Spatial-Temporal Analysis of Land Use and Land Cover Change Detection Using Remote Sensing and GIS Techniques

Karar H. Fahad*, Hussein S.† and Hayder Dibs‡

1 Surveying Engineering Department, College of Engineering, University of Baghdad
2 Hydraulic Structures Department, Water Resources Engineering Faculty, Al-Qasim Green University, Babylon, Iraq.

Email: Dr.hayderdibs@wrec.uoqasim.edu.iq

Abstract. Remote sensing has become a central factor in approaches to managing natural resources and observing environmental fluctuations. Urban development has brought severe losses of farming land, vegetation land and water bodies. Urban sprawl is responsible for a variety of urban environmental issues including reduced air quality, increased local temperature and reduction in water quality. In this study, we have taken the city of Baghdad as a case study and explore the land use and land cover variation that took place over approximately 28 years from 1990 to 2018. Remote sensing practice was implemented to analyse the city of Baghdad’s land cover and land use changes throughout the study period. Landsat TM and OLI 8 images of Baghdad were collected from the USGS Earth Explorer website. Having pre-processed the image, we used supervised classification to categorize the images in different land cover classes. The study region was classified into five categories: urban area, water bodies, vegetative area, barren land and wetland. The accuracy assessment of classification we obtained was 85.11% and 88.14%. From these results, change detection analysis shows that urban area and soil land levels have gone up by 3% and 20%, respectively. In another area the vegetation has diminished, wetlands and water bodies have also decreased by 5%, 17%, and 1% respectively.

Keywords: Land use, Land cover, GIS, RS, Classification

1. Introduction
The term ‘land use’ usually refers to the changes wrought on the surface of earth by way of increasing human activities. ‘Land cover’ refers to the physical manifestation of the surface of the earth; the distribution process of water, soil, vegetation or urban area arrangement. Land cover and land use are distinct terms but they represent interrelated concepts. Information about land cover and land use variation has a significant role in domestic, local and also on general scheduling and administration. Frequently, the scheduling and organization of environmental projects and tasks are disturbed due to a lack of information on land use and land cover variations.

Changes to and variations in the land cover tend to happen in a progressive manner, but from time to time such changes might be fast and unexpected, because of human activities [1-3]. Land use and land cover modifications may threaten the ecosystem as an outcome of the devastation of areas nature and vegetation [2-4]. Land cover and land use variations are among the major human activities changing hydrology [7-9]. Remote sensing provides advantages for land cover and land use mapping and analysis of relevant alterations. The main benefits of remote sensing techniques include the capacity for repetitious covering that is essential for modification discovery studies on a worldwide scale. The
variations in land cover and land use due to human and natural activities may be monitored through contemporary and stored remote sensing [8-11].

Remote sensing can determine modifications in land cover and land use and monitor the effects of human and natural activities. Among the most important benefits of remote sensing are savings in cost and time. Land cover and land use products are used for worldwide mapping, altering identification, scenery planning. Image classification using remote sensing may be regarded as a combination of image processing and techniques of image classification [3, 4, 12-19]. Multi-spectral image classification is a significant method in the quantitative interpretation of remotely-sensed images whereby a multispectral image, that usually involves a pixel, has its properties registered on a number of spectral channels. Remote sensing data plays a significant part in image classification [20-22].

In this paper, we use satellite imagery investigate spatial and temporal changes in Baghdad Province, Iraq, that occurred between 1990 and 2018. Satellite images are regarded as a good method of interpreting changes in land use and land cover, also they permit a full overview of spatial relationships and the ground between, in addition to geographic information systems. The result is an objective map of the ground cover. For this paper, a supervised classification method was applied.

2. Material and method
2.1. Study area
Baghdad is the capital city and economical center of Iraq, as Figure 1 shows. Geographically, the location of Baghdad is in the centre of the country. It now counts among the largest and most important cities in the Middle East, being extremely sophisticated in terms of infrastructure, with large universities and schools, facilities and sports stadia. But, in recent years Baghdad has suffered greatly from severe damage as a result of various military operations and wars. The city of Baghdad is positioned in the central part of Iraq on both sides of the Tigris river with the following geographic coordinates: latitude (33°25′46") to (33°24′21") N, longitude (44°15′55") to (44°17′38") E.

