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The Land Use and Land Cover Classification on the Urban Area

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Abstract

The Land Use/ Land Cover (LULC) is an essential application in many remotely sensed projects and problems. Land use is simply man-made objects such as urban, road complex targets, etc., while land covers are defined as any target and phenomenon that appear neutral. The LULC study is essential for all current and future engineering projects, as it shows the nature of the land's components, which is evident in studying and modernizing residential areas. One of the essential operations for studying LULC is the heterogeneity detection and classification calculations of satellite images and topographic maps. A part of the Baghdad, Iraq region was selected for the Landsat satellite group at different periods to detect variance and make classifications for extracting and calculating the changes. Many digital techniques were used to extract the results, such as; digital change detection and two classification methods. The study showed a significant decrease in the vegetation cover areas after 2015 and the expansion of buildings and unincorporated slums due to the housing crisis. The digital methods and results were evaluated using the ENVI (Environment for Visualizing Images) ver. 4.5 and written subroutines in visual basic 6.0.

Keywords: Classification methods, Land use/ Land cover, Remote Sensing.

تصنيف استخدامات الأراضي والغطاء الأرضي في المناطق الحضرية

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الخلاصه

استخدام الأراضي / الغطاء الأرضي (LULC) من التطبيقات المهمة في العديد من المشاريع والمشكلات التي يتم استشعارها عن بعد. استخدام الأرض ببساطة هو كائنات من صنع الإنسان مثل الأهداف الحضرية، وأهداف الطرق المعقدة، وما إلى ذلك، حيث يمثل الغطاء الأرضي أي أهداف وظاهرة تظهر بشكل طبيعي. تعتبر دراسة LULC مهمة وضرورية لجميع المشاريع الهندسية الحالية والمستقبلية، حيث توضح طبيعة مكونات الأرض، وهذا واضح في حالة دراسة وتحديث المناطق السكنية.حيث تعتبر من أهم العمليات لدراسة LULC كشف عدم التجانس وحسابات التصنيف لصور الأقمار الصناعية والخرائط الطبوغرافية.

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في هذا البحث تم اختيار جزء من منطقة بغداد لمجموعة القمر الصناعي لاندسات بفترات زمنية مختلفة لغرض الكشف عن التغاير وعمل التصنيفات لغرض استخراج مناطق التغيير وحساب منطقة التغيير. أظهرت الدراسة انخفاضاً ملحوظا في كثافة الغطاء النباتي بعد عام 2015 وتوسع المباني والأحياء العشوائية غير المدمجة بسبب أزمة السكن. تم استخدام عدة طرق رقمية لاستخراج النتائج مثل طرق كشف التغاير الرقمية، وطريقتين للتصنيف. تم تقييم الطرق الرقمية والنتيجة باستخدام ENVI الإصدار 4.5. والبرمجيات الفرعية المكتوبة في Visual Basic 6.0.

1. Introduction

Land cover refers to the land surface's physical, chemical, and biological processes, such as vegetation areas, soil, water, and geological structures. Land use is defined as any changes in the physical, chemical, and biological characteristics that man makes on the earth's surface through settlement and organization processes. The land use/land cover changes (LULCC) declined the ecological balance leading to a change in the climate, increasing desertification and temperatures, and declining vegetation cover. The knowledge of LULCC data is essential to the life cycle of modern societies and ecosystems, which is related to urban development and planning, environmental planning, and natural resource management [**1**].

The (LULC) classification is considered one of the essential and modern applications of remote sensing because it ensures the speed in completing work and accuracy of results and analysis. Suitable satellite images are used in terms of spatial resolution accuracy and topographic maps of appropriate scale. The issue of urban expansion and the increase in urban residents are among the most important problems facing governments and societies due to changes in ecosystems and the consumption of available natural resources. The study area in this research is a part of Baghdad-Iraq, considered one of the world's most crowded capitals, with the number of residents and random construction [**2**]. For this purpose, space data of the Landsat sensors during 2000, 2010, 2015, and 2017 were used. The reason for choosing these years is that the complete satellite views of the study area are available and free of radiometric defects. This research used digital change detection calculation techniques and supervised and unsupervised classification methods to extract (LULC) areas affected by the change.

