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# Green Areas Change Detection in Baghdad South City Using Remote Sensing Techniques: A Case Study

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**ABSTRACT**

This study employed advanced technology advancements and modern physical examinations to investigate and comprehend the development and utilization of land patterns in the Doura region within a specific timeframe. This study emphasizes the influence of urban geography on the physical expansion of the city, specifically in the Doura area, where the existence of the Doura refinery is a significant factor. The project aims to examine the factors and methodologies that contribute to comprehending this development. Furthermore, due to its location on the outskirts of the capital, Baghdad, and its industrial nature, the Doura region saw a transformation from an industrial area to a residential area as the population increased, The minimum distance classifier was used to classify the study area for the years 2013 to 2023 into five categories, namely urban, water, soil, streets, and plant, using remote sensing data and the ENVI program. The result showed that the southern region of Baghdad witnessed major changes, with the urban area expanding exponentially and the lack of green spaces, as the urban area constituted 12% in 2013, rising to 42% in 2018 and reaching 53% in 2023. The categories reflect a decrease in soil and agricultural land, suggesting Al-Doura's residential growth. Residential development, at the expense of both green and arid regions. may harm native plant life along with the ecology, affecting animals and plants that depend on this habitat. Urban sprawl raises land temperatures and pollutes the air.

# كشف تغير المناطق الخضراء في مدينة جنوب بغداد باستخدام تقنيات الاستشعار عن بعد: دراسة حالة

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**الخلاصة**

استخدمت هذه الدراسة التقدم التكنولوجي المتقدم والفحوصات الفيزيائية الحديثة لدراسة وفهم تطور واستخدام أنماط الأراضي في منطقة الدورة ضمن إطار زمني محدد. تؤكد هذه الدراسة على تأثير الجغرافيا الحضرية في التوسع العمراني للمدينة، وتحديداً في منطقة الدورة، حيث يشكل وجود مصفاة الدورة عاملاً مهماً. ويهدف المشروع إلى دراسة العوامل والمنهجيات التي تساهم في فهم هذا التطور. علاوة على ذلك، ونظراً لموقعها على أطراف العاصمة بغداد وطبيعتها الصناعية، شهدت منطقة الدورة تحولاً من منطقة صناعية إلى منطقة سكنية مع زيادة عدد السكان، وتم استخدام مصنف المسافة الدنيا لتصنيف منطقة الدراسة للأعوام من 2013 إلى 2023 إلى خمس فئات وهي المناطق الحضرية، والمياه، والتربة، والشوارع، والنباتات، وذلك باستخدام بيانات الاستشعار عن بعد وبرنامج ENVI. وأظهرت النتيجة أن المنطقة الجنوبية من بغداد شهدت تغيرات كبيرة، مع توسع المساحة الحضرية بشكل كبير وقلة المساحات الخضراء، حيث شكلت المساحة الحضرية 12% في عام 2013، وترتفع إلى 42% في عام 2018 وتصل إلى 53% في عام 2023. تعكس الفئات انخفاضاً في مساحة التربة، مما يوحي بالنمو السكني في الدورة. التطوير السكني على حساب المناطق الخضراء والقاحلة. قد يضر بالحياة النباتية المحلية والبيئة، مما يؤثر على الحيوانات والنباتات التي تعتمد على هذا الموطن. يؤدي الزحف العمراني إلى ارتفاع درجات حرارة الأرض وتلويث الهواء.

الكلمات الافتتاحية **:**مصنف الحد الأدنى للمسافة، الدورة، نظم المعلومات الجغرافية، كشف التغير، التحسس النائي.

## INTRODUCTION

The Daura Refinery, situated in Iraq, serves as a major plant for processing petroleum products in the area (Al-Qarakhli, Hamid Mudher, Mahmood Ali, & Yakub Majid, 2022). The facility has machinery with sophisticated refining capabilities that enable the extraction of substantial parts and their transformation into lighter oil products. Although this refinery is essential to improving the quality and efficiency of oil utilization, it presents hazards that can be harmful to the environment and the general population. Refining tasks may produce toxic pollutants, such as sulfur dioxide and nitrogen oxides, which add to air pollution. Releasing such pollutants can result in negative effects on the environment and the health of people (Al-Ramahy, 2024). The conversion of farmland into homes occasionally requires removing of native plants. A shortage of plants leads to a reduction in essential biological functions, such as the absorption of carbon dioxide and the development of areas for water draining. Therefore, this results in a rise in the absorption of contaminants into underground water reserves, resulting to the poisoning of both water and air (Sadiq & Shakoor, 2022). Converting land into housing might lead to modifications in air pollution. High levels of vapor organic compounds (VOCs) and the particles may have negative impacts on the health and well-being people who live inside (Hummadi & A.Khalaf, 2024).

