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Landsat8 vs. Sentinel-2: Land Use / Land Cover Change mapping for Karbala Governorate, Iraq, 2017 and 2021

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ABSTRACT

Satellite images are the essential data source for analyzing and monitoring land cover on various time scales, particularly across large regions. Landsat satellite data with a medium resolution was used to estimate land cover change over a 40-year period.This data contains information on land use and land cover patterns, is now freely available in the international archives. The LULC Remote Sensing Study assists in the ongoing detection and mitigation of crucial habitat risks to protect the environment. Sentinel-2, a satellite mission launched by the European Space Agency between 2015 and 2017 that uses high-resolution 10-day time-lapse multispectral data, gives a new opportunity for ground-based mapping and monitoring in the tropics. We employed 2015 ERDAS, a supervised classification method employing the maximum likelihood technique, to achieve this goal in Karbala/Iraq. This study examines if There is a significant difference in quality of data supplied by Landsat 8 and Sentinel-2 photographs in terms of change-detection maps of land use and land coverfor 2017 and 2021, the results of two satellites were compared ,They showed that their overall accuracy increased by 2.07% for 2017 and 1.83% for 2021, which is more overall accuracy than Landsat-8.

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Landsat8 مقابل Sentinel-2: استخدامات الأراضي / تغير خرائط الغطاء الأرضي لمحافظة كربلاء ، العراق ، ٢٠١٧ و ٢٠٢١

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الكلمات المفتاحية:

– Landsat-8
Sentinel-2
خصائص الاستشعار
كربلاء / العراق
استخدامات الأراضي / رسم خرائط الغطاء

الـــخُــلاصـــة

صور الأقمار الصناعية هي مصدر البيانات الأساسي لتحليل ومراقبة الغطاء الأرضي على نطاقات زمنية مختلفة ، لا سيما عبر المناطق الكبيرة. تم استخدام بيانات القمر الصناعي لاندسات ذات الدقة المتوسطة لتقدير تغير الغطاء الأرضي على مدى ٤٠ عامًا. تحتوي هذه

البيانات على معلومات حول استخدام الأراضي وأنماط الغطاء الأرضي ، وهي متاحة الآن مجانًا في الأرشيفات الدولية. تساعد دراسة *LULC* للاستشعار عن بُعد في الكشف المستمر عن مخاطر الموائل الحرجة والتخفيف من حدتها لحماية البيئة. توفر *Sentinel-2* ، وهي مهمة أقمار صناعية أطلقتها وكالة الفضاء الأوروبية بين عامي ٢٠١٥ و ٢٠١٧ والتي تستخدم بيانات متعددة الأطياف عالية الدقة لمدة ١٠ أيام ، فرصة جديدة لرسم الخرائط الأرضية والمراقبة في المناطق المدارية. استخدمنا ٢٠١٥ *ERDAS* ، وهي طريقة تصنيف خاضعة للإشراف تستخدم تقنية الاحتمال الأقصى ، لتحقيق هذا الهدف في كربلاء / العراق. تبحث هذه الدراسة في ما إذا كان هناك اختلاف كبير في جودة البيانات المقدمة من صور *Landsat-8* و *Sentinel-2*من حيث خرائط الكشف عن التغيير في استخدام الأراضي والغطاء الأرضي لعامي ٢٠١٧ و ٢٠٢١ ، وتمت مقارنة نتائج قمرين صناعيين ، وأظهرت أن زادت دقتها الإجمالية بنسبة ٢.٠٧٪ لعام ٢٠١٧ و ١.٨٣٪ لعام ٢٠٢١ ، وهي دقة أكثر إجمالاً من *Landsat-8*.

