ANALYSIS OF MODIS VEGETATION INDEX IN THE EASTERN PART OF IRAQ FROM 2000 TO 2020

2021
MASTER THESIS
DEPARTMENT OF GEOGRAPHY

Mohammed SALAM YOUSIF

Supervisor
Assist.Prof.Dr. Sohaib K M ABUJAYYAB

ANALYSİS OF MODIS VEGETATİON İNDEX İN THE EASTERN PART OF IRAQ FROM 2000 TO 2020

Mohammed SALAM YOUSIF

T.C

Karabuk University

Institute of Graduate Programs

Department of Geography

Prepared as

Master Thesis

Assist.Prof.Dr. Sohaib K M ABUJAYYAB

KARABUK

December 2021

CONTENTS LIST

THESIS APPROVAL PAGE

I certify that in my opinion the thesis submitted by mohammed SALAM YOSIF YOUSIF titled "ANALYSIS OF MODIS VEGETATION İNDEX İN THE EASTERN PART OF IRAQ FROM 2000 TO 2020 " is fully adequate in scope and in quality as a thesis for the degree of Master of Arts.

Assist.Prof.Dr. Sohaib K M Abujayyab ....

Thesis Advisor, Department of Geography

This thesis is accepted by the examining committee with a unanimous vote in the Department of Geography as a Master of Arts thesis. December,2021

Examining Committee Members (Institutions)		Signature
Chairman	: Prof.Dr. Mucahit COSKUN (KBU)	....
Member	: Assoc.Prof.Dr.Halil GÜNEK (AEU)	....
Member	: Assist.Prof.Dr.Sohaib K.M. ABUJAYYAB (KBU)	....

The degree of Master of Science by the thesis submitted is approved by the Administrative Board of the Institute of Graduate Programs, Karabuk University.

Prof. Dr. Hasan SOLMAZ ....

Director of the Institute of Graduate Programs

DECLARATION

I hereby declare that this thesis is the result of my own work and all information included has been obtained and expounded in accordance with the academic rules and ethical policy specified by the institute. Besides, I declare that all the statements, results, materials, not original to this thesis have been cited and referenced literally.

Without being bound by a particular time, I accept all moral and legal consequences of any detection contrary to the aforementioned statement.

Name Surname: mohammed salam

Signature :

FOREWORD

First, I would like to thank my Dr. Sohaib Abujayyab, without whom this thesis would not have been possible. I would like to thank my dear professor, Prof. Dr. Mücahit Coşkun for his support, guidance, encouragement, and assistance during the past study stages. In addition, I thank my professor, Prof. Dr. Fatih Aydin for his guidance and encouragement at this stage. I thank the staff of the Department of Geography of Karabuk University and all the teachers and students who helped me at Karabuk University.

Finally, I appreciate my brothers, sisters, and friends in Iraq for supporting me.

My special thanks and gratitude to my family, Parents who had a great role in encouraging me and giving me the morale to complete this stage**.**

Mohammed Salam

ABSTRACT

The study of the natural vegetation cover is one of the modern topics to detect changes in the vegetation cover, which has a significant impact on human life and the preservation of the ecological balance. This study aimed to reveal the changes in the time series of the natural vegetation of the northeastern governorates of Iraq (Sulaymaniyah, Kirkuk, Diyala and Wasit) during the time period from 2000 to 2020. The NDVI index from MODIS satellite data with a spatial resolution of 250 m was used in this study. The results were obtained and checked by remote sensing techniques. The results were interpreted by converting NDVI index into maps using ArcGIS software. The data of four climatic stations for the study area (Wasit, Khanaqin, Sulaymaniyah, Kirkuk) were used to study the relationship of rainfall with the density of vegetation cover**.**

Based on the results obtained from the study, the year 2019 recorded the highest density of vegetation cover in the time period and for all study regions, while the NDVI values were 0.29 for Sulaymaniyah, 0.30 for Kirkuk, 0.24 for Diyala and 0.22 for Wasit. The lowest values of NDVI were recorded for the regions of Sulaymaniyah and Kirkuk in 2008, where the ratios of NDVI rates were 0.18 for Sulaymaniyah and 0.13 for Kirkuk, while Diyala and Wasit recorded the lowest values in the year 2007, with similar rates of 0.12 for both. The results of the year 2001 showed high values in NDVI and for the regions except for the city of Wasit, where the rates of vegetation cover were 0.29 for Sulaymaniyah, 0.23 for Kirkuk and 0.29 for Diyala. As for Wasit, the vegetation cover was at 0.9. There were medium and weak relationships between NDVI vegetation cover indicators and rainfall rates for the study areas, where the positive relationship was medium for Sulaymaniyah (0.458), Diyala (0.490) and for Wasit (0.544), while Kirkuk governorate witnessed a weak relationship (0.303). The results showed a strong inverse correlation (-0.75) between vegetation density and heights in winter. While it showed very weak relationships between the vegetation cover index and the rest of the terrain elements such as the slope, Aspect of the land surface and the Hillshade.

The study recommends the need to establish scientific centers specialized in geographic information systems and remote sensing in all Iraqi governorates to monitor changes in vegetation cover permanently and provide databases and monthly and annual reports on changes in vegetation density in order to address them and contribute to improving their decision-making.

Keywords: remote sensing, geographic information systems, natural vegetation, MODIS.

ÖZ

Doğal bitki örtüsünün incelenmesi, insan yaşamı ve ekolojik dengenin korunması üzerinde önemli bir etkiye sahip olan vejetatif değişiklikleri tespit etmek için kullanılan güncel araştırma konularından biridir. Bu çalışma, Irak'ın kuzeydoğu eyaletlerinde zamansal olarak (Süleymaniye, Kerkük, Diyala ve Vasit) 2000-2020 yılları arasındaki doğal bitki örtüsü değişimlerinin açığa çıkarılmasını amaçlamaktadır. Çalışmada, 250 m mekânsal çözünürlüğe sahip MODIS NDVI uydu verileri kullanılmıştır. Elde edilen sonuçlar uzaktan algılama teknikleri ile kontrol edilmiş ve ArcGIS yazılımı kullanılarak NDVI indeks haritalarına dönüştürülerek yorumlanmıştır. Çalışma alanı için dört ayrı meteoroloji istasyonunun (Wasit, Khanaqin, Süleymaniye, Kerkük) verileri, yağışın bitki örtüsü yoğunluğu ile ilişkisini incelemek için kullanılmıştır.

Çalışmadan elde edilen sonuçlara göre, çalışma sahasında tüm zaman periyodu içerisindeki en yüksek bitki örtüsü yoğunluğu 2019 yılında kaydedilmiştir. NDVI değerleri Süleymaniye için 0.29, Kerkük için 0.30, Diyala için 0.24 ve Wasit için 0.22'dir. En düşük NDVI değerleri Süleymaniye ve Kerkük bölgelerinde 2008 yılında sırasıyla 0,18 ve 0,13 olarak kaydedilirken, Diyala ve Wasit için en düşük NDVI değerleri 2007 yılında 0,12 olarak ikisi için de aynı değerde kaydedilmiştir. 2001 yılı, NDVI değerlerine göre bitki örtüsü oranları Wasit şehri dışındaki bölgeler için yüksek değerler göstermiştir. Süleymaniye için 0.29, Kerkük için 0.23 ve Diyala için 0.29 iken Wasit'te bu değer 0,9 olarak kaydedilmiştir. NDVI bitki örtüsü göstergeleri ile yağış oranları arasındaki ilişkiye bakıldığında Süleymaniye (0,458), Diyala (0,490) ve Wasit (0,544) için pozitif ve orta derecede ilişki görülürken Kerkük'te zayıf (0,303) bir ilişki tespit edilmiştir. Ayrıca sonuçlar, kış mevsiminde bitki örtüsü yoğunluğu ile yükseklik değerleri arasında güçlü bir ters korelasyon (-0,75) görülmüştür. Bitki örtüsü indeksi ile eğim, bakı ve yamaç gölgeleme (hillshade) gibi arazi unsurları arasında çok zayıf ilişkiler görülmüştür.

