Iraqi Journal of Environmental Sciences
Vol. 01, No. 01, pp. 09-18, Aug. 01, 2025
https://ijes.uomustansiriyah.edu.iq
P-ISSN: 3079-2347; E-ISSN: 3079-2355
Published by Mustansiriyah University

Research Article

Open access

Monitoring the Normalized Difference Vegetation Index (NDVI) in the Kurdistan Region of Iraq using Remote Sensing Techniques

Athraa Jamhor Abd Harbi, Yaseen K. AL-Timimi, Nagham Abbas Mohammed*

Department of Atmospheric Science, College of Science, Mustansiriyah University, Baghdad, Iraq

Email (NTI): azrjmm@gmail.com; Email (JHK): yaseen.altimimi.atmsc@uomustansiriyah.edu.iq

* Correspondence Author Email: setnagham@uomustansiriyah.edu.iq

ARTICLE INFO

Received: May 05, 2025
Revised: July 15, 2025
Accepted: July 29, 2025
Published: August 01, 2025

Abstract: Rapid and widespread use of remote sensing and accurate acquisition of information on the spatiotemporal distribution of large-scale vegetation is of great importance for improving and managing the environment. This research aimed to monitor the agricultural drought in the Kurdistan Region of Iraq by used the spatiotemporal variability of vegetation cover. NDVI images have been used from MODIS over 24 years (2000-2023). The results showed that the vegetation cover was mainly distributed in the northeast to southeast of the Kurdistan Region of Iraq, while the western region was less distributed and had almost no vegetation cover. This is clearly shown in the southwestern part of the region. While Duhok Governorate has the most control over vegetation cover in the Kurdistan Region of Iraq during the study period. There is a significant temporal variation in vegetation cover over 24 years in the Kurdistan Region of Iraq. A decrease in vegetation cover area was observed in 2000 and 2008. The increase or decrease in vegetation cover area is not only affected by climatic conditions. Human resources are also one of the main resources that have a great influence on the increase or decrease in vegetation cover.

Keywords: Iraq; Drought; NDVI; GIS.

1. Introduction

Drought is one of the major environmental challenges facing Iraq at present. Drought causes severe rainfall shortages and low water levels in rivers and lakes, negatively impacting agriculture, the economy, environment, and exposing the population to health and social risks. Changing natural conditions and global climate change exacerbate this phenomenon in Iraq, requiring effective strategies and measures to address its repercussions and reduce its impact on the population and the environment [1]. In addition, drought reduces water supplies for drinking and agriculture, affecting the country's food security and economic development [2]. Drought is one of the important geographical climatic phenomena that has begun to occupy the attention of many researchers, especially recently, as it is one of the global problems and one of the natural disasters that has left many effects that are difficult to determine.

Drought is a recurring and periodic climate phenomenon that occurs as a result of a decrease in the amount of rainfall below its general average for a long or short period, which leads to a decrease in the amount of running water from rivers, a decrease in soil moisture, and a decline in the areas of vegetation cover and agricultural lands [1]. Drought refers to a specific period in which the amount of rainfall decreases. It may be long, short, or fall at an inappropriate time. Drought is defined as the period in which the amount of rainfall and relative humidity decrease and is characterized by high temperatures and wind speeds [3]. Yaseen AL-Timimi, et al (2012) [4] studied the drought levels in Iraq using Remote Sensing and GIS Techniques. Meteorological and Agricultural droughts were calculated based on the Standardized Precipitation Index (SPI) and Anomaly of Normalized Difference Vegetation Index (NDVI), respectively. The results indicated that 14.4% area has Slight drought, 61.6% area faces moderate risk, 23.2% area face severe risk and 0.8% area faces very severe risk within the study area. Heman Abdulkhaleq, et al (2022) [5] analyzed a Landsat time-series dataset from 1998 to 2021 to determine the drought severity status in the KRI. The Modified Soil-Adjusted Vegetation Index (MSAVI2) and Normalized Difference Water Index (NDWI) were used as spectral-based drought indices to evaluate the severity of the drought and study the changes in vegetative cover, water bodies, and precipitation. The Standardized Precipitation Index (SPI) and the Spatial Coefficient of Variation (CV) were used as meteorologically based drought indices.