The growing development of these chemicals in the environment could represent an imminent threat to human health. In essence, the continuing operation of the Daura Refinery and the transformation of surrounding land into homes have negative effects. Specifically, this relates to the contamination of water and air(Al-Sharify et al., 2023). The mentioned changes highlight the necessity of employing sustainable addresses and implementing environmental laws that minimize the impact on people and habitats (Mohajeri, Eydi, & Mirshafiei, 2024). The choice of the area for research was decided on these established standards. The surface area of the world has undergone rapid and unexpected changes due to several factors, including a decline in agriculture, climate change, population growth, and many other reasons(Mashee Al Ramahi, Mutlag, & Shnain, 2023). These factors led to environmental deterioration, and changes in the physical features of the Earth's surface due to human activity have led to the impact of land cover and a decrease in biological and agricultural procedures (Mashee, Ramahi, Khalil, & Bahadly, 2020). Detailed evaluation and careful tracking of shifts in land cover is crucial for the preservation of the environment Monitoring these developments is essential for achieving administrative and growth goals. In addition to human activity, natural phenomena lead to continuous changes in land cover (Alkurtany & Sarhan, 2024). The process of tracking these changes has become easier By combining geographic information systems (GIS) and remote sensing (RS), the combination of these two systems provides useful data about cities and their surrounding areas(Ibrahim, Ibrahim, Shaban, Jasim, & Mohammed, 2017; Kahdim & Abood, 2024).

Many research indicates the importance of GIS and RS for monitoring land degradation. Technology and geography are evolving, proving that scientific study can follow land degradation and changes(Mohsen, Al-Jiboori, & Kadhim, 2021). Through sensors that operate across different image directions, important results have been achieved through the successful application of RS methods supported by the remote sensing group(Grmasha et al., 2023). These results are very useful for designers and executives who need complete knowledge of terrain features. RS data has now achieved recognition as an essential tool for predicting the condition of land cover, monitoring the state of the environment, and controlling resources from nature (Raheem & Hatem, 2019). Previous research has used multiple satellite sources to determine land cover change processes over time. Land cover assessment is considered an essential element in environmental, social and economic studies It provides vital data necessary for developing legislation that encourages a harmonious relationship with the environment(Hamzaa, Malik, & Al-Shammary, 2022). The management of environmental systems is improved through the services provided by research services and geographic information systems. When GIS methods are combined with digital image processing methods, it facilitate the process of monitoring and evaluating changes in land cover and monitoring many temporal and geographical dimensions that cover global and local spaces(Hussein & Asmael, 2021). Monitoring changes is an essential strategy for monitoring the development of cities and the state of the environment. It includes noticing of alterations in the state or presence of things or events over an amount of time. Many automated techniques have been developed for categorizing images by dividing them into various categories based on their spectral features(Khalel, Hamza, & Khaled, 2023).

This study used technological progress and contemporary physical tests to study and understand the growth and use of land patterns in the Doura region over a certain period of time. Therefore, this study highlights the impact of urban geography on the physical growth of the city, with a focus on the Doura area, due to the presence of the Doura refinery there and the project seeks to study the variables and methods that contribute to understanding this progress. In addition to studying the variables in the Doura region, given that it is an industrial area located on the outskirts of the capital, Baghdad, and because it was surrounded by vegetation, with the increase in population, this industrial area turned into a residential area.

