Land Cover Mapping using Maximum Likelihood Classification Approach and Sentinel 2 Data in Babil governorate

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Abstract

Deriving land cover information from earth observation satellite data is one of the most common applications for environmental monitoring, evaluation, and management. Land cover mapping using remotely sensed data is more effective when using a robust classification method. In this study, the Maximum Likelihood Classification (MLC) method is applied to remote sensing data from the European Space Agency's new Sentinel-2 satellite program, which was launched in 2015. MLC method and Sentinel 2 data for the date 28 Feb 2019, with a spatial resolution of 10 m were used to in capturing land cover utilizing ArcGIS 10.5 software. Four land cover classes were recognized in Babil, namely water, vegetation, urban area, and bare soil. The results showed that the MLC method is an effective technique with few chances of misclassification. The area and percentage for each class were calculated; water 107 km^2 (2%), vegetation 1387 km^2 (26%), urban area 1866 km^2 (35%), and bare soil 1937 km^2 (37%). This study expected to help the urban planners and decision-makers for future development in the study area.

Keyword: Land cover, Classification, Remote sensing, GIS.

رسم خرائط الغطاء الأرضي باستخدام طريقة التصنيف الموجه (**MLC**) وبيانات القمر الصناعي (**Sentinel-٢**) في محافظة بابل

الخلاصة

يعد استخلاص معلومات الغطاء الأرضي من بيانات الأقمار الصناعية لرصد الأرض أحد أكثر التطبيقات شيوعًا للرصد والتقييم والإدارة البيئية. ان دراسة غطاء الارض باستخدام البيانات التحسس النائي أكثر فاعلية عند استخدام طريقة تصنيف قوية. في هذه الدراسة، تم استخدام طريقة التصنيف الموجه (MLC) على بيانات القمر الصناعيSentinel-٢ التابع لوكالة الفضاء الأوروبية، والذي تم إطلاقه في عام ٢٠١٥. تم استخدام طريقة MLC وبيانات Sentinel ٢ للتاريخ ٢٨ شباط ٢٠١٩، مع الدقة المكانية البالغة ١٠ أمتار في التقاط الغطاء الأرضي باستخدام برنامج ArcGIS. ١٠.٥ تم التعرف على أربعة طبقات للغطاء الأرضي في محافظة بابل، وهي المياه، الغطاء النباتي، المنطقة الحضرية والتربة العارية. أظهرت نتائج التصنيف أن طريقة التصنيف (MLC) هي طريقة ناجحة وفعالة. تم حساب المساحة والنسبة المئوية لكل صنف؛ المياه ١٠٧ كم^2 (٢ ٪)، الغطاء النباتي ١٣٨٧ كم^2 (٢٦ ٪)، المنطقة الحضرية ١٨٦٦ كم ^{2} (٣٥ ٪)، التربة المجردة ١٩٣٧ كم ^{2} (٣٧ ٪). ستساعد هذه الدراسة المخططين وصناع القرار من أجل التطوير المستقبلي للمحافظة.

الكلمات المفتاحية: الغطاء الأرضي، التصنيف، التحسس النائي، نظم المعلومات الجغرافية.

1. Introduction

Deriving land cover and land use (LCLU) information from remotely sensed data has become a critical component for effective environmental monitoring, evaluation, and management. Accurate and up-to-date land cover information is essential to understand and assess the consequences of environmental change. Characterizing LCLU over large areas is a fundamental task in any environmental, cultural and political study since it provides a baseline for governments to undertake and monitor policies that look for sustainable livelihoods in harmony with the ecosystems. Remote sensing in synergy with image processing makes possible the identification and mapping of the land cover system, and then, the assessment and monitoring of the resources at different temporal and spatial scales (Rogan and Chen, 2004). After almost four decades of earth observation and development of powerful algorithms in mapping LULC, the research continues adapting new approaches that lead to its update to be operationally efficient and benefit from the massive data available through new technology with open data policy (Gomez et al., 2016).

The recent operation of the satellites Sentinel 2A and 2B of the European Union's Earth observation program Copernicus can play a crucial role in the new and future generation of LULC maps (Gomez et al., 2016). With an increase of the revisit frequency and better spatial resolution imagery - as never before- the research can improve the lack of production of global and regional LULC maps with a _ne scale and up-to-date information. In this context, the availability of intra-annual maps can be central in a broad spectrum of applications such as forest _re propagation (Navarro et al., 2017), crop monitoring (Vuolo et al., 2018), inundation mapping (Kordelas et al., 2018), and climate change models (Radoux et al., 2014). However, increasing the continuity in a time of the characterization of the land cover system over large areas by using this new technology can also lead to new operational challenges. Especially, in making operationally efficient its production while its consistency and accuracy keep high quality (Radoux et al. (2014). The synergy of earth observation and image processing has made possible the monitoring and identification of the land cover system at a global and regionals scale (Rogan and Chen, 2004). Despite the early experience of thematic mapping with Sentinel 2 imagery (data from 2015), it has shown potential in a different number of applications. Specifically, in the production of a new generation of land cover maps on a regional scale and up to date information (Kordelas et al. (2018), Vuolo et al. (2018), Navarro et al. (2017)).

Traditionally, remote sensing image classification is an automatic approach of making LULC mapping where the level of human intervention may vary depending on the classification procedure (Rogan and Chen (2004), Inglada et al. (2017)). In this context, unsupervised procedures (K means, SOM) are attractive for an automatic definition of classes boundaries in comparison with supervised classifiers that require the construction of training data (Mather and Tso, 2016). However, in the context of classification over large areas, high dimensionality, and fast reproduction, unsupervised methods can lose effectiveness due to the time-consuming post-processing and complexity in the interpretation of clusters (Chen and Gong, 2013). Therefore, the better experience with supervised classification over large areas with high dimensionality.

MLC is one of the most commonly supervised classification methods. MLC was originated from electrical engineering field of study (Nilson, 1925). MLC algorithm is based on statistical assumptions that the statistics for each training class in each band should be following Gaussian distribution or bell-shaped distribution. Mean and variance is calculated from each training class to form the probability distribution of each pixel in an image. An unknown pixel will be assigned to a specific class if it has the highest probability belonging to that class. A sufficient number of training data should be required for calculating the mean and variance of each class (Richards and Richards, 1999). Since the first initiation of Landsat satellite in the 1970s, the MLC algorithm has become a popular approach for the environment and earth scientists in monitoring and deriving physical earth information from remotely sensed data. Detecting land cover/land-use changes was probably the most widely used this classification technique (Dewan and Yamaguchi, 2009).

This study aims to map the land cover using Maximum likelihood classification method and the high-resolution Sentinel 2 data (10 meters) for Feb 2019 in Babil governorate.

2. Methodology

2.1 Study area

Babil governorate is one of the provinces in central Iraq (Fig. 1), located about 100 km south of Baghdad (Al Khalidy et al., 2010). Its considerate as the fifth most populous province in Iraq, with an estimated population of about 2,200,000, according to the estimates of 2017 (Iraqi Ministry of Planning 2017). The governorate covers an area of about 5337 km2, which represents about 1.2 percent of Iraq. Administratively, it is divided into five main districts includes Hilla, Al-Mahawil, Al-Musayyib, Al-Hashimiyah, and Al-Qasim (Chabuk, et al., 2019). Babil governorate shares its internal borders with Baghdad, Al-Anbar, Karbala, Najaf, Al-Diwaniya and Wasit governorates. Babil has many archaeological sites that are tourist attractions, such as, the ruins of the ancient city of Babylon, and is believed to contain large reservoirs of gas and oil, precious metals, which strengthens the economy of the governorate.

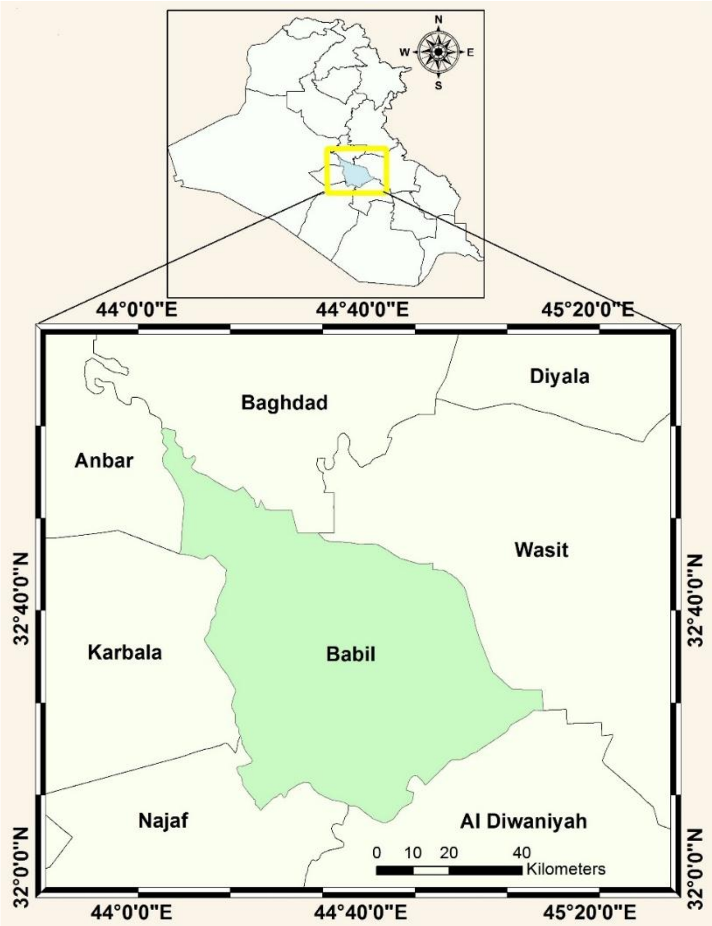

Figure 1: Location of the study area.

2.2 Sentinel 2 Imagery

In this study, Sentinel-2 image was used for the date 28 Feb 2019 with 10 m spatial resolution. The instruments consider 13 spectral bands in the visible, near-infrared and short wave infrared spectral range. The images were downloaded by using the online system Copernicus Open Access Hub developed by ESA. The imagery was utterly free. The Sentinel-2 mission developed by the European Space Agency (ESA) comprises two satellites (Sentinel-2A and Sentinel-2B) operating in the same orbit (786 km) launched in 2015 and 2017, respectively. A revisit time of 5 days for each satellite can be achieved. Sentinel-2 satellites provide high resolution (10 m, 20 m, and 60

m) multi-spectral imagery (13 spectral bands) with the swath width of 290 km (Feilhauer et al., 2014).

2.3 Maximum likelihood classifier (MLC)

The maximum likelihood classifier is a statistic-based technique, which is one of the most widely used classifiers for land cover classification (Erbek et al., 2004). According to Richards and Richards (1999), the algorithm is based on Bayes' theorem to calculate the likelihood of every pixel. The MLC assumes that each class in each band is normally distributed, and calculates the probability distribution if a given pixel belongs to a specific land cover class. A given user can define a threshold at which one pixel is assigned to unclassified if the probability of that pixel is below the threshold. Due to its simplicity and popularity, there are many open-source and commercial software packages supporting this classification algorithm such as ArcGIS and QGIS. In this study, ArcGIS 10.5 software was used to produce classified land cover maps, the methodology flow chart illustrated in Figure 2.

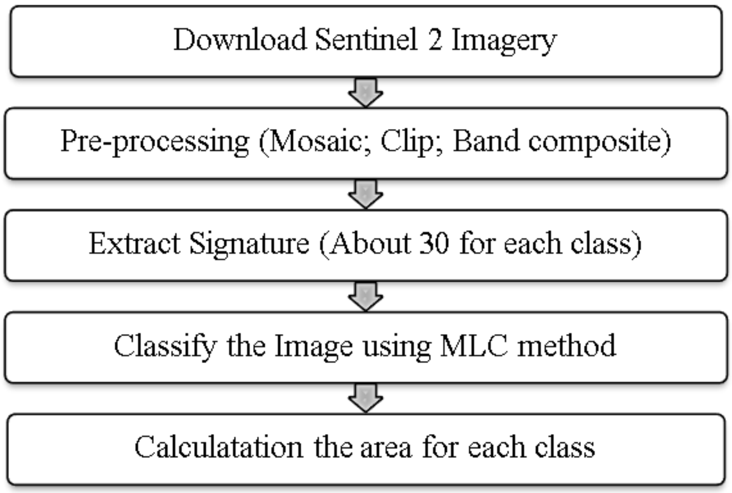

Figure 2: The methodology flowchart for this study.

3. Results and Discussion

The Sentinel-2 multi-spectral image was used to map land cover using MLC approach in ArcGIS 10.5 software. The input variables include band2, band 3, and band 4. After that, use the combination of Sentinel-2 data. Figure 3 shows the classification result using Sentinel-2 multi-spectral image in Babil governorate. Four signature was identified, namely water, urban area, bare soil, and vegetation. There are more than 30 training sites collected for each class. Then, four land cover classes were identified using the MLC method. The results of the classification gave the land cover image for the study area. Finally, the area for each chapter class that separately according to the pixel geometry and the statistical distribution of pixels in the study area was calculated. The area for each class illustrated in Table 1, as well as, the percentage was shown in the pie chart (Figure 4).

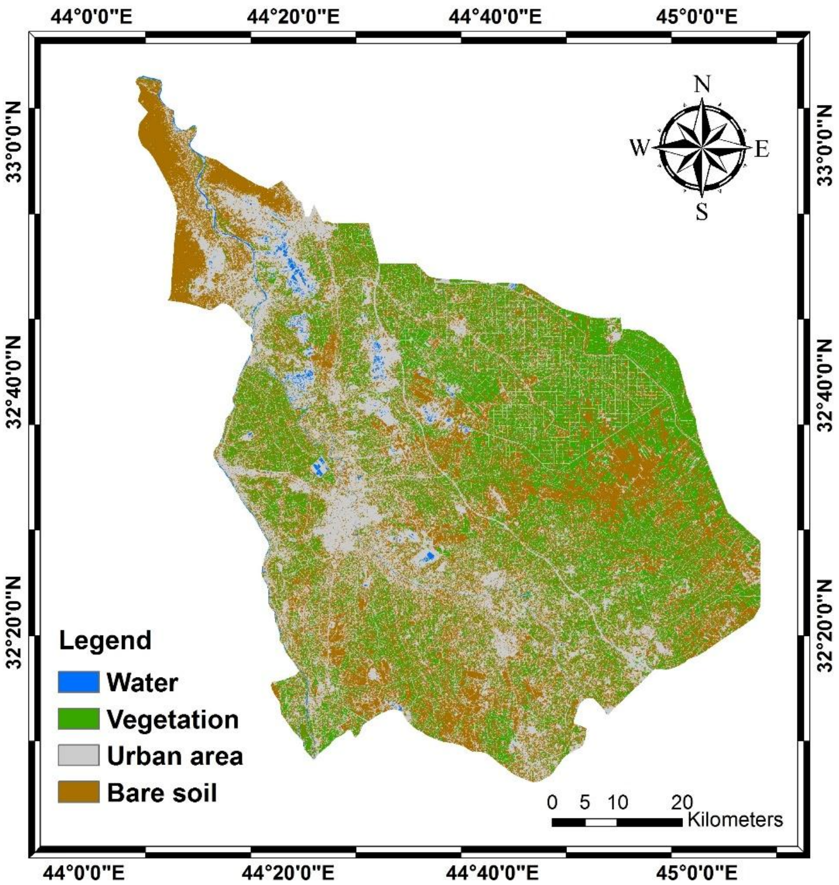

Figure 3: Classification results using MLC and Sentinel 2 data.

Table 1: Area for each land cover class.

Class	**Percentage**	**Area (Km^2)**
Water	2%	107
Vegetation	26%	1387
Urban area	35%	1866
Bare soil	37%	1973
Total area	5333 Km^2	

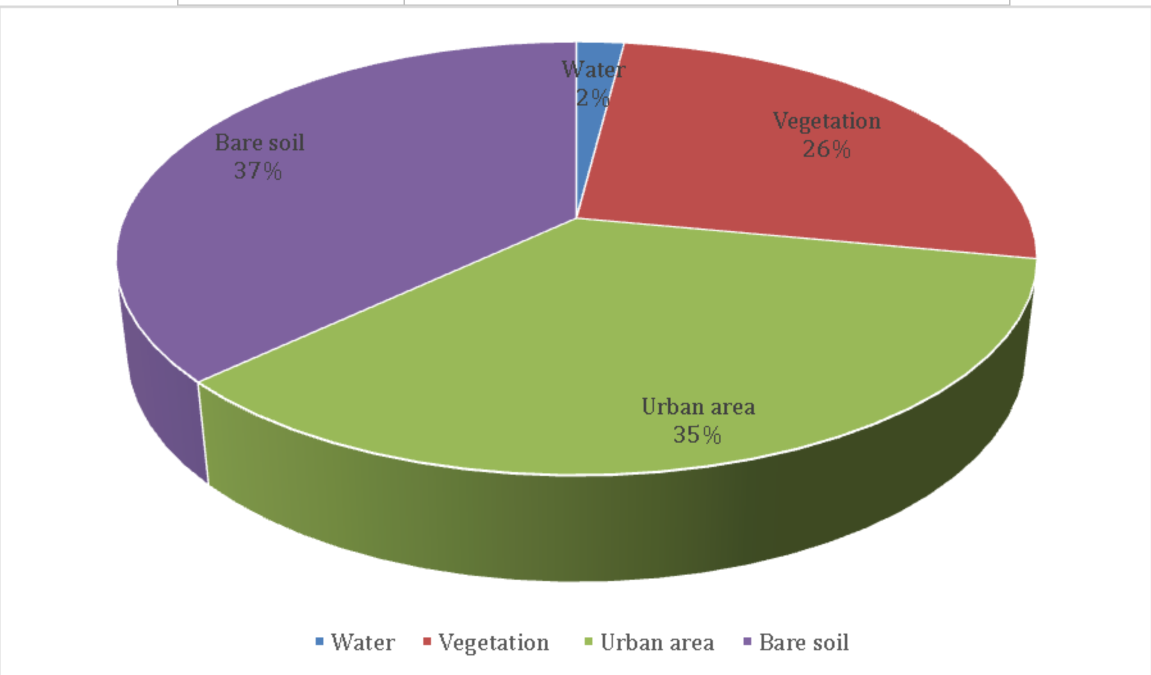

Figure 4: Percentage for each land cover class.

4. Conclusion

This study illustrates the capability of the Remote Sensing data in mapping the land cover. An attempt was made to map as accurate as possible the land cover classes using Sentinel 2 data with a spatial resolution of 10 m, namely water, vegetation, urban area, and bare soil. The results showed that the MLC method is an effective technique with few chances of misclassification. The area and percentage for each class were calculated; water 107 Km^2 (2%), vegetation 1387 Km^2 (26%), urban area 1866 Km^2 (35%), and bare soil 1937 Km^2 (37%). The classified images provide detail information to understand the land use and land cover of the study area. This study expected to help the urban planners and decision-makers for future development in the study area.

References

Al Khalidy, K.S., Chabuk ,A. J., Kadhim, M.M. (2010) Measurement of lead pollution in the air of Babylon Governorate, Iraq during year 2010. World Acad Sci Eng Technol, Vol. 6, pp.830–833.

Chabuk, A., Al-Ansari, N., Hussain, H.M., Laue, J., Hazim, A., Knutsson, S., Pusch, R., (2019) Landfill sites selection using MCDM and comparing method of change detection for Babylon Governorate, Iraq. Environ Sci Pollut Res, pp.1–15. https://doi.org/10.1007/s11356-019-05064-7

Chen, Y., Gong, P., 2013. Clustering based on eigenspace transformation-cbest for e_cient classi_cation. ISPRS journal of photogrammetry and remote sensing , Vol. 83, pp. 64-80.

Dewan, A. M., and Yamaguchi, Y. (2009). Using remote sensing and GIS to detect and monitor land use and land cover change in Dhaka Metropolitan of Bangladesh during 1960–2005. Environmental Monitoring and Assessment, Vol.150(1),pp. 237-249.

Erbek, F. S., Özkan, C., Taberner, M. (2004). Comparison of maximum likelihood classification method with supervised artificial neural network algorithms for land use activities. International Journal of Remote Sensing, Vol. 25(9), pp.1733-1748.

Feilhauer, H., Dahlke, C., Doktor, D., Lausch, A., Schmidtlein, S., Schulz, G., & Stenzel, S. (2014). Mapping the local variability of Natura 2000 habitats with remote sensing. Applied Vegetation Science, Vol. 17(4), pp.765–779.

Gomez, C., White, J. C.,Wulder, M. A. (2016) Optical remotely sensed time series data for land cover classi_cation: A review. ISPRS Journal of Photogrammetry and Remote Sensing , vol.116, pp.55-72.

Inglada, J., Vincent, A., Arias, M., Tardy, B., Morin, D., Rodes, I. (2017) Operational high resolution land cover map production at the country scale using satellite image time series. Remote Sensing, Vol. 9 (1), pp.95.

Iraqi Ministry of Planning (2017) Records of directorate of census Babylon, Internal Reports. Iraqi Ministry of Planning, Baghdad.

Kordelas, G., Manakos, I., Aragon_es, D., Diaz-Delgado, R., Bustamante, J. (2018) Fast and automatic data-driven thresholding for inundation mapping with sentinel-2 data. Remote Sensing, vol. 10 (6), pp. 910.

Mather, P., Tso, B. (2016) Classification methods for remotely sensed data. CRC press.

Navarro, G., Caballero, I., Silva, G., Parra, P.C., Vazquez, A., Caldeira, R. (2017) Evaluation of forest fire on madeira island using sentinel-2a msi imagery. International Journal of Applied Earth Observation and Geoinformation, Vol. 58, pp.97-106.

Nilson, N. J. (1925). Learning Machines: Foundations of trainable pattern-classifying systems: McGraw-Hill.

Radoux, J., Lamarche, C., Van Bogaert, E., Bontemps, S., Brockmann, C., Defourny, P. (2014) Automated training sample extraction for global land cover mapping. Remote Sensing, Vol. 6 (5), pp. 3965-3987.

Richards, J. A., Richards, J. (1999). Remote sensing digital image analysis, Vol. 3, Springer.

Rogan, J., Chen, D. (2004) Remote sensing technology for mapping and monitoring land-cover and land-use change. Progress in planning, Vol.61 (4), pp.301-325.

Vuolo, F., Neuwirth, M., Immitzer, M., Atzberger, C., Ng, W.T. (2018) How much does multi-temporal sentinel-2 data improve crop type classification. International journal of applied earth observation and geoinformation, Vol. 72, pp.122-130.