![Figure 1: Maps of the study area.](image-url)
2.2. Data use in this study

In this study we downloaded four satellite images from the USGS website (http://glovis.usgs.gov) covering the 28-year time frame from 1990 to 2018. These satellite images taken are explained in Table 1. It is clear from the table that satellite images of different years were taken during the same season, which permits easy differentiation between land cover and land use. Data sets are projected in UTM projection with zone number 38 and WGS 84 datum. Mosaic was created to cover the whole area. The number of satellite image downloaded were eight in the same month for Mosaic.

| Sensor category | Acquiring date | Spatial resolution |
|-----------------|----------------|--------------------|
| Landsat TM 5    | 20/9/1990      | 30 m               |
| Landsat TM 5    | 20/9/2018      | 30 m               |
| Landsat OLI 8   | 1/9/2018       | 30m                |
| Landsat OLI 8   | 10/9/2018      | 30m                |

2.3. Image pre-processing

The aim of this research was to identify changes in the city of Baghdad, using multi-temporal satellite imaging, with digital image processing such as geometric correction, radiometric calibration, image sub setting and classification. ENVI software was used. Figure 1 shows the outcome of the histogram of radiometric calibration. Supervised classification using a maximum likelihood method was used to categorize areas of interest.

Five distinct categories such as urban area, vegetation, water bodies, soil land and wetlands were applied. Landsat satellite images were used for the detection region. The pre-processing began with radiometric calibration, then noise was eliminated from all the Landsat images. With help topographic map of Baghdad we performed geometric correction of the images to eliminate the alteration from them, which come from differences in orientation sensor parameters and noise from the platform itself. In keeping with the rectification technique the full root mean square error (RMSE) mistakes for 2018 picture were 0.42m. Satellite image of 2018 was regarded as the base data and image of 1990 was registered relative to image 20018.

![Figure 2: Radiometric correction for image of 2018](image)

3. Result and discussions

3.1. Classification

Five categories were created and applied to the region of interest for the four images; we applied a maximum likelihood method at classification stage for every image to generate the thematic map and to
discover the variation between 1990 and 2018. The supervised classification was performed with Envi 5.3 software. More than 60 training locations were gathered for every category. After the classification step the confusion matrix was utilized to determine the accuracy of classifications, certainty sample locations were gathered for validation. Figure 3 shows the thematic maps of land cover for both years.

![Figure 3 Thematic map 1990](image1)

![Figure 4 Thematic map 2018](image2)
3.2. Assessment of classification accuracy
To evaluate the exactness of the classification, each land cover and land use map was matched to a data source. The source data was set by considering random sample point’s historical data of Google Earth and from the topographic map thus, the classification accuracy was proven by the ground samples. Accuracy assessments of classifications for 1990 and 2018 were 85.13% and 88.22% respectively. The accuracy calculation of Landsat TM images was less than that for 2018 and that may be due to the necessity of gathering more samples to gain improved results. As can be seen from Table 2, the kappa statistic for the studied years is over 60% and this shows that the map classification for the years 1990, 2018 can be trusted and is reliable in the development of future plans this corresponds to the findings of both Boyd and Foody (2011) and Group and Science (2011).

Table 2 overall accuracy and kappa statistic

| Classification       | Accuracy assessment | Kappa statistic |
|----------------------|---------------------|-----------------|
| Thematic map 1990    | 85.13%              | 0.81%           |
| Thematic map 2018    | 88.22%              | 0.84%           |

3.3. Spatial-temporal change detection
The variations in land cover and land use identified in this paper were based on the statistics extracted from the two thematic maps of Baghdad city. The variations in land cover throughout the study time frame (1990 to 2018) are visualised in Figure 5. Vegetation, water bodies, wetlands have all been decreased by 6.11%, 1%, 15.58% respectively. Urban area and soil land have been increased by 3%, 20% respectively. The thematic maps for each year, for land cover and land use, are in Table 2.
Table 3: The study area, 1990–2018

| Class          | 1990 Area in km² | 1990 Percentage % | 2018 Area in km² | 2018 Percentage % |
|----------------|------------------|-------------------|------------------|-------------------|
| Urban area     | 347              | 6.79              | 629              | 12.33             |
| Water bodies   | 91               | 1.80              | 41               | 0.8               |
| Wetlands       | 3060             | 59.96             | 2163             | 44.38             |
| Vegetation     | 891              | 17.46             | 589              | 11.53             |
| Soil           | 714              | 13.99             | 1580             | 30.96             |
| total          | 5103             | 100%              | 5103             | 100%              |

4. Conclusion
Baghdad is the biggest town in Iraq and is the country’s capital. This paper sought to identify environmental variations within the period 1990 to 2018. Remote sensing can observe such variations, analysing the modifications in data from satellite images. In this paper, data was obtained from USGS, including Landsat images of Baghdad. The images belonged to 1990 TM, and 2018 OLI respectively. We have used supervised classification of the images to find changes in area five categories, which have been designated as vegetation, urban, water body, soil. Classification accuracy for 1990 and 2018 is 85.13% and 88.22 % respectively. Change detection explains that urban has gone up by 3%, wetlands have declined by 17%, and vegetative areas have also decreased by 5%, as have water bodies (1%). Meanwhile, soil areas increased by 20%. Land use/land cover and Information on opportunities for their optimal use are vital for the choice, planning and realization of land use systems that are needed in the face of increased burdens for human necessities and well-being.

References
[1] Abd, Hayder, Al-Razzaq Abd, and Husam Abdulrasool Alnajjar. 2013. Maximum Likelihood for Land-Use/Land-Cover Mapping and Change Detection Using Landsat Satellite Images: A Case Study South Of Johor. *International Journal of Computational Engineering Research* 3 (6): 26–33. www.ijceronline.com.
[2] Dibs, H, S Al-Hedny, and H S Abed Karkoosh. 2018a. Extracting Detailed Buildings 3D Model with Using High Resolution Satellite Imagery by Remote Sensing and GIS Analysis; Al-Qasim Green University a Case Study. *International Journal of Civil Engineering and Technology* 9 (7): 1097–1108. https://www.scopus.com/inward/record.uri?eid=2-s2.085052391926&partnerID=40&md5=454ef0f42cf2b6e67ffe32fe38a4a6b7b4.
[3] with Remote Sensing and GIS Analysis.” *Journal of University of Babylon, Pure and Applied Sciences* 26 (6): 109–23.
[4] Butenuth M, Gösseln GV, Tiedge M.2007. Integration of heterogeneous geospatial data in a federated database. *Journal of Photogrammetry and Remote Sensing*, 62(5): 32.
[5] Verburg, P.H. (2006). Analysis of the Effects of Land-Use Change on the Protected Areas in the Philippines.
[6] Calder, I.R. 1998. Water Resource and Land-Use Issues, SWIM Paper 3, International Water Management Institute, Colombo, Sri Lanka.
[7] Mahmood Zander, H. 2007. Digital change detection using remotely sensed data for monitoring green space destruction in Tabriz, *Int. J. Environ.* Res. 1 (1): 35–41.

[8] Perumal K and R Bhaskara. 2010. Supervised classification performance of multispectral images, *Journal of Computing*, vol. 2, issue 2, and pp. 124–129.

[9] Agrawal, N. Kumar and M. Radhakrishna. 2007. Multispectral image classification: a supervised neural computation approach based on rough–fuzzy membership function and weak fuzzy similarity relation, *International Journal of Remote Sensing* Vol. 28, No. 20.

