Land Cover Mapping Using Spectral Vector Machine Classification Approach and Sentinel-2 Data in Al-Kut, Iraq

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Abstract:

Deriving land cover information from earth observation satellite data is one of the most common environmental monitoring, evaluation, and management applications. Land cover mapping with remotely sensed data is more efficient when employing a robust classification approach. This study uses the Spectral Vector Machine Classification (SVM) technique to analyze remote sensing information from the 2015-launched Sentinel-2 satellite program run by the European Space Agency. SVM method and Sentinel 2 data for the date March 2023, with a spatial resolution of 10 m were used to in capturing land cover. Four land cover classes were recognized in Al-Kut: vegetation, water, barren soil, and urban area. Then, the area of each class was computed as follows 1136.7,159.2,3349.7, and 174.3 Km^2 Respectively. The

classification accuracy was computed based on 160 ground truth points; the overall accuracy was 75%.

Keywords: LULC; classification; SVM; Remote sensing.

تصنيف الغطاء الأرضي باستخدام نهج تصنيف آلة المتجه الطيفي وبيانات Sentinel-2 في الكوت ، العراق

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3- جامعة تبريز ، كلية التخطيط والدراسات البيئية ، قسم الاستشعار عن بعد ونظم المعلومات الجغرافية ، تبريز ، إيران.

الملخص:

يعد استخراج معلومات غطاء الأرض من بيانات الأقمار الصناعية لمراقبة البيئة وتقييمها وإدارتها أحد أكثر تطبيقات الاستشعار عن بعد شيوعًا. يصبح رسم خرائط غطاء الأرض باستخدام بيانات الاستشعار عن بعد أكثر كفاءة عند استخدام نهج تصنيف قوي.

تستخدم هذه الدراسة تقنية التصنيف بطريقة آلة الدعم المتجه الطيفي (SVM) لتحليل معلومات الاستشعار عن بعد باستخدام القمر الصناعي Sentinel-2 الذي أطلقته وكالة الفضاء الأوروبية في عام 2015. تم استخدام طريقة SVM وبيانات Sentinel 2بتاريخ مارس 2023، بدقة مكانية 10 متر ، في التقاط غطاء الأرض. تم التعرف على أربع فئات من غطاء الأرض في مدينة الكوت: الغطاء النباتي والمياه والتربة القاحلة والمنطقة الحضرية. ثم تم حساب مساحة كل فئة على النحو التالي: 1136.7 و 159.2 و 3349.7 و 174.3 كيلومتر مربع على التوالي. تم حساب دقة التصنيف بناءً على 160 نقطة مرجعية أرضية ؛ وكانت الدقة الكلية 75.%

الكلمات المفتاحية: استخدامات الأراضي، التصنيف، SVM، الاستشعار عن بعد.

1. *Introduction*

Many environmental and management operations, particularly those in the sectors of environmental management, natural resources, and water resources, heavily depend on the geographical distribution of land cover (Thanh and Kappas, 2018). Researchers from several fields are now using the comprehensive and quickly developing technique of mapping land use/cover, which uses data from multiple satellite sensors (Yousefi et al., 2017). The analysis of satellite imagery reveals human interactions with natural resources. In particular, using multispectral imaging can be an effective tool for determining the kind of land cover (Yousefi et al., 2015). Traditionally, supervised and unsupervised classification have been used to categorize images. Using training sets for each defined class, satellite images are categorized using the supervised technique. In the unsupervised approach, the classification of the satellite photos is done using a statistical indicator created from the targets' spectral reflectance (Tigges et al., 2013).

Overall, a variety of categorization techniques, such as neural network (NN), maximum likelihood (ML), random forest (RF), and SVM, can be used to build land cover maps from satellite images (Srivastava et al., 2012). SVM is a well-liked and reliable method for supervised image classification (Mohammadi et al., 2019). SVM is a recently developed, statistical learning theory-based supervised classification approach (Lindquist et al., 2012). Compared to the most prominent supervised classification techniques, SVM frequently yields better accurate classification outcomes from spectral data that is extremely variable. The majority of image classification techniques require optimizing many variables and parameters. One of the most important features of the SVM classification approach for land use mapping is the ability to export classified images with high accuracy from small training sets. (Huang et al., 2002).

This study aims to map the land cover in Al-Kut/ Iraq using the Spectral Vector Machine Classification (SVM) method based on Sentinel-2 data for the date March 2023, with a spatial resolution of 10 m.