Bitki örtüsündeki değişiklikleri kalıcı olarak izlemek, bunları ele almak ve iyileştirmeye katkıda bulunmak için bitki örtüsü yoğunluğundaki değişiklikler hakkında veri tabanları, aylık ve yıllık raporlar hazırlamak gerekmektedir. Bu sebeple bu çalışma tüm Irak valiliklerinde coğrafi bilgi sistemleri ve uzaktan algılama konusunda uzmanlaşmış bilimsel merkezlerin kurulmasına ihtiyaç olduğunu göstermektedir.

Anahtar Kelimeler: uzaktan algılama, coğrafi bilgi sistemleri, doğal bitki örtüsü, MODIS.

ARABIC ABSTRACT

تعتبر دراسة الغطاء النباتي الطبيعي من المواضيع الحديثة للكشف عن التغيرات في الغطاء النباتي وذلك مما له اثر كبير على حياة الانسان والحفاظ على التوازن البيئي. هدفت هذه الدراسة الي الكشف عن التغيرات في السلاسل الزمنية للنبات الطبيعي للمحافظات الشمالية الشرقية من العراق (السليمانية وكركوك وديالى وواسط) خلال الفترة الزمنية 2000-2020. تم استخدام القرينة القرينة النباتية (NDVI) من بيانات القمر الصناعي (MODIS) بدقة وضوح مكاني 250 متر. تم الحصول على النتائج وفحصها بشكل دقيق عن طريق تقنيات الاستشعار عن بعد. تم تفسير النتائج بتحويلها الى خرائط عن طريق نظم المعلومات الجغرافية وبرنامج ArcGIS. تم الاستعانة ببيانات أربع محطات مناخية لمنطقة الدراسة وهي (واسط، خانقين، السليمانية، كركوك) لدراسة علاقة الهطول المطري مع كثاف الغطاء النباتي.

بناء على النتائج التي تم الحصول عليها من الدراسة، سجلت سنة سجلت سنة 2019 اعلى نسب في الفترة الزمنية ولجميع مناطق الدراسة حيث بلغت معدلات ال NDVI 0.29 للسليمانية و0.30 لكركوك و 0.24 لديالى و 0.22 لواسط. بينما سجلت ادنى قيم ال NDVI للمناطق السليمانية وكركوك بسنة 2008، حيث بلغت نسب معدلات ال NDVI 0.18 للسليمانية و 0.13 لكركوك ، اما ديالى وواسط فسجلت اقل القيم سنة 2007، بمعدلات متشابه 0.12 لكليهما. أظهرت نتائج سنة 2001 قيم عالية في NDVI وللمناطق عدا مدينة واسط حيث بلغت معدلات نسب الغطاء النباتي للسليمانية بنسب 0.29 وكركوك 0.23 وديالى 0.29 اما واسط فكانت معدل الغطاء النباتي فيها بنسبة 0.9. كانت هناك علاقات متوسطة وضعيفة بين مؤشرات الغطاء النباتي NDVI ومعدلات الامطار لمناطق الدراسة، حيث كانت العلاقة ايجابية متوسطة لمحافظة السليمانية (0.458) وديالى (0.490) و لواسط (0.544)، اما محافظة كركوك فشهدت علاقة ضعيفة (0.303). أظهرت النتائج وجود علاقة ارتباط عكسي قوي (0.75-) بين كثافة الغطاء النباتي والارتفاعات في فصل الشتاء. في حين أظهرت علاقات ضعيفة جدا بين مؤشر الغطاء النباتي وبقية العناصر التضاريسية مثل الانحدار واتجاه سطح الأرض وخارطة الظلال.

توصي الدراسة بضرورة إنشاء مراكز علمية متخصصة في نظم المعلومات الجغرافية والاستشعار عن بعد في جميع المحافظات العراقية لرصد التغيرات الحاصلة في الغطاء النباتي بشكل دائم وتوفير قواعد بيانات وتقارير شهرية وسنوية عن التغيرات في كثافة الغطاء النباتي من اجل معالجتها والمساهمة في تحسين صنع القرار الخاص بها.

كلمات مفتاحية : الاستشعار عن بعد، نظم المعلومات الجغرافية، النبات الطبيعي،MODIS.

ARCHIVE RECORD INFORMATION

Title of the Thesis	Analysis Of Modıs Vegetation İndex İn The Eastern Part Of Iraq From 2000 To 2020
Author of the Thesis	Mohammed SALAM YOUSIF
Supervisor of the Thesis	Assist.Prof. Dr.Sohaib K M ABUJAYYAB
Status of the Thesis	Master’s Degree
Date of the Thesis	23.12.2021
Field of the Thesis	Physical Geography
Place of the Thesis	KBU/LEE
Total Page Number	124
Keywords	Ndvi, Modis, Vegetation, Remote Sensing, Gis

ARŞİV KAYIT BİLGİLERİ (in Turkish)

Tezin Adı	2000'den 2020'ye Irak'ın Doğu Kısımdaki Modıs Vegetation İndex Analizi
Tezin Yazarı	Mohammed SALAM YOUSIF
Tezin Danışmanı	Assist.Prof. Dr.Sohaib K M ABUJAYYAB
Tezin Derecesi	Yüksek Lisans
Tezin Tarihi	23.12.2021
Tezin Alanı	Fiziki Coğrafya
Tezin Yeri	KBU/LEE
Tezin Sayfa Sayısı	124
Anahtar Kelimeler	Ndvi, Modis, Vejetasyon, Uzaktan Algilama, Cbs

ABBREVIATIONS

NDVI- Normalized Difference Vegetation Index

NASA- National Aeronautics and Space Administration

MODIS- Moderate-resolution Imaging Spectroradiometer

SPSS-Statistical Package for the Social Sciences

N-NORTH

GIS- Geographic Information System

EOS- Earth Observing System

GIMMS- Global Inventory Modelling and Mapping Studies

LIS- Laboratory Information Management System

HSA- Hot Spot Analysis

DEM- Digital elevation model

USGS- United States Golf Association

μm- Micrometre

EMS- Electromagnetic

EO-Earth Observation

VIR- Visible Imaging record

SD-Southren Desert District

WD- Western Desert District

K- Karkuk District

PF- Persian Foothill Districy

MM- Milimetre

P- Precipitation

1. INTRODUCTION

Vegetation is an important resource in the ecosystem, as it participates in biogeochemical cycles, such as water, carbon and nitrogen, and is considered to be influencing the energy balance at the Earth’s surface and within the atmosphere (Baldwin et al., 2019)**.** It also performs photosynthesis, absorbs carbon dioxide, and excretes oxygen. It is also considered one of the most important environmental systems in purifying the air from toxic gases, preserving the soil from erosion, and maintaining the cycles of mineral and organic elements in the soil (Centeri, 2002). Vegetation is one of the most important terrestrial environmental components on the Earth's surface and is also important for maintaining the gaseous atmosphere and reducing global warming (Massei et al, 2016).

