

Vegetation Cover Receding Analysis In Baghdad City Through (2017-2024) Using Remote Sensing Imagery And Geographical Information System

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Abstract

This study analyses the vegetation cover receding in Baghdad city through 2017-2024 by the use of the Landsat 8 imagery, Sentinel2 imagery, and Arcgis10.7 program. The imagery of Landsat8 and Sentinel2 is taken in certain times, which are chosen according to the growth season and the best climatic conditions. Those two satellites are chosen for that they give more accuracy because Landsat gives data for the same point every 16 days and Sentinel gives the data for that point every five days. After producing the NDVI and NDBI indices the results show that the highest value of the NDVI in the year 2017 was 0.599 and the lowest value was -0.255 while in the year 2024 the highest value for the same index was 0.438 and the lowest value was -0.083, which declares the decreasing in the vegetation cover in Baghdad city throughout the last years, in the same time the values of NDBI show increasing within the same years. These results illustrate the problem that Baghdad will face if solutions are not found to the problem of the receding of the vegetation cover.

Keywords: *vegetation cover, Landsat8, Remote Sensing indices, NDVI, Sentinel-2, NDBI, GIS.*

INTRODUCTION

The vegetation cover has a big importance for the city environment; it is described as the city's lungs. A city without vegetation cover that meets the standards will cause many different environmental problems. One of the causes of the vegetation cover receding in Baghdad city and its center is the different kinds of investments and the unplanned urban creep.

The research focuses on the values of the vegetation cover receding in Baghdad city through the years (2017-2024) by calculating the vegetation and building normal differences indices depending on the imagery of Landsat8 and Sentinel2 and ArcGIS 10.7. In the beginning, Landsat 8 images were applied to a GIS program to calculate the NDVI and NDBI indices. Also, Sentinel2 imagery analysis is used to study the percentage of vegetation and the percentage of buildings in Baghdad city over the same years. Then, one of Baghdad's districts, which is Al Jadriyah district, was studied, and the same indices were calculated to show how vegetation cover is affected. The result for both imagery emphasizes that the values of NDVI were decreasing and the values of NDBI were increasing according to Landsat8 and Sentinel2 imagery analysis, which gave a clear result of certain vegetation cover decreasing in Baghdad city.

STUDY AREA

Baghdad city is the study area of this research. Baghdad is the capital of Iraq and the largest city in it, with area (204.2km²), and population (8780422) [1]. Located between 33° 18 ' 55 'N latitude and 44° 22 '58 'E longitude (UTM WGS84 ZONE38N), It is situated on Tigris River at its closest point to the Euphrates (40km) to the west, Diyala River joins the Tigris just southeast of the city and borders its eastern suburbs. The terrain surrounding Baghdad is flat (34 meters) above mean sea level. The city extends along banks of the Tigris. The east bank settlement is known as Rusafah, the west bank is Al-Karkh.