2. *Materials and Methods*

2.1 Study Area

Figure 1 depicts Al-Kut City in Wasit Province, which is about 170 kilometers southeast of Baghdad, as the research area. The Al-Gharraf and Dujaili Rivers, two branches of the Tigris River, meet in Al-Kut City, the province's administrative hub (Mohammad, 2014; Jasim et al., 2021). It is situated on the highway system that connects Baghdad with the southern governorates. The city of Al-Kut is located between the two banks of the Tigris River and has a total area of about 55 km2. Its land uses include commercial, educational, industrial, and other activities. However, the northern part is distinguished by being more successful than the southern part in terms of administration, services, and commerce (AL-Mamoori and ALMaliki, 2016).

Figure 1: The study area's location.

2.2 Sentinel-2

Several satellites are currently employed to create an image of the land cover. Sentinel-2 satellites are the most popular satellites for study. A European optical imaging satellite named Sentinel-2 was launched on June 23, 2015. It is a satellite that was launched as part of the Copernicus program of the European Space Agency (Mandanici and Bitelli, 2016). 13 bands were collected for Sentinel-2 by the Multispectral Imager sensor. Sentinel-2 has a temporal resolution of 10 days, with one satellite performing it for 10 days, followed by two spacecraft performing it for 5 days.

Combining Short-Wave Infrared (B12, B8A, and B4) was employed in this investigation. This composite depicts flora in a variety of green tones. Darker

green hues typically denote thicker vegetation. Brown, meanwhile, is a sign of bare ground and urban regions. The band arrangement in Figure 2.

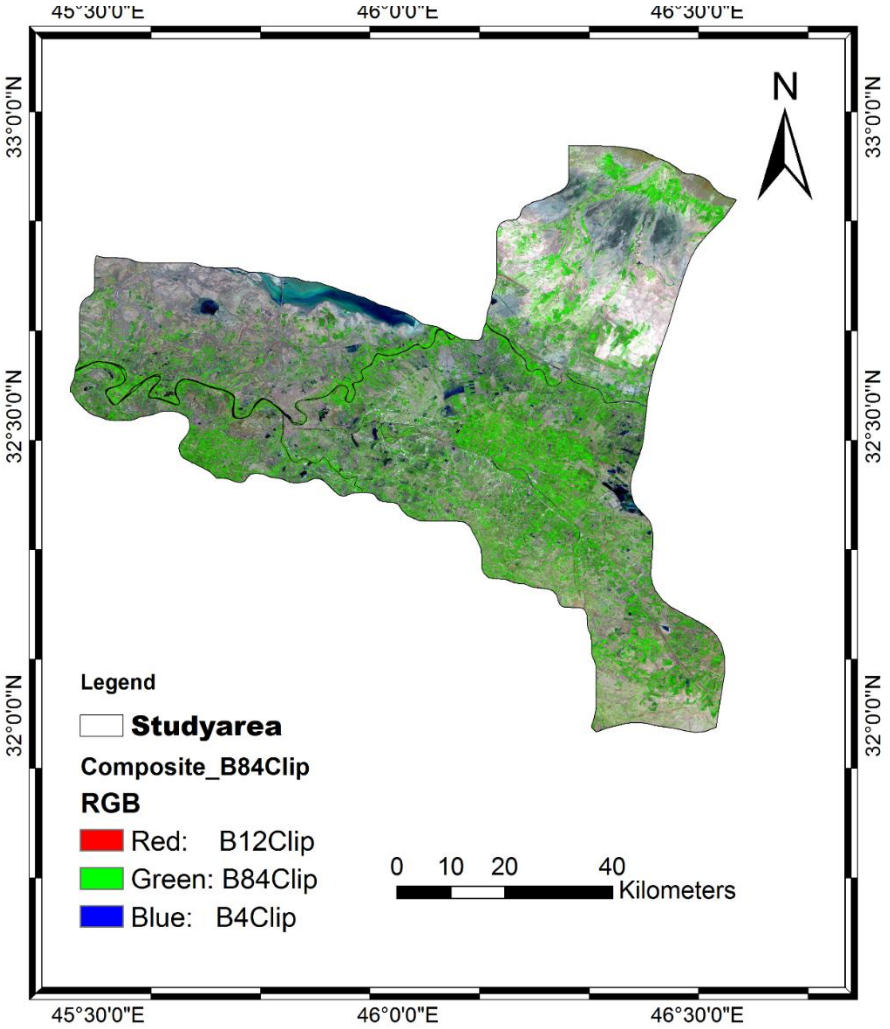

Figure 2: Band combination (Short-Wave Infrared (B12, B8A, B4).