الأرضي

1. INTRODUCTION

LULC (Land Use and Land Cover) is a well-known term that presents important facts about humanity's relationship with the environment[1]. On the other hand, land cover refers to the physical characteristics of the Earth's surface, such as water, soil, and vegetation cover[2].As a result, LULC data can help us understand how humans and the environment are interconnected [3]. Remote sensing satellite data is a valuable resource, for producing up-to-date LULC classifications [3].To obtain information about LULC and LULCC, large Earth Observation (EO) datasets are frequently used [4]. Medium resolution sensors such as (L8 / OLI) Landsat 8 / Operational Land Imager and (S2 / MSI) Sentinel-2 / Multispectral Instrument should be used to obtain more detailed information.[5]. Because many technical aspects of S2/MSI and L8/OLI data are shared [6]. According to Bassem and Maitham, The marshes are a one of a kind habitat that spans a vast portion of southern Iraq. The Iraqi wetlands dried up due to an environmental disaster, particularly in the 1990s, and drought and limited water imports from the Tigris and Euphrates rivers from Turkey and Iran prevented their restoration to their former extent. This study aims to determine the values of the Natural Vegetation Variation Index from 1977 to 2017.water bodies was illustrated degradation through image analysis and classification[7]. Antonio and Christoph considered the questions that researchers might have about how general-purpose Sentinel-2 is the study uses Sentinel-2 and Landsat 8 images to produce LULC maps. The results show that object-based classification using Landsat 8 and Sentinel-2 image information, provides very similar results for most LULC classes, with an overall accuracy of about 87-88% with slightly better results when using Sentinel-2, without band indexes or auxiliary data. File size and processing times increase while using Sentinel-2, and analysis of some land use and land cover classes is improved over Landsat 8, which exposes more and smaller line segments and allows for better identification of the image feature on the sorted map[8].

2. AREA FOR RESEARCH

This research focuses on the city of Karbala / Iraq. Therefore, it is located astronomically, longitude east and latitude north, and on the eastern side of the desert plateau west of the Euphrates River. In Iraq's south and southwest, the governorate of Karbala is located, 78 kilometers from the city's center and 106 kilometers from Baghdad, the capital of Iraq[9] .Karbala is an Iraqi governorate whose irrigated agriculture extends along the Euphrates River to the east of Karbala, while the western parts of the governorate are desert plains. Al-Razzaza salt lake is located a few kilometers west of Karbala. Summer temperatures can easily reach 40°C or higher, while winter precipitation is limited and concentrated. Karbala's economy is based on agriculture and tourism, and agricultural enterprises in the city produce a wide range of fruits, vegetables and horticultural products. In terms of religious tourism, the shrines of Imam Hussein and Abbas are among the famous holy places in Karbala. In addition to natural attractions such as Lake Razzaza[10].