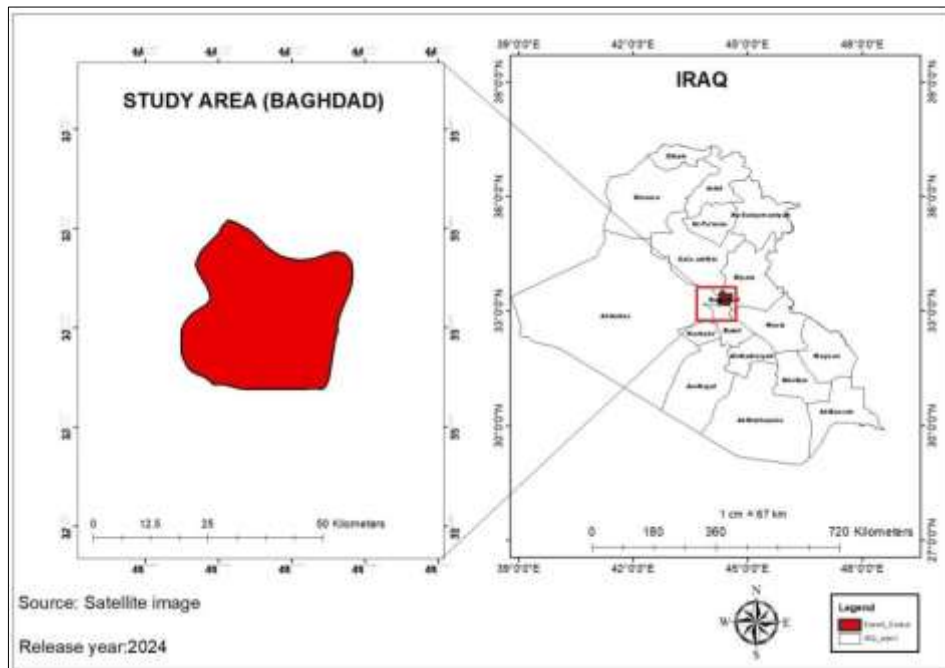


Figure 1. Study area Baghdad city, Reference: Diva GIS version 7.5

THE PROBLEM

The city of Baghdad is witnessing extensive investment process most of the times unplanned one, as well as the migration of the nearby and distant governorates residents to search for work which leads to increasing in housing demands and unplanned housing projects which exceeding the basic plan for the city of Baghdad causing vegetation cover receding in the city.

The expansion of urban areas causes a decrease in vegetation cover due to the transformation of natural and agricultural lands into construction and urban areas [2]. The benefits of vegetation cover or green lands within cities are globally known, whether in terms of reducing air pollution, heat, and traffic noise or improving the mental and physical health of individuals(3), as they act as the lungs of cities[4].

In the other hand degreasing the vegetation cover in the urban areas causes significant effects [5] such as increased surface temperature (6) as plants naturally cool the environment through shade and evapotranspiration, other significant effect is air quality degradation as plants play crucial role in improving air quality by filtering pollutants and producing oxygen, so declining in vegetation cover will cause higher levels of pollutants, such as particulate matter and volatile organic compounds leading to poorer air quality and associated health risks,[4,7], the other effects are loss of diversity, increasing dissertation[8] and impact on mental health.

In Baghdad city the problem of vegetation cover receding is becoming worse with time, the creeping of construction on green areas is increasing because of many reasons as big investments in housing sector, improper planning and fragility of laws, all of this reflects its effect on the environment, especially in increasing of air pollution as Baghdad city suffers nowadays from recording high values of different air pollutants[9,10],pm2.5 concentration is currently 8.6 times the world health organization annul pm2.5 guideline value [11].

LANDSAT AND SENTINEL-2 IMAGERY

Landsat data and Sentinel data are primary important data for analyzing different environmental changes. Generally, Landsat data are used for classification and have several bands based on their wavelength. Landsat 8 data has 11 bands. For analysis of Normal Difference Vegetation Index (NDVI), Normal Difference Built-up Index (NDBI), only four bands are used (Green, Red, NIR, SWIR).[12]. Sentinel-2 was distinguished by its extensive coverage (10 to 60m), spatial precision, Spectrum capacity (13 spectrum bands), and different revisit cycles (10 days for one satellite and 5 days for a pair of satellites).[13],The main mission of Sentinel-2 is to monitor the Earth regions by providing imagery that verifies the desired accuracy to improve the ability to detect the variation in vegetation status [13].

SPECTRAL INDICES

Vegetation indices are a mathematical combination of two or more spectral bands that enhances the contrast between vegetation that has high reflection and bare soil, manmade structures, and quantifies plants'

characteristics, such as biomass, vigor, and density [14].

Normalized difference vegetation index NDVI

This index was used to assess the amount of green cover. The normalized difference formula is done by comparing the chlorophyll region of high reflection and absorption with the spectral properties of red and NIR waves [15]. It is also used to measure and monitor the environmental conditions in terms of yield estimation to understand the vegetation cover acreage [16].

$$NDVI = \frac{NIR-RED}{NIR+RED} \quad (1)$$

Where: RED – (Band 4) with wavelength between (0.64-0.67m), NIR – (Band 5) with wavelength between (0.85-0.88m). The range of the NDVI index is between -1 and +1. For green plants, it is between (0.2-0.8) [12,17].