1.1. Normalized Differences Vegetation Index (NDVI)

NDVI is a widely index used in remote sensing to assess and monitor the health, density, and strength of vegetation cover in a given area. The NDVI is derived from satellite images in different spectral bands, especially in the visible and near-infrared regions of the electromagnetic spectrum [2]. It can be calculated by the following formula:

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

Where: NIR is the reflectance in the near-infrared range. Red is the reflectance in the red range. The values of the vegetation index range from (-1 – 1), where negative values indicate clouds and water, positive values close to zero indicate bare soil, and higher positive values of (NDVI) indicate:

Table 1. The values of the vegetation index range.

NDVI Range	Feature
0.1-0.2	Spread vegetation
0.2-0.3	Low vegetation
0.3-0.5	Moderate vegetation
0.5-0.75	Dense vegetation
0.75-1.0	Very dense vegetation

The NDVI index is widely used in various applications, including agriculture, forestry, environmental monitoring, and climate change studies. It provides valuable insights into vegetation dynamics and ecosystem health at local, regional, and global scales.

2. Materials and Methods

2.1. Area Study

The Kurdistan Region is located in northern Iraq and has an area of 40643 km^2. The region includes two main rivers: the Greater Zab and the Lesser Zab, which originate from the Tigris River. Its elevation ranges between (88 - 3600) m. It includes the governorates of Dohuk, Erbil, and Sulaymaniyah as shown in figure 1.

The Kurdistan Region enjoys a Mediterranean climate, which is cold and humid in winter and hot and dry in summer [6,7]. In general, the climate is determined by high rainfall rates in the north and a dry climate in the plains [8,9]. From October to May, rainfall ranges from 350 mm in the southern regions to more than 1,200 mm in the northern and northeastern regions [10]. The average daily temperature ranges from 5°C in winter to 30°C in summer, while in the south it can reach 50 °C. Physiologically, the Kurdistan Region of Iraq can be divided into the Zagros Mountains and the foothills. The total area of land suitable for rainfed agriculture is 10682 km^2, which represents 87.6% of the total agricultural land. Approximately 7202 km^2 of the farming area in the Kurdistan Region of Iraq has been allocated to the production of field crops, which constitutes a large share of the agricultural area in the Kurdistan Region of Iraq [11].

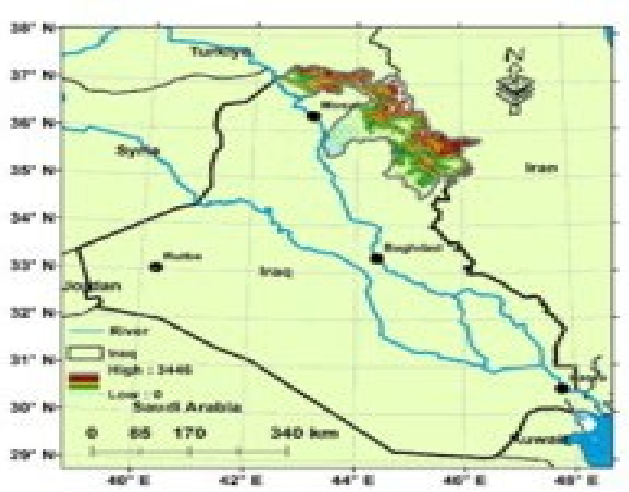


Figure 1. Study area.

2.2. Data

In this study, data were obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS). Data were downloaded from NASA's Earth Observing System satellites. NASA's Earth Observations (NEO) is part of the EOS Project Science Office located at NASA's Goddard Space Flight Center. Over 50 different global datasets are represented with daily, weekly, and monthly imagery data. Images are available in a variety of formats including JPEG, PNG, Google Earth and GeoTIFF. All imagery data were available at (https://neo.gsfc.nasa.gov/). GPM data were extracted using ArcGIS version 10.7. The data are MODIS images taken for the years 2000, 2010, 2020, and 2023. The data were prepared and because these images are prepared to cover a very large area, it was necessary to extract the study area, which is Iraq, and subtract it from each image using GIS Arc and then classify the MODIS image.

3. Results

Mathematical and computational operations were performed on the MODIS image series covering the study area over 24 years from 2000 to 2023 during the spring season (April), as shown in figures (2-5).