## MATERIAL AND METHODS

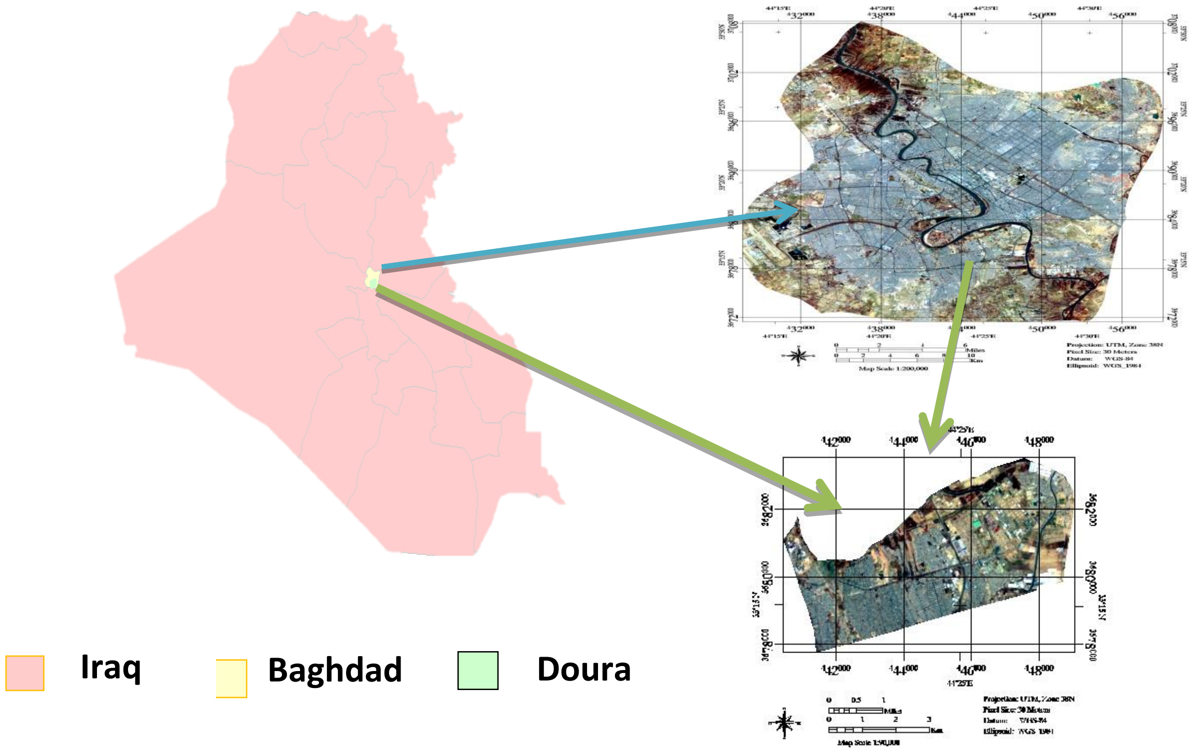
The following steps were followed to know the developments occurring subsequent 2013in the study area.

## MAXIMUM LIKELIHOOD CLASSIFIER

Maximum likelihood classifier (MLC) is a statistical model used for classification and is frequently applied in fields including artificial intelligence and remote sensing. This method relies on calculating the probability density for each class based on the statistical features of each class(Ali, Qazi, & Aslam, 2018). Using the training data, this approach computes statistical parameters like variance and mean. The probability distribution that each class has is unique and is typically thought of as a Gaussian distribution. The greatest likelihood is assigned to this class(Shivakumar & Rajashekararadhya, 2018). When working with a data collection that contains several qualities, each of which has unique properties, this strategy is seen as beneficial. The steps of the MLC classifier can be summarized by modeling a distribution for each row, estimating the coefficients and probability distributions using the training data, calculating the probability function, and then classifying the data given the highest probability for each class(Hamzaa et al., 2022). The MLC method is effective and is widely used based on basic assumptions. This method is considered an effective classification tool for dealing with complex data using Probability distribution(Hackman, Gong, & Wang, 2017).

## IMAGES USED AND DATA AVAILABLE

The study area was located in the southern region of Baghdad city (the Al-Doura area) with an area of 26.6517 $km^2$ and this region is situated between (33° 25' 73.371") latitude and (44° 39' 45.656") longitude. Figure1(a) in this study, is a satellite image download of the USGS United States Geological Survey(Mahdi, 2022). Were taken via operational land imager (OLI) which was picked on (19/9/ 2013), (17/9/ 2018) and (16/9/ 2023) which covers the research region within seven spectral packages beginning the first for the seventh, located in the space coordinates row (38) and path (167), as shown in figure1. ENVI 5.3 is the program used in the study where the chosen beams for the image in the study area are blue, green, red, near-infrared, and shortwave infrared (SWIR2).