The term vegetation is used in ecology to describe the land cover in an area and to denote the growth of the dominant plant such as terrestrial weeds, or forest plants, or to denote certain species (Faber-Langendoen et al., 2014). There are many definitions of vegetation, which means the plant that grows on the surface of the earth naturally without human intervention and is affected by all factors of climate, topography, and soil (Al-Ani,1988). Vegetation represents a symbiotic relationship of similar plant communities growing in any geographical area which includes trees, shrubs, algae in shallow water or cacti on a large scale in the desert (Akman and Ketenoglu, 1987).

Vegetation is considered an important resource in the northern and eastern central parts of Iraq because of its great importance for animal feed. Vegetation in the northeastern Iraq is characterized by diversity such as forests, desert plants, shrubs, weeds and perennial and annual herbs. (National Action program to Combat Desertification in Iraq,2018).

Despite the diversity of vegetation in the northeastern part of Iraq, the region has recently witnessed a decrease in the density of vegetation and the spread of desertification, where the percentage of desertified lands reached 4 million dunums (The National Action Program to Combat Desertification in Iraq, 2018). There are several factors such as global warming, encroachment on agricultural lands by urban expansion, and overgrazing that contributed and led to the decline of vegetation areas and the deterioration of its density in the study area. In addition, climatic factors are one of the biggest reasons that lead to the diversity and scarcity of vegetation in northeastern Iraq. (Sakar, 2015)

Fluctuation in vegetation cover density is indeed a critical component that has a substantial impact on the natural system's capacity and condition (Abujayyab & Demiral, 2019). especially in recent years, such as biodiversity, climate change, After the emergence of modern technologies and techniques such as remote sensing, and the data it provides such as aerial images, satellite visuals and computer software, it has become possible to study vegetation and monitoring agricultural practices better (kit et al, 1999). Where it is possible to study the vegetation at any time, and make temporal comparisons by studying a group of photos taken at different times for the same place, and it also allows to know the nature of the change that occurs in a place (Ali Shaawan, 2012). Also, the presence of modern programs and applications for processing this data, such as ArcGis and ERDAS, plays a major role in providing, analyzing and dealing with historical data. Remote sensing is defined as the process of detecting and monitoring the physical properties of the Earth for a region from long distances (Schott, 2007) by measuring the reflected radiation emitted from the surface of the Earth by satellites and images captured by aircraft. The data used in the study, which is sourced from satellites, is characterized by its ability to record data day and night, in addition to its ability to monitor, plot and analyze large-scale data at low cost.

Remote sensing data has been used in many applications (Schowengerdt, 2007),such as: detecting climate changes and monitoring their effects such as deforestation, depletion of ozone layer in the atmosphere, and global warming, in addition to exploring non-renewable resources such as minerals, natural gas, and petroleum. Remote sensing has been used in the study of renewable materials such as wetlands, soils and forests, in addition to meteorology and weather forecasting. It was also used in agricultural applications such as studying the condition of crops, soil erosion, and forecasting yields and production quantities. Remote sensing techniques have been used for many tasks, including assessment of vegetation, desertification, drought detection, and crop growth statues (Bhandari et al, 2012).

Remote sensing techniques are used to monitor and map environmental conditions to any part of the land (Karaburun, 2010). The remote sensing is also of great importance in analyzing changes by integrating the visuals from previous years with modern visuals and then measuring the area difference (Dawod, Gomaa M, 2015). The vegetation is known to be the green covers that allows the sensor to detect it from any direction (Purevdorj at al, 1998), where vegetation and land cover can be monitored by satellite visuals, which leads to early detection of plant and planting injuries and their density.

There are many sources of satellite data that allow the study of vegetation, such as (LANDSAT and SPOT MODIS) data. However, determining the source of the data depends on the nature of the topic and the study area. The study was limited to the use of data (NDVI MODIS13Q1250M) due to its advantages in providing a continuous time series of vegetation. Continuity helps data to be available for monitoring of vegetation over large geographic ranges (Lunetta et al, 2006). NDVI is an effective, simple and powerful indicator for measuring vegetation on the Earth's surface (Pereira &L.S, 2015).

1.2. SCOPE OF THE RESEARCH

1.2.1. Subject Scope of the Research

1.2.1.1. Research Aims

This research aims to study and monitor the growth of vegetation in the study area through the Vegetation Indicator (NDVI) between 2000 and 2020 by using techniques and sensor data (TERRA MODIS13Q1, 250M) dedicated to monitoring environmental systems, which is available free of charge on the (NASA) website. This purpose aims at a set of goals:

A: Detection of vegetation cover in the study area by remote sensing and GIS.

B: Shedding light on the monthly and seasonal changes in the land cover during the time period of the study area.

C: Study of the influence of climatic factors on the density of vegetation.

D: Study of the statistical correlation between topographical factors and the density of vegetation.

1.2.1.2. Importance and Limitations of the Research

The subject of the study is important because it is the first study that provides a clearer understanding in an understanding of the trends of natural vegetation cover through the Normalized difference vegetation index, for four regions of Iraq. With this extent, the study contributes to developing plans for interest in studying vegetation cover.

Natural plants are of great importance in ecosystems, this effect is manifested in maintaining air purification and helping to reduce temperatures in nearby areas. During the course of the research, some difficulties appeared in terms of the scarcity of climatic data for the places, so only temperature and rain data were taken from each station city and over a period of 21 years. Besides that, the most important difficulties that were faced are the lack of sources and references for studies in the natural vegetation cover.

1.2.1.3. Hypothesis of the Research

-There is a decrease and deterioration in the density of vegetation in the study area during the time period 2000 - 2020.

-There is a clear relationship in vegetation changes and climate elements.

-There is a clear relationship in the changes of vegetation cover and topographical factors during the annual seasons.

-Are there constant monthly annual and seasonal changes during the time period of the study area?

-Are there seasonal changes in hotspots?

1.2.2. Field scope of the research

Study Area

The study area occupied the largest eastern part of Iraq and some chosen regions in the north, south and the middle of Iraq, such as Sulaymaniyah with an area 11618 km^2, Kirkuk with 9679 km^2, Diyala 19086 km^2 and Wasit 17153 km^2. The study area occupied 57536. km^2 of the total area of Iraq 435052 km^2 with a percentage 14% of the total area of Iraq. The study area is located astronomically between two latitudes 32°5 - 37° and longitudes 47°-5'42 (google earth) as shown in figure 1.