2. Region of Interest and Available Data

The region of interest is located in the center of Baghdad, the capital of Iraq. The area can be described as a densely populated city and streets with some vegetation cover and bared soils. Upper left point Lat. 33° 21′ 25.73″ N, Long. 44° 17′ 3.39″ E, lower right point Lat 33° 8′ 31.78″ N, Long. 44° 32′ 34.90″ E, within an area of about 530 km^2. The Tigris River appears in the study area and bisects the capital into two halves, considered one of the most important landmarks of the land cover. The average height of the region is about 36 m over sea level, decreasing from north to south; Figure 1 represents the map of 1/100000 for the region of interest.

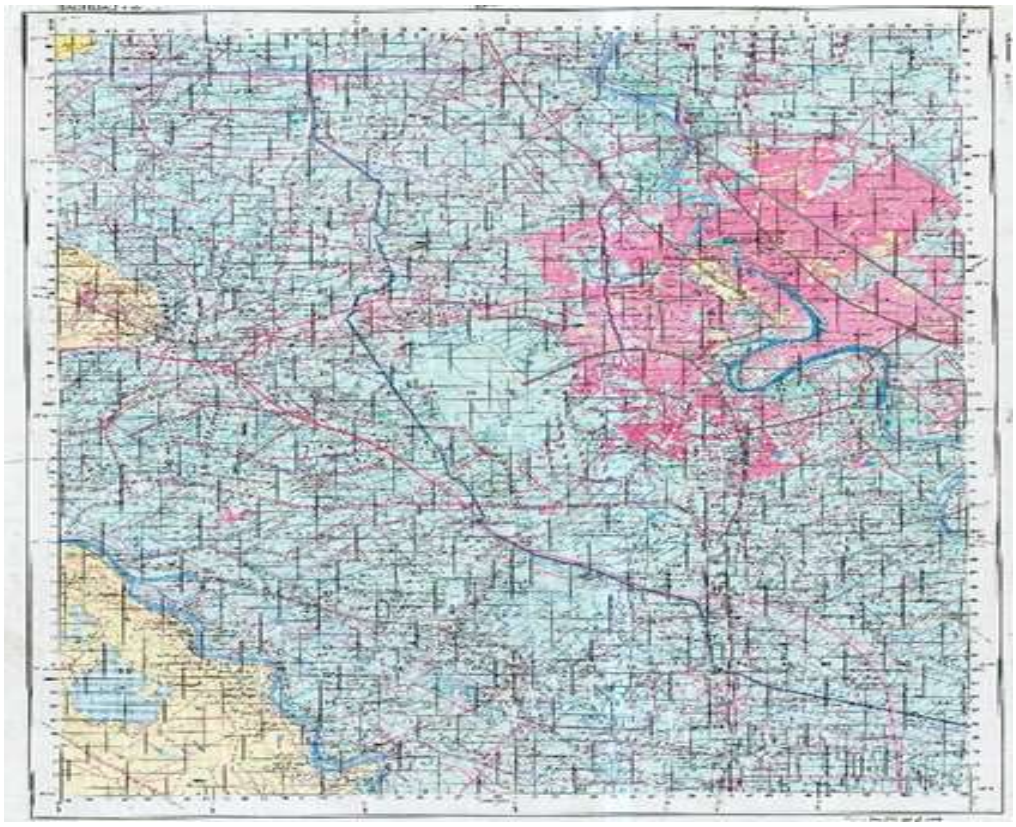


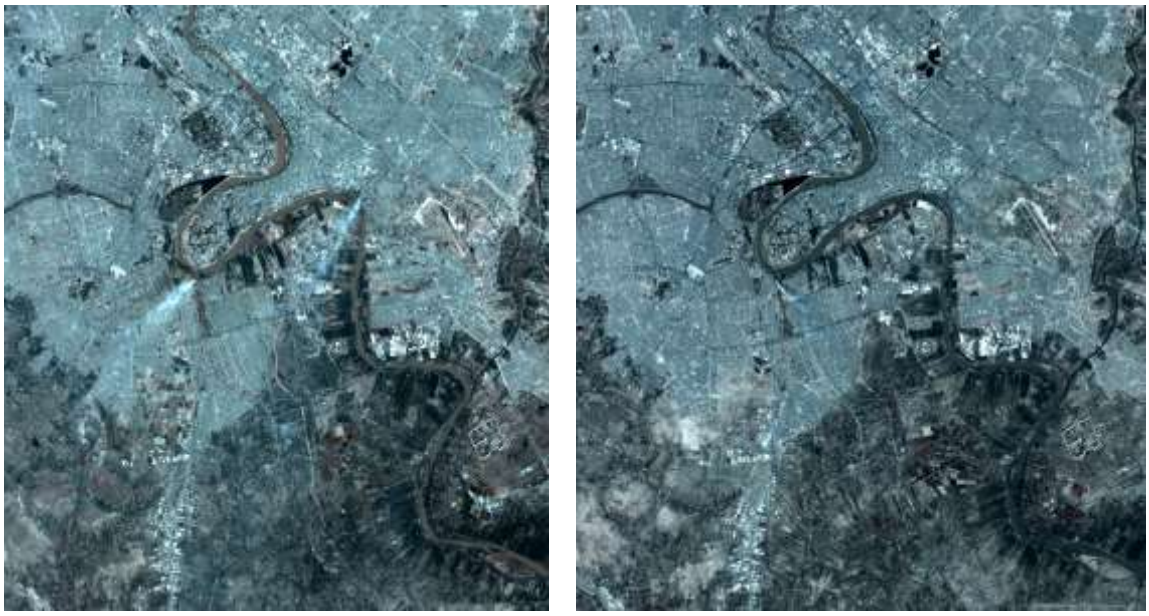
Figure 1: A Topographic Map Represent The Region of Interest

