Change Detection Methods Using Band Ratio and Raster to Vector Transform

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Abstract

LandSat Satellite ETM+ images have been analyzed to detect changes in Euphrates river boundaries area at the middle of Iraqi country from the year 1990 to the year 2001**.** Changes are determined by applying the rationing method on the bands 3 and 5 then using Raster to Vector (R V)Transform method .GIS 9.1 program is used to apply the rationing method and Raster to Vector (R V)Transform technique then determined the results (changes in boundaries area were calculated).

تقنيات كشف التغيير باستخدام نسبة الحزمة والتحويل مصفوفة الى متجه

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الخلاصة

تم تحليل صور القمر الاصطناعي لاندسات لتحديد التغيرات في مساحة حافات نهر الفرات في منطقة وسط العراق في العراق منذ العام 1990 الى العام 2001.، ملتقطة في آذار عام 1990 و في آذار عام 2001. التغيرات تم استحصالها بتطبيق تقنية النسبة على الحزمتين الثالثة والخامسة ومن ثم تقنية التحويل مصفوفة إلى متجه: تم استخدام برنامج GIS 9.1 لتطبيق نظرية النسبة وتقنية التحويل مصفوفة إلى متجه وأستحصال النتائج (تم حساب التغيرات في مساحة الحافات).

Introduction

Remote sensors usually record electromagnetic radiation (EMR) which travels at a velocity of $3\times10^{8}ms^{-1}$ from the source, directly through the vacuum of space or indirectly by reflection or reradiation to the sensor As such, electromagnetic radiation EMR represents a High - speed communications link between the sensor and remotely located phenomena [1].

Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation [2].

Land is the most important natural resource which embodies soil, water and associated flora and fauna involving the total ecosystem. The growing population and human activities are increasing the pressure on the limited land and soil resources for food, energy and several other needs. Comprehensive information on the spatial distribution of the land use/ land cover categories and the pattern of their change is a prerequisite for planning, utilization and management of the land resources[3].

The Earth's surface is constantly changed by natural factors and human activities. Human is adapted to various environmental changes, so that the need of change detection researches gained their importance in spotting the

Variances occur at certain interesting parts of the Earth's surface [4].

For physical and cultural features on the landscape, there are optimal time periods during which these features may best being observed. Remotely sensed data acquired at the fixed time interval becomes an important factor [5].

The reflectance from a water body can stem from an interaction with water's surface (specular reflection), with material suspended in water, or with the bottom of the water body. Even with deep water where bottom effects are negligible, the reflectance properties of a water body are not only a function of the water but also the materials in the water, clear water absorbs relatively little energy having wavelengths less than about 0.6 μm. High transmittance typifies these wavelengths with a maximum in the blue - green portion of the spectrum. However, as the turbidity of water changes, transmittance and therefore reflectance changes dramatically. For example, waters containing large quantities of suspended sediments resulting from soil erosion normally have much higher visible reflectance than other "clear" waters in the same geographical area. Likewise, the reflectance of water changes with the chlorophyll concentration involved; i.e. increases in chlorophyll concentration tend to decrease water reflectance in blue wavelengths and increase it in the green wavelengths [2].

Image differencing involves subtracting the imagery of one date from that of another. The subtraction results in positive and negative values in areas of radiance change and zero values in areas of no change. In an 8-bit (i.e. 2^8gray levels) analysis with pixel values ranging from 0 to 255, the potential range of difference values is -255 to 255. The results are normally transformed into positive values by adding a constant "c". The operation is expressed mathematically as:

$$\Delta X_{ijk} = BV_{ijk}(1) - BV_{ijk}(2) + c \quad \ldots\ldots\ldots (1)$$

Where ΔX_{ijk}= change in pixel values, $BV_{ijk}(1)$ is brightness value at time 1, $BV_{ijk}(2)$ is brightness value at time 2,

c is aaconstant (e.g., 255), (i, j) representing image coordinates, while k is the image band's number.

Sometimes differences in brightness value from similar surface materials are caused by topographic conditions, shadows, or seasonal changes in sunlight illumination angle and intensity [1].

These conditions may hamper the ability of an interpreter or classification algorithm to correctly identify surface material or land use in a remotely sensed image. Ratio transformations of the remotely sensed data can be applied to reduce the effects of such environmental factors;[1] i.e.

$$BV_{ijn} = \frac{BV_{ijk}}{BV_{ijl}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where: BV_{ijn} is the output ratio value, BV_{ijk} is the brightness value in band k, and BV_{ijl} the brightness in band l.

Water Bodies Generally reflect high in the visible spectrum, however, clearer water has less reflectance than turbid water.

In the Near IR and Mid-IR regions water increasingly absorbs the light making it darker [6].

