Assessment of the Land Use-land Cover Changes in Baghdad City Before and After 2003

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Abstract

Monitoring changes in land use/land cover are considered crucial issues in environmental sustainability strategies processes. In this study, the supervised technique was followed to classify the land cover of Baghdad city as a study area of this paper, and to demonstrate both the benefits and viability of employing optical satellite data to estimate and monitor the various land cover categories. The purpose of this research is to determine the trends in land use and land cover change in the Baghdad metropolitan region. As a comparison between two important dates that are before and after the year 2003. Land cover types were classified into 7 categories through supervised classification using two types of satellite imagery. The first one is Landsat 7 for the date 2002, and Sentinal-2 for the date 2019. This study reveals that a big increase in the urban category, with a decrease in the total green land category. The other indicator obtained by this study is the great expansion that occurred in the urban category at the expense of agricultural lands and the groves category. This expansion has resulted in the unplanned growth of settlements and the difficulties that go with it. These are the primary negative consequences of this region's increasing urbanization.

Keywords: Land Use-land Cover, Supervised Classification, Urban Category and Baghdad.

تقييم تغيرات استخدامات الأرض والغطاء الأرضي في مدينة بغداد قبل وبعد عام 2003

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بغداد – العراق

الخلاصة

تعد مراقبة التغيرات في استخدامات الأرض– الغطاء الأرضي من المواضيع المهمة في عمليات استراتيجيات الاستدامة البيئية. في هذه الدراسة أتبعت تقنية التصنيف الخاضع للإشراف لغرض تصنيف الغطاء الأرضي لمدينة بغداد، وكذلك لبيان فوائد وإمكانية استخدام بيانات الأقمار ألاصطناعية (الطيفية الضوئية) لتقدير ورصد التصنيفات المختلفة للغطاء الأرضي. تهدف هذه الدراسة إلى التعرف على اتجاهات استخدامات الأراضي وتغير الغطاء الأرضي في بغداد كمقارنة بين تاريخين قبل عام 2003 وبعده. صنفت أنواع الغطاء الأرضي إلى 7 فئات من خلال التصنيف الخاضع للإشراف باستخدام نوعين من صور الاقمار الاصطناعية. الأول هو Landsat 7 لتاريخ 2002، والثاني Sentinal-2 لتاريخ 2019. كشفت الدراسة عن زيادة كبيرة في الفئة العمرانية، مع انخفاض إجمالي للأراضي الخضراء. وان هذه الزيادة الكبيرة في التغيير العمراني كان على حساب الأراضي الزراعية والبساتين من خلال ولادة النمو العشوائي للمستوطنات والمشاكل المرتبطة بها. هذه هي النتائج السلبية الرئيسية التي تمخضت عن هذه الدراسة.

الكلمات المفتاحية: استخدام الأراضي – الغطاء الأرضي، التصنيف الخاضع للإشراف، الصنف الحضري وبغداد.

Introduction

Changes in land use/land cover (LULC) have an impact on the both of a regional and local climate, biodiversity, water and carbon, for that have been thus considered as a main factor of environmental change. (Grimm, *et al*., 2008); (Turner, *et al*., 2007). The availability of accurate data on the status of changes land use/land cover is important for ecosystem monitoring, land use management, the environmental change studies, and planning (Turner, *et al*., 2007). Remote sensing spatial-temporal change is the analyzing variations in the state of an object or phenomenon by remotely monitoring it at two or more different times. (Pilon, *et al*., 1988). Urban growth monitoring in developing countries has become a major application of remote sensing data and GIS. The definition of the concept of urban growth monitoring is the method for finding variations in land-cover and land-use characteristics depending on multi-temporal remote sensing data. Some researchers have studied the accurate of changes in monitoring land-cover and land-use in several varieties of environments (Shalaby and Tateishi, 2007). The land use and urban expansion in remote sensing include analysis of two recorded, aerial or satellite multi-spectral bands taken at two separate times from the same geographical area. This type of analysis seeks to detect changes that have occurred in the same geographical location between the two times under consideration (Radke, *et al*., 2005). Satellite remote sensing is a potentially powerful means of monitoring land-use change at high temporal resolution and lowers costs than those associated with the use of traditional methods (El-Raey, *et al*., 1995). Remote sensing data is very useful because of its synoptic view, repetitive coverage, and real-time data acquisition. Remote sensing data have been widely employed for land use/land cover categorization and analysis of change because they clearly depict spatial patterns of changes in land use/land cover over a vast geographic area in a recurring and consistent manner. (De Fries, *et al*., 1998); (Vogelmann, *et al*., 2001); (Homer, *et al*., 2007); (Peng, *et al*., 2012); (Zhang, *et al*., 2014). Several approaches for analyzing land cover change using remotely sensed data have been developed. (Coppin, *et al*., 2004); (Lu, *et al*., 2004); (Hussain, *et al*., 2013); (Tewkesbury, *et al*., 2015). These approaches can be divided into two types: post-classification comparison and pre-classification change detection. (Singh, 1989); (Lu, *et al*., 2004).