The available data consists of three visible bands for the Landsat series, path (168) and row (37) in the Landsat Images index, where all images were exposed in December 2000, 2010, 2015, and 2017. The images are free from radiometric errors and cloud effects, subsetted from the origin scenes in 800×800 pixels with a ground spatial resolution of 28.5m. All images are georeferenced from the provider. Table 1 shows some of the header information of the satellite images, and Figure 2 represents a quick look at those images.

Table 1: Some of the Header Information for the Images, [3]

Exposure Date	2000	2010	2015	2017
Sensor	Landsat5 TM	Landsat5 TM	Landsat8 OLI	Landsat8 OLI
Projection	UTM Zone38 N	UTM Zone38 N	UTM Zone38 N	UTM Zone38 N
Datum	WGS84	WGS84	WGS84	WGS84
Spatial Resolution m	30	30	30	30

2000 **2010**



2015 **2017**

Figure 2: A Quick Look for The Satellite Temporal Images, RGB Composite

3. Methodology

Calculating digital change and classifying covariance results are essential applications of using remote sensing data, especially in the case of LULC. One of the essential things in LULC applications is to know the relationship of the elements and how they interact, their relationship to climatic conditions, and the nature of human work and planning in the study area [**4**]. For calculation, the following represents the general description of procedures.

a. The Digital Change Detection.

Digital change detection algorithms are widely used in remote sensing applications such as image differencing, rationing, Principal Components Analysis, PCA detector, etc. In all these methods, there is a general condition, such as the two or more temporal images must be the same in spatial resolutions, although from different sensors, same quantization digit

numbers, the images must be well matched to the accuracy of less than half a pixel. It is preferable to perform change calculations for the same spectral bands, and sometimes it is available to perform the calculations for different spectral bands. The mathematical calculation is given as [**5**];

$$Change_{(differncing)} = b1 - b2 + c \quad (1)$$

$$Change_{(ratioing)} = \frac{b1}{b2 + 1} \quad (2)$$

Where *b1* and *b2* are the temporal bands.

c: is a digital threshold value that can be determined by extracting perfect results.

For the PCA detector, all temporal bands must be merged in one computer file; therefore, applying the PCA kernel, the first PC represents the enhanced image or no change, the second PC represents the changing image, and the other PCs are noise [**6**].

b. The Vegetation and Soil Detection.

The vegetation and soil detection methods depend on the red and near-infrared bands. The Normalized Difference Vegetation Index (NDVI) is a vegetable cover detector based on the satellite images' spectral bands. The reciprocal of the NDVI is NDSI, such as;

$$NDVI = \frac{NIR - \mathrm{Re}\, d}{NIR + \mathrm{Re}\, d} \quad (3)$$

$$NDSI = \frac{NIR + \mathrm{Re}\, d}{NIR - \mathrm{Re}\, d} \quad (4)$$

NIR and *Red* are near-infrared and red bands for the same scene [**7**].