This is dependent upon water depth and wavelength. Increasing amounts of dissolved inorganic materials in water bodies tend to shift the peak of visible reflectance toward the red region from the green region (clearer water) of the spectrum.

The ratio band3/band5 enhanced turbid water. This ratio is useful for observing differences in water turbidity [6].

The Studied Area and Data Forms

The Euphrates River is one of the twin rivers in Iraq, which is one of the reasons for the development of the great civilization in Mesopotamia.

Both the Tigris and the Euphrates are trans boundary rivers, originating in Turkey. Before their confluence, the Euphrates flows for about 1160 km and the Tigris for about 1418 km within the territory of Iraq.

Iraq today occupies the old land of Mesopotamia, this fertile land between the two rivers Tigris and Euphrates, which both flow through Iraq from North and west parts these two rivers meet at 10 Km north of Basrah city forming Shatt al Arab river (length 110 km), which drains into the Gulf[7].

The first Satellite image captured from Landsat-5 (TM) in march (1990) and the second Satellite image captured from Landsat-7 (ETM+) in march (2001) illustrated in fig.(1) with false color red (band 4), green(band 3) and blue (band 2).

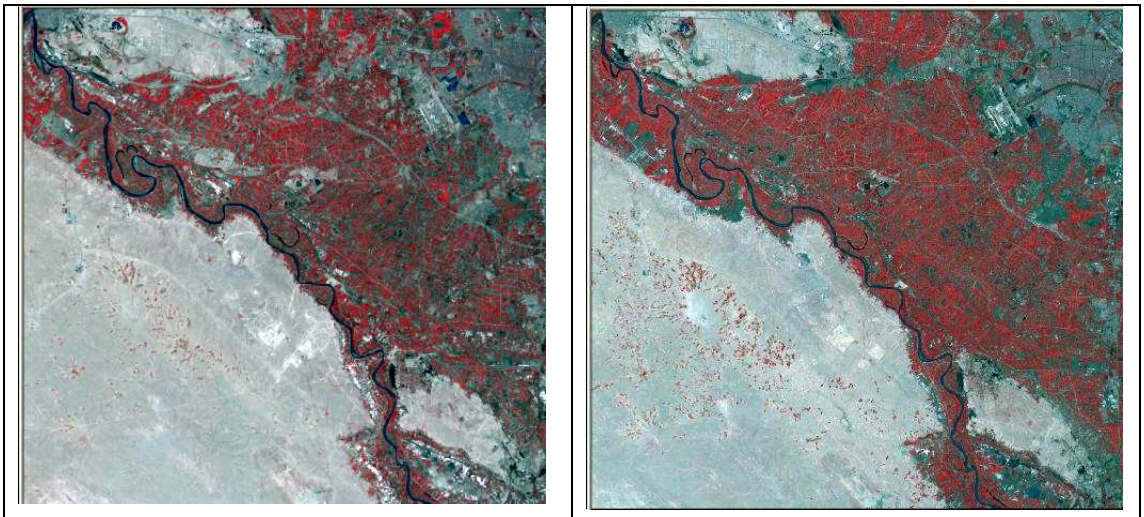
For each of the two images the third and the fifth bands were used with wavelengths (0.63-0.69) and (1.55-1.75) Micrometer respectively. With pixel size (28.5 × 28.5) m and image size (2054 × 1915) Pixels the water bodies for the Euphrates river were extracted from the two scenes.

The Change Detection Methodology

band ratio method has been applied on the multispectral remotely sensed image to detect water body in each image. This method can be show as follows:-

1. Apply image ratioing technique, by ratioing band3/band5, to produce image with different water areas.
2. Perform normalization technique (i.e. Using Unique Values Criterion) on the rationing image to make Raster to Vector Transform on the rationing image.
3. Perform Raster to Vector Transform for each class of water for both images to Select the pixels that turned to Euphrates river only from other water areas pixels in each of the two images.
4. The pixels of water outside the river were selected and removed then the areas of classes along Euphrates river were calculated.
5. Perform subtraction process (Absolute differencing) to isolate the changed boundaries at Euphrates area; it is of points having absolute differences >0).
6. The area of changed class was calculated.

Figure (2) demonstrates the operational steps involved in method, while Tables- (1 and 2) represents the number of points and the percentage of classes areas obtained by implementing the band ratio method.



a **b**

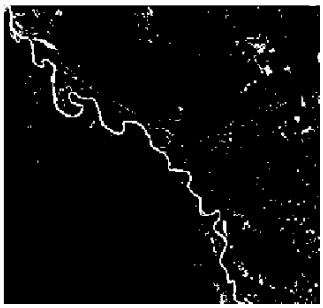
Figure 1-The Middle Of Iraq Images Acquired On;
(a) March 1990, (b) March 2001.