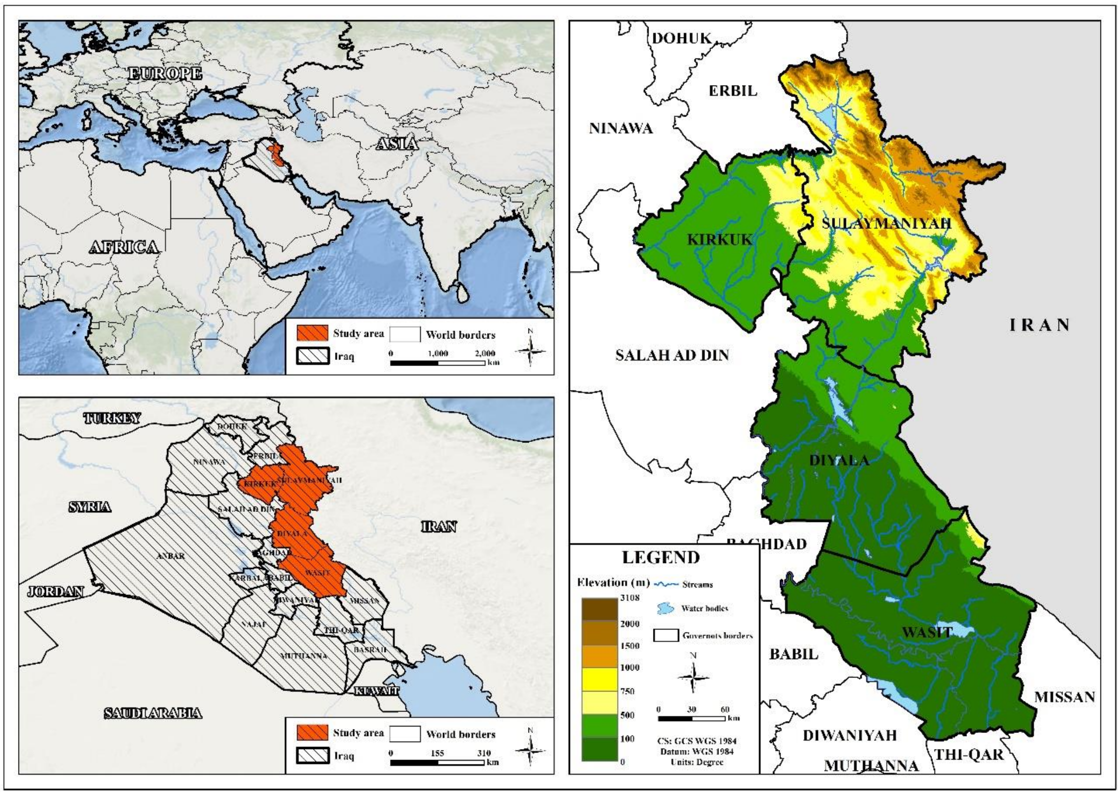


Figure 1: Location map of the study area.

1.3. MATERIALS and METHODS

The study relied on a set of stages for collecting, analyzing and extracting data.

1.3.1. The stage of office work

It is represented in reviewing the sources, research, theses and previous messages related to the content of the study in order to become familiar with what the researchers have addressed and reached in terms of information, results and methods related to plants and the detection of vegetation.

1.3.2. Data collection

The study included several Iraqi governorates located in the northeastern and southeastern part. Figure 2 shows that there are four climatic regions affecting Iraq, and they are four zones, humid, semi-humid, semi-dry, and dry. The wet part is located in the northernmost part of Iraq represented in Sulaymaniyah governorate, while Kirkuk and Diyala governorates are located in the semi-humid and semi-dry part, and lastly Wasit governorate is located in the dry part. Figure (12) also shows the divisions of climate in Iraq according to Koppen classification, which divided the climate on the globe into five main classification (kottek et el. 2006): Tropical, Dry (Arid and semi-arid), Temperate, and Continental and polar and Alpine.

In figure (2), the study area falls within the boundaries of these divisions of the regions, as (Bwh) is a dry hot desert climate, while (Bsh) includes hot semi-arid areas, (Bsk) is a cold semi-arid (subtropical) climate, (Dsb) is a territory of cold humid climate. On this basis the study area included four regions distributed over these territories to represent in general the conditions of Iraq, analyze its patterns and find the differences between them. In addition, due to the large volume of data and the difficulty of analyzing data over the entire area of Iraq, these regions were chosen to express it.

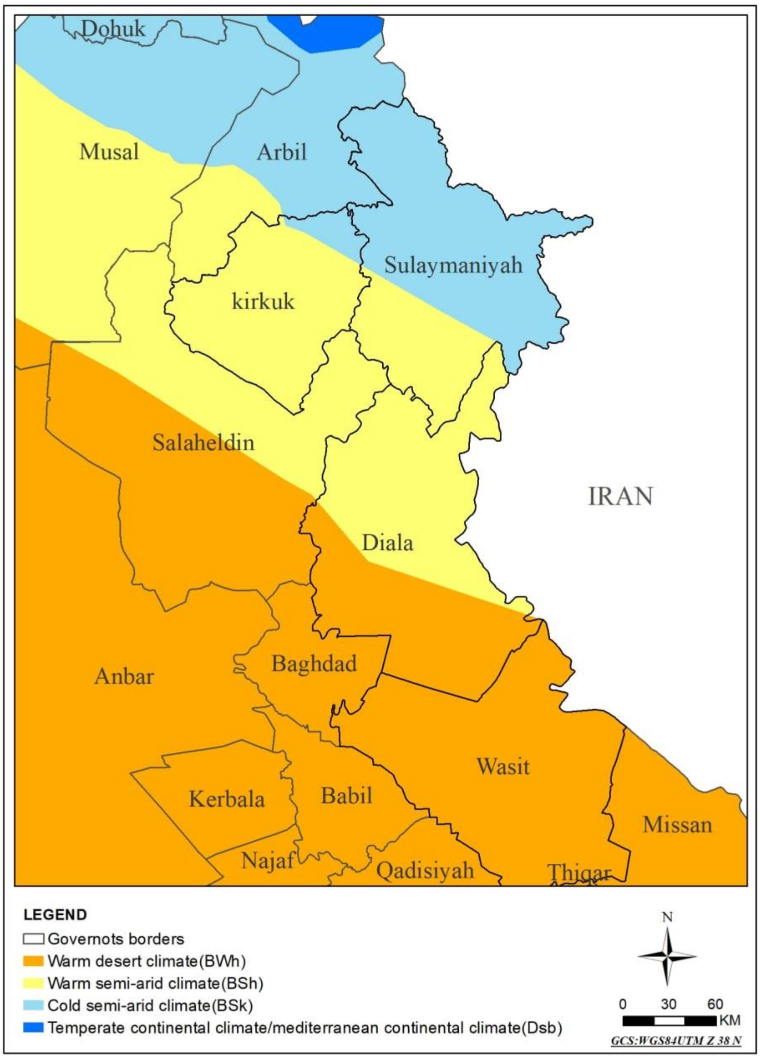


Figure 2: Iraq map of Köppen-Geiger climate classification

(MODIS.gsfc) is one of the websites of the US geological survey USGS, which provides a huge amount of satellite images band visuals. The study was limited to satellite visualizations of vegetation (MODIS13q1). The 480 images were obtained for use in the process of analyzing vegetation and revealing its changes. The study included the time period from 2000 to 2020. The website (MODIS gsfc) was interred to download the data that will be relied upon in the study. Figure 3 and figure 4 illustrate the mechanism of data acquisition.

