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Urbanization and Environmental Impacts in Al-Dura Area, Baghdad

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Abstract

In the study of urban changes in the Dora area of Baghdad between 2013, 2018, and 2023, analyses revealed a significant increase in residential areas and a reduction in desert areas based on a shortest-distance classification for land use study. The findings highlight quantitative and qualitative shifts, with the first period (2013-2018) showing a 29.25% increase in residential space and the subsequent period (2018-2023) an additional 11.52% rise, reflecting a clear pattern of urban expansion. This transformation has impacted the area's environmental balance, as the reduction of desert land coupled with increased pollution from the Dora Refinery and other urban activities has led to notable environmental consequences. Furthermore, economic and social effects have emerged, such as additional pressure on infrastructure and public services. These insights underscore the importance of sustainable expansion plans and the development of green spaces to help mitigate the environmental impacts.

Keywords: Al-Doura refinery, Baghdad, Minimum distance, Remote sensing, Geographic information systems

التحضر والآثار البيئية في منطقة الدورة،بغداد

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الخلاصة

في دراسة التغيرات الحضرية في منطقة الدورة في بغداد بين الأعوام 2013 و2018 و2023، أظهرت التحليلات زيادة ملحوظة في المساحات السكنية تزامنت مع انخفاض في المساحات الصحراوية، وفقًا لتصنيف المسافة الأقصر لدراسة استخدامات الأرض. وتبيّن أن هذه التغيرات ليست فقط كمية؛ فقد سجلت الفترة الأولى (2013–2018) زيادة في المساحات السكنية بنسبة 29.25%، بينما شهدت الفترة اللاحقة (2018–2023) زيادة إضافية بنسبة 11.52%، مما يعكس نمطًا واضحًا للتحول الحضري. هذا التحول ساهم في تغير التوازن البيئي للمنطقة، حيث أدى تقلص المساحات الصحراوية إلى تأثيرات بيئية ملحوظة، كزيادة

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التلوث الناتج عن الأنشطة الحضرية المتزايدة. بالإضافة إلى ذلك، ظهرت آثار اقتصادية واجتماعية متمثلة بضغط إضافي على البنية التحتية والخدمات العامة، مما يعزز أهمية تطوير خطط للتوسع المستدام وتشجيع إنشاء المساحات الخضراء للتخفيف من الآثار البيئية السلبية.

1. Introduction

The Daura Refinery, situated in Iraq, serves as a major plant for processing petroleum products in the area ,to get information regarding the refinery, head over to the official website of the refinery: https://mrc.oil.gov.iq [1]. 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 harm the environment and the general population [2].Refining tasks may produce toxic pollutants, such as sulfur dioxide and nitrogen oxides, which add to air pollution. Releasing such pollutants can negatively affect the environment and people's health [3]. 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, poisoning both water and air [4].
Converting land into housing might lead to modifications in air pollution. High levels of vapor organic compounds (VOCs) and the particles may negatively impact the health and well-being of people who live inside. 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 adverse effects. Specifically, this relates to the contamination of water and air[5]. The changes highlighted the necessity of employing sustainable addresses and implementing environmental laws that minimize the impact on people and habitats [6]. The choice of the area for research was decided on these established standards. The world's surface area has undergone rapid and unexpected changes due to several factors, including a decline in agriculture, climate change, population growth, and many other reasons[7]. 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[8]. Detailed evaluation and careful tracking of shifts in land cover are crucial for preserving 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[9].

The process of tracking these changes has become easier by combining geographic information systems (GIS) and remote sensing (RS), which provide valuable data about cities and their surrounding areas[9]. Much 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[10]. Through sensors that operate across different image directions, important results have been achieved by successfully applying RS methods supported by the remote sensing group[11]. These results benefit 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[12]. Previous research has used multiple satellite sources to determine land cover change processes over time. Land cover assessment is essential in environmental, social, and economic studies. It provides vital data for developing legislation that encourages a harmonious relationship with the environment[13].

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 facilitates the process of monitoring and evaluating changes in land cover and monitoring many temporal and geographical dimensions that cover global and local spaces[14]. There are many concerns about congestion and environmental pressures resulting from the growth of radioactivity due to the expected increase in population in Iraq, especially in major cities such as Baghdad. This has led to the transformation of wild areas into urban areas, leading to environmental imbalance and increased economic and social security concerns[15]. Urban geomorphology includes assessing the impact of human activities on land use, especially the supervision and planning of development projects. Human considerations help manage urban growth. Therefore, these factors must be studied to manage urban expansion and reduce the risks it poses to the city's surroundings[16].