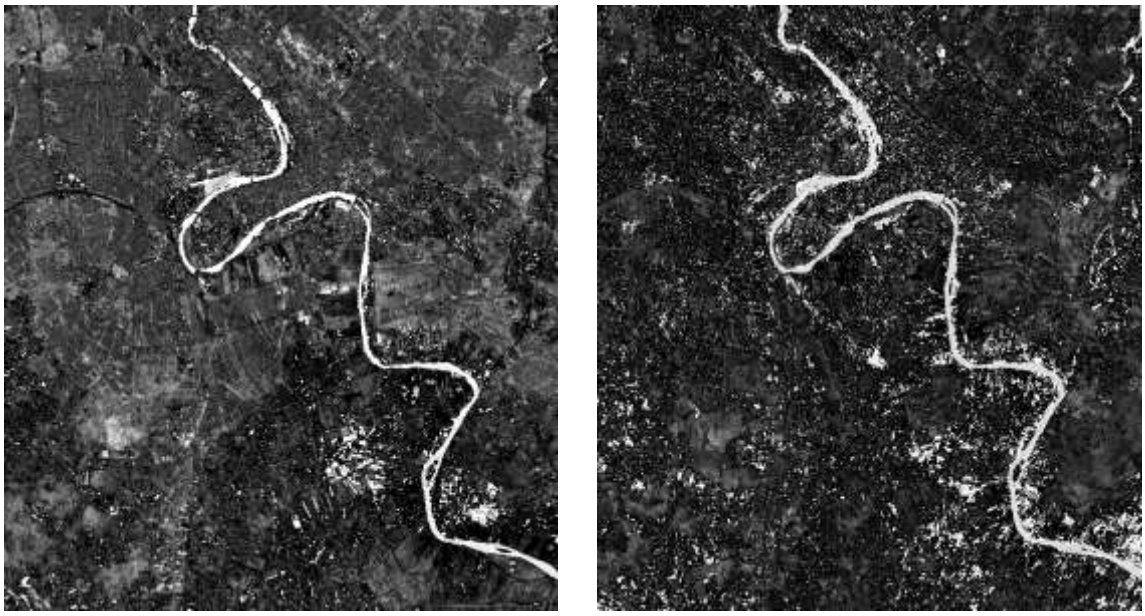
c. The Classification Methods

Classification of satellite images is one of the most important stages of any remote sensing project, as it is essential to isolate LULC classes depending on the digit numbers value. The classification of satellite images is generally divided into two main methods: supervised and unsupervised. Each method was evaluated using many digital and statistical algorithms. The main difference between the two methods is that in the supervised classification, the user must train the computer about the class types and colors, while in the second method, the computer examines the satellite image according to the maximum and minimum digital numbers. Also, the user must feed the computer the total number of classes. In this research, the two methods will be used to extract the LULC features [**8**].

4. Results and Discussion

The results included digital change detection calculations, such as image differencing, image rationing, and PCA kernal as change detector. The results showed the classification output for the above change detection as in the following.

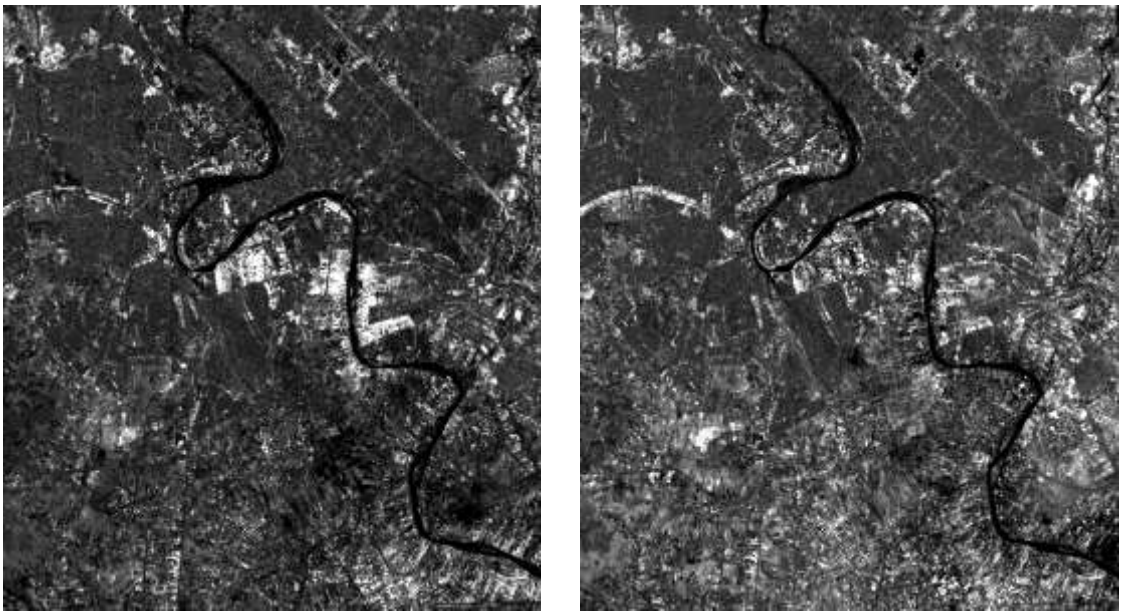
The differencing change detection was performed using the green band from the satellite temporal imagery; the reason for using this spectral band is that it is free from radiometric errors, as shown in Figure 3. The thresholding value used for extracting this result, i.e., the (c) value in equation (1), is about 55.