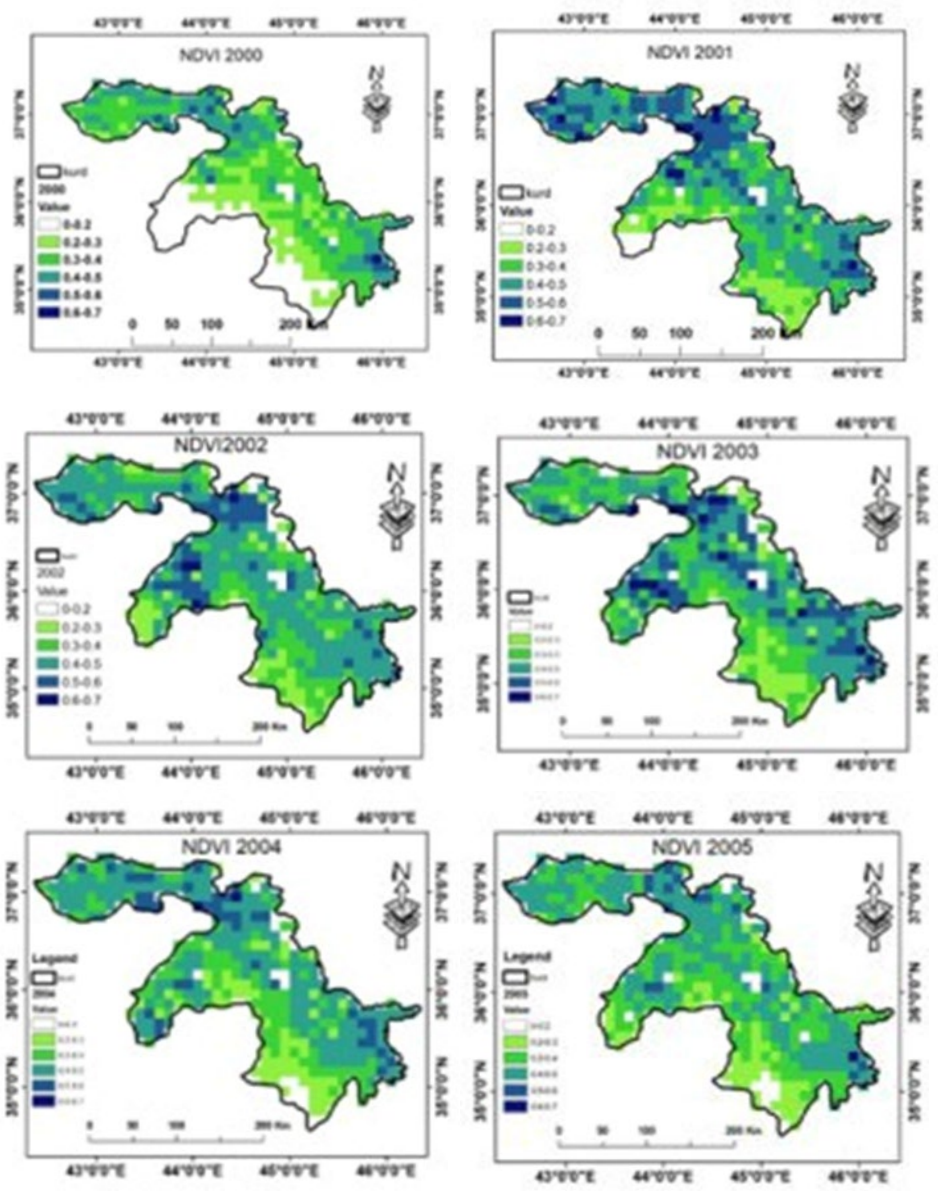


Figure 2. Spatial distribution of the NDVI index during the period 2000 to 2005 for the Kurdistan region of Iraq.

The operations included classifying the image based on the NDVI thresholds, which include 6 classes: the first class is no vegetation cover ranging from (0-0.2), the second class is light vegetation cover ranging from 0.2 to 0.3, the third class is ranging from 0.3 to 0.4, the fourth class is ranging from 0.4 to 0.5, representing moderate vegetation cover, the fifth class is dense vegetation cover ranging from 0.5 to 0.6, and the last class is very dense vegetation cover ranging from 0.6 to 0.7.