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. Therefore, this study highlights the impact of urban geography on the city's physical growth, focusing on the Doura area due to the presence of the Doura refinery there. The project seeks to study the variables and methods contributing 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.

2. Literature Review

Shahad Mohammed Ahmed et al.[17] (2022) used RS data analysis to evaluate humidity levels on the growth of the Baghdad region. In addition, the research studied the relationship between urbanization in Baghdad and brick levels using RS images. The European Center for Medium-Range Weather Forecasting (ECMWF) obtained the images. The found differences in urban areas have been confirmed by analyzing numerous variables such as the humidity ratio (RH), temperature (Ta), and evaporation. Images from Landsat-5 and Landsat-8 were analyzed using the ArcGIS 10.8 system between 2010 and 2020. The research shows a clear association between urbanization and the relative humidity rate; the study also analyzes the impact of increasing urban development on the rate of temperature increase inside metropolitan areas. This study aims to evaluate the impact of the relative humidity on the climate of Baghdad city from 2010 to 2020 while noting the rise in the built-up area from 19.60% to 27.44%. The NDVI prediction shows a significant reduction in healthy plants, with the proportion falling from 0.05% to 0.00.

Ahmed Salman Hasan et al.[18] (2022) produced continuous topographical maps using vector data to solve the issue of periodic not overlapping issues that occur throughout map generation. However, there is extra stress with positioning borders and failing to comply with the requirements stated in the MS1759 approach. To deal with this problem, The ArcGIS 10.3 program processes data, evaluates index maps, and produces geographic information using smooth methods. The database is generated by integrating the properties and encoding standards offered in the MS1759 standards.

Abdulrahman A. Abdulsamad et al. [19] (2022) produced seamless topographic maps using vector data to get around the problem of no-overlapping when making maps. Analyzed the potable water network in the Al-Yarmouk region using Water GEMS and GIS. There is another problem with matching edges and not meeting the standards set by the MS1759 procedure.

Hadeel Kh. Hammood et al. [20] (2021) employed RS techniques to measure and analyze the distribution of the Pb-214 Lead isotope in the soil of Baghdad. Radiological dangers associated with Baghdad, Iraq. The concentration of particular radioactivity of radioactive elements was measured and evaluated, both naturally occurring and artificially induced, in 48 soil samples from distinct sites in Baghdad. The isotopic distribution of heavy rounds in Baghdad has been analyzed using RS data techniques and the Global Positioning System (GPS). Concentrations were measured and observed using GIS. The interpolation maps revealed that the concentration of lead isotopes is highest in Baghdad's central and western regions, gradually decreasing in other locations.

Layla Kais Abbas et al.[21] (2021) implement RS and GIS to map land cover and land for change derivation. Using Landsat 8 images, this study aims to find changes in land cover and land use and measure the places with different land cover types in Baghdad, Iraq, from 2015 to 2020. The images were put into groups using the supervised maximum likelihood classification method. Four land cover types were found: urban, vegetation, water, and bare dirt. During the study time, changes were seen in all four land cover types. The urban, forest, and water areas got about 7.5%, 9.5%, and 1.5% bigger, respectively.

3. Methodology

The efforts taken to understand the developments in the study region after 2013 were as follows:

3.1 Minimum Distance Classifier

The Minimum Distance Classifier is a technique that is frequently used in the fields of data processing and machine learning. It provides valuable classification skills by determining the distance between the target element and the typical points of each class. It serves a wide variety of applications effectively and precisely [22]. A man and a center were assigned to each class by this classifier to represent the fundamental components of that class. The element that is most closely related to it was placed in the class that is most closely related to it by the classifier, which computes the distance between the input and the class centers. Multiple steps were required for the operation of the classifier [23]. The feature extraction process identifies novel variables defining the classified components. At this step, data was gathered to classify things accurately. In the following step, the representation of each class is established by calculating the mean or center value of each class based on the samples. This technique is the class components' focal point [24]. A technique known as distance calculation was used to determine the distance between the provided input point and the class's predicted center [25]. This is an essential step in the classification decision-making process.

Last, the classification step helps with categorization by positioning the point closest to the class's center [26]. However, the Minimum Distance Classifier may have difficulty dealing with data with unpredictable distributions even though it is straightforward. Performance may suffer if information is not distributed evenly among subclasses. On the other hand, it tackles classification issues straightforwardly and efficiently [27]. Researchers are looking for improvements and novel ways to resolve its usage challenges.