2017-2000 **2010-2000**

Figure 3: The Image Differencing Results for Green Band

The digital change detection image rationing was extracted for the green band with the same temporal images; Figure 4 represents the results. The differencing and rationing results were evaluated using the written program in Visual Basic.



2017 /2000 **2010/ 2000**

Figure 4: The Image Rationing Results for Green Band

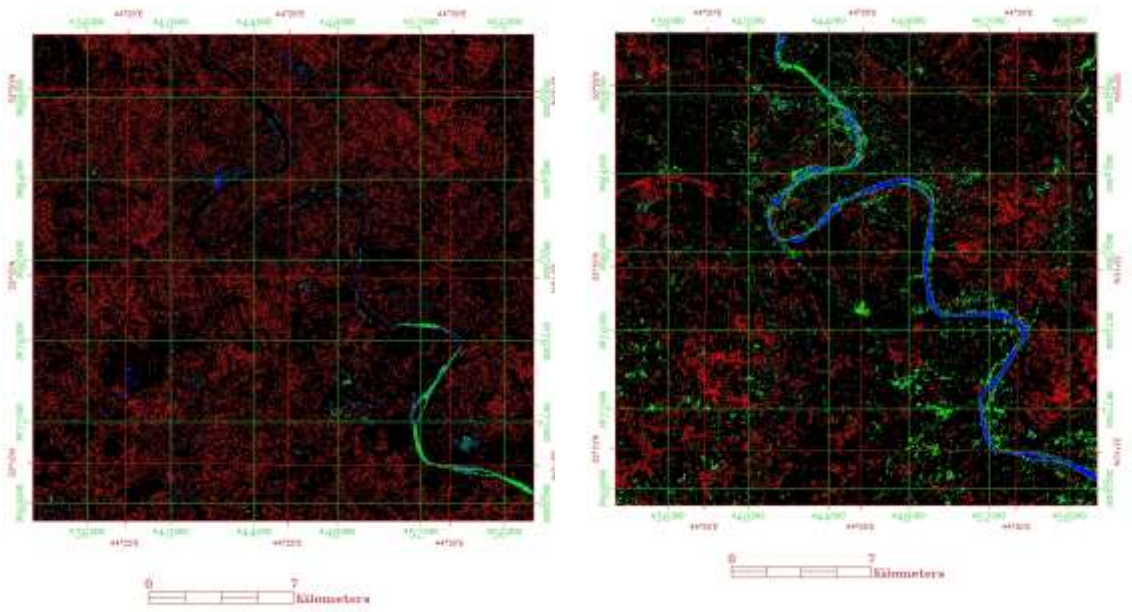
The PCA change detector was performed using the ENVI transformation facility; all temporal imagery was merged in one image file of 12 spectral bands, i.e., using three bands from each temporal imagery. After applying the forward PCA transform, the first PC is the no change image (enhanced image), and the second PC is the changing image, whereas the other PCs are considered as noise; Figure 5 represents the changing image (PC2), and the Eigenvalues of the variance-covariance matrix are given in Table 2.

Figure 5: The PC2, Change Image yielded From PCA Change Detector.