Normalized difference Building Index NDBI

The NDBI is used to calculate the building density index, which is used to determine the density of building. Band 5 and Band 6 Landsat imagery is used by:

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR} \quad (2)$$

Where: SWIR – Band 6 wavelength of (1.566-1.652m), the range of NDBI value is from -1 to +1, higher NDBI indicates built-up regions, and lower values indicate water bodies, vegetation NDVI is low.[12,19].

PROCEDURE AND RESULT DISCUSSION

Focusing on the problem of this study, there is a need to assess the changes in the vegetation cover in Baghdad city. To achieve this, Landsat8, Sentinel-2 imagery, and ArcGIS techniques are used. First Landsat8 images presented from USGS are used and processed by ArcGIS program to calculate the NDVI and NDBI in Baghdad city through the years 2017-2024 using the calculator option Fig. (2-5), then averaging the results with the same values given by Landsat8 imagery[18] (Fig.6-9). The NDVI and NDBI values and the average values are shown in Tables (1, 2).

It seems from the figures below that the highest value of the vegetation differences index in the year 2017 was 0.599 and the lowest value was -0.255, while in the year 2024 the highest value for the same index was 0.410 and the lowest value was -0.083. Table (1) shows the highest, the lowest and the average values for NDVI for the years 2017 to year 2024 while Table (2) shows the highest, the lowest and average values for NDBI for the same years, it can be recognized that the vegetation cover decreases throughout those years for many different political, economic and social reasons, such as large investments that are implied on the agricultural areas, from the other side the cost of the residential areas continuously rising which encourage the owners to change the gardens of their houses to residential units and that happened widely in all of the districts in Baghdad city.



Figure 2. NDVI2017 By ArcGIS 10.7

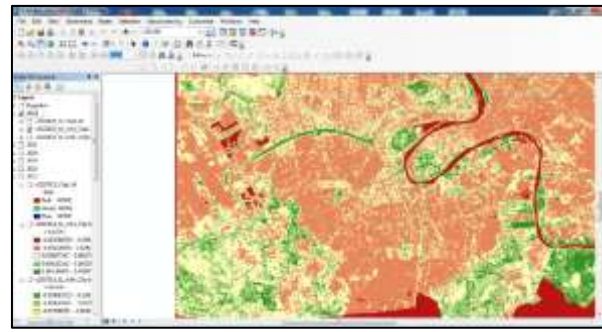


Figure 3. NDVI2024 By ArcGIS 10.7

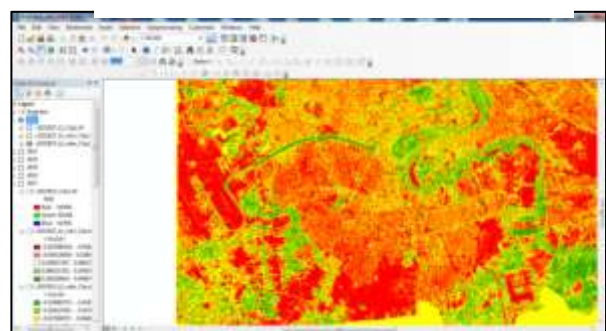
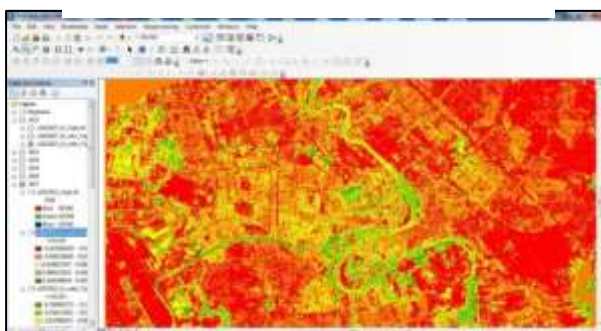