As depicted in Figure 1, the process diagram illustrates each minimal distance classification method step, visually representing the entire process.

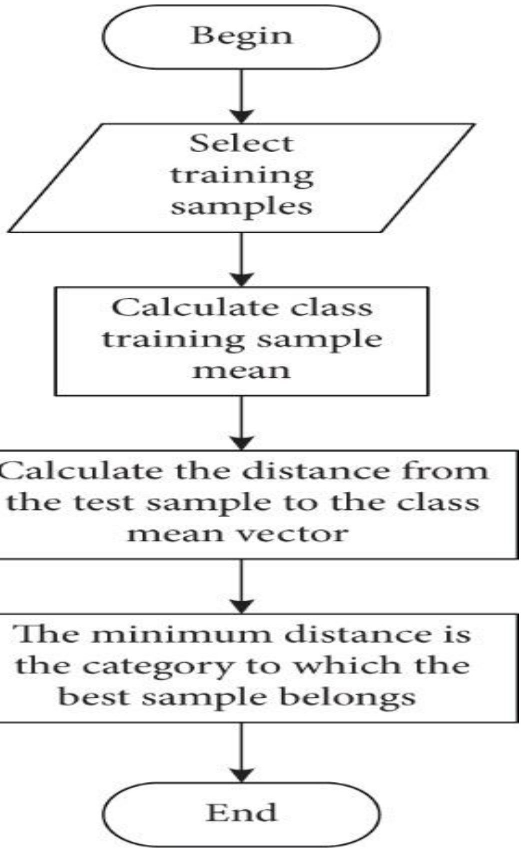
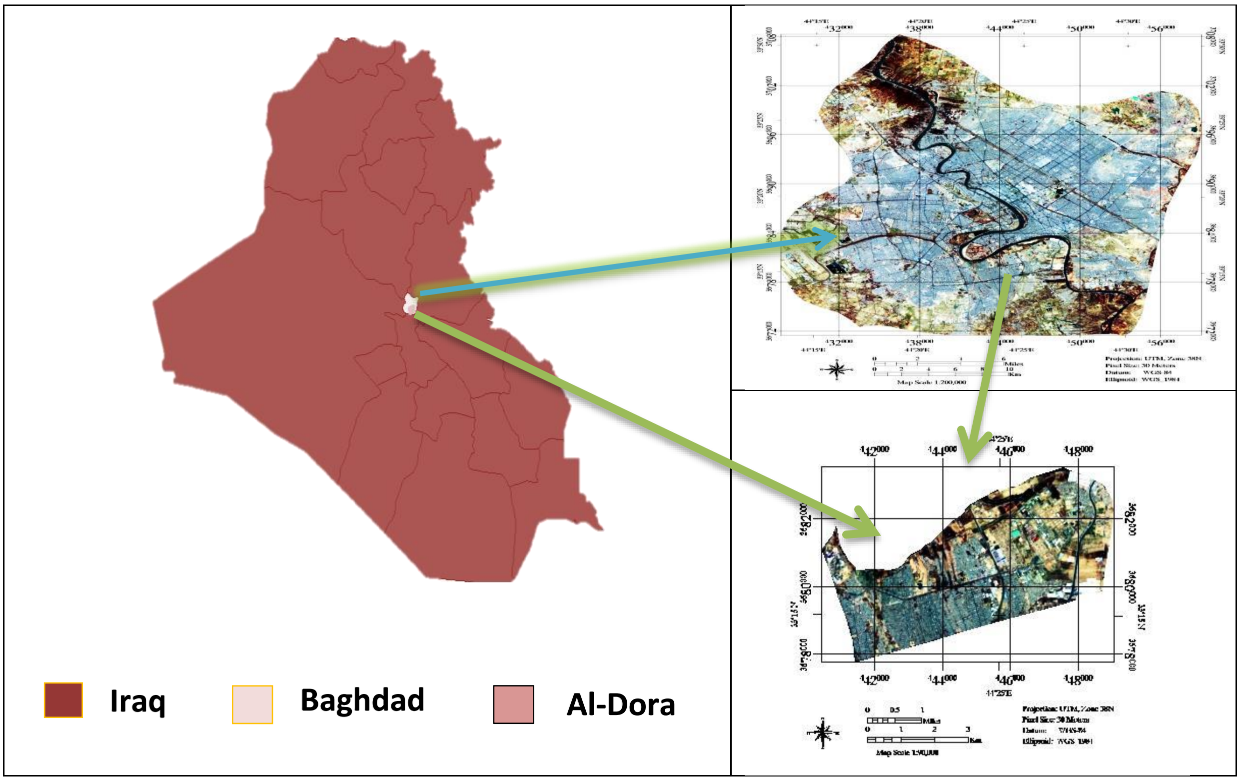


Figure 1: Flowchart of the minimal distance classification model [24].