Table 1- The Number Of Points And Percentages Area Of Euphrates In The Two Scenes (1990 And 2001).

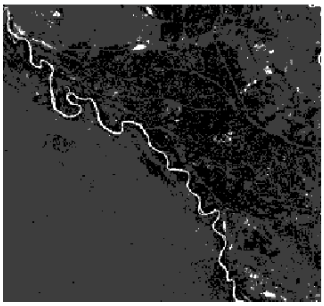
	The 1990 scene			**The 2001 scene**		
Class name	**No. of class points(pixels)**	**Class area (m^2)**	**Percentages area of the class**	**No. of class points (pixels)**	**Class area (m^2)**	**Percentages area of the class**
Euphrates	10749	8730875.25	0.2733	11202	9098824.5	0.285
Outstanding features pixels in the scenes	3922661	3186181397.25	99.7267	3922208	3185813448	99.715

Table 2- The Number Of Points And Percentages Area For Changed Boundaries Of The River Water Regions.

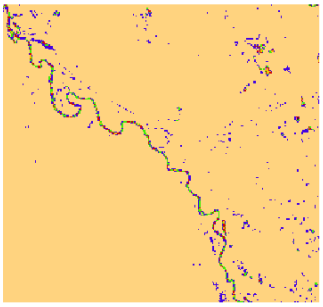
Class name	No. of points (pixels)	Class area (m^2)	Percentages of area
Blue (Changing water region)	6713	5452634.25	0.171%
white (other regions)	3926697	3189459638.25	99.829%



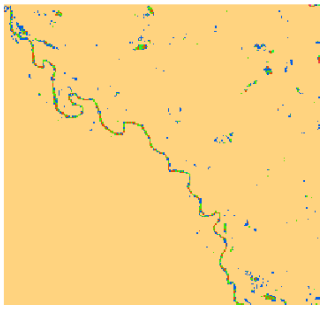
(a)Ratio of Band3/Band5 of 1990 scene



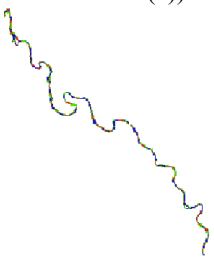
(b)Ratio of Band3/Band5 of 2001 scene



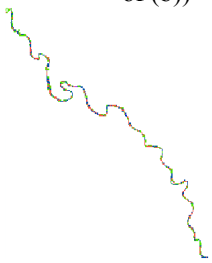
(c)Unique Values Criterion (classification result of (a))



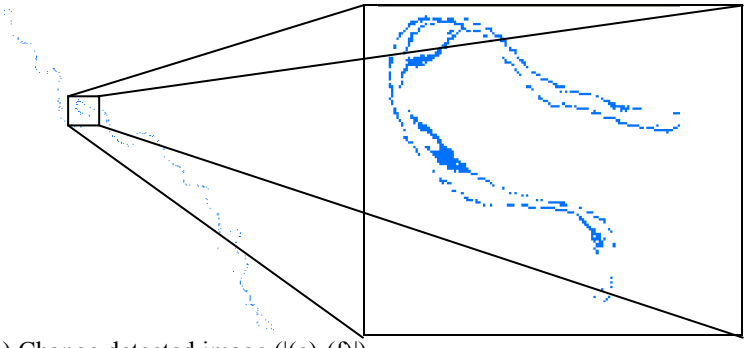
(d)Unique Values Criterion (classification result of (b))



(e)R.V. Transform to extract Euphrates points from 1990 scene



(f)R.V. Transform to extract Euphrates points from 2001 scene



(g) Change detected image (|(e)-(f)|)

Figure 2-Illustrating The Processes Involved By The Ratioing And R.V. Classification Method

Results and Discussion

As showing in table (1), The number of pixels of Euphrates river were increase at the year 2001 then the total area increase.

Table (2) shows the detected changes in the river boundaries from the year 1990 to 2001.

Figure (2) (a and b) showing the result of dividing band3 on band5 for the two images. Then the water appears as a bright region.

Then for each image classification method (unsupervised classification) was applied to classify the water region in one class as shown in Figure 2 (c and d). After that raster to vector transform was applied to extract the pixels of Euphrates from the other water regions shown in Figure 2 (e and f). Then a subtraction process was applied to detect the change pixels in the river boundaries as shown in Figure 2 (g).

Conclusions

Change detection in water area is a complicated process influenced by multiple factors. The ratioing Method and Raster to Vector Transform (R.V.T.) were perfect to appear the body water in the scenes and then extracting the pixels of the river (Euphrates river). The ratioing analysis method de-correlates image data is performed on the two scenes to accumulating the water body in one class as a first step to detect the changes in in the river boundaries. As it was obvious (subjectively), that after applying the R. V. Transform, the extraction of the river pixels was possible and the change detection between scenes was done.

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