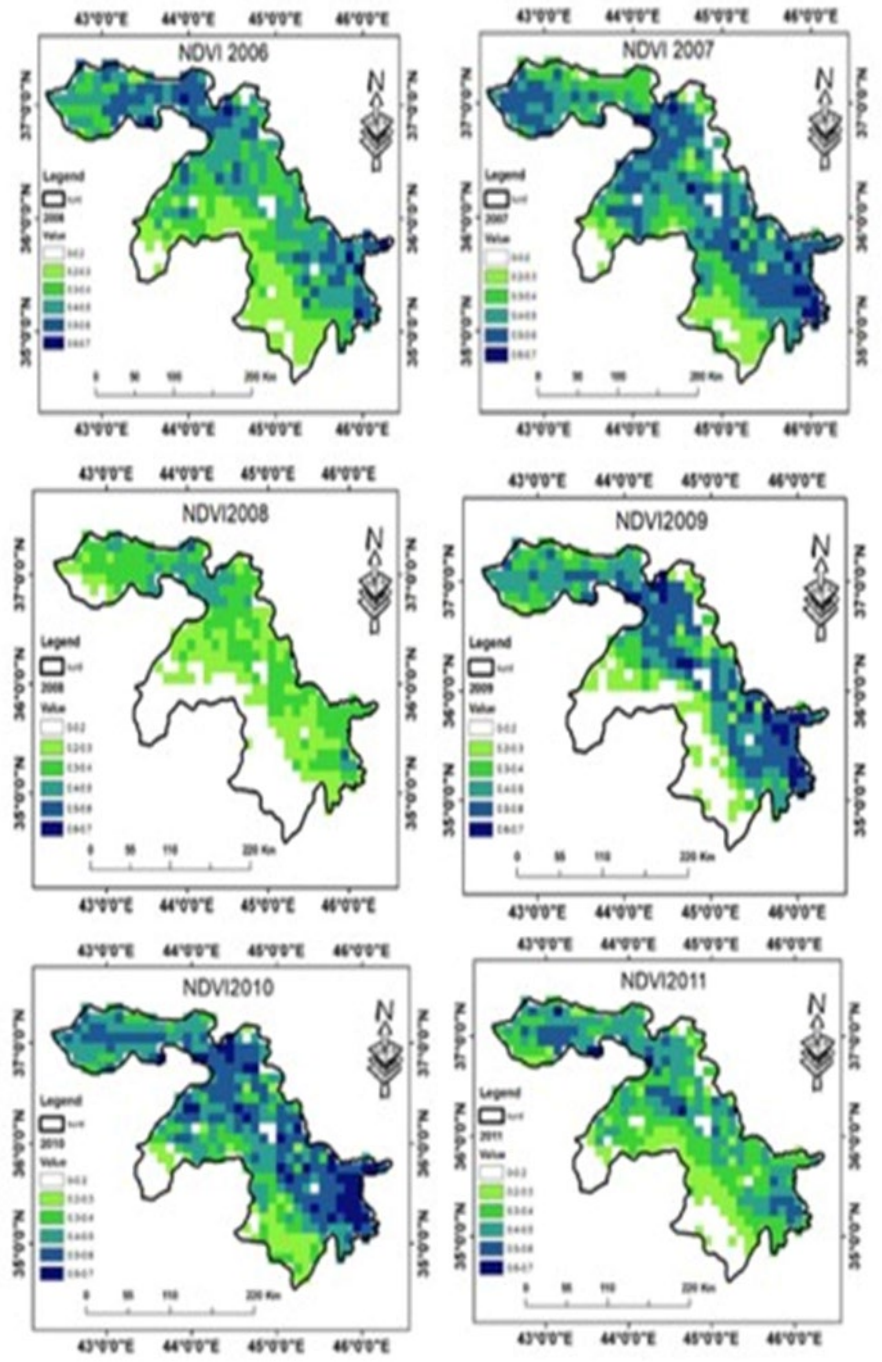
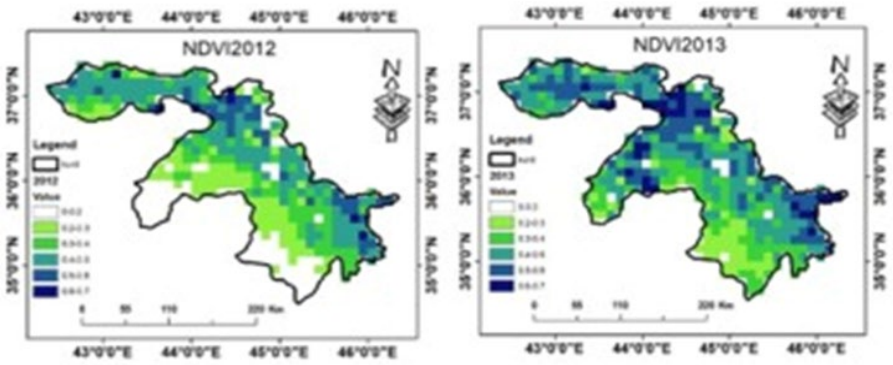


Figure 3. Spatial distribution of the NDVI index during the period 2006 to 2011 for the Kurdistan region of Iraq.