a b

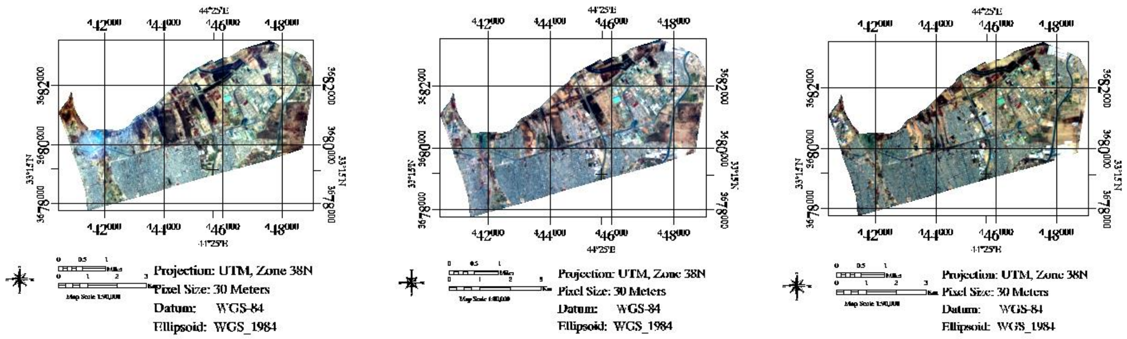
**Figure 1. (a) Location of the studied area of Iraq (b) Image of the study area by Landsat_8 satellite (Al-Al-Doura area).**

## WORKING ENVIRONMENT

Using the equation below, the digital number was converted into a reflectance value (physical unit) for the reflectivity of the top of the atmosphere(Chung & Lee, 2023):

$$\rho\lambda' = \frac{M_p * Q_{cal} + A_p}{\sin\theta} \qquad (1)$$

$\rho\lambda'$ = TOA reflection of the planets, $M_P$= reversal multiplicative calibration agent to package, $Q_{cal}$ L1 pixels quantity at DN, θ = Angles for sun altitudina$_l$ = reflectance additional scaling agent to band. The process of stacking image packets through layer stacking is initiated. Opening the image involves launching the ENVI 5.3 program and selecting the desired satellite image for band gathering. An available instrument for band gathering is chosen, typically located in the toolbar or resource menu. Variable techniques like image rectification and contrast enhancement can be used. Bands from the initial image are chosen by preference and analysis. The band gathering procedure begins after band selection. ENVI 5.3 collects bands using satellite image data. The processed image is stored for study or data use. We should study an ENVI 5.3 user manual for band-collecting tool instructions. Accurate satellite image processing and analysis need knowledge. The band-collecting approach in ENVI 5.3 makes it easy to clip images using administrative limits of the study region from satellite images and research planes. The software analyzes and interprets satellite images. Shapefiles on ENVI 5.3 are essential for recognizing and evaluating spatial information from aerial or space data. Form files, or geospatial data files, display geographic data such as points, lines, and regions. Apply Shapefiles from the toolbar or list applies form files to images. Postapplication analysis helps understand and adjust geographical data for different applications. Apply Shape Files creates geographic limits, examines points distribution, of projects geographic information onto images for spatial analysis and aerial image data interpretation. Figure 2 shows Shape file images -after administrative boundary trimming.




**2013 2018 2023**

**Figure 2. Images of the study area after the cutting**

The satellite image is opened in ENVI 5.3 to gather bands. An available instrument is selected for band gathering, typically found in the toolbar or resource menu. Versatile approaches such as image rectification and contrast enhancement are examples of techniques that can be utilized. The specific bands to assemble from the original image are chosen based on the analysis criteria. Once the desired bands are selected, the process of collecting bands is initiated in ENVI 5.3. The program performs the band-gathering procedure based on the available data in the satellite image. After completing the band collection process, the processed image is saved in a format suitable for future research or data usage. The image to which type files will be applied is opened in ENVI 5.3. The Apply Shape Files tool is located by searching the toolbar or list and selecting accordingly. The file name of the form to be applied to the selected image is provided. Apply Shape Files is then used to apply form files to the images, which allows for the display or identification of the file's geographic information in the image.After applying the format file, there may be a need to analyze the findings to better comprehend and adapt geographical data to various applications. Apply Shape Files can define geographic bounds, analyze point distribution, and project geographical data onto an image.By employing this method, a powerful tool for geographic analysis and the advancement of understanding of geographical data found in space and aerial images is provided. The research region is selected by utilizing training sets each year through a maximum probability classification method. The survey area's land cover may be classified into five primary categories: Soil, vegetation, water, urban areas, and streets, as seen in Table 1.