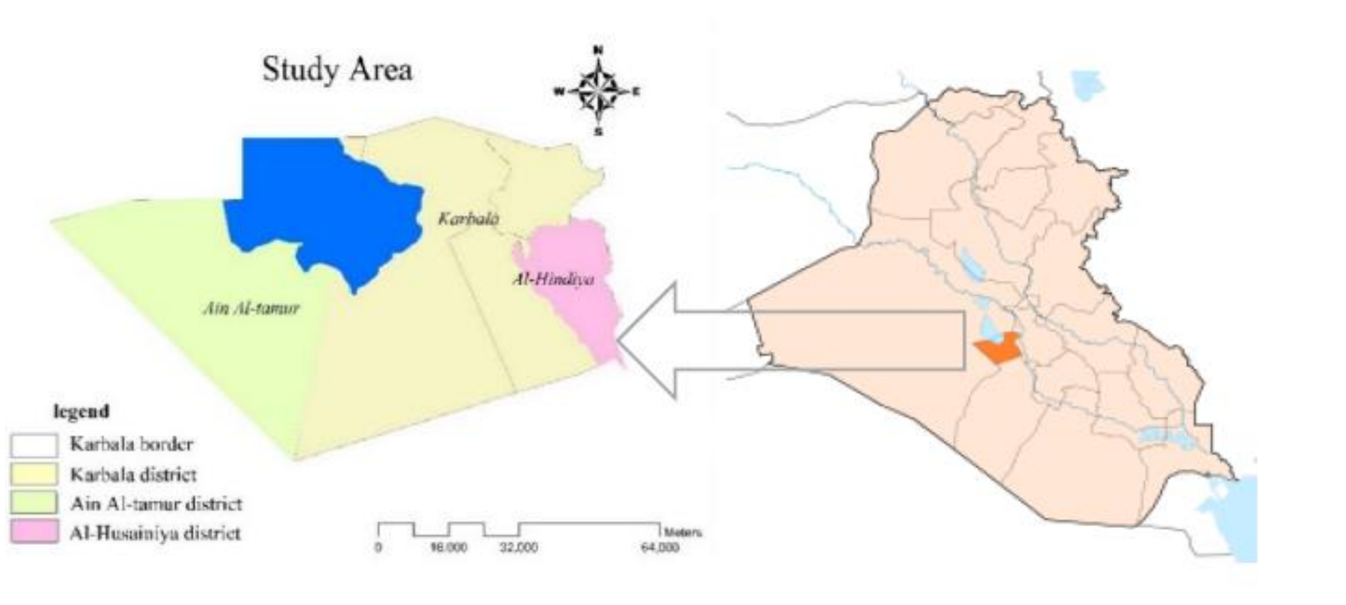


Figure 1: Map of the Research Area [11].

3. SATELLITES USED FOR THE STUDY.

3.1. The Landsat 8 Satellite.

On February 11, 2013, Landsat 8 was launched. The Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) are two research instruments aboard the Landsat 8 satellite[12]. There are nine spectral bands in this data, Bands 1 through 7 and 9 have a spatial resolution of 30 meters, while Band 8 has a spatial resolution of (15) meters . For coastal and aerosol investigations, the new ultra-blue band 1 is useful, In addition, the new band 9 aids in the detection of cirrus clouds. Bands 6 and 7 are also associated with the SWIR spectrum. Thermal ranges 10 and 11 are combined with an accuracy of 100m and effectively provide more accurate surface temperatures[13].

3.2. The Sentinel-2 Satellite.

Sentinel-2 is a satellite constellation consisting of two satellites, Sentinel-2A and Sentinel-2B; A third satellite, Sentinel-2C, will be launched in 2024 and is currently being tested.[14]. Sentinel-2A was launched on June 23, 2015, and Sentinel-2B on March 7, 2017. The MultiSpectral Imager is the only optical instrument payload carried by the Sentinel-2 spacecraft. The MSI analyzes 13 spectral bands in the visible-near infrared and short wave infrared spectral spectrum at three distinct spatial resolutions (10, 20, 60 m) and with a high revisit frequency of 10 days from a sun-synchronous orbit (the combined constellation revisit frequency will be 5 days)[15].

3.3. L8/OLI and S2/MSI characteristics.

Data from S2/MSI and L8/OLI are widely incorporated as inputs for LULC and LULCC applications since they are: obtainable for free [16].as well as the ability to keep an eye on large areas [17]. These sources rotate in a sun-synchronous orbit[18]..Landsat photos have witnessed a dramatic increase in use, particularly in data-poor and economically challenged areas[19].The S2/MSI mission gives novel mapping possibilities as a result of its spectral abilities (two bands in the SWIR and three bands in the Red-edge)[20].The S-2 MSI's spectral band configuration is developed around the utilization of Landsat wavelengths due to similar mission ideas of Sensors from the Landsat series .The S-2 MSI features spectral bands that are close to those of the Landsat 8 OLI, permitting the combined use of data from the S-2A, S-2B, and Landsat OLI. Figure (2) shows the band-average relative spectral response (RSR)to match of an S-2 MSI with a L8 OLI[21]. These advantages can provide more accurate results for LULC and LULCC analysis compared to Landsat data, which have problems in terms of spatial and spectral resolution, and because of the 16-day re-visit period, this affects cloud cover[8]. An average global re-visit period of about 3 days is obtained, when combining S2 / MSI and L8 / OLI data[22].With the Landsat 9 satellite, the virtual constellation will become even more frequent,Getting close to a two-day revisit cycle [23]. This enables the creation of algorithms for calculating biophysical vegetation properties at various temporal and geographical resolutions, as well as spectrum unmixing of sub-pixel fractions, which enables for sub-hectare resolution mapping of dynamic processes[24].