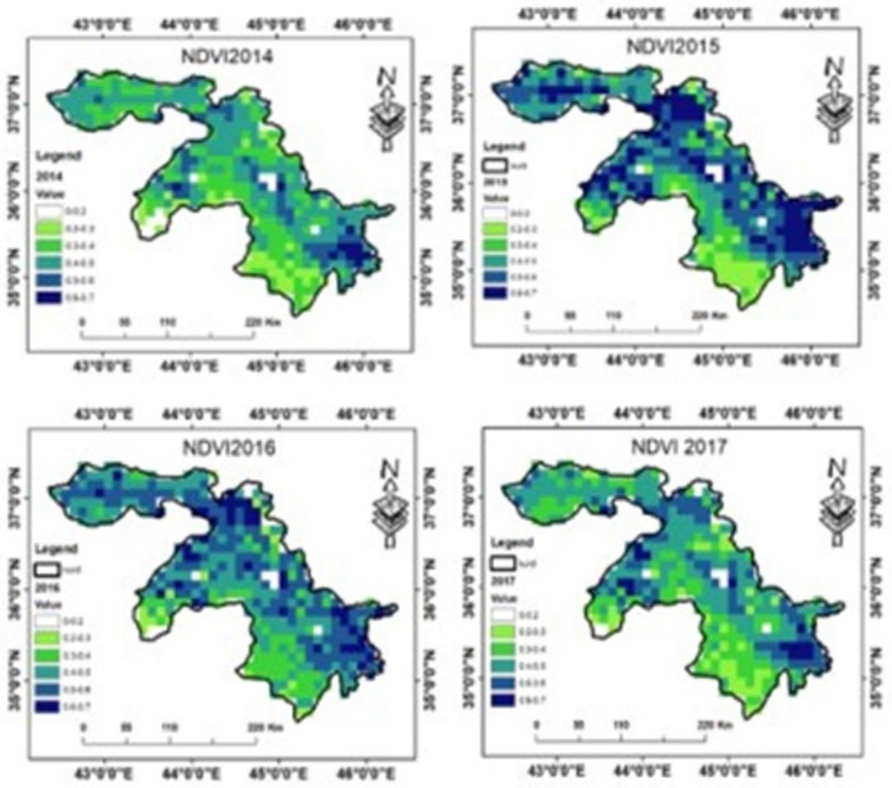
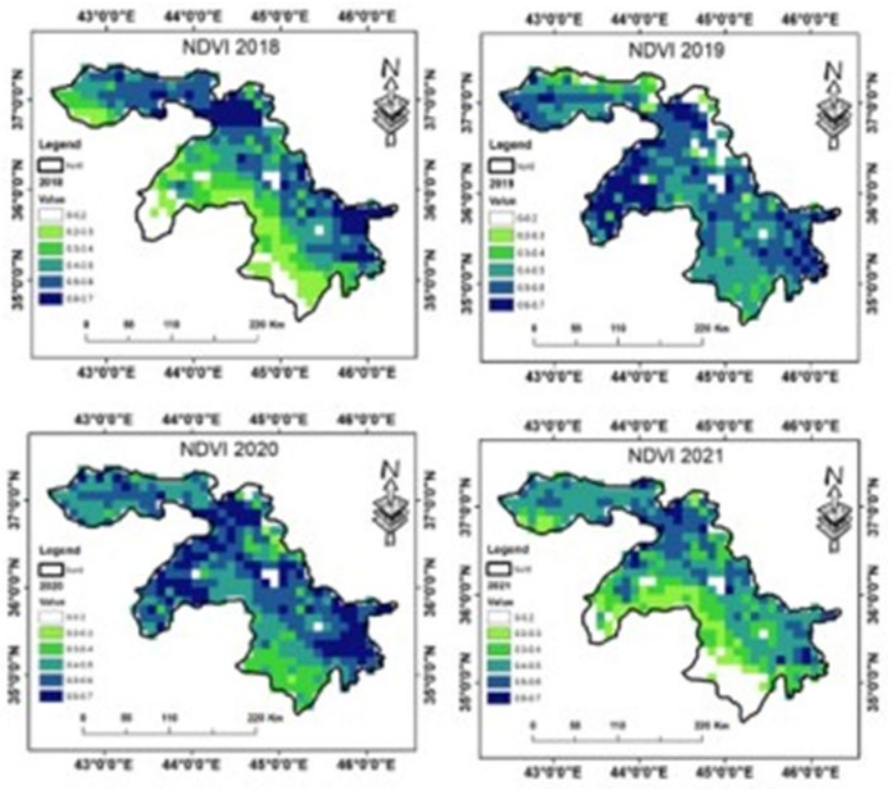


Figure 4. Spatial distribution of the NDVI index during the period 2012 to 2017 for the Kurdistan Region of Iraq.