3.2 Images Used and Data Available

The study area is located in the southern section of Baghdad city, namely in the Al-Doura neighborhood. It covers an area of 26.6517 km^2 and is positioned between 33° 25' 73.371" latitude and 44° 39' 45.656" longitude. Figure 2(a). This investigation involved downloading satellite images from the USGS United States Geological Survey [28]. These images were downloaded from Landsat 8 satellite. The operational land imager (OLI) captured images on September 19, 2013, September 17, 2018, and September 16, 2023. The images cover a study area with seven spectrum packages, ranging from the first to the seventh. The coordinates are row 38 and route 167, Figure 2. The study utilized ENVI 5.3 software to choose beams for the image in the study region, including blue, green, red, near-infrared, and shortwave infrared (SWIR2).



a b

Figure 2: (a) Location of the studied area of Iraq. (b) Image of the study area by landsat_8 satellite (Al-Al-Doura area).

3.3 Working Environment

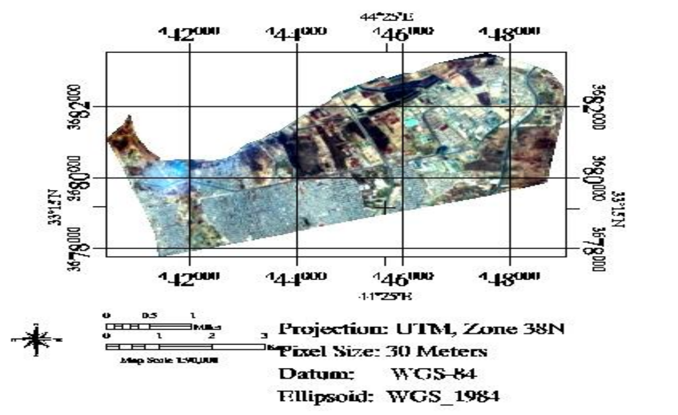
Using the equation below, the digital number was converted into a reflectance value (physical unit) for the reflectivity of the top of the atmosphere [29]:

$$\rho\lambda` = \frac{M_P * Q_{cal} + A_P}{sin\theta}$$

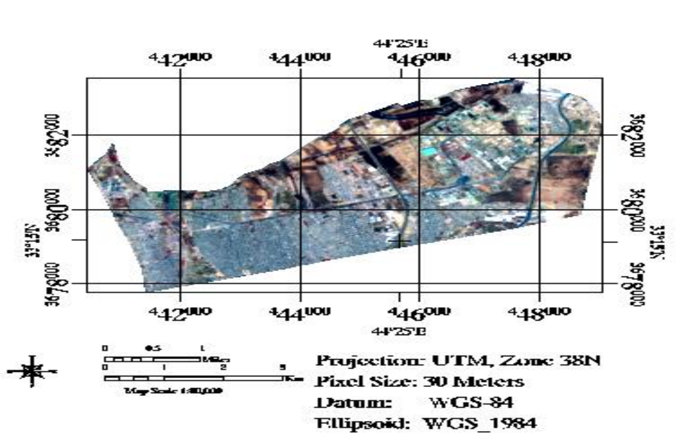
$\dot{\rho}_\lambda$ = TOA Reflection of the planets, M_ρ = reversal multiplicative calibration agent to package, $Q_{cal=}$ L1 pixels quantity at DN , θ = Angles for sun altitude , A_ρ = Reflectance additional scaling agent to band

Layer stacking was used to hierarchize image packets on top of one another. The ENVI 5.3 program allows the selection of satellite images to extract bands. Afterward, go to the tool that allows gathering bands and look for the objects corresponding to them on the taskbar or the resource menu. Techniques such as image rectification and contrast enhancement are often utilized and can be utilized in various contexts. Next, select the wish bands to collect from the first image presented. The present analytical features determined the bands selected, and after the selection, the bands were promptly assembled. In order to obtain bands, ENVI 5.3 makes use of satellite images. After collecting the bands, save the changed image for later use in data analysis or research. Detailed instructions for the band collection tool may be found in the ENVI 5.3 user handbook. In order to obtain the correct findings, users were required to analyze satellite imagery. Analysis was performed more precisely using administrative border-based image cutting in the research area. The acquisition of the ENVI 5.3 band is essential for collecting data from research planes and satellite images. Satellite images are more straightforward to analyze, giving researchers fresh viewpoints. Following these methods guarantees ENVI 5.3 band gathering efficiency. Select bands from the original image to gather. Keep analytical-ready bands. It would help if started collecting bands soon after choosing them. The bands will be assembled using ENVI 5.3 using satellite imagery.

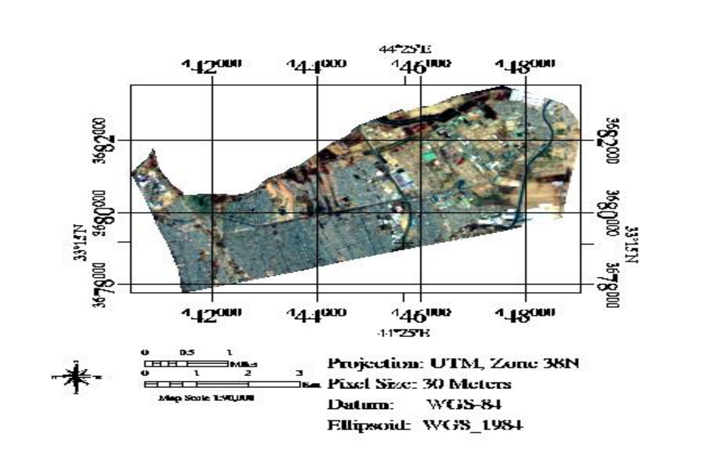
Once the bands were collected, the altered image should be saved in a format acceptable for research or data processing. In ENVI 5.3, shape files are required to apply spatial information for identification and analysis. Examples of such information include satellite or aerial images. Geospatial data files, or shapefiles, may depict points, lines, and areas geographically. Users can apply type files to air or space images with ENVI 5.3. Toolbar or list "applying shapes file" option. This instrument was utilized in the context of spatial and geographical analytic tools. For image usage, form-related files were chosen. When the file is clicked, the image with geographical information is displayed in the format that the user has selected. After selecting the form file, the process of applying shape files to the image is finished. While the format file is being applied, analyzing the findings to comprehend and modify geographical data for various applications may be essential. The use of Shape Files allows for the definition of geographical borders, the evaluation of point distribution, and the superimposition of geographic data onto existing images. This technique is an invaluable instrument for geographical analysis and gaining knowledge of spatial and aerial image data. Following removing the administrative borders through Shapefiles, the images will be shown in the manner shown in Figure 3. By going through this procedure, administrative borders may be more clearly defined, and the interpretation of the geographical data in the images can be made clearer.



2013



2018



2023

Figure 3: images of the study area after cutting.

4. Results and Discussion

The number of classes is determined based on the characteristics observed in the image. In ENVI 5.3, the satellite image is accessed, and bands are extracted using the available tools. The band collecting icon is located in the toolbar or resource menu. Image correction and contrast enhancement are utilized as techniques. Bands are selected from the original image according to analysis parameters. The band stacking process is initiated within ENVI 5.3 to collect bands from the satellite image data.

Immediately following the gathering of bands, the processed image is stored in a manner suitable for subsequent analysis. The Shape Files tool allows for the overlaying of form files onto an image to represent geographical data. After selecting the file name of the form, the Apply Shape Files tool is navigated to either the toolbar or the list of available options. This instrument analyzes geographical boundaries, point transportation, and the projection of geographical data onto the image. The study region is characterized by utilizing training sets for each year and applying a minimum distance classification strategy. According to the information in Table 1, the land cover of the region under investigation may be broken down into five primary categories: soil, plant, water, urban areas, and pedestrian streets. This approach makes available a powerful instrument for studying geographic data in area and aerial images and comprehending geographical information. It makes the classification and analysis of land cover features easier, improving the knowledge of the fluctuations that have occurred over time in the surveyed region.

Table 1: selecting the appropriate training group.

Classes and color	Out of image	urban	water	soil	street	plant

For categorization, the image is opened up. The ENVI 5.3 program is initiated, and the satellite image that is going to be used for band collection is chosen, along with the instrument that is accessible. It is necessary to look in the toolbar or the resource menu for the item corresponding to the band collecting. Two procedures that could be beneficial across various situations, namely image rectification and contrast enhancement, are considered. Based on the characteristics of the analysis, bands from the original image are then selected for consolidation. Once the desired bands are chosen, the process of gathering bands commences within ENVI 5.3, which systematically collects spectral bands from the satellite imagery. Subsequently, the image post-band-gathering is saved in a format suitable for future research or data utilization. Users must possess knowledge of satellite image processing and analysis to ensure the accuracy of findings. Following the selection of training groups and the classification work, the next steps in the analysis process are undertaken, Figure 4.

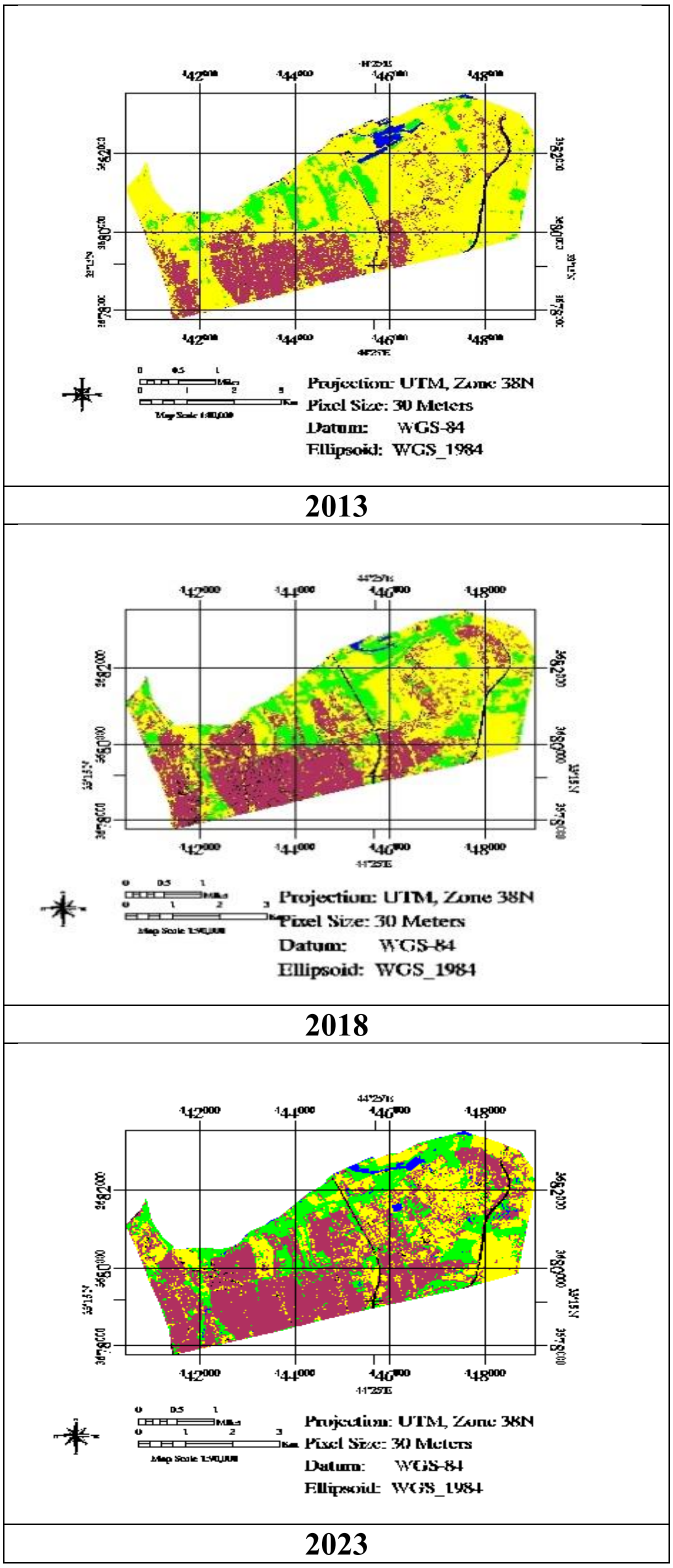


Figure 4: Images after classification

Researchers in image processing use the Jeffries-Matusita scales to compare digital images in chosen collections. Utilize statistical fluctuations in the dispersion of data among many locations. This distance quantifies classification accuracy, which is essential for evaluating discrimination in image categorization across different categories. A significant disparity between Jeffries -and Matusita suggests strong layer distinction and results from a substantial data variance between the two groups. Jeffries-Matusita distance might be affected by noise or distortion, necessitating extensive datasets for classification. It is typically utilized as a supplementary tool for assessing correctness rather than a complete replacement.

The Jeffries-Matusita distance is a valuable technique in image analysis and classification for assessing the distinguishability of distinct classes in digital images and using the Jeffries-Matusita dimension standard to measure the spectral separability of training subclass pairs to assess the coaching groups' quality quantitatively. All pairings of group training from subclasses attained a distance greater than 1.9 throughout the two years, except for two subclasses with low separability values. The first pair (urban and soil) has a value of 1.82209316, and the second pair (soil and street) has a value of 1.88939241. For the estimation of precision, researchers utilize the Jefferies and Matusita distance as a statistical method to assess overall accuracy, a widely used metric for evaluating the effectiveness of classification and prediction models in fields including image processing, remote sensing, and machine learning. Overall accuracy assesses the precision and effectiveness of a model in predicting various classes within the dataset. Verified correctness by comparing factual data with classified image data. Classification accuracy was measured using user, product, and total accuracy. The perturbation matrix determines the total accuracy derived from the outcome's precision and the user's accuracy. Product correctness is calculated by dividing the total number of correctly sorted pixels by the total number of pixels. User accuracy is the metric used to determine how well individual pixels are sorted into the same category. The equation below represents overall precision[30]:

Overall accuracy= $\frac{\text{digit of right categorized}}{\text{total number of pixels}} * 100\%$

K the Kappa factor, which extends from 1.0-0. The characterization of the Kappa factor is shown:

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

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 finding's validity was assessed by analyzing the selected coaching groups to determine the overall ranking accuracy. Accuracy values for 3 years were 78.5199% in 2013, 90.1408% in 2018, and 91.1330% in 2023. The Kappa coefficient values for the same years were 0.7297 in 2013, 0.8792 in 2018, and 0.8935 in 2023. The classification results showed a substantial degree of agreement, as evidenced by high kappa values and a high level of accuracy, as indicated by high gross precision. Determine the statistics for each categorized scenario and describe the methods used in this study, Figure 5.

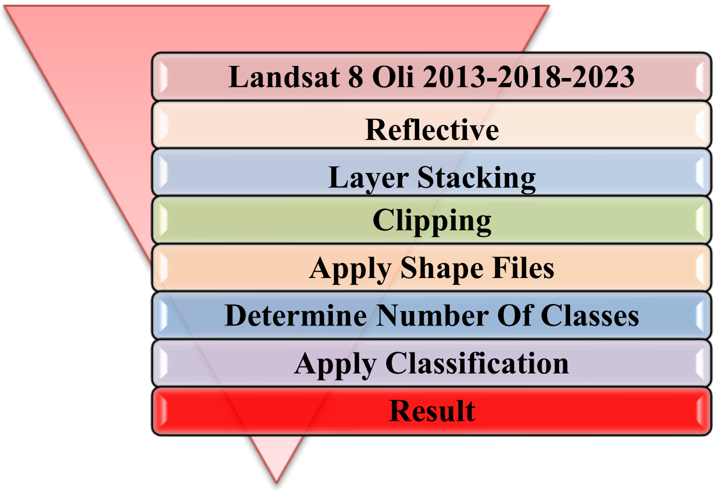


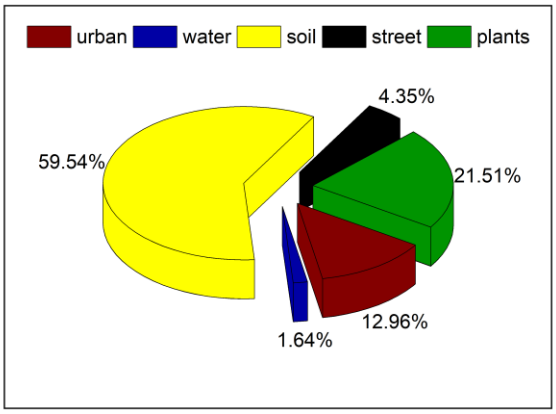
Figure 5: The steps of our operations to the results

After operations were completed in order of results, they appeared in Table 2 and during 2013, 2018, and 2023.