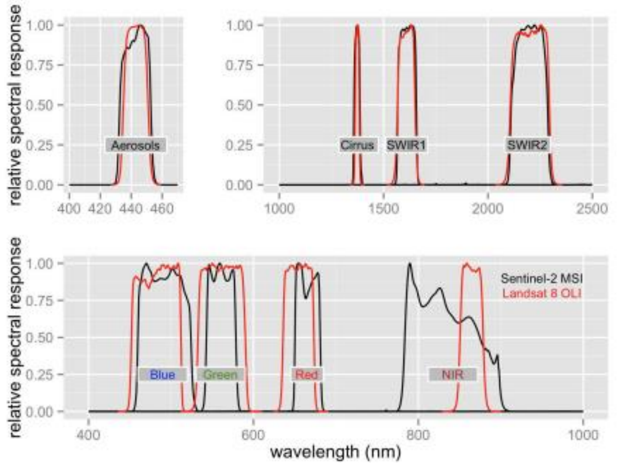


Figure 2: (RSR) Relative Spectral Response of Sentinel-2 / MSI and Landsat 8/ OLI [21].

4. STUDY AREA DATA.

In conducting LULC change studies, satellite data has an advantage over aerial photos. It also aids in determining the precision of LULC categorization and prediction findings. [25]. Satellites are the primary data source for this study's LULC mapping and LULCC analysis. Landsat 8 and Sentinel-2 satellite pictures were used in the research. The search area was imaged using Landsat 8 OLI satellite imagery (2017, 2021) and a comparison with Sentinel-2 MSS imagery (2017, 2021) from the US Geological Survey's online image database (http://earthexplorer.usgs.gov). Compared to Landsat (30 m) data sets, the Sentinel-2 (10 m, 20 m) image has a high spatial resolution. All pictures of the search region were taken During a spring day and processed with ERDAS IMAGE 2015, which includes cloud pixel removal and atmospheric correction. The data is presented in Table (1).

Table 1: Details on the Satellite Data Used in This Study.

Date of photography		Sensor	Spatial Resolution of Reflective Bands	Number of Bands	Format
2017	2021				
2017-03-06	2021-03-01	Landsat 8 OLI	30 m	11	Geo TIFF
2017-03-06	2021-03-01				
2017-03-15	2021-03-10				
2017-03-10	2021-03-07	Sentinel-2 MSI	(10,20,60)m	13	JPEG 2000
2017-03-10	2021-03-07				
2017-03-13	2021-03-09				
2017-03-13	2021-03-09				

5. MATERIALS AND METHODS

5.1. Pre-processing.

Preprocessing is an important step in refining satellite images and assisting with satellite data processing[26]. To eliminate noise, the researchers used a variety of preprocessing techniques, mistakes, and other cloud effects from satellite data[27].The study's raw satellite images / Karbala was preprocessed with radiometric correction [28]. The purpose of radiological correction is to remove noise-like image banding, bit errors, and scan-line corrector failure from the satellite[27]. Most of the remote sensing images cannot cover the entire study area, because the sensor image capacity has limits, a large number of images must be sliced together to achieve the desired complete target image. Mosaic image that is part of remote sensing, cannot be overlooked in the development of remote sensing[29].

5.2. Classification of images.

Classification is a necessary component of creating standardized maps that aid decision-making and planning procedures [30]. Advances in image classification methods were bolstered by Earth Observation (EO) data sets, made available by various space agencies[31].In recent years, better categorization algorithms have been employed to study intra-urban characteristics utilizing Landsat and Sentinel products[32]. Selecting a classification system is one of the first steps in every LULC classification study. The classification system is usually built to meet the user's needs, including the availability of reference samples and classification algorithms, as well as reproducibility at various scales[33]. Unsupervised classification and supervised classification are the two types of classification processes—The supervised classification approach is the key instrument for retrieving quantitative data from remotely sensed picture data. The maximum likelihood classification (MLC) is the most common supervised classification[34].In this research, the supervised classification was used to classify Karbala, Governorate into four classes (water bodies, urban lands, agricultural lands, and barren lands).

5.3. Methodology of Research.

Figure (3) depicts the entire study workflow.

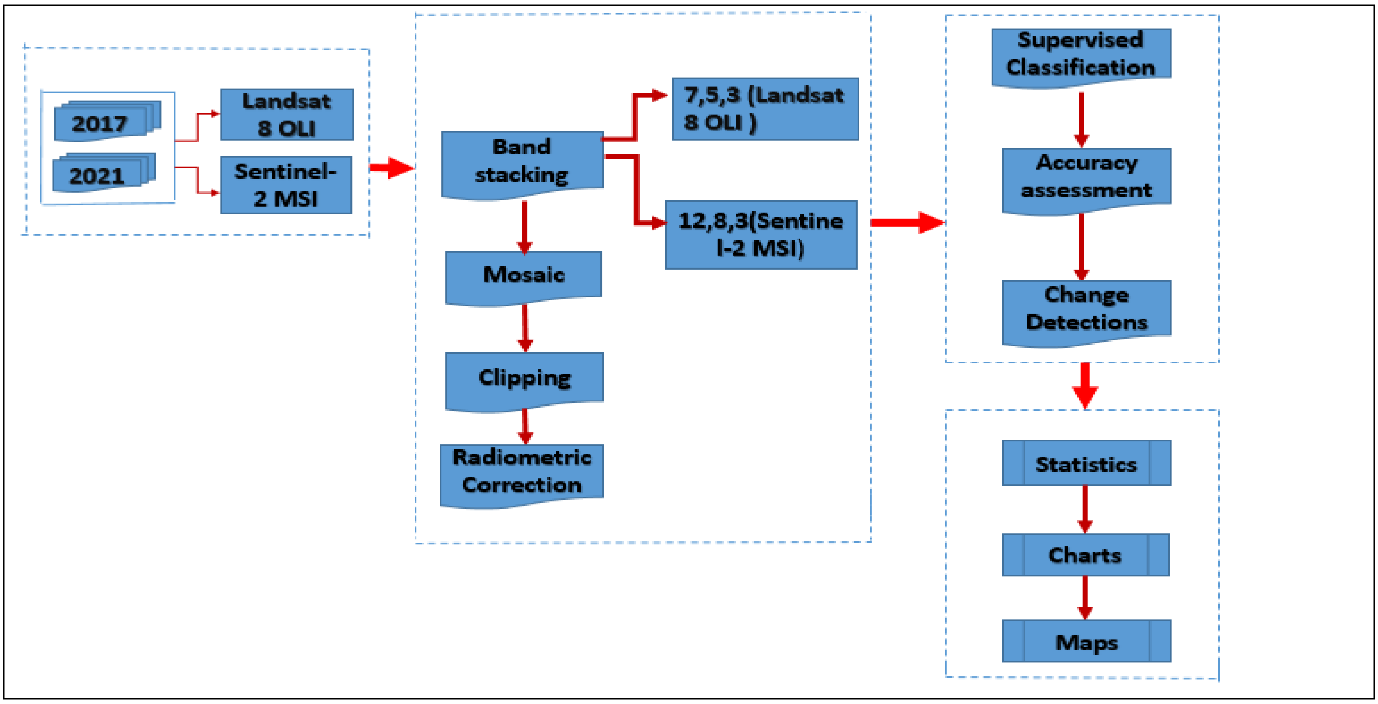
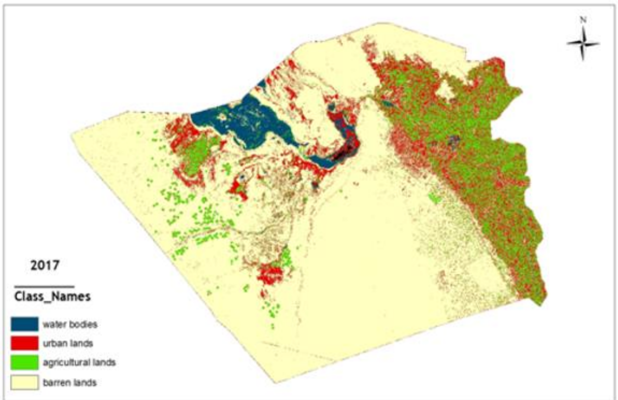


Figure 3: Land use and land cover change research methodology for the study area / Karbala, Iraq.