[10] Enete C. Ifeanyi, E. N. Adoh and M. O. Alabi. 2010. Evaluation of eco-environmental vulnerability in Efon-Alaye using remote sensing and GIS techniques, *Journal of Geography and Regional Planning* Vol. 3(1), pp. 8–16.

[11] Dibs, Hayder, Shatri Mansor, Noordin Ahmad, and Biswajeet Pradhan. 2015. Band-to-Band Registration Model for near-Equator Earth Observation Satellite Images with the Use of Automatic Control Point Extraction. *International Journal of Remote Sensing* 36 (8): 2184–2200. https://doi.org/10.1080/01431161.2015.1034891.

[12] Gao, J., & Liu, Y. (2010). Determination of land degradation causes in Tongyu County, Northeast China via land cover change detection. *International Journal of Applied Earth Observation and Geoinformation*, 12(1), 9–16

[13] Heydari, S.S., Mountrakis, G., 2017. Effect of classifier selection, reference sample size, reference class distribution and scene heterogeneity in per-pixel classification accuracy using 26 Landsat sites. *Remote Sens. Environ.* http://dx.doi.org/10.1016/j.rse.2017.09.035.

[14] Dibs, Hayder, Mohammed Oludare Idrees, and Goma Bedawi Ahmed Alsalhin. 2017. Hierarchical Classification Approach for Mapping Rubber Tree Growth Using Per-Pixel and Object-Oriented Classifiers with SPOT-5 Imagery. *Egyptian Journal of Remote Sensing and Space Science* 20 (1): 21–30. https://doi.org/10.1016/j.ejrs.2017.01.004.

[15] Dibs, H., Idrees, M. O., Saeidi, V. and Mansor, S. 2016. Automatic Keypoints Extraction from UAV Image with Refine and Improved Scale Invariant Features Transform (RI-SIFT), *International Journal of GeoInformatics*, Vol. 12, No.3, September.

[16] Dwivedi, R.S.; Sreenivas K.; Ramana, K.V. Land-use/land-cover change analysis in part of Ethiopia using Landsat Thematic Mapper data. *International Journal of Remote Sensing* 2005, 26 (7), 1285-1287.

[17] Dibs, Hayder, Ahmed Al-Janabi, and Chandima Gomes. 2018b. Easy to Use Remote Sensing and GIS Analysis for Landslide Risk Assessment.” *Journal of University of Babylon* 26 (1): 42–54. El-Asmar, H.M.; Hereher, M.E. Change detection of the coastal zone east of the Nile Delta using remote sensing. *Environ. Sci. 2011*, 62, 769–777.

[18] Raja, R.A.A.; Anand, V.; Kumar, A.S.; Maithani, S.; Kumar, V.A. Wavelet based post classification change detection technique for urban growth monitoring. *J. Indian Soc. Remote Sens.* 2013, 41, 35–43.

[19] Sun, F.; Sun, W.; Chen, J.; Gong, P. Comparison and improvement of methods for identifying, Water bodies in remotely sensed imagery. *Int. J. Remote Sens.* 2012, 33, 6854–6875.

[20] Volpi, M.; Petropoulos, G.P.; Kanevski, M. Flooding extent cartography with Landsat TM imagery and regularized Kernel Fisher’s discriminant analysis. *Comput. Geosci.* 2013, 57, 24–31.

[21] Yuan, F.; Sawaya, K.E.; Loeffelholz, B.C.; Bauer, M.E. Land cover classification and change analysis of the Twin Cities (Minnesota) metropolitan areas by multi-temporal Landsat remote sensing. *Remote Sensing of Environment* 2005, 98, 317-328.

[22] Zhu, X.; Cao, J.; Dai, Y. A Decision Tree Model for Meteorological Disasters Grade Evaluation of Flood. In Proceedings of 4th International Joint Conference on Computational Sciences and Optimization 2011, Kunming and Lijiang, Yunnan, China, 15–19 April 2011; Institute of Electrical and Electronics Engineers: New York NY, USA, 2011; pp. 916–919.