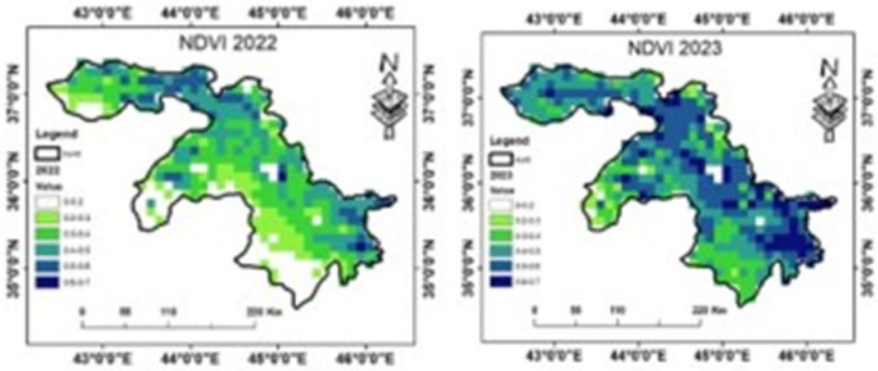


Figure 5. Spatial distribution of the NDVI index during the period 2018 to 2023 for the Kurdistan Region of Iraq.

Figures (2-5) show, it was noted that the sixth class, which represents dense vegetation, was absent or present in small quantities during the following years: 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2011, 2012, 2017, 2021. The years 2015 and 2020 were the years with the highest frequency of dense vegetation area. During 2006, it was noted that vegetation cover was present in the north and east at a very low rate. Then in 2007, the vegetation cover began to increase, as the vegetation cover was present in the north, east, and west to a reasonable extent. As for 2008, it was the most dangerous year due to the complete drought. During 2013, an increase in the vegetation cover area was observed compared to 2012, and the vegetation cover was present in the direction of the northeast and west, in proportion to the moderate vegetation cover as well as the dense vegetation cover. During the year 2018, the concentration of vegetation cover became high in the northeast direction, and it can be notice that the increase in all classes except for the fourth class, which is very light blue, which is class 0.4-0.5, and the third class 0.3-0.4. During the year 2020, which has the highest concentration of vegetation cover in the northeast and northwest direction, especially in the fifth and sixth classes. 2021 the average vegetation cover value decreased significantly again, and the presence of vegetation cover became fluctuating and small in the northern direction, and increased the values of the classes 0-0.2, 0.2-0.3, and 0.3-0.4. During 2023, the vegetation returned with high concentration in the northeast and northwest directions, and the values of the last three important classes became high for the dark blue, light blue and very light blue colors. Figure 6 shows the percentage of vegetation cover area distributed over the Kurdistan Region of Iraq for 24 years (2000-2023). In general, Duhok Governorate comes first because it has the largest vegetation cover area. It is followed by Sulaymaniyah and Erbil. It was noted that the highest vegetation cover area in the Kurdistan Region was in the years 2015,2020. The moderate vegetation cover area was observed in the years 2001, 2003, 2005, 2010, 2014, 2017. The least vegetation cover area was observed in the years 2000, 2008, 2009.