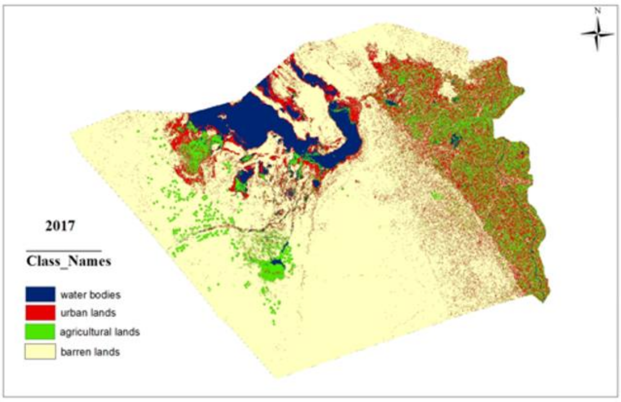
6. THE RESULT AND DISCUSSION.

6.1. Land Use/Land Cover Mapping.

Land cover mapping is required to reliably detect the change. Land cover maps are developed by analyzing the spectral reflectance of pixels in satellite photographs. Each pixel can be classified using a variety of methods. The picture resolution used during pixel classification determines the map's quality or detail. Figures 4 and 5 show maps of Karbala Governorate from the Landsat 8 OLI and Sentinel-2/ MSI satellites for 2017 and 2021, respectively. The map shows that the Sentinel-2 MSI images of the research region are accurate.

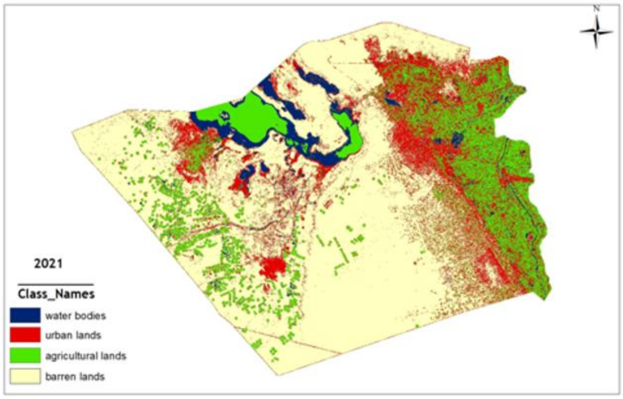


A. Image of the study area Landsat 8 / OLI satellite for the 2017

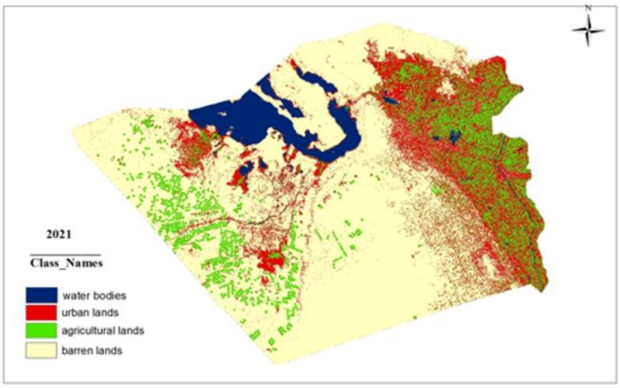


B. Image of the study area Sentinel-2 /MSI satellite for the 2017

Figure 4- A, B: Comparison of images of the study area for the year 2017 for both Landsat 8 / OLI and Sentinel-2 / MSI satellites



A. Image of the study area Landsat 8 / OLI satellite for the 2021



B. Image of the study area Sentinel-2 /MSI satellite for the 2021

Figure 5- A, B: Comparison of images of the study area for the year 2021 for both Landsat 8 / OLI and Sentinel-2 / MSI satellites

6.2. LULC change maps analyzed.

Land use and land cover change maps for 2017 and 2021 were obtained after applying the pretreatment using supervised classification and maximum likelihood algorithm for the study area to categorize them into four categories: water bodies, urban lands, agricultural lands and arid lands.

When comparing the 2017 results of the Landsat 8 satellite, the area of the categories (171.521 km2), (674.907 km2), (546,762 km^2), and (3501.75 km2) for the classes of water bodies, urban lands, agricultural lands, and arid lands, respectively, while For the Sentinel-2 satellite, the area is (242.247 km^2), (792.0733 km^2), (434.1745 km^2) and (3426.445 km^2) for the categories of water bodies, urban lands, agricultural lands, and arid lands, respectively.

When comparing the results of the year 2021 for the Landsat 8 satellite, it shows the area of the categories (231.87 km2), (700.6785 km2), (870.164 km2), and (3092.227 km2) for the classes of water bodies, urban lands, agricultural lands and arid lands on the Respectively, while for the Sentinel-2 satellite, the area is (325.933 km2), (882.8413 km2), (604.9617 km2) and (3081.204 km2) for the categories of water bodies, urban lands, agricultural lands, and arid lands, respectively. In other words, Sentinel-2 shows water bodies and urban lands accurately, as for agricultural lands and arid lands, Landsat 8, while more accurately. Show (Table 2) the analysis of the categories for both satellites and the increase and decrease in the area between Landsat 8 and Sentinel-2.

Table 2: Comparison of increase/decrease for LULC change for 2017 and 2021 in Karbala Governorate/Iraq for both satellites

LULC / Class	Area -Km2 /2017 Landsat 8	Area -Km2 /2021 Landsat 8	Area Change /Km2 (٢٠٢١-2017) (L8)	Area -Km2 /2017 Sentinel-2	Area -Km2 /2021 Sentinel-2	Area Change/ Km^2 (٢٠٢١-2017) (S2)
water bodies	171.521	231.87	+60.349	242.247	325.933	+83.686
urban lands	674.907	700.6785	+25.7715	792.0733	882.8413	+90.768
agricultural lands	546.762	870.164	+323.402	434.1745	604.9617	+170.7872
barren lands	3501.75	3092.227	-409.523	3426.445	3081.204	-345.241

6.3. Accuracy assessment.

In the past, picture classification studies did not place a high premium on accuracy evaluation. However, because of the increasing risk of inaccuracy that digital imaging presents, accuracy evaluation has become more crucial than ever[35]. The error matrix is a table containing the land cover categories of the remote sensing data set represented as rows and the land cover categories of the reference data set represented as columns. Individual cells in the table display the area or number of pixels for a given set of reference data and remotely sensed land cover classes[36] Producer accuracy measures how well real-world land cover categories can be identified. Errors of omission measure how well real-world land cover categories can be identified. The user's accuracy, which is expressed as errors of commission, is used to determine the chance of a classified pixel matching the land cover type of its corresponding real-world location[37]. The most popular and valuable way for evaluating change detection outcomes is the error matrix-based accuracy assessment method. To test change accuracy, an error matrix and a Kappa analysis were utilized.[38].The kappa statistic is often used to assess accuracy since it represents the degree of matching between the reference data set and categorization. It's a metric that can be used to compare two matrices[39]. To represent different types of land cover in the current study , a stratified random approach was used. Previous Google Earth satellite data is utilized to verify the base point reference data. Compare the 450 reference points in pixels that match the LULC features of the sorted photos . The error matrix is created from Through User Accuracy (UA), Product Accuracy (PA), and the Confusion Matrix combined to form the error matrix (Table 3). The general accuracy and kappa statistics are studied to validate the LULC map classification for different years. The overall accuracy is 90.26%, 90.83 for 2017, 2021, respectively (for Landsat 8) and 92.33%, 92.66% for 2021, 2021 respectively (for Sentinel-2). The Kappa statistics were 0.8147 and 0.7925 for 2017 and

2021, respectively (for the Landsat 8 satellite) and 0.8210, 0.8764 for 2017 and 2021, respectively (for the Sentinel-2 satellite).

The results show the overall resolution of the Sentinel-2 satellite. We observed that the images captured by the Sentinel 2 had the highest resolution, which could lead to a more accurate classification. From its closeness to the results of the Landsat 8 satellite for the two years of study, the Kappa statistics for the Sentinel-2 satellite were more accurate than the Landsat 8 satellite for the same two years of study.

Table (3): Data and analysis of land use/land cover classification in general for the years (2017, 2021) for Landsat 8/OLI and Sentinel-2/MSI satellites in Karbala Governorate, Iraq.

satellite	Date	Classes	Area		Producer's Accuracy (%)	User's Accuracy (%)	Overall Classification Accuracy (%)	Kappa Coefficient
			Km2	(%)				
Landsat 8 / OLI	2017	water bodies	171.521	3.50	77.78	82.35	90.26	0.8108
		urban lands	674.907	13.78	93.60	93.60		0.8175
		agricultural lands	546.762	11.16	63.16	80.00		0.7847
		barren lands	3501.75	71.53	93.10	85.71		0.8203
								Tat: 0.8147
	2021	water bodies	231.87	4.73	100.00	80.95	90.83	0.7991
		urban lands	700.6785	14.31	81.82	84.38		0.8262
		agricultural lands	870.164	17.77	70.73	87.88		0.8614
		barren lands	3092.227	63.17	94.92	92.95		0.7465
								Tat: 0.7925
Sentinel-2 / MSI	2017	water bodies	242.247	4.94	100.00	100.00	92.33	1.0000
		urban lands	792.0733	16.18	68.97	80.00		0.7775
		agricultural lands	434.1745	8.86	86.49	86.49		0.8404
		barren lands	3426.445	69.99	96.68	95.77		0.8449
								Tat: 0.8210
	2021	water bodies	325.933	6.65	100.00	89.47	92.66	0.8881
		urban lands	882.8413	18.03	87.50	87.50		0.8498
		agricultural lands	604.9617	12.35	96.15	90.91		0.8889
		barren lands	3081.204	62.94	92.31	95.12		0.8808
								Tat: 0.8764

7. CONCLUSIONS

The goal of this study is to determine the value of Sentinel-2 data in land cover/ land use monitoring. According to the current research, Sentinel-2 data can monitor land use and land cover , according to the majority of the studies analyzed. Sentinel-2 has also been shown to outperform similar sensors like Landsat-8 in several tests. The application of Data Sentinel-2 differs per area. In comparison to previous medium spatial resolution satellite images, such as Landsat, studies have demonstrated that Sentinel-2 data may attain high resolution due to its high geographic resolution. Both the commercial sector and the government will benefit from Sentinel-2. To expand regional and national availability, organizations, scientists, and practitioners must work together.

The results showed the accuracy of Sentinel-2 analysis for classifying the categories of the study area, namely, water bodies, urban lands, and arid lands for the years 2017 and 2021, where the percentage of water bodies was 4.94% and 6.65%, respectively. In contrast, the rate was in Landat-8 for 2017. And 2021 were 3.50% and 4.73% on straight. . As for the urban lands for 2017, 2021 Sentinel 2, by 16.18%, 18.03%, respectively, while the percentage in the same years Landsat 8 was 13.78%, 14.31%, respectively, Sentinel 2 for arid lands. In 2017 and 2021, they were 69.99% and 62.94%, respectively, while Landsat-8 was 71.53% and 63.17%, respectively.

The agricultural land results were also more accurate in Landsat-8,. The percentage of agricultural land for The results of an analysis of the classification of agricultural lands were also more accurate for the Landsat-8 satellite. The percentage of farmland for 2017 and 2021 was 11.16% and 17.77%, respectively, while the rate of Sentinel-2 farmland for 2017 and 2021 was 8.86% and 12.35%, respectively.

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