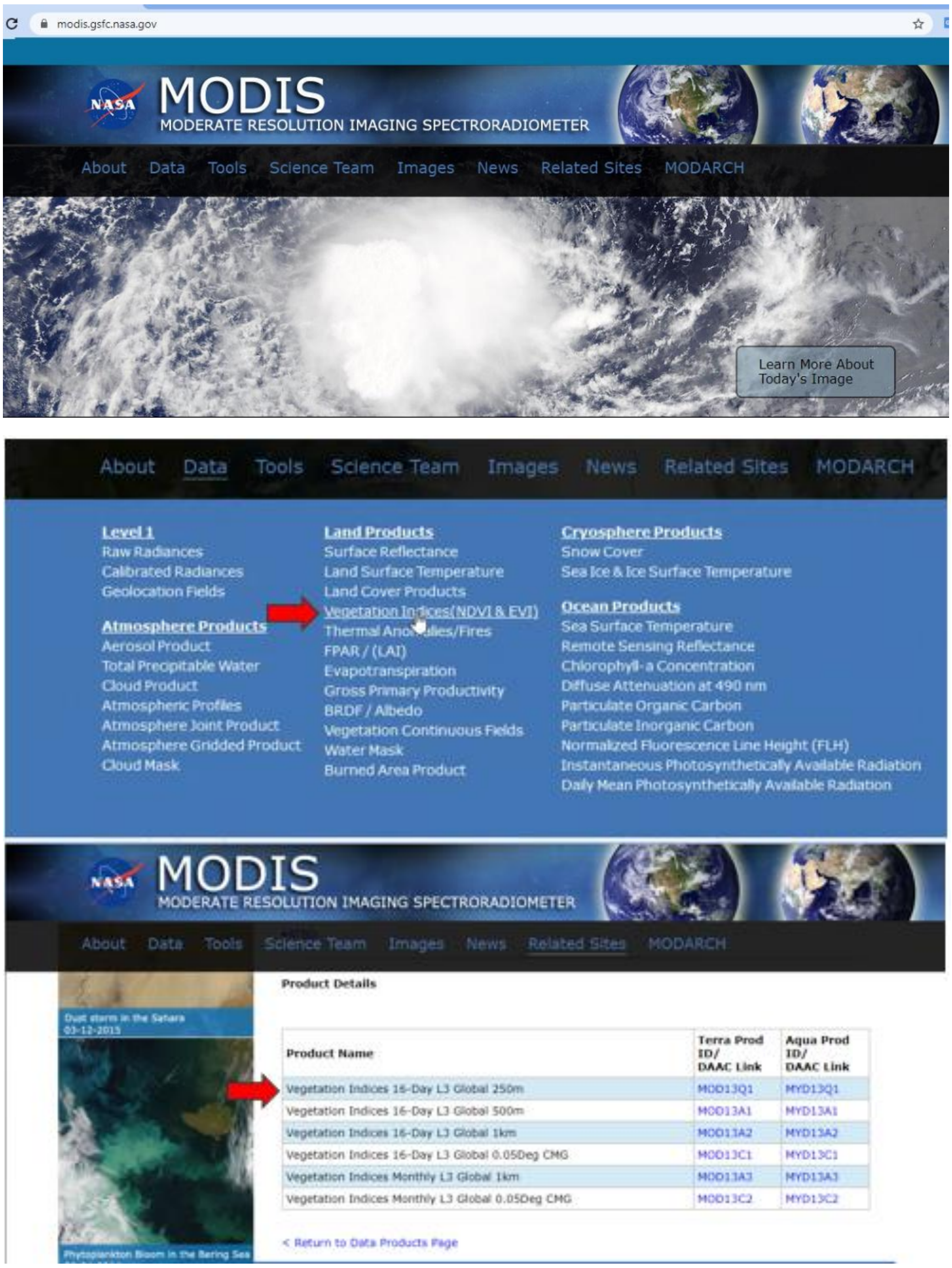


Figure 3: Data download mechanism (Source; URL1)

After entering the site then selecting the order (Data) then the order (Vegetation Indices (NDVI& EVI), then (product Details). Then the choice (Vegetation Indices 16-

Day L3 Global 250m MOD13q1). Then moving to (MODIS /TERRA Vegetation Indices 16 'Day L3Global 250 m SIN Grid), selecting Access Data, then selecting: NASA Earth Data Search, then selecting: Download Data.

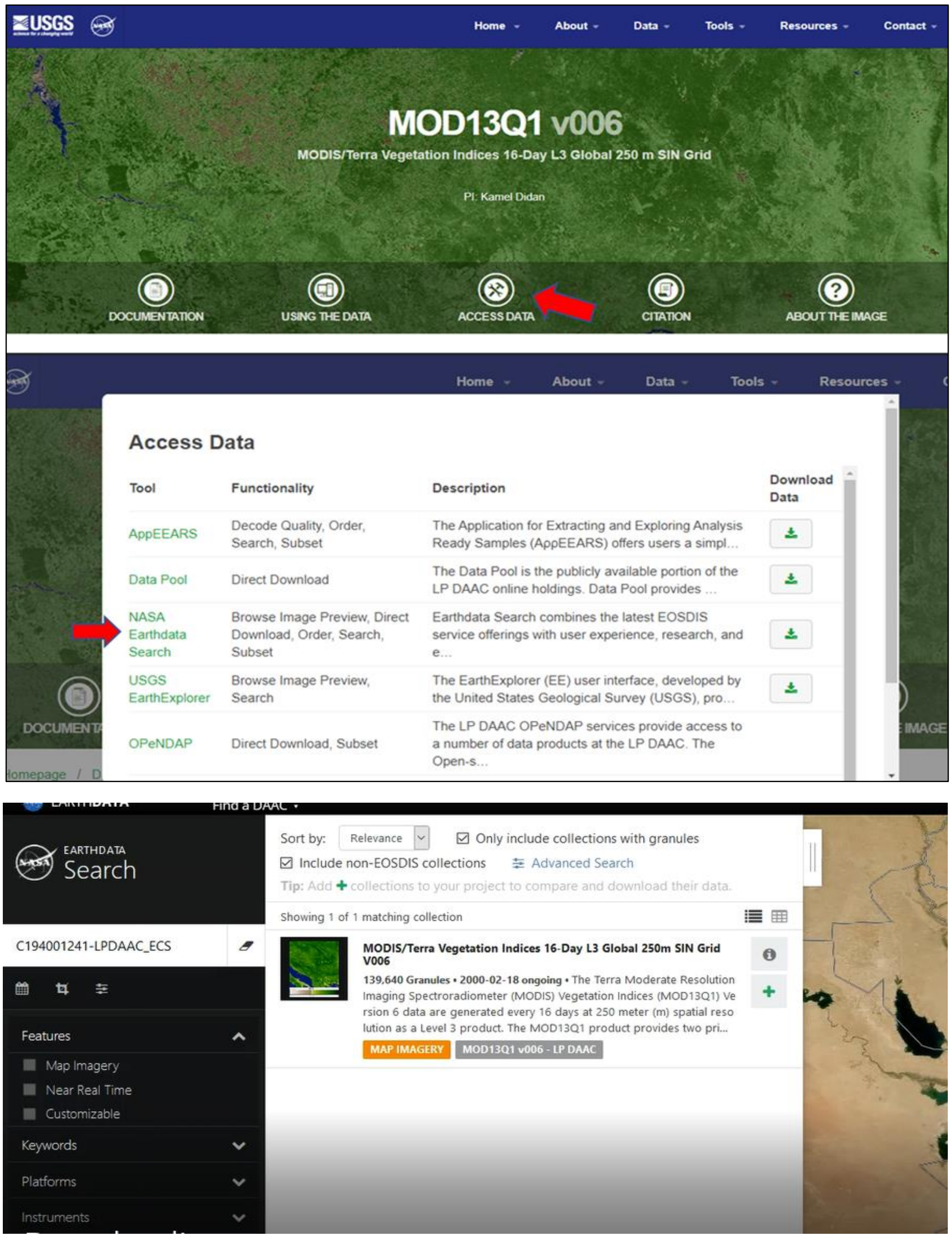


Figure 4: Data download mechanism

Figure 5 shows the final total of the available data. It shows the availability of 480 vegetation data layers over the study period from the year 2000 to 2020. The data was downloaded for processing and analyzing in the later stages.