Table 2: The Eigenvalue for forwarding PCA Transform

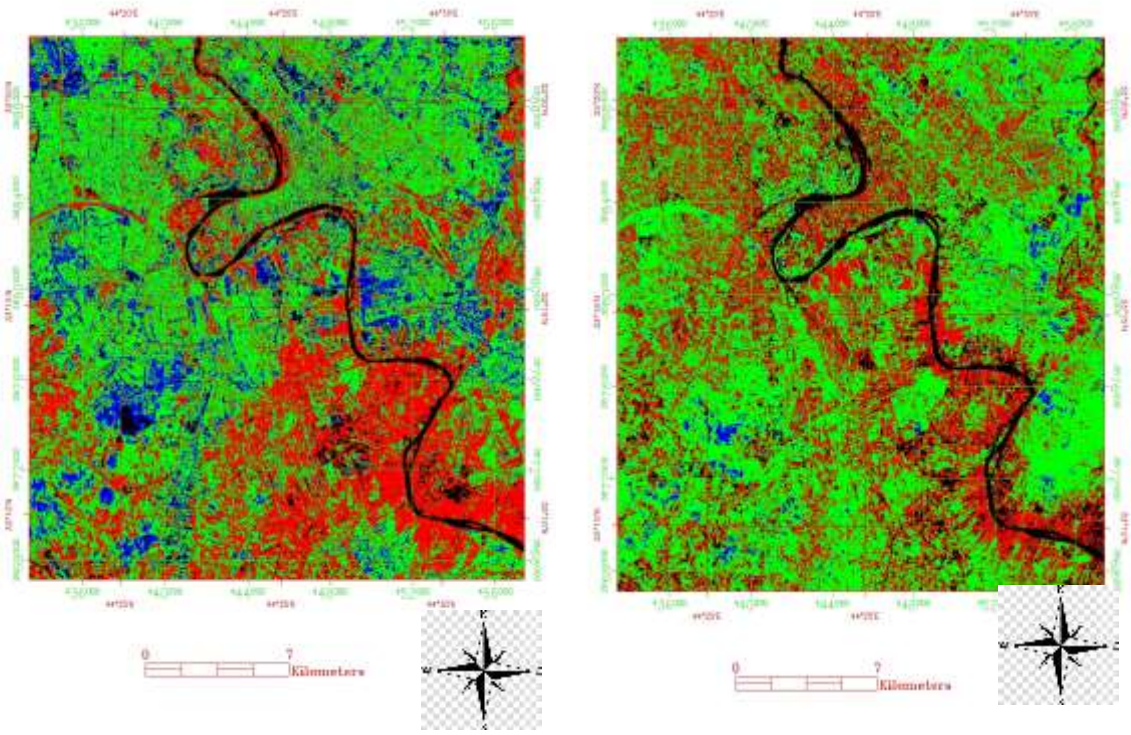
PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12
0.68	0.18	0.095	0.009	0.008	0.006	0.004	0.0009	0.0007	0.0005	0.0004	0.0003

The supervised and unsupervised classification methods were used to extract the changes in (LULC) in a part of Baghdad city (during 2000-2017). The minimum distance classifier was used for supervised, whereas the K-mean classifier was used in the unsupervised classification methods. These methods were applied to the change results, including differencing, rationing, and PCA change detector. The Figures (6 to 10) represent the classification results as described in each figure's captions. In all figures, the red n umber represents the UTM projection, whereas the green numbers denoted the geographic projection.



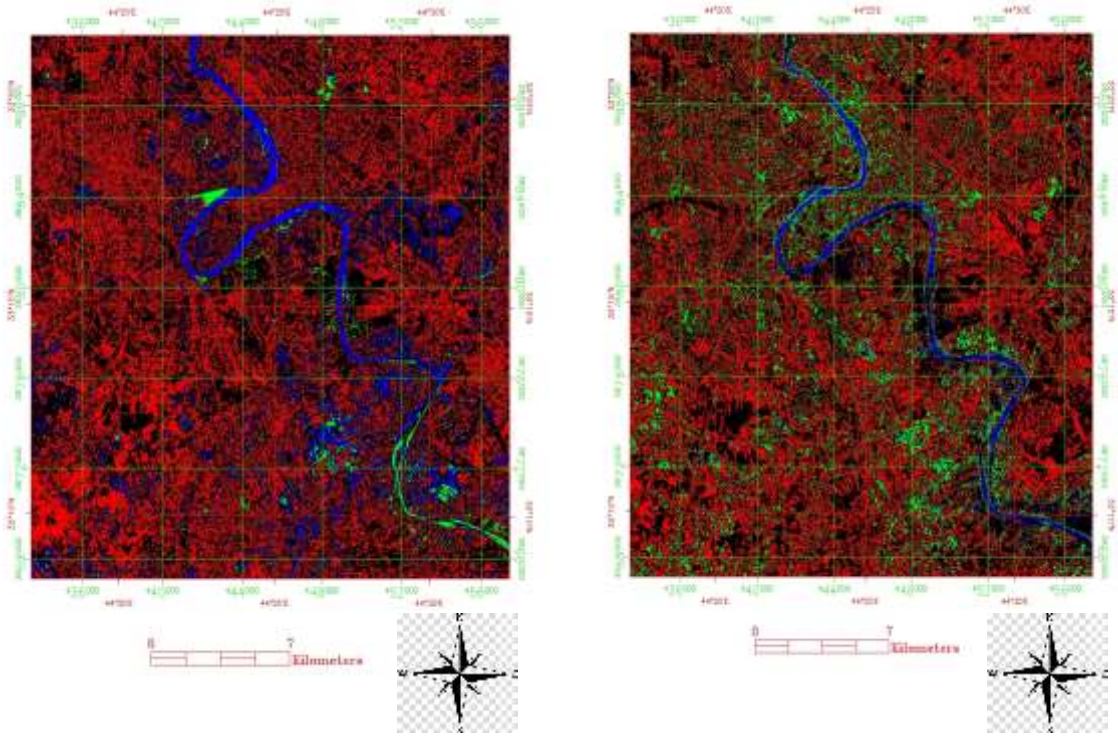
2017-2000 **2010-2000**

Figure 6: The Supervised –Minimum Distance Classifier For Differencing Change



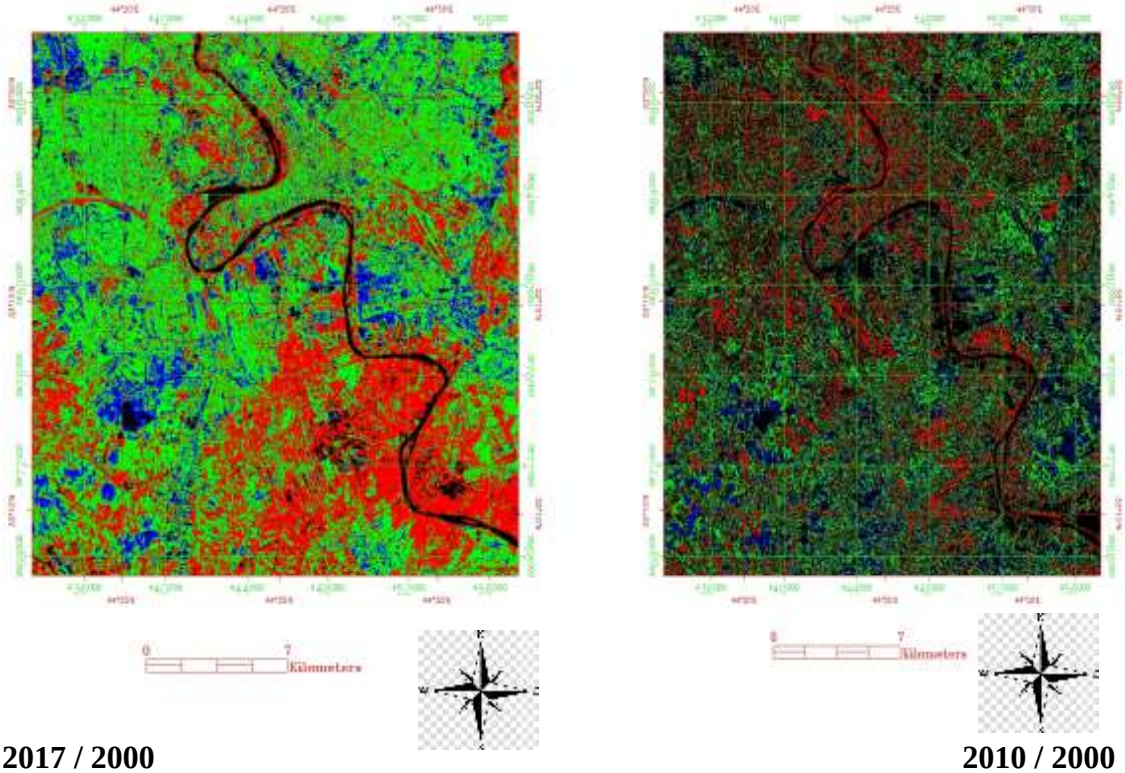
2017-2000 **2010-2000**

Figure 7: The Unsupervised –K-Mean Classifier For Differencing Change



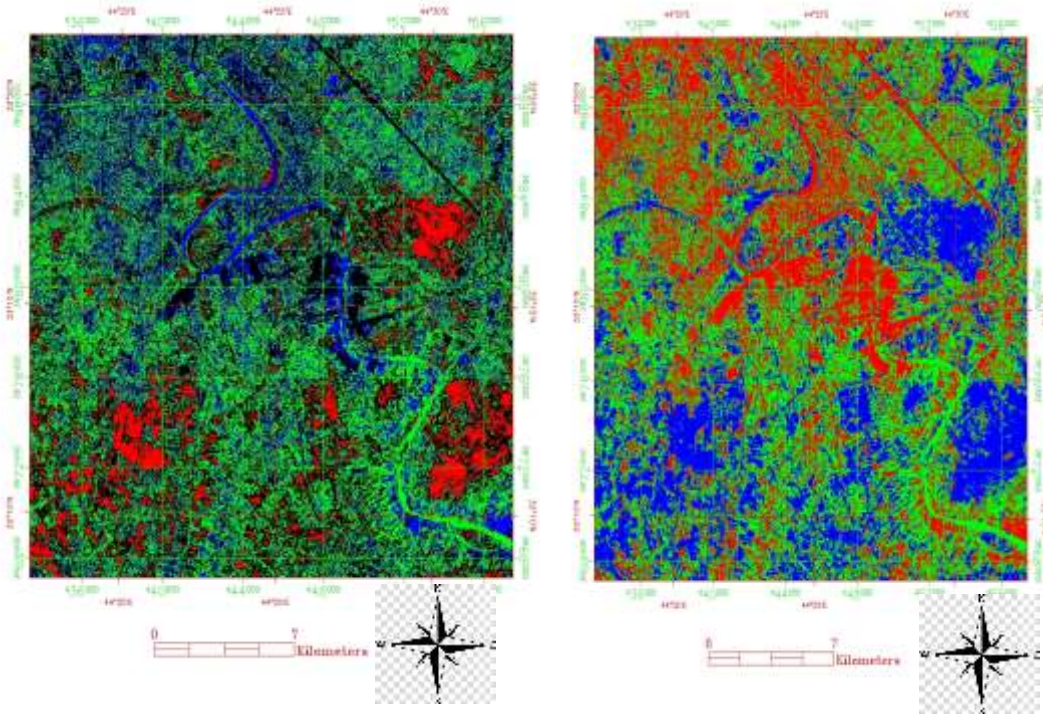
2017 / 2000 **2010 / 2000**

Figure 8: The Supervised –Minimum Distance Classifier For Rationing Change



2017 / 2000 **2010 / 2000**

Figure 9: The Unsupervised –K-Mean Classifier For Rationing Change



Supervised- Min. Distance **Unsupervised- K- Mean**

Figure 10: The PC2 (Change Image) Classification Results

From the change and classification results, the following can be considered such as;

1. For LULCC extraction, the total number of classes is considered as three: water, vegetation, and urban area, and this is true through field data, as Baghdad city has faced

random buildings spreading, even within the administrative borders of the province, since 2006-current.

2. From change detection, the appearance of the Tigris River from all methods was clear and strong; the reason is due to the pollution of the river with soil sedimentation and the decline of water levels, which led to a difference in the spectral reflectance of water.

3. The change detection basis was adopted in 2000, where the results were calculated based on a comparison with the year 2000.

4. From classification results, the change in LULC can be calculated in the Km^2 unit for each feature. The calculation was based on each pixel representing 30*30 m^2 on the ground.

5. In general, the supervised results are more accurate than the unsupervised; this was true due to the training areas (Region Of Interest, ROI) fed to the program.

6. The differencing and rationing classification changes go to some error from the radiometric and images histogram, so the PCA change detector was considered best for change extraction; it can be noted from the change detection results.

7. From the PC2 unsupervised classification, the urban expansion is about 157 km^2 for all periods, within a percentage ratio of 27.3%.

8. From the PC2 supervised classification, the urban expansion is about 44 km^2 for all periods, within a percentage ratio of 7.8%.

9. The average urban expansion of the two methods is about 100 km^2, within a percentage ratio of 17.3%.

10. From the real field data, all the urban expansion occurred in the vegetative areas, i.e., the decrease in the vegetative areas equals the increase in the urban areas with the same value and percentage ratios.

11. The other features, such as roads, highways, etc., have not changed.

12. These changes caused many environmental problems, such as the increasing weather temperature; the global weathering sites recorded more than 50 $\mathring{C}$ in from Julay 1, 2020 to September 1, 2020.

5. Conclusions

1. A part of Baghdad city was considered a study area to find the change in LULC (2000-2017).

2. The Landsat visible band's four full scenes were used for this purpose.

3. The area has been subjected to solid land use and cover changes from the digital change detection and classification methods.

4. The Tigris River suffers from pollution due to water level declination, developing islands, and increasing soil sedimentation.

5. The increase or expansion of urban areas was constructed on the vegetative areas, causing many environmental problems.

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