Table 1: Selecting the appropriate training group

| **Classes** | **color** | **Classes** | **color** |
|---|---|---|---|
| **Out of image** | | **soil** | |
| **urban** | | **street** | |
| **water** | | **plant** | |

The ENVI 5.3 program is opened, and the satellite image intended for band gathering is selected. An available instrument for band gathering is chosen, typically found in the toolbar or resource menu. Procedures such as image rectification and contrast enhancement, which offer versatility in various scenarios, are considered. The bands from the original image that are to be combined and used for analysis are selected. Band selection is influenced by the characteristics of the analysis. After selecting the desired bands, the band collection process is initiated within ENVI 5.3, which gathers bands using satellite image data. The image post-band gathering is saved in a format suitable for future research or data usage. The methodology used in this study as shown in Figure 4.

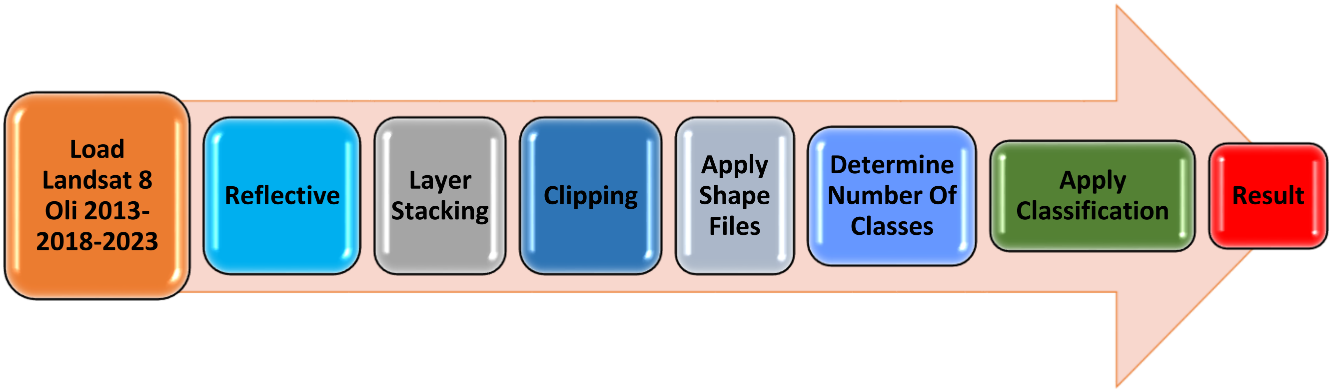
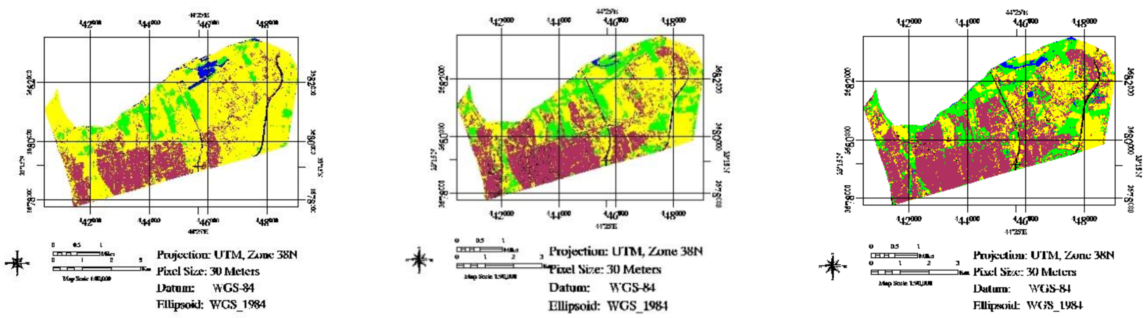



**Figure 4. The steps of our operations to the results**

## RESULTS AND DISCUSSION

Users must also possess an understanding of satellite image analysis and processing to ensure accurate results. Once the training groups are chosen and the classification task is finished, the classification is shown, as seen in Figure 3.




