural Land have many types, like cropland, pasture, orchards, groves and other Agricultural Land (Fig. 4). With magenta color in RGB 432 and 453 in ALI image and dark green in 123 RGB Ikones image (Fig. 5). The NDVI shows the agricultural land in white color (see figure 6, 7, 8, 9 and 10).

Fig.4: Vegetation in the study area
In this study five periods of Landsat MSS, TM, ETM tried to explain the observed change in NDVI, by using the NDVI algebra to explore and assess the dynamics of desertification processes affecting and estimating green vegetation cover and monitored in Figs. (6, 7, 8, 9 and 10) for period 1976, 1986, 1992, 2003 and 2010 respectively. It has interval grey scale from -1 to 1 with 8 bit and all vegetation pixels have pixel value more than zero. The raster map was divided into two classes depending on its histogram, with equal number of pixels, with two ranges of that specific index.

Fig. 5: Agricultural Land in A and B - Ikones 123 RGB, C – ALI 742 RGB
Fig. 6: NDVI in 197

Fig. 7: NDVI in 1986

Fig. 8: NDVI in 1992

Fig. 9: NDVI in 2003

Fig. 10: NDVI in 2010
7. Change in Landsat NDVI

The reflectance values for Landsat bands 3 and 4 were put into equation 3 in order to calculate the NDVI values for the different areas. The values from 1986 were then subtracted from the 1990 values. This way all values greater than 0 indicates a NDVI increase and all values smaller than 0 show a NDVI decrease. Then the areas which have increased and decreased in NDVI were calculated.

A second approach was to implement a threshold value of 0.03 NDVI units in each direction from 0 (no change) since very small changes could be seen as no change (Runnström, 2000). This way the areal change of three categories, increased NDVI, decreased NDVI and no change in NDVI were calculated. The threshold images of NDVI (1976, 1986, 1992, 2003, 2010) are shown in figures (11,12,13,14 and 15).
Figure 11: The Threshold image of NDVI in 1976

Figure 12: The Threshold image of NDVI in 1986

Figure 13: The Threshold image of NDVI in 2003

Figure 14: The Threshold image of NDVI in 2010

Figure 15: The Threshold image of NDVI in 2010
8. Integration of Remote Sensing and GIS Data

From satellite images all threshold images of NDVI (1976, 1986, 1992, 2003, 2010) are converted to vector by using Arc GIS programs to calculate the change in three periods. To escape from the difference in spatial resolution, we used the vector structure exchange from the raster structure, the Boolean Operation logic (intersect and eras) was used to determine the change in five periods 1976, 1986, 1992, 2003, 2010. The outcomes of the change detection steps were performed on the Landsat images that cover the study area in five different times 1976 to 2010, as pointed out in the previous section are summarized in the steps below (figure 16):

![Boolean Operation logic (intersect and eras) that used in this project](image)

9. NDVI Results

Finally, all raster data of NDVI are converted to vector data and shown in Figs. (17, 18, 19, 20 and 21) for five periods (1976, 1986, 1992, 2003, 2010). The maximum density of vegetation located in the western part of the study area, the vegetation cover 296.691 km² in 1976 and increased in 1986 to be 600.483 km² then decreased in 1992 to be 340.469 km² and increased in 2003 to be 550.110 km² and decreased in 2010 to be 420.779 km² (Fig. 22). The change in vegetation of five periods displays in Figs. (17, 18, 19, 20 and 21).


Figures 27, 28 shows the high difference between re-growth and degradation of vegetation between 1986–1976, the re-grow is more than degradation, the high vegetation increase was happened between 1976–1986 (Fig. 27), generally, the best period for vegetation re-grow was in 1986.
Fig. 19: Vector of NDVI in 2003

Fig. 20: Vector of NDVI in 2010

Fig. 21: Histogram showing vegetation density in study area for the five periods
Fig 22: Change in vegetation detection in the study area 1976-1986

Fig 23: Change in vegetation detection in the study area 1986-1992

Fig 24: Change in vegetation detection in study area 1992-2003
10. CONCLUSIONS

Application of multi-temporal (MSS, TM and ETM) remote sensing data offer an effective opportunity for mapping desertification processes in study area as well as in arid lands at relatively low cost.

NDVI is a powerful technique in characterization and mapping of desertification processing in the study area by providing direct measurements.

The maximum density of vegetation located in the western part of the study area NDVI algebra results show an increase in vegetation cover in 1976, 1986 and 2003 for study area.

NDVI algebra results show decrease in vegetation cover in 1992 and 2010.

NDVI algebra results show decrease in vegetation cover in eastern part of study area in 2010.

The re-grow in period 1986–1976 is more than degradation

In general the desertification processes in study has increase.

11. RECOMMENDATIONS

Making lands cover land use classification maps for study area depends on Landsat ETM data and built the data base for it.

Using of high resolution and more advanced remote sensing data as hyperspectral one for monitoring desertification and land degradation.

References
Hinderson , Tobias , 2004 , Analysing environmental change in semi-arid areas in Kordofan, Sudan , MSc. Thesis , Geobiosphere Science Centre ,Physical Geography and Ecosystems Analysis, Lund University