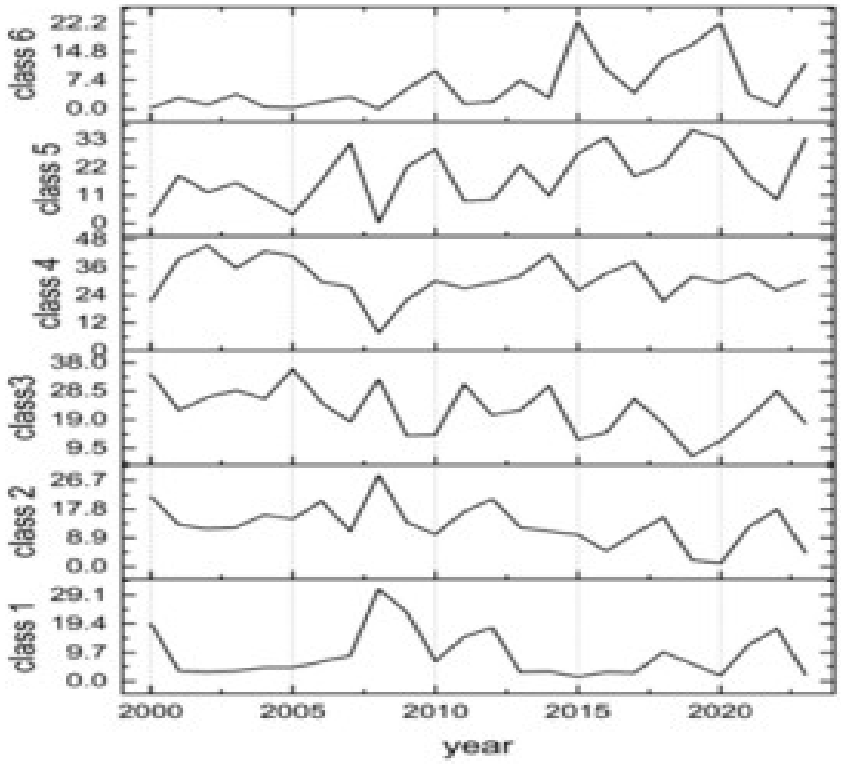


Figure 6. Temporal distribution of the percentage of the NDVI index for the six classes during the period from 2000 to 2023.

Figure 7, it can be noted that the lowest value of NDVI was 0.264 in 2008. This low value occurred due to the low annual rainfall, which is an important factor in determining the vegetation cover. While the highest value of NDVI was 0.508 in 2020. The years that exceed the Above average are 13 years, with an average value of 54.1. The years that exceed the Below average are 11 years, with an average value of 45.8, where the sum of the average values is 99.9. The value of the vegetation cover index changed to maximum values from 2016 to 2020, which is the highest average value, indicating vegetation cover. The effects of drought in 2008 indicate that all regions were affected. This year the greatest loss occurred during the growing season (April) due to severe drought, especially in the southern, central and southeastern parts of the Kurdistan Region of Iraq. In 2008, the percentage of land covered by plants was 0.2. This low percentage may be due to the mismatch between seasonal rainfall and plant needs during the assessment of the critical growth stage. The results of the spatial pattern of vegetation coverage from 2000 to 2023 indicate that the average spatial vegetation coverage is 75% and the average non-vegetation coverage is 25%. The largest decrease was recorded in 2008, which was the most important drought event over the past 24 years. It can be noted that there is a general trend of increasing NDVI values over the past 24 years.

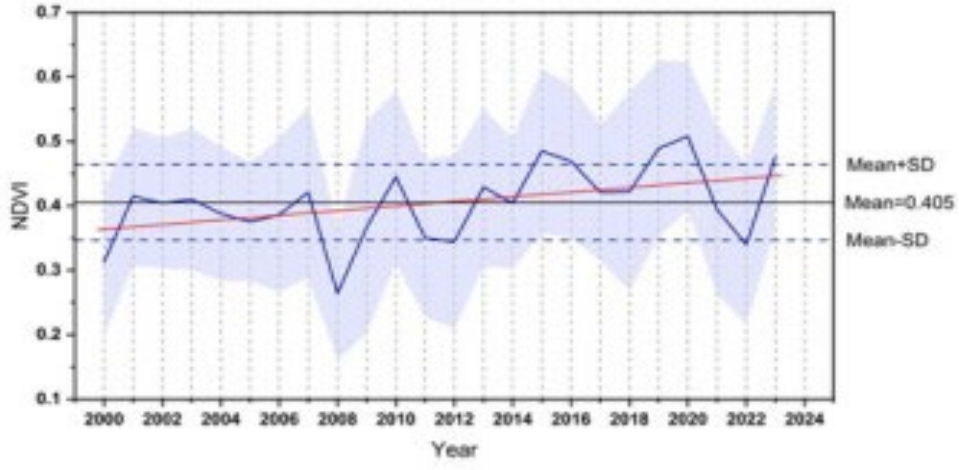


Figure 7. Temporal distribution of NDVI rate during the period from 2000 to 2023 for the Kurdistan region of Iraq.

4. Conclusions

The decrease in NDVI values in the Kurdistan Region of Iraq between 2000 and 2019 was in the years 2000, 2008 and 2009.The largest vegetation cover area in the Kurdistan Region of Iraq during the 24 years was in 2015 and 2020, but the vegetation cover area was smaller in 2000 and 2008. Spatial distribution of vegetation cover based on NDVI index in the Kurdistan Region of Iraq is generally concentrated in the northeast and southeast. During the 20-year period (2000-2023), Duhok Governorate has the largest vegetation cover area. Considering the distribution of vegetation in the Kurdistan Region of Iraq According to the MODIS data collected, the Kurdistan Region of Iraq showed high levels of vegetation cover regardless of the time of the year. There was an increasing trend in the rate of vegetation cover during the study period, which lasted 24 years.