**2013** **2018** **2023**

**Figure 3. Images after Maximum likelihood classifier**

Researchers, especially in image processing, employ the Jeffries and Matusita scales to compare the selected collections' digital images. Use statistical variations in the distribution of data across several places. This distance measures classification accuracy, which is crucial for analyzing image classification discrimination across categories. A large gap between Jeffries and Matusita indicates good layer differentiation and is caused by a large data difference between the two groups(Kadhim & Kamil, 2022b). Jeffries-Matosita's distance may be noisy or distorted, requiring large data sets for classification. It is generally used as an extra tool to measure evaluation accuracy rather than as a full substitute. A useful method in image analysis and classification for determining how differentiable certain classes are in digital images is the Jeffries-Matusitadistance. By the Jeffries-Matusita dimension standard calculate the spectral separability of each pair of training subclasses to quantitatively evaluate the quality of coaching groups. The distance achieved via all pairs of training groups from subclasses was higher than 1.9 over the two years, except for two subclasses that obtained low separability values. Where the first pairs (urban and soil) are (1.82209316) while the second pairs (soil and street) are (1.88939241). precision estimation The Jefferies-Matusita distance is a statistical technique used by researchers to evaluate Overall Accuracy is a common metric used to evaluate the performance of classification and prediction models in areas such as image processing, remote sensing, and machine learning. Overall accuracy aims to measure how accurately and effectively a model predicts different classes in the data. Factual data is compared with Classified image data to verify its accuracy. Where user, product, and overall accuracy were applied to measure classification accuracy. The overall accuracy is calculated depending perturbation matrix that can be gained from the product accuracy and the user accuracy. Individual category accuracy can be obtained by dividing the total by the correct number of pixels sorted, and this is known as product accuracy. User accuracy is the measure by which an individual class of pixels is classified to a similar denomination, and the equation below describes total precision(Kamil & Jassam, 2020; Mahal, Al-Lami, & Mashee, 2022):

$$Accuacy = \frac{Digit\ of\ right\ categorized}{Total\ number\ of\ pixels} \times 100\% \qquad (2)$$

The Kappa factor, which extent from 1.0-0 The characterization of the Kappa factor is shown below(Kadhim & Kamil, 2022a):

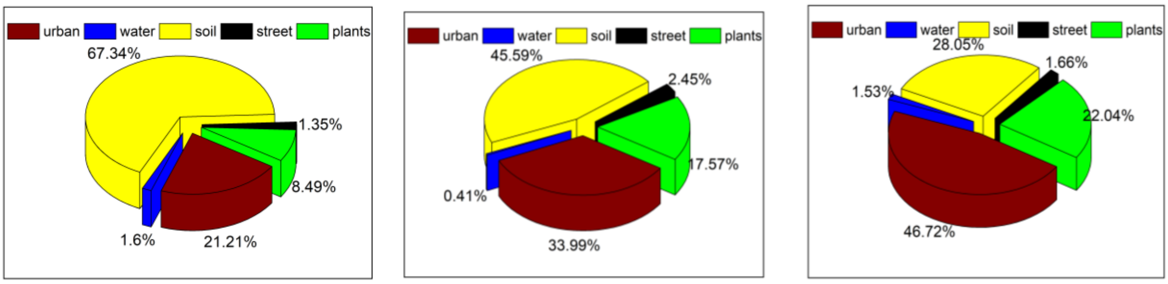
$$K = \frac{\mathrm{n} \sum_{\mathrm{i=1}}^{\mathrm{p}} \mathrm{xii} - \sum_{\mathrm{i=1}}^{\mathrm{p}} (\mathrm{xi} \times \mathrm{x+i})}{\mathrm{n}^2 - \sum_{\mathrm{i=1}}^{\mathrm{p}} (\mathrm{xi} \times \mathrm{x+i})} \qquad (3)$$

N = overall digit for practice pixel,P = digit for portion,$\sum xii$ = overall crumb for confusion matrix,$\sum xi$ = totality for line I,$\sum x{+}i$ = totality for pole $i$. The validity of the results was evaluated based on the elected coaching groups to calculate the total ranking precision. (Overall accuracy) values of 3 years are 96.7078% in 2013, 94.0341% in 2018, and 99.5074% in 2023, while the Kappa Coefficient values are 0.9560 in 2013, 0.9197 in 2028, and 0.9941 in 2023, The classification findings demonstrated a high level of agreement (as shown by high kappa factors) and a high level of accuracy (as indicated by high gross precision). After operations were completed in order of results, they appeared in Table 2 and during 2013, 2018, and 2023.