Figure 4. NDBI2017By ArcGIS 10.7

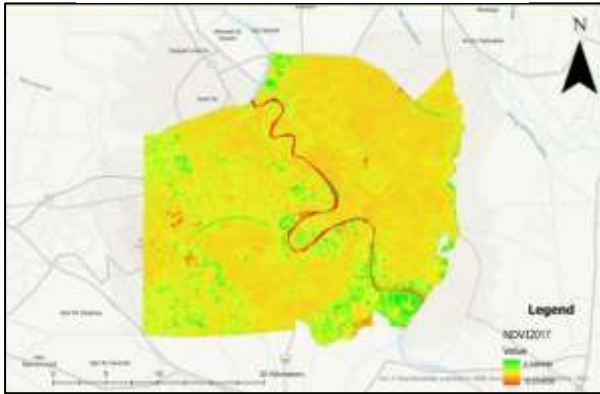


Figure 6. Baghdad NDVI Values 2017, Landsat8

Figure 5. NDBI2024 By ArcGIS 10.7

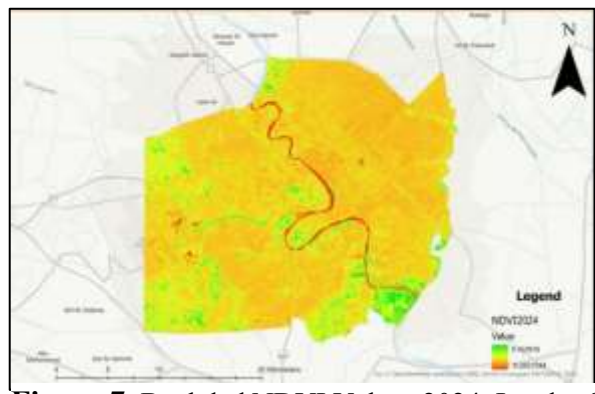


Figure 7. Baghdad NDVI Values 2024, Landsat8

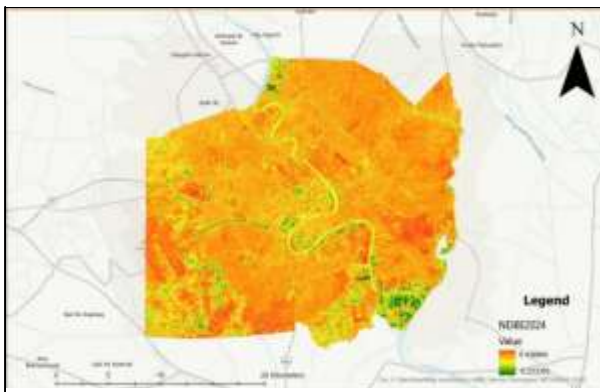


Figure 8. Baghdad NDBI Values 2017, Landsat8

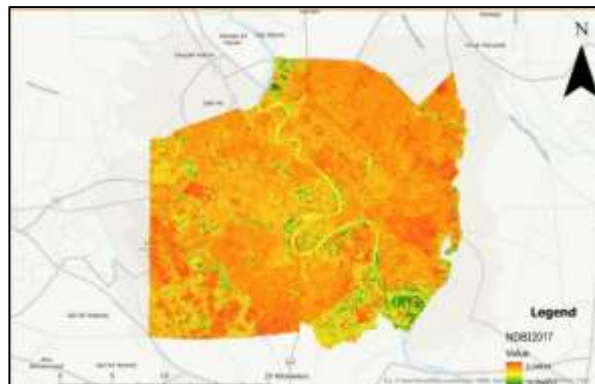


Figure 9. Baghdad NDBI Values 2024, Landsat8

Table 1. Maximum, minimum, and average values of NDVI through years (2017-2024)

Year	Max. value	Min. value	Average
2017	0.599	-0.255	0.172
2018	0.488	-0.15	0.169
2019	0.496	-0.183	0.157
2020	0.565	-0.192	0.187
2021	0.44	-0.128	0.156
2022	0.467	-0.149	0.159
2023	0.497	-0.185	0.156
2024	0.41	-0.083	0.163

Table 2. Maximum, minimum, and average values of NDBI through years (2017-2024)