2.3 Support Vector Machine (SVM)

The SVM is a non-parametric image classification algorithm that consists of a collection of related regression and classification learning algorithms (Hayri Kesikoglu et al., 2019). The SVM can discriminate between classes by maximizing the spread between classes on the decision surface. The surface is called the ideal hyperplane in most studies, whereas the support vectors are the data closest to the hyperplane. In this case, the support vectors are the most important aspects of the training set.

The SVM algorithm is increasingly used to map land use/land cover using sentinel imagery, determining the optimal values of the penalty parameter in the SVM method is thus essential, by notably taking into account the different types of land cover and the corresponding surface land reflectance in arid and humid regions. The Radial Basis Function (RBF) served as the study's kernel function. In addition, the ENVI 5.3 image multiclass processing environment employed a paired SVM classification algorithm.

2.3 Error Matrix

An error matrix is the most common way to describe the classification accuracy of remotely sensed data. Many researchers have recommended using an error matrix to define accuracy, and it should be accepted as the standard reporting convention. An error matrix is a square array of numbers laid out in rows and columns that expresses the number of sample units assigned to a particular category in comparison to the actual category as checked on the ground. The reference data (ground truth) is represented by the columns, while the classification produced by remotely sensed data is represented by the rows. The number of rows and columns in such matrices is equal to the number of categories whose classification accuracy is being measured (Lillesand et al., 2015).

A variety of descriptive and analytical statistical methods can be initiated from the error matrix. Overall accuracy, for example, is calculated by dividing the total correct (i.e., the sum of the major diagonal) by the total number of pixels in the error matrix. This value was part of the older, site-specific evaluation and is the most widely mentioned accuracy assessment statistic (Congalton, 1991).

3. *Results and Discussion*

In This study, the SVM method was used to create a land cover map for the study area. Machine learning algorithms are widely employed in land use/cover and mapping among other applications. However, the impact of parameter selection on classification performance has received insufficient attention. Many studies have demonstrated that when SVM is used for classification, the kernel function, and parameter values have a significant impact on classification results. The SVM classification was performed using ENVI software to extract four land cover in Al-Kut, namely, vegetation, water, barren soil, and urban area as shown in Figure 3.