Supplementary Materials:

Author Contributions: Athraa Jamhor Abd Harbi and Yaseen K. AL-Timimi completed the experiments; Nagham Abbas Mohammed prepared the draft

Funding: unavailable

Data Availability Statement: We declare that the submitted manuscript is our work, which has not been published before and is not currently being considered for publication elsewhere.

Acknowledgments: Authors thank Mustansiriyah University (https://uomustansiriyah.edu.iq/), College of Science, for their help in completing this work.

Conflicts of Interest: no interest

References

[1] H. A. A. Gaznayee, A. M. F. Al-Quraishi, K. Mahdi, J. P. Messina, S. H. Zaki, H. Abdulrzaq, Razvanchy, K. Hakzi, L. Huebner, S. H. Ababakr, M. Riksen, and C. Ritsema, "Drought severity and frequency analysis aided by spectral and meteorological indices in the Kurdistan Region of Iraq," *Water*, vol. 14, p. 3024, 2022, https://doi.org/10.3390/w14193024.

[2] A. M. F. Al-Quraishi, Y. T. Mustafa, and A. M. Negm, ''Environmental Degradation in Asia: Land Degradation, Environmental Contamination, and Human Activities,'' *Springer Cham*, Switzerland, 2022, https://doi.org/10.1007/978-3-031-12112-8.

[3] H. A. A. Gaznayee, "Modeling spatio-temporal pattern of drought severity using meteorological data and geoinformatics techniques for the Kurdistan Region of Iraq," Ph.D. dissertation, Salahaddin Univ., Erbil, Iraq, pp. 1–11, 2020, http://doi.org/10.13140/RG.2.2.17234.30402.

[4] S. M. Al-Hedny and A. S. Muhaimeed, "Drought monitoring for Northern Part of Iraq using temporal NDVI and rainfall indices," *Environmental Remote Sensing and GIS in Iraq*, pp. 301–331, 2020, https://doi.org/10.1007/978-3-030-21344-2_13.

[5] M. Gholamnia, R. Khandan, S. Bonafoni, and A. Sadeghi, "Spatiotemporal analysis of MODIS NDVI in the semi-arid region of Kurdistan (Iran)," *Remote Sens*., vol. 11, no. 14, p. 1723, 2019, https://doi.org/10.3390/rs11141723.

[6] H. A. Gaznayee and A. M. F. Al-Quraishi, "Analysis of agricultural drought's severity and impacts in Erbil Province, the Iraqi Kurdistan region based on time series NDVI and TCI indices for 1998 through 2017," *J. Adv. Res. Dyn. Control Syst*., vol. 11, no. 11, pp. 287–297, 2019, https://doi.org/10.5373/JARDCS/V11I11/20193198.

[7] L. Eklund, A. Persson, and P. Pilesjö, "Cropland changes in times of conflict, reconstruction, and economic development in Iraqi Kurdistan," *Ambio*, vol. 45, pp. 78–88, 2016, https://doi.org/10.1007/s13280-015-0686-0.

[8] S. Seeyan, B. Merkel, and R. Abo, "Investigation of the relationship between groundwater level fluctuation and vegetation cover by using NDVI for Shaqlawa Basin, Kurdistan Region-Iraq," *J. Geography Geol*., vol. 6, no. 3, p. 187, 2014, https://doi.org/10.5539/jgg.v6n3p187.

[9] UNESCO, *Integrated Drought Risk Management–DRM Executive: National Framework for Iraq, an Analysis Report*, 2nd ed., UNESCO Office: Jordan, Iraq, 2014. Available: https://unesdoc.unesco.org/ark:/48223/pf0000228343_ara

[10] K. Al-Timimi, L. E. G. Loay, and M. H. Al-Jiboori, "Drought risk assessment in Iraq using remote sensing and GIS techniques," *Iraqi J. Sci.,* vol. 53, no. 4, pp. 1078–1082, Dec. 2012, https://doi.org/10.24996/ijs.2012.53.4Appendix.%25g.

[11] UNESCO, *Survey of Infiltration Karez in Northern Iraq*, in *History and Current Status of Underground Aqueducts*, Dept. of Geography, Oklahoma State Univ., Stillwater, OK, USA, p. 56, 2009. Available: https://www.researchgate.net/publication/242729587_Survey_of_Infiltration_Karez_in_Northern_Iraq_History_and_Current_Status_of_Underground_Aqueducts