Year	Max.	Min.	Average
2017	0.548	-0.397	0.076
2018	0.345	-0.31	0.018
2019	0.556	-0.351	0.103
2020	0.486	-0.353	0.067
2021	0.321	-0.285	0.018
2022	0.381	-0.291	0.045
2023	0.515	-0.299	0.108
2024	0.439	-0.253	0.093

SENTINEL-2 IMAGERY ANALYSIS

The analysis for Sentinel-2 imagery is declared in Fig.10, the figure shows the percentage of water bodies, trees, flooded vegetation, crops, and built area in Baghdad throughout the years (2017-2023), The results are summarized in Table 3. Figure 10 shows the trees in green color, the crop in yellow, and the built areas in

red. These analyses confirm the magnitude of the problem facing Baghdad city.

Table 3. Percentage of NDVI, NDBI values throughout (2017-2023) [20]

Year	2017	2018	2019	2020	2021	2022	2023
Trees	1%	1%	1%	1%	0.9%	0.4%	0.9%
Flooded vegetation	0%	0%	0%	0%	0%	0%	0%
Crops	15%	16%	15%	14%	13%	13%	12%
Built area	68%	68%	70%	71%	73%	71%	76%
Water	3%	3%	4%	3%	3%	3%	3%

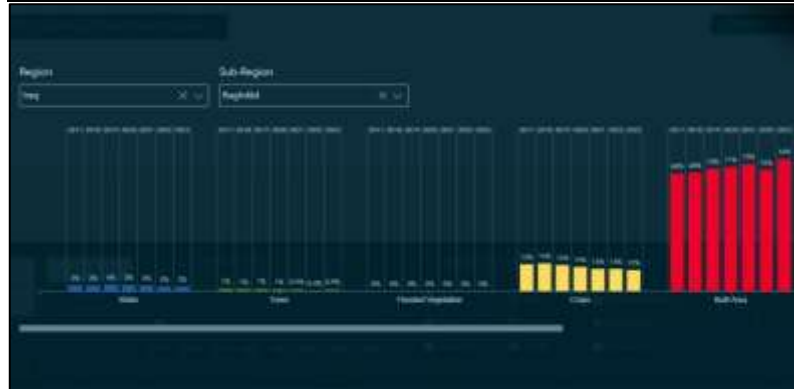


Figure 10. Baghdad Land Cover Sentinel-2 analysis [20]

AL-JADRIYAH DISTRICT NDVI AND NDBI ANALYSIS

As an example of creeping of investment on the agricultural areas, is that part of Baghdad which is shown in Figures (11, 16, 18), below which covers Al- Jadriyah district, Figure(13) shows areas of the vegetation cover in 2017 while figure(14) shows the same areas in 2024 and figure(15) shows the clear decreasing difference in the period between the two years.