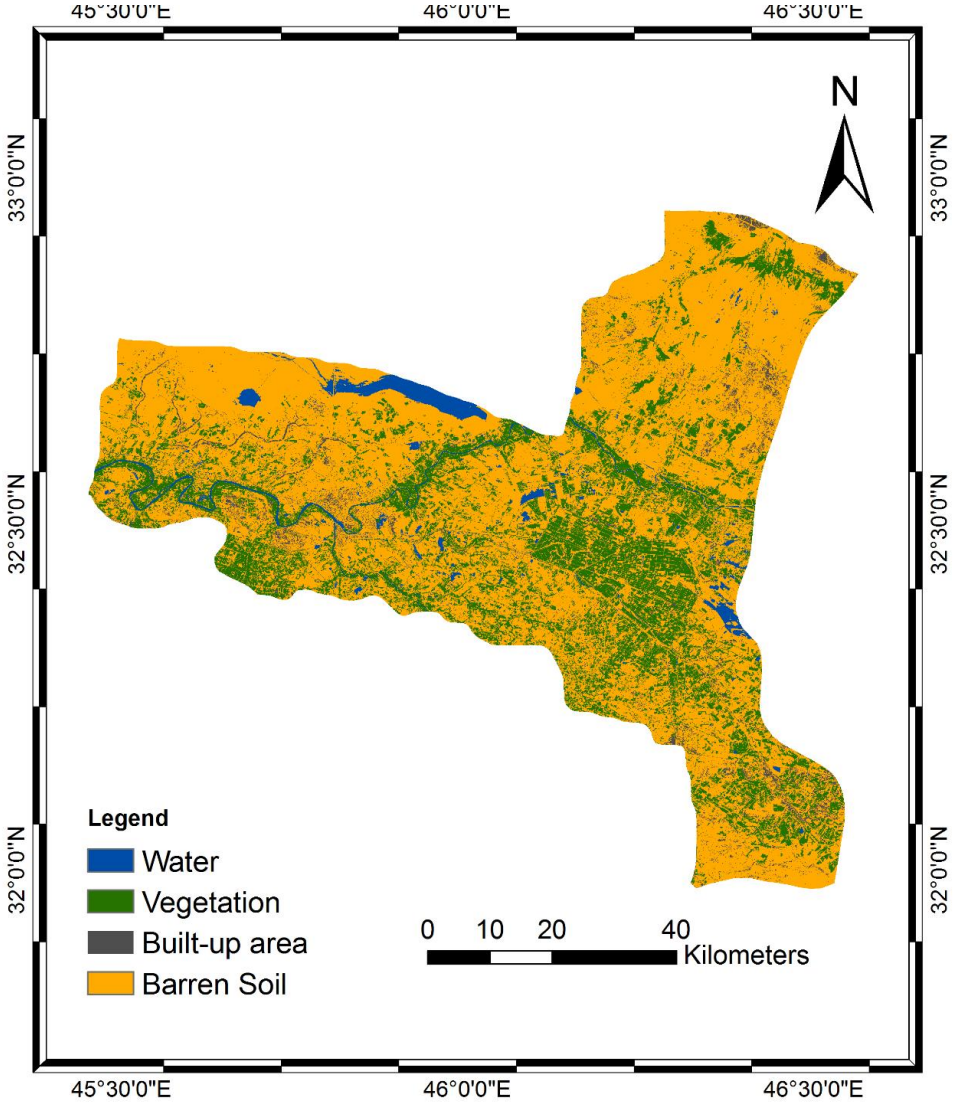

Figure 3: SVM classification result.

Four land cover classes were recognized in Al-Kut: vegetation, water, barren soil, and urban area. Then, the area of each class was computed as follows 1136.7,159.2,3349.7, and 174.3 Km^2 Respectively. The result was illustrated in Table 1.

Table 1: Area for each land cover class

Class	Area km^2	percentage
vegetation	1136.7	23.6%
Water	159.2	3.3%
Barren soil	3349.7	69.5%
Built-up area	174.3	3.6%
Total area	4819.9	100%

Finally, the classification accuracy was computed based on ground truth data. According to the Rule of thumb, the number of samples for each class is computed by (No. of classes *10). The error matrix was illustrated in Table 2. Then, the overall accuracy was computed which is equal to 75%.

In this study, there are four land cover classes, so it needed to 40 samples of each class. The total number of ground truth points is 160. The ground truth sample distribution was shown in Figure 4.

The findings of this study demonstrate the importance of the SVM as a technique for image classification in land cover mapping. This result

demonstrated how the SVM settings have a significant impact on how accurate the land use/cover maps are.

Table 2: Confusion matrix for SVM method.

Class	Water	Vegetation	Built-up	Soil	Ground Truth
Water	35	0	0	0	35
Vegetation	0	33	0	1	34
Built-up	0	0	15	2	17
Soil	5	7	25	37	74
Total	40	40	40	40	160
Overall Accuracy = 0.75					

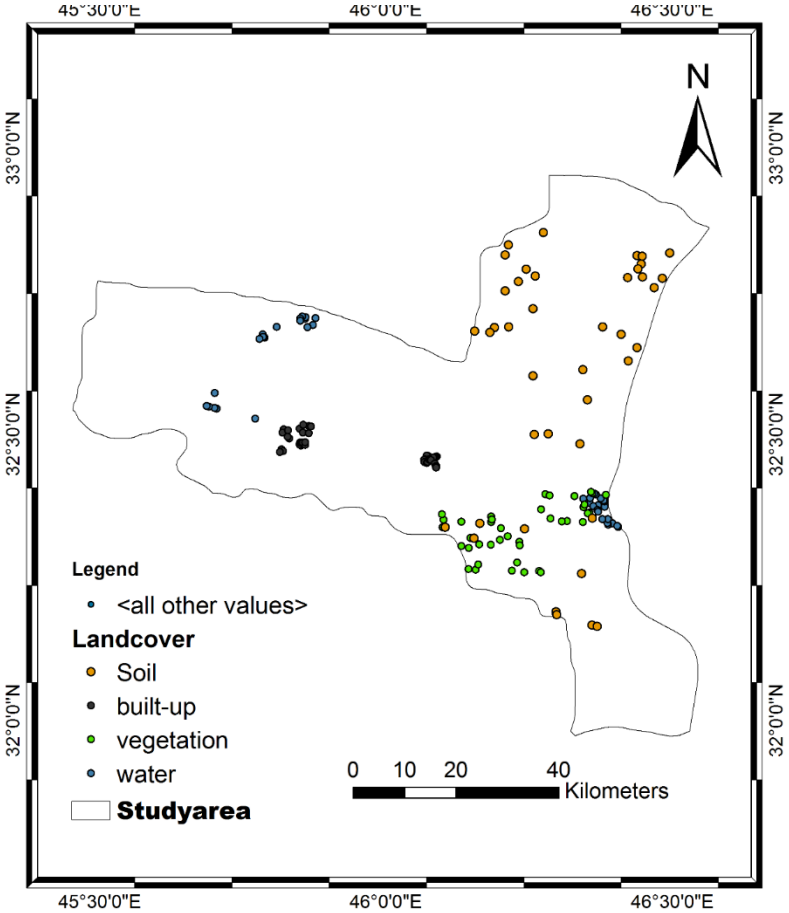

Figure 4: Ground Truth sample points.

4. *Conclusion*

Land cover mapping is necessary to manage many natural and human resources. The SVM algorithm has been proposed in this field as an efficient and accurate approach for classifying satellite imagery to produce land use maps, although optimization of SVM parameters requires extensive knowledge and frequent experimentation with different settings. Four land cover classes were recognized in Al-Kut: vegetation, water, barren soil, and urban area. The area of each class is 1136.7,159.2,3349.7, and 174.3 Km^2 Respectively. The classification accuracy was computed based on 160 ground truth points; the overall accuracy was 0.75. The results of this study show that the SVM is a critical method in image classification for land use/cover mapping. This finding illustrated that the accuracy of the land use/cover maps is highly dependent on the SVM parameters.

References

1. Thanh Noi, P.; Kappas, M. Comparison of random forest, k-nearest neighbor, and support vector machine classifiers for land cover classification using Sentinel-2 imagery. Sensors 2018, 18, 18.
2. Yousefi, S.; Keesstra, S.; Pourghasemi, H.R.; Surian, N.; Mirzaee, S. Interplay between river dynamics and international borders: The Hirmand River between Iran and Afghanistan. Sci. Total Environ. 2017, 586, 492–501.
3. Yousefi, S.; Mirzaee, S.; Tazeh, M.; Pourghasemi, H.; Karimi, H. Comparison of different algorithms for land use mapping in dry climate using satellite images: A case study of the Central regions of Iran. Desert 2015, 20, 1–10.

4. Tigges, J.; Lakes, T.; Hostert, P. Urban vegetation classification: Benefits of multitemporal RapidEye satellite data. Remote Sens. Environ. 2013, 136, 66–75.
5. Srivastava, P.K.; Han, D.; Rico-Ramirez, M.A.; Bray, M.; Islam, T. Selection of classification techniques for land use/land cover change investigation. Adv. Sp. Res. 2012, 50, 1250–1265.
6. Mohammadi, A.; Shahabi, H.; Ahmad, B. Bin Land-cover change detection in a part of cameron highlands, malaysia using ETM+ satellite imagery and support vector machine (SVM) algorithm. EnvironmentAsia 2019, 12, 145–154.
7. Lindquist, E.J.; D'Annunzio, R.; Gerrand, A.; MacDicken, K.; Achard, F.; Beuchle, R.; Brink, A.; Eva, H.D.; Mayaux, P.; San-Miguel-Ayanz, J. Global Forest Land-Use Change 1990–2005; FAO/JRC: Rome, Itlay, 2012; ISBN 9251073996.
8. Huang, C.; Davis, L.S.; Townshend, J.R.G. An assessment of support vector machines for land cover classification. Int. J. Remote Sens. **2002**, 23, 725–749.
9. Jasim I.A., Mahmood T.S., Al-Mamoori S.K., Al-Maliki L.A. 2021. The relationship between traffic congestion and land uses: A case study of Al-Kut city, Iraq. Journal of Urban Regeneration and Renewal, 14, 3: 32–39.
10. Mohammad O. 2014. Evaluation of Suitability of Drainage Water of Al-Hussainia sector (Kut-Iraq) For Irrigation. Wasit Journal of Engineering Sciences, 2, 1: 30--45.
11. Al-Mamoori S.K., Al-Maliki L.A. 2016. Evaluation of suitability of drainage water of Al-Hussainia sector (KUT Iraq) to irrigate cotton crop. Kufa Journal of Engineering, 7, 1: 67–78.

12. Mandanici, E., Bitelli, G, “Preliminary Comparison of Sentinel-2 and Landsat 8 Imagery for a Combined Use”, Remote Sensing Journal,vol. 8, pp.10-14, 2016.

13. Hayri Kesikoglu, M.; Haluk Atasever, U.; Dadaser-Celik, F.; Ozkan, C. Performance of ANN, SVM and MLH techniques for land use/cover change detection at Sultan Marshes wetland, Turkey. Water Sci. Technol. 2019, 80, 466–477.

14. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Remote sensing and image interpretation. Hoboken (p. 18). NJ: Wiley.

15. Congalton, R. G. (1991). A review of assessing the accuracy of classifications of remotely sensed data. Remote Sensing of Environment, 37(1), 35–46.