Table 2: Displays the classifications that represent the percentage and area covered within the research region

| Classes | Urban | Water | Soil | Street | Plants | Out of image |
|---|---|---|---|---|---|---|
| **Color** | **Maroon** | **Blue** | **Yellow** | **Black** | **Green** | **White** |
| 2023 % | 28.8690 | 0.4140 | 13.0610 | 3.0580 | 8.339 | 46.260 |
| 2023 km$^2$ | 14.3172 | 0.2052 | 6.4773 | 1.5165 | 4.131 | 22.9419 |
| 2018 % | 22.6830 | 0.2890 | 22.5280 | 3.7370 | 4.504 | 46.260 |
| 2018 km$^2$ | 11.2491 | 0.1431 | 11.1726 | 1.8531 | 2.2338 | 22.9419 |
| 2013 % | 6.9630 | 0.8840 | 31.9960 | 2.3390 | 11.558 | 46.260 |
| 2013 km$^2$ | 3.4533 | 0.4383 | 15.8679 | 1.1601 | 5.7321 | 22.9419 |

Some changes have occurred that we will explain as follows: The decrease in soil decreased in 2018 due to the overlap between the classification of streets and soil, and between the classification of urban, and also because some of these areas were transformed into green spaces, as we noticed their increase in the table. Therefore, some discrepancies in the percentages occurred. The categorization rates for urban areas were studied and compared over different years. The analysis revealed that in 2023, there was significant urban expansion compared to 2013, as seen in Figure 5.




**2013** **2018** **2023**

**Figure 5. Displays the categorization results of the research region from 2013 to 2023 utilizing supervised maximum likelihood**

The validity of the results was assessed by calculating the overall classification accuracy based on the selected training groups. The classification accuracy scores for the three years are shown in Table 3, indicating high overall accuracy along with elevated Kappa coefficients in the classification results.

Table 3: Classification results with the highest accuracy and kappa coefficients

| Title | 2013 | 2018 | 2023 |
|---|---|---|---|
| **Overall Accuracy** | 96.7078% | 94.0341% | 99.5074% |
| **Kappa Coefficient** | 0.9560 | 0.9197 | 0.9941 |

From 2013 reaching 2023, the southern part of Baghdad had a significant urban expansion, with the urban area doubling from 21% in 2013 to 46% in 2023, steadily increasing throughout the years. It was difficult to measure residential change with high accuracy because of the random distribution of residential areas, and this method was used because the method was simpler than the other classification methods, this area was chosen because the Al-Doura filter was old and important to study the pollution resulting from its effect on the surrounding environment in terms of pollution, the lack of green areas and desert areas, which would reduce the oxygen ratio, increase carbon dioxide and also reduce the effect of the Al-Doura filter as a pollution of the surrounding environment, where it was considered a repellent wall and a filter of those pollutants, and reduce the effect of temperature change, all of which made the study of the Al-Doura area important and made it a sample of future contamination for the entire city of Baghdad.

## CONCLUSION

By displaying the outcomes of the classifications, we observe a loss in soil. which is evidence of the clear and continuous growth of residential spaces in the Al-Doura region. Expanding residential zones while loss green and desert regions can result in environmental deterioration and a decline in biodiversity in the area. Construction could impact indigenous flora and the region's ecosystem, which in turn could influence the animals and plants that rely on this specific habitat. Residential growth may raise land temperatures and impair air. Decreasing plants in green and dry places may impair carbon dioxide sequestration and global warming mitigation. The expansion of residential areas might intensify the demand for public services, including schools, hospitals, and roads. Residential areas can contribute to background noise and traffic congestion, impacting the overall quality of life and mental well-being of residents. The absence of green areas and the expansion of residential space may impede regional environmental sustainability in the region. The surrounding environment may have adverse impacts on residential areas' environmental, economic, and social sustainability due to the surrounding environment. Ensuring sustainable development and preserving the quality of life in the region necessitates ongoing collaboration between the government and the community to balance the expansion of dwelling space with the preservation of green and desert areas. The Al-Doura oil refinery presence in the region has to be addressed comprehensively and sustainably, focusing on balancing economic, social, and environmental demands. Attaining this equilibrium necessitates strong collaboration among governments, companies, and society as a whole, with a dedication to implementing policies and measures that advance sustainability and safeguard the environment for current and future generations. Efficient monitoring of pollution control technologies, advocacy for environmental upkeep and safety protocols, development of environmental consciousness development, and community engagement. Promoting innovation in energy efficiency and clean technology is important for loss harmful emissions.

## CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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