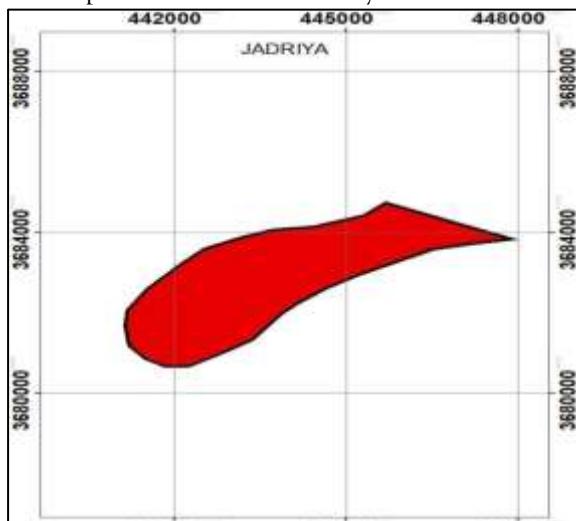


Figure 11. Al-Jadriyah district, Diva GIS version 7.5



Figure 12. Al-Jadriyah district within Baghdad city

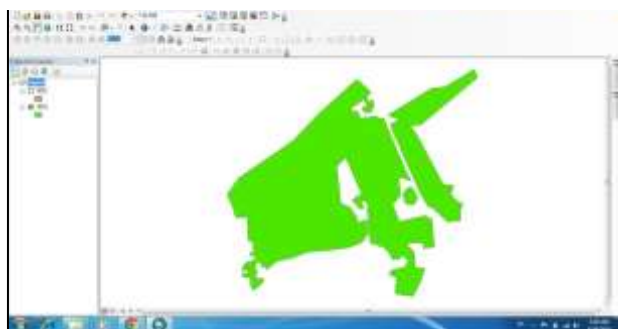


Figure 13. Vegetation cover in AL-Jadriyah (2017) Landsat8 and ArcGIS10.7



Figure 14. Vegetation cover in AL-Jadriyah (2024), Landsat8 and ArcGIS10.7

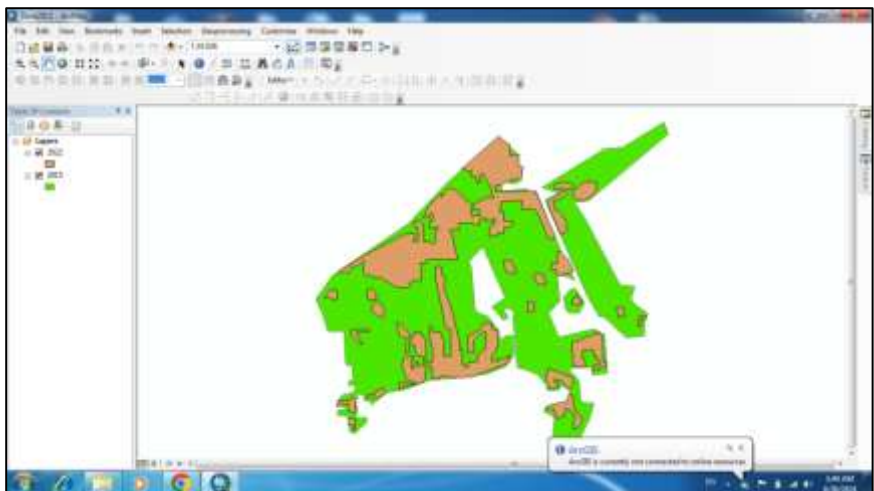


Figure 15. Deference in vegetation cover in AL-Jadriyah (2017-2024)

ANALYSIS OF VEGETATION COVER IN AL-JADRIYAH DISTRICT BY SENTINEL2 IMAGERY

Figure 16 shows the NDVI values in the AL-JADRIYAH district by Sentinel2 imagery. On the other hand, Figure 17 shows the statistical analysis with a smaller peak near 50 and a broader peak from 150 to 250, and suggests a mixture of bare soil, sparse vegetation, and moderately to densely vegetated areas. Mean NDVI: 152.96: This is the average gray scale NDVI value, which is just above the midpoint (128). It suggests that overall vegetation is moderately healthy, leaning toward higher NDVI values (greener, more biomass).



Figure 16. Al-Jadriya NDVI Values, Ref. (Sentinel2 imagery (2023))