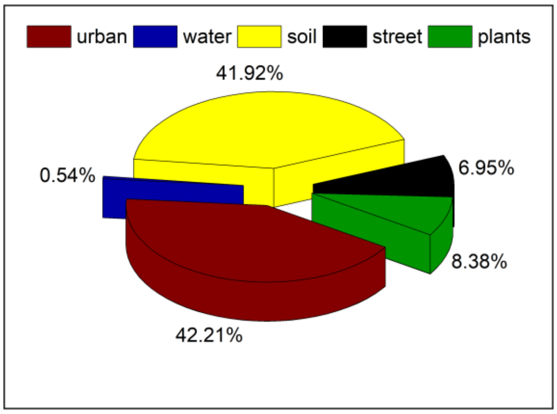
Table 2: The classes covering percent and area of the study area

classes	urban	water	soil	street	plants	Out of image
color	maroon	blue	yellow	black	green	white
2023 km^2	28.8690	0.4140	13.0610	3.0580	8.33	46.260
2023%	14.3172	0.2052	6.4773	1.5165	4.131	22.9419
2018 km^2	22.6830	0.2890	22.5280	3.7370	4.504	46.260
2018%	11.2491	0.1431	11.1726	1.8531	2.2338	22.9419
2013 km^2	6.9630	0.8840	31.9960	2.3390	11.558	46.260
2013%	3.4533	0.4383	15.8679	1.1601	5.7321	22.9419

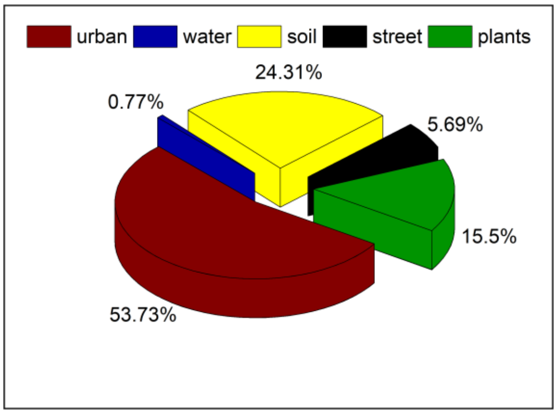
Analysis of urban area categorization rates during the research years reveals significant urban expansion in 2023 compared to 2013, Figure 6.



2013



2018



2023

Figure 6: The classification results of the study area using supervised minimum distance for 2013-2023

The validity of the results was evaluated by calculating the overall classification accuracy using the chosen training groups. The classification accuracy values for the three years can be found in Table 3, showing high overall accuracy and Kappa coefficients.

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

Title	2013	2018	2023
Overall Accuracy	78.5199%	90.1408%	91.1330%
Kappa Coefficient	0.7297	0.8792	0.8935

Between 2013 and 2023, the southern region of Baghdad had significant changes, with the urban area expanding twofold. The urban area accounted for 12% in 2013, rose to 42% in 2018, and continued to develop steadily, reaching 53% by 2023. Residential change was challenging to measure accurately due to the scattered distribution of residential areas. This method was chosen for its simplicity compared to other classification methods. The study focused on the Al-Doura area due to its historical significance and impact on pollution in the surrounding environment. The lack of green spaces and the presence of desert areas in the region could lead to decreased oxygen levels and increased carbon dioxide and hinder the effectiveness of the Al-Doura Refinery in reducing pollution. The study deemed the Al-Doura area crucial as it is a barrier against pollutants and helps mitigate temperature fluctuations, making it a significant case study for potential contamination in Baghdad.

5. Conclusion

The categories reflect decreased soil land, suggesting Al-Doura's residential growth. Residential development, at the expense of both green and arid regions, can degrade the ecosystem and reduce biodiversity. Construction may harm native plant life and the ecology, affecting animals and plants that depend on this habitat. Urban sprawl raises land temperatures and pollutes the air. Reduced vegetation in lush and arid locations may hinder carbon dioxide collection and climate change mitigation. The growth of residential areas may increase the need for public services such as hospitals, schools, and roads. Residential areas can add to ambient noise and vehicular congestion, affecting inhabitants' general quality of life and mental health. The lack of natural spaces and the growth of residential areas might hinder environmental sustainability at a regional level. The surrounding environment can negatively affect residential communities' environmental, economic, and social sustainability. Sustainable development and maintaining the quality of life in the region need continuous coordination between the government and the community to balance the growth of residential areas with the conservation of green and desert spaces. The Al-Doura oil refinery's impact on the region must be thoroughly and sustainably managed, emphasizing balancing economic, social, and environmental needs. Achieving this balance requires close cooperation between governments, businesses, and society, committed to enacting policies and actions that promote sustainability and protect the environment for present and future generations. Effectively monitoring pollution-management technology, lobbying for environmental maintenance and safety measures, promoting environmental awareness, and community involvement. Advocating for energy-efficient and clean technology innovations is crucial for decreasing detrimental emissions.

6 Acknowledgments

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