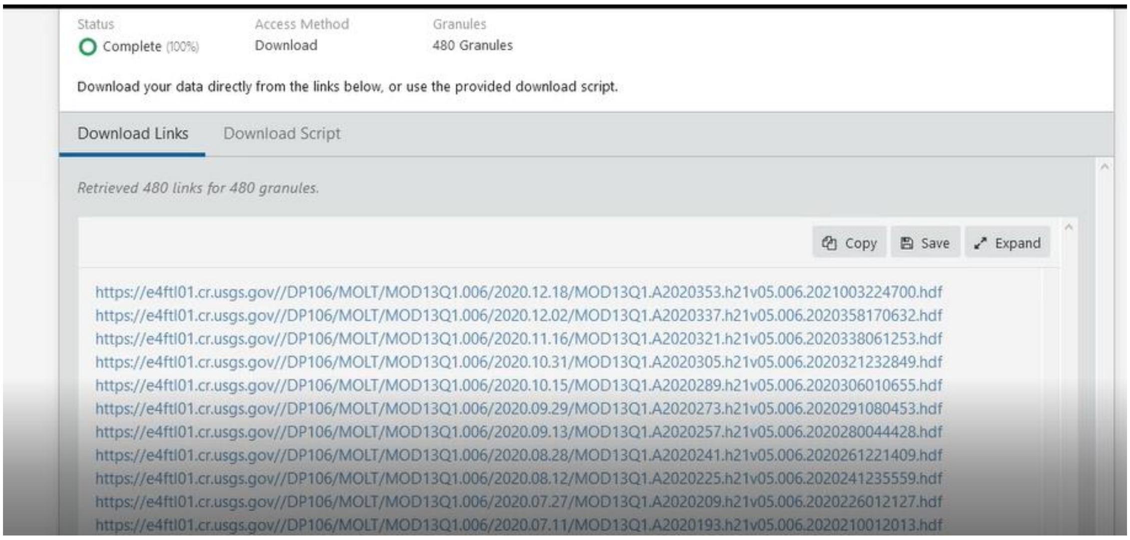


Figure 5: Final form of the data list from the MODIS platform before downloading.

The stage of data collection

It also consisted of:

Climatic data: Monthly and annual data were obtained from four climatic stations within the study area, represented by (rain and temperatures), sourced from the General Authority for Meteorology and Seismic Monitoring for the period (2000-2020), the stations used in the study.

Satellite images

Digital elevation model: The ASTER GDEM digital elevation model is loaded with an accuracy of 30 meters and subtracted for the study area.

DATA MODIS13Q1: A set of 480 16-day-interval satellite images of the region and a twenty-year times series of MODIS13Q1 downloaded from the NASA website. It has a spatial accuracy of 250 meters. MODIS/Terra 16-Day L3 Global 250m SIN Grid is a key instrument on board NASA's Terra satellite for science and space. It was launched in December (1999). Terra orbits the Earth as it passes from north to south across the equator in the morning while Aqua passes from south to north over the equator in the afternoons. It displays the entire surface of the Earth and obtains data in 36 spectral bands. MODIS provides indicators in the form of spatially coordinated isometric images to monitor monthly changes in vegetation activity. The data is available in several different spatial accuracy such as 500 m, 1000m, and 250m. (Kit et al., 1999).

One of the objectives of MODIS is to facilitate the discovery of human influences on the Earth and climate system, as well as the ability to determine the impact of human activities on the climate. In addition to the permanent monitoring of the ecosystem and the global climate for a long time and the detection of change in the global climate. Also, providing global and seasonal measurements of the Earth system, including critical functions such as Earth's biological productivity, land cover, surface temperature, snow, ice, oceans and clouds (Didan et al, 2015)

NDVI as Vegetation Cover Indicators: What distinguishes satellite images is their accuracy and possession of multiple spectral fields, which allow great possibilities to distinguish changing ground targets from each other. The vegetation index is directly related to the photosynthetic capacity. NDVI is one of the most widely used of these indicators and it is widely applied to detect land cover movement at local and global scales (Vrieling et al., 2013). Where its value ranges between -1 and 1,if the results are closer than - 1,this means that the area has a weak vegetation, but if it is close to 1 and more, it means that the area has a high vegetation (Rouse et al., 1974). The NDVI is an effective and simple marker for measuring land cover on the Earth's surface. (Pereira, L,. S. 2015). The NDVI index can be calculated using the following equation :

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

- NIR=pixel values from the near-infrared band
- RED= pixel values from the red band

1.3.3. Programs Used in the Study

- (Arc GIS 10.5) program to digitally process satellite images, extract, draw and produce maps. The NDVI values were statistically processed (Figure 6).
- Programs (Microsoft Excel 2016, word, power point) to create graphics and charts.
- The program (SPSS 21) is one of the most prominent statistical programs. It was used to extract the relative correlation from the climatic data with the NDVI data through the Spearman correlation by the program in order to extract links.
- Global Mapper 18 program to download a digital elevation model. ADTER GDEM and extract terrain elements Hill Shade, slope, elevation.

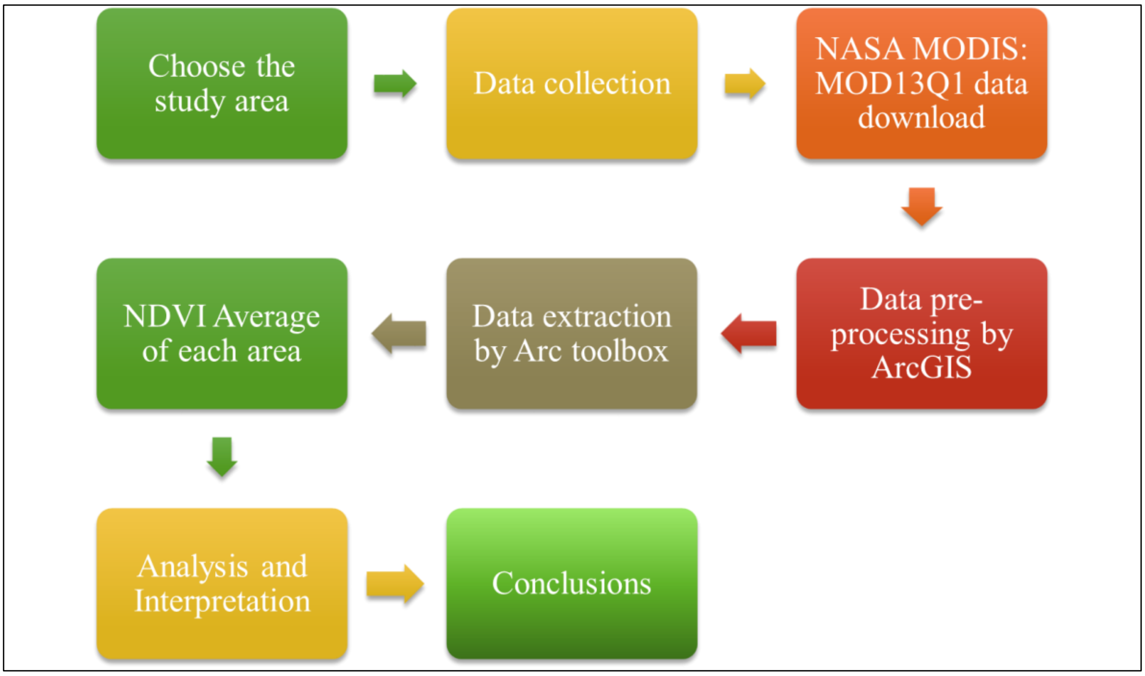


Figure 6: Workflow / Research design

1.3.4. Primary Processing and Extraction of Time Series Data from Images

The initial processing of the images was done through the MODIS data platform, such as the (radiometric) corrections, and the geometric corrections where the data was returned to the geographic coordinate system (WGS 1984).

After downloading the required vegetation data from the MODIS data platform, the data were worked on in (Arc GIS) and by using (Arc Map). Where it is considered one of the most important programs in analyzing, classifying and extracting geographical data completely and in a more fast and easy way. The study area was deduced because these images were intended to cover large areas, and through the program (Arc Map 10.5), the data and images were arranged and their names were modified sequentially. Figure 7 shows the general methodology for data processing, starting with satellite visuals and ending with extracting time series.