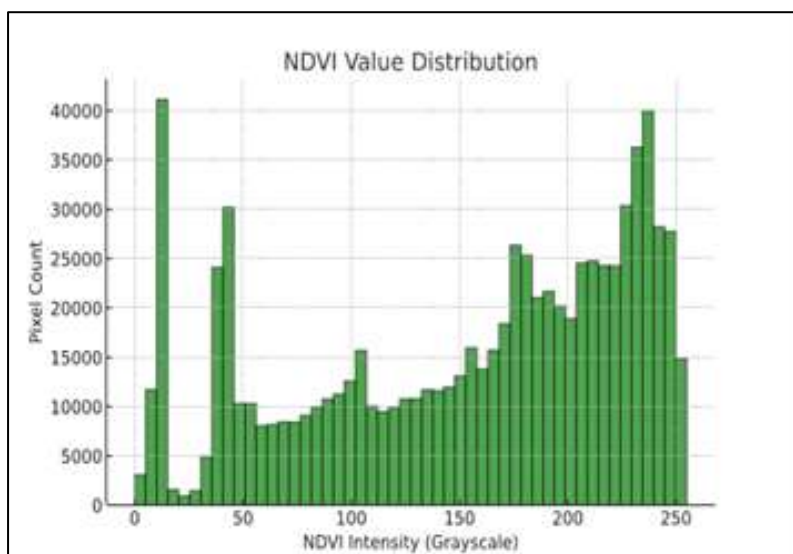


Figure 17. Statistical Analysis for Sentinel 2 Imagery (2023)

The standard deviation is 75.01. A high standard deviation means there is a wide spread of NDVI values, which matches what has been shown in the histogram, a broad range from barren to vegetated areas. Figures 18 and 19 below, for the same district after one year, show that the statistical analysis declares that the standard deviation is (42.57) less than that before one year (75), which indicates the rapid change in the vegetation cover and is decreasing more and more every year.



Figure 18. Al-Jaderiya NDVI values ,Ref. (Sentinel2 imagery 2024)

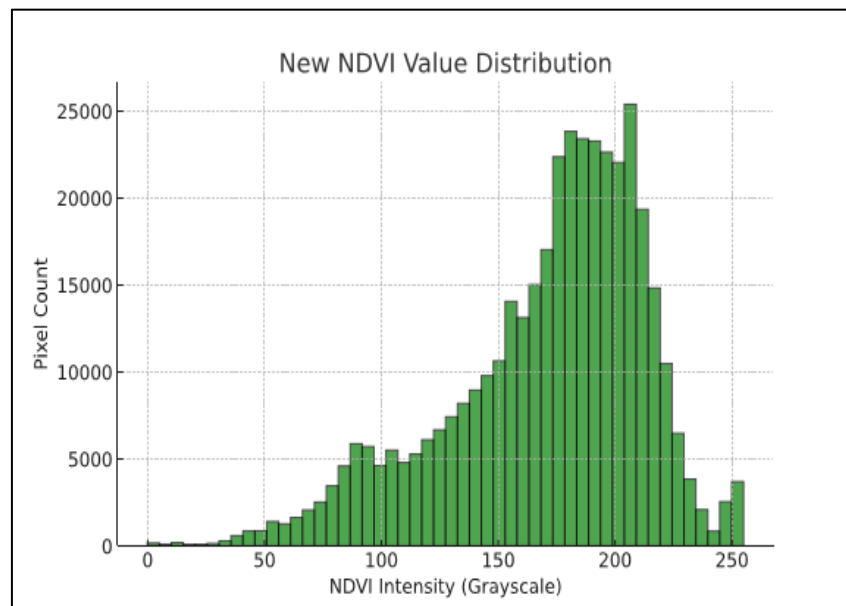


Figure 19. Statistical analysis for Sentinel2 Imagery 2024

CONCLUSION

The NDVI images show that yellow dominates most of the area, indicating that Baghdad suffers from a general lack of vegetation cover, which is typical in urban areas and arid climates.

Green areas are limited and linked to water sources (such as the Tigris River), highlighting the importance of irrigation in improving vegetation cover.

From the environmental sight of view, low values indicate risks such as desertification, decreased biodiversity, and rising temperatures (urban heat island). Green areas help mitigate these problems. [

For economics, Areas with high values may be centers of agricultural production, while areas with low values may require investments in irrigation infrastructure or afforestation.

The values of NDVI can be used in environmental management: Identifying areas in need of environmental restoration (such as tree planting), urban planning: Improving the distribution of parks and green spaces in cities and identifying areas with high agricultural potential for crop development.

Monitoring is needed to track annual changes in vegetation cover to assess the impact of policies or natural disasters.

Values of NDVI do not reach 0.6 or higher, indicating that Baghdad lacks dense forests or tropical vegetation, as would be expected in its semi-arid climate. The focus on the Tigris River demonstrates that water is the decisive factor in increasing vegetation cover.

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