The aim of current research is to determine the trends and patterns, as well as the change of intensity in land use/land cover of Baghdad province for the period before and after 2003.

Materials and Methods

Study Area

This study focused on the whole area of Baghdad province and around it. It is the capital of Iraq, located in the central of country Figure (1). Geographical area of Iraq located at 38° 45′ to 48° 45′E and 29°5' to 37°22'N. The whole area of 435,052 Km2, contained main four categories follows: Desert, Mesopotamia (between the Euphrates and the upper of Tigris Rivers), Highlands and, Lower Mesopotamia. The geographical location of Baghdad province center is at the 44.43333°E, and latitude 33.33333°N, which covers a total area of 846.29 Km^2. It is located at an altitude of 34 meters above sea level.

The Study Area's Climate

The temperature in the study area varies greatly between winter and summer seasons, also between day and night throughout the year, reaching maximum temperatures of roughly 45-50°C. Annual rainfall ranges between (100-180) mm.

The majority of the rain falls between December and April. (Planning, *et al*., 2002).

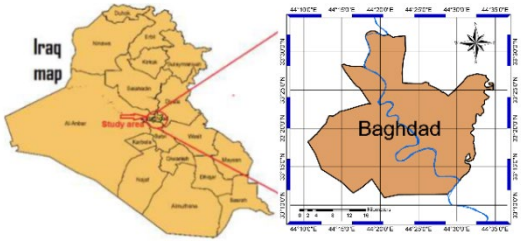


Figure (1) Study Area.

Methodology

Materials and Software Packages

Two types of satellite images are used in this study. The first one is the Landsat 7 ETM image (30 m Spatial Resolution) to presents the period before 2003. The second satellite image is the Sentinel-2 (20 m Spatial Resolution) to presents the period after 2003, Having a time span of several years that has been used to examine the changes in the environment. The track of the satellite images that have been downloaded in this study are: Path168 /row 37. (April 15, 2002) for the Landsat and for the Sentinel-2 image was in (April 14, 2019). The data utilized in this study was obtained from the website www.earthexplorer.com. Were taken during the same season (Spring Season) were clouds free. For image processing and analysis, ArcView-GIS software was employed.

Image pre-processing

For the purpose processing of the satellite images, Arc Map 10.5 software has been used. Several types of image preprocessing have been applied.

Classification of Images

Based on the classification methods, both satellite images classified for the two dates in 2002 and 2019. In the supervised classification technique, the maximum livelihood algorithm will classify the image based on the training sets (Signatures) provided by the user based on his field verification. The supervisor classification finally gives land use/land cover image of the study area. Seven classes of land use/land cover have been determined in the whole study area, they are as follows: urban, green land, uncultivated agricultural land, and grove class, as well as water bodies, bare area, and patio class. These classes are present the main land cover types in the study area. Figure (2) depicts a summary of the processing processes used in this study.

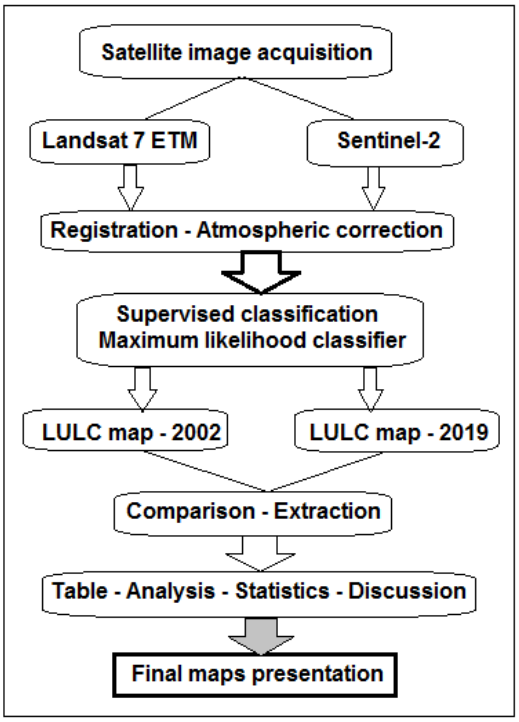


Figure (2) Flow-chart of the Methodology.

Results and Discussion

Image classification results in this study for two dates April 2002 and April 2019 are shown in Figures (3 and 4). The maps that arise are color-coded, with seven classes reflecting the extent of the differences between the two photos. The categories of classes were divided as followed: Urban, green land, uncultivated agricultural land, grove, bare area, patio, as well as water. The measured area for every category as well as the statistical analysis for the two dates April 2002 and April 2019 for the whole area of Baghdad city were shown in Table (1). This was given special consideration to the

category of green land, uncultivated agricultural, and urban as well as grove class because they are the primary goal of this research.

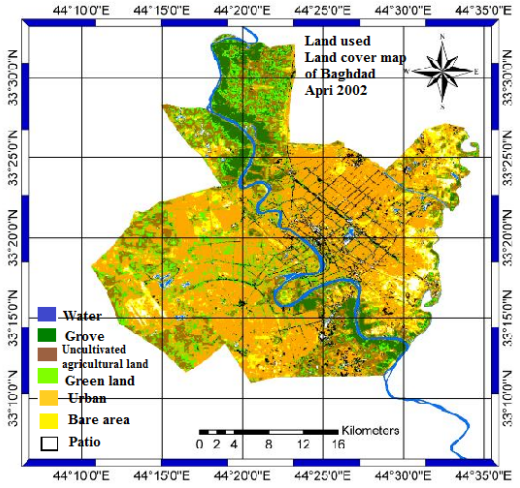


Figure (3) Land Used Land Cover Map of Baghdad /April 2002.

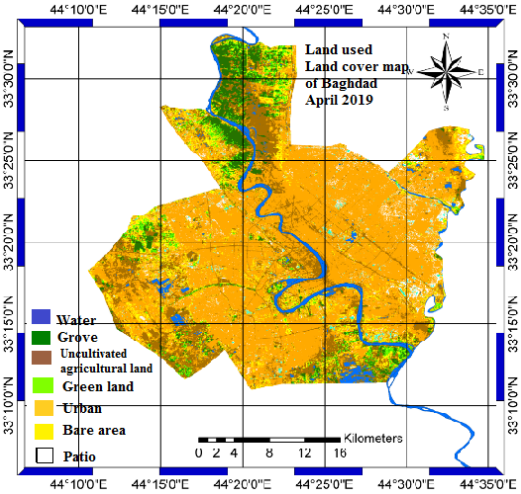


Figure (4) LULC Map of Baghdad /April 2019.

Based on the classification maps, Table (1) shows in 2002, urban areas spanned approximately 385.0947 Km^2 and have since grown to 465.4132 Km^2 in 2019. On other hand, the dense of the green land category decreased from 123.4557 Km2 (in 2002) to 24.262 Km^2 (in 2019). Regard to the uncultivated agricultural land category. It is increased from 79.5996 km^2 (In 2002) to 159.424 Km^2 (In 2019), and for the groves category, also found decreases in the total area of them. From 57.5766 Km^2 (In 2002) to 46.186 Km^2 (In 2019).

To analyze the trends and the geographical locations of the categories changing, an image of each category in the study area was extracted from both LU/LC maps in Figures (3 and 4). Figure (5) shows the statistical comparison in the areas of the main four LULC categories between the two years (2002 and 2019), because they are the primary goal of this research as mention above. Based on these photographs of urban expansion, it is possible to deduce that the urban region has been greatly expanded. Also, in Figure (6) can understand the percentage changes in the area of each category. Baghdad province has seen more rapid changes in LULC, especially in built-up/urban areas, than in other land use categories. The data found that urban areas rose from 385.0947 Km^2 to 465.4132 Km^2 compared the year 2002 to the year 2019. Which resulted in a substantial reduction in the area of green land, vegetation, cultivated areas.

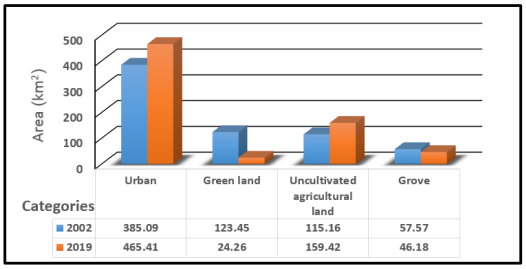


Figure (5) Demographics of the Study Area (Baghdad) between Date 2002 and 2019.

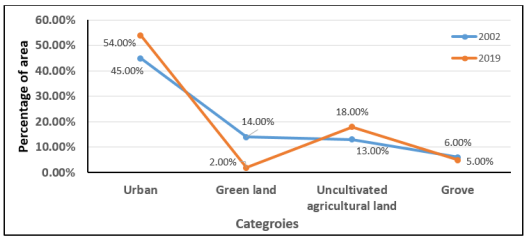


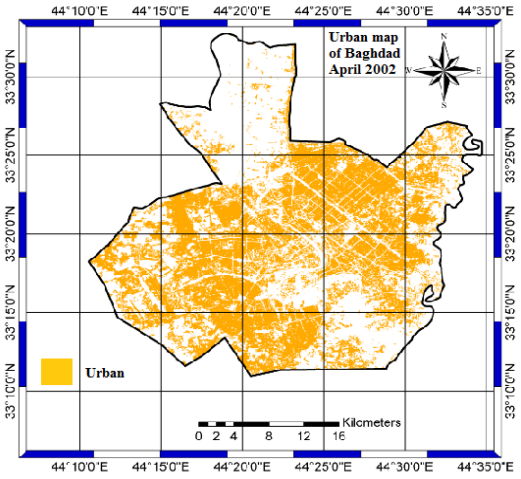
Figure (6) Comparison in the Percentage of Area for The Categories Based on The Study Area in The Years 2002 and 2019.

Table (1) The Total Area of Categories Based on the LULC Classification of Baghdad City in April 2002 and April 2019.

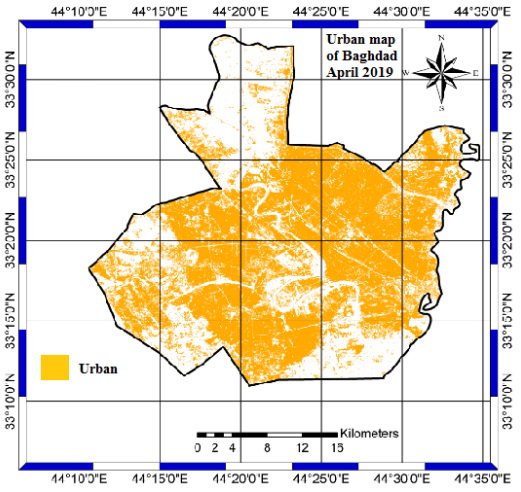
No.	Category of LU/LC	Area(km²)			
		April 2002	Percentage of the Category Based on Study Area	April 2019	Percentage of the Category Based on Study Area
1	Urban	385.09	0.45	465.4132	0.54
2	Green land	123.45	0.14	24.26	0.02
3	Uncultivated Agricultural Land	115.16	0.13	159.42	0.18
4	Grove	57.57	0.06	46.18	0.05

In addition, urban expansion has gone beyond agricultural land which led to a decrease in the area of agricultural land. This expansion of urban areas has caused an extensive bad environmental impact. The expansion of unplanned settlements has been the biggest negative consequences of Baghdad's rapid urban development. The reduction of green land in the city has a bad impact on the ecosystems of the city. So, the concerned authorities should initiate a strict law to prevent the transformation of green land into residential areas.

Figures (7 to 10) explain the spatial changes that are happened in the main four categories urban, green land, uncultivated agricultural land, and grove, which are distributed in the whole area of Baghdad city. As well as showing the comparison of changes between the two dates year 2002 and year 2019.

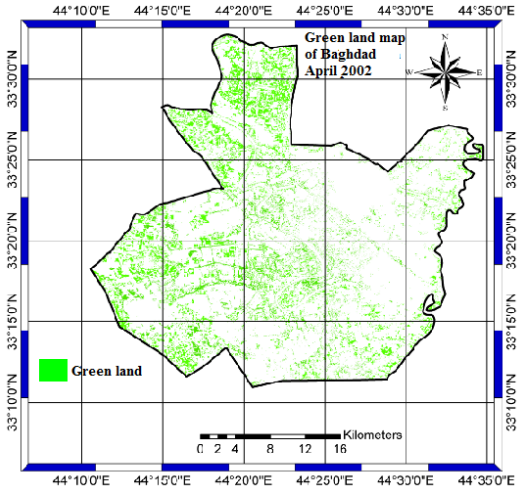


(a) Urban Category / April 2002.

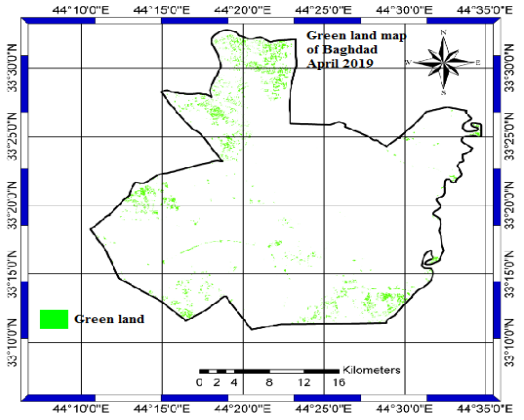


(b) Urban Category / April 2019.

Figure (7) Urban Map of Baghdad/ (a) April 2002. (b) April 2019.

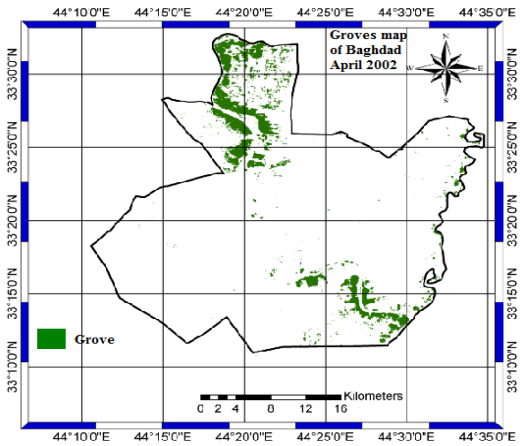


(a) Green land Category/ April 2002.

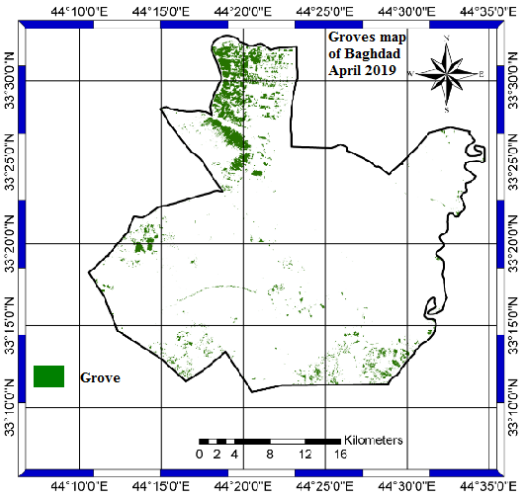


(b) Green land Category/ April 2019.

Figure (8) Green land Category Map of Baghdad/ (a) April 2002. (b) April 2019.

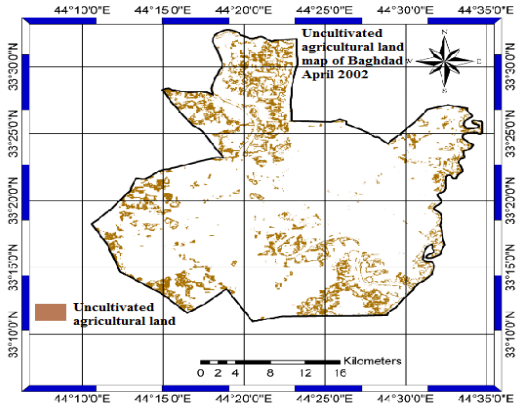


(a) Groves Category/ April 2002.

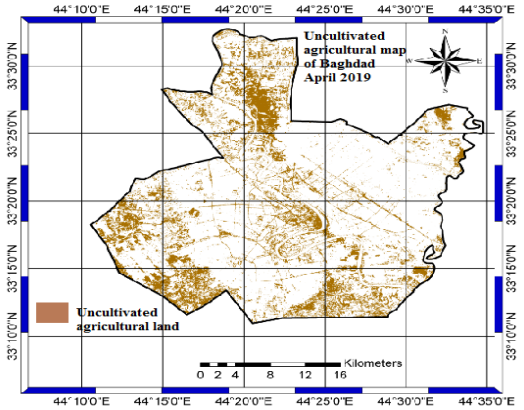


(b) Groves Category/ April 2019.

Figure (9) Green land Category Map of Baghdad/ (a) April 2002. (b) April 2019.



(a) Uncultivated Agricultural Land Category/ April 2002.



b) Uncultivated Agricultural Land Category/ April 2019.

Figure (10) Uncultivated Agricultural Land Category Map of Baghdad/ (a) April 2002. (b) April 2019.

The results show significant urban expansion in Baghdad city associated with contraction of green areas. These results can be attributed to the high annual rate of population increase in the city of Baghdad as well as human economic conditions successively affecting Iraq in general. The results were obtained based on the remote sensing and the Geographic Information Systems methodology to identify changes in LULC in Baghdad city during the years before and after 2003. The supervised classification results showed a variation in LULC due to the effects of the human activities. The declines in the area of vegetation cover were associated with converting agricultural, and open land into populated areas for industrial and commercial uses, in addition to a large number of random settlements that appeared after 2003 in Baghdad city .

Similar changes in LULC that has been happened in many cities around the world. One of these cities is Greater Cairo Metropolitan. The Greater Cairo Metropolitan Region has experienced an unprecedented rate of informal urbanization over productive arable lands, forming. Recent data show that 62% of Greater Cairo and 87% of Giza are informal settlements resulting from urban sprawl, with 80% of these informal settlements built on privately owned agriculture lands (Youssef, *et al*., 2020).

Conclusions

The outputs of this research can be used to evaluate and detect the changes as an increase or decrease for the main categories of LULC that had happened in Baghdad city after the year 2003. This study has been focused on the four main important categories that are related and have an effect on the environment. These important categories were urban, green land, uncultivated agricultural land, and grove class because they represent the main objective of this study. The results of using remote sensing and GIS techniques revealed that Baghdad's environment has altered dramatically. When comparing the years 2002 and 2019, the urban area has grown by more than 9%. In addition, the categories of green land in Baghdad city have decreased so much. The decrease was about more than 12% in the year 2019 compared with the year 2002. The study's conclusion gives an idea that remotely sensed tools are useful regarding monitoring land use/land cover in cities and will give the right information to the interesting decision-making for future planning and monitoring strategies. Furthermore, this study makes the following recommendations to be utilized as rules for planning in the future also in the expansion of urban and monitoring of Baghdad's green land.

1- Detail field work is needed to get more accurate LULC map.

2- The planning for the two levels long-term and the Short-term is very important for directing development to the right place and avoiding the wrong development.

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