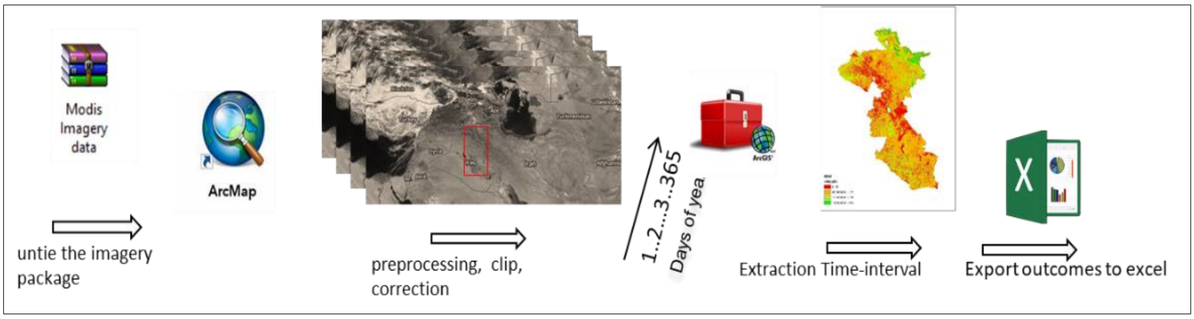


Figure 7: General methodology for extracting MODIS time series.

The images, consisting of 480 images, were arranged, each year containing 23 images, divided according to the year of study for the period (2000-2020). Figure 8 shows a sample of the data that was brought up within a work environment (Arc Map). The included data shows all data for the year 2000 with an interval of 16 days.

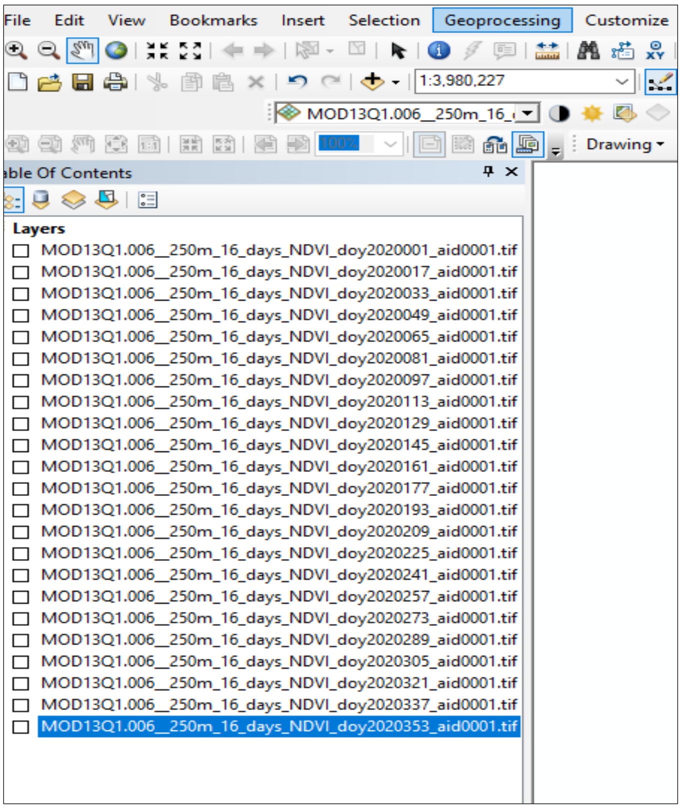


Figure 8: A sample for data called within a work environment (ArcMap)

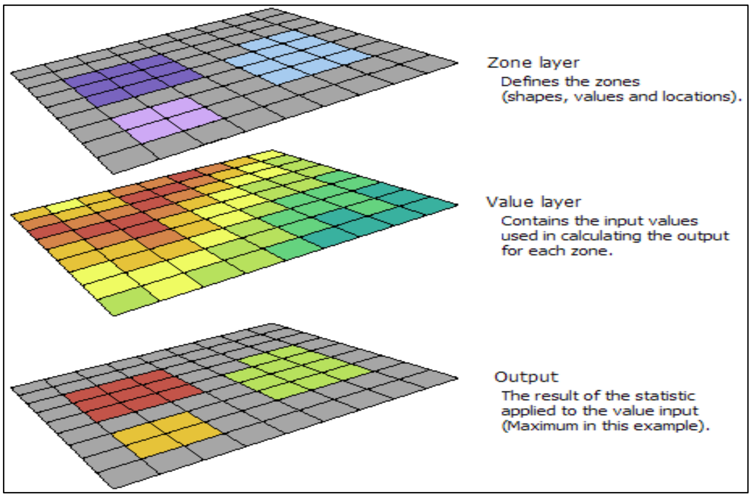


Figure 9: How to make a zonal statistic (Source; URL2)

After arranging the data as in figure 9, the zonal statistics tool from the (Arc toolbox) was used. This tool calculates the statistics of the selected areas within the boundaries of the data to be worked on based on a set of point values, one output value is also calculated for each region in the input data set. This output data can be used by storing it as a table. For example, the values of cells within a geographic region can be averaged and the arithmetic mean of cells stored in a table for each region polygon

(ESRI, 2016). Figure 10 show how the (Zonal Statistics) tool works, and how to access and apply it.

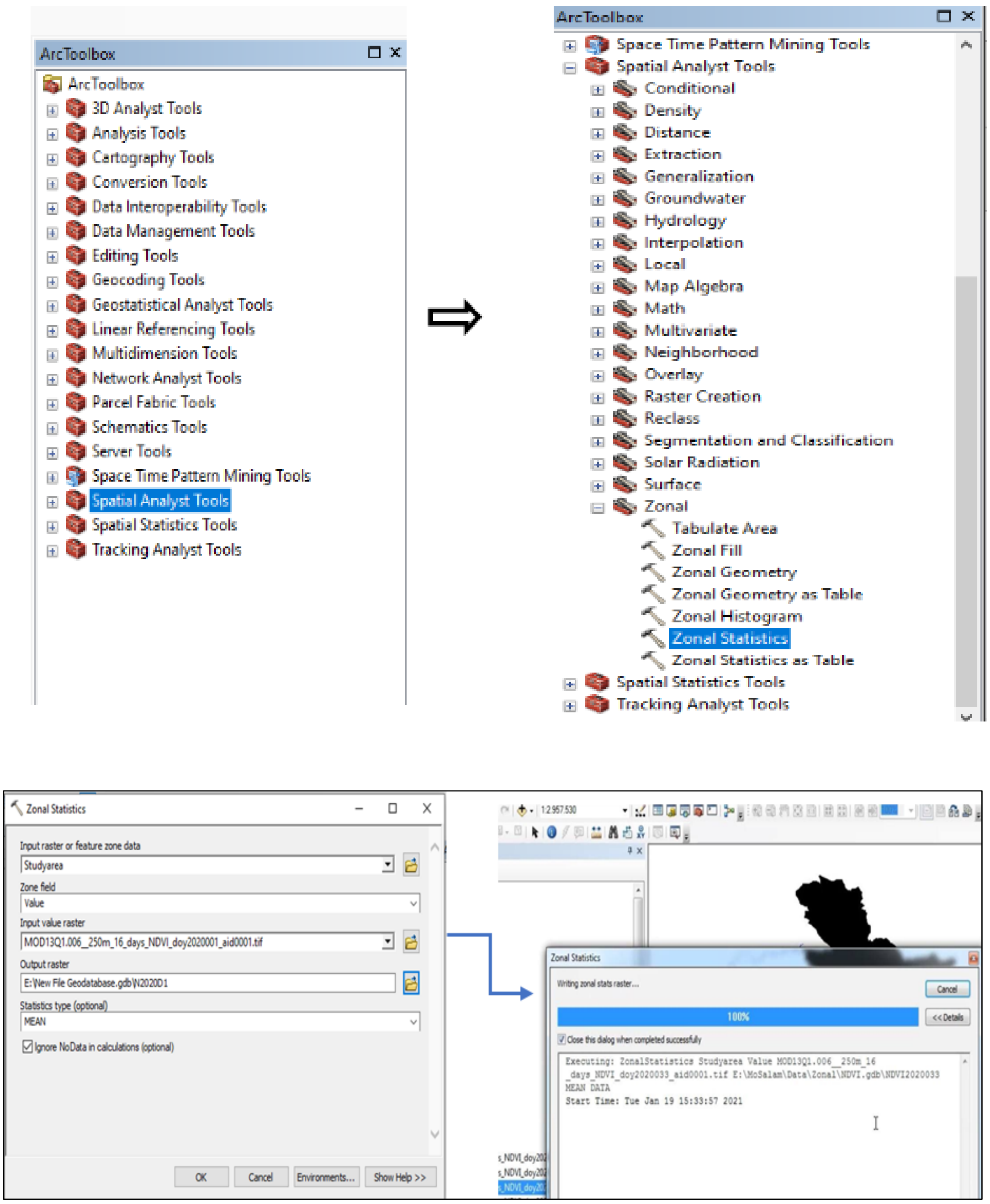


Figure 10: How the zonal statistics tools works, accesses and applies it

After preparing the arithmetic average of the vegetation for each of the study areas, which was stored in the form of an image, the (extract multi values to points) tool was used to extract the time series for each area for the period from 2000 to 2020. Figure 11 illustrates the application of the process of time series extraction for each region within the limits of study area. Figure 12 shows a simple model of the data that was extracted, which shows the density of vegetation of the four regions for several time periods.

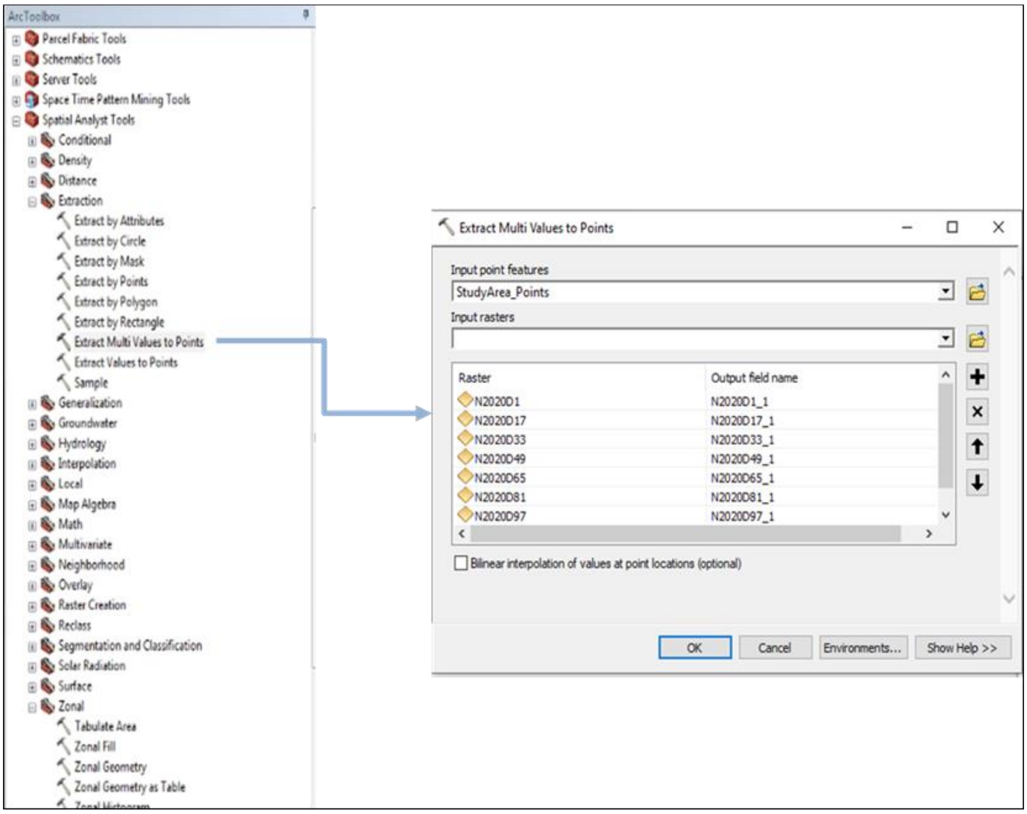
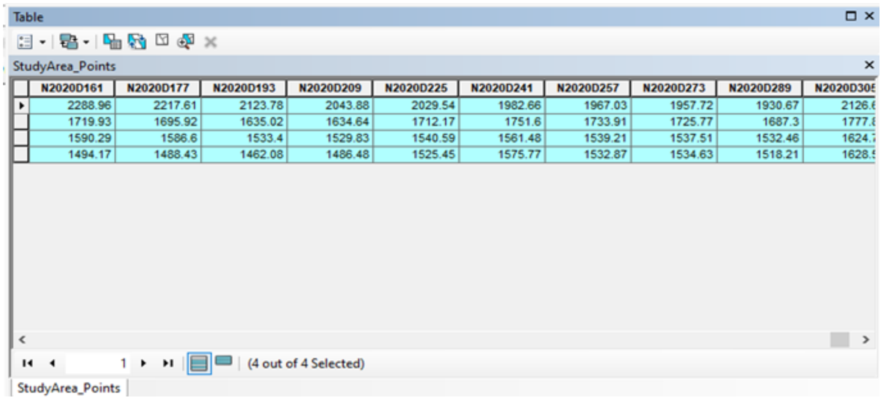


Figure 11: extract multi values to point.



N2020D161	N2020D177	N2020D193	N2020D209	N2020D225	N2020D241	N2020D257	N2020D273	N2020D289	N2020D305
2288.96	2217.61	2123.78	2043.88	2029.54	1982.66	1967.03	1957.72	1930.67	2126.[illegible]
1719.93	1695.92	1635.02	1634.64	1712.17	1751.6	1733.91	1725.77	1687.3	1777.[illegible]
1590.29	1586.6	1533.4	1529.83	1540.59	1561.48	1539.21	1537.51	1532.46	1624.[illegible]
1494.17	1488.43	1462.08	1486.48	1525.45	1575.77	1532.87	1534.63	1518.21	1628.[illegible]

Figure 12: The NDVI values

1.3.5. Data analysis

The results were analyzed and extracted from the vegetation time-series data according to the administrative division of the four governorates, and the results were extracted using the (Arc Map) program, then divided according to months, years and seasons, in addition they were stored using (Excel) program.

The temporal correlations of the extracted data were analyzed with the climatic data over months, years and seasons, so correlate values were obtained. Where the correlation is one of the statistical elements, it is a numerical measure of two types, which means that there is a statistical relationship between two variables. The aim of the correlation study is to find the relationship between the variables, and to examine whether the relationship is direct or inverse, strong or weak.

The correlation coefficient expresses the strength and trends of the relationship between these two variables, and the correlation is expressed by two variables restricted by [1.-1]. And if it is a positive value, the correlation is completely direct, but if it is 0.7 to less than +1, then this is a direct correlation, and if it is -1, then it is a negative correlation, and so the higher the number, the stronger the correlation, but if the value is 0, there is no correlation (Chalil, 2020). The degree of correlation between two variables is measured by the correlation parameter, and is denoted by the letter "r". The correlation coefficient (Pearson) (Edwards, 2014) can be calculated through the following equation:

Pearson's Correlation Coefficient Formula

$$r = \frac{n(\sum xyz) - (\sum y)\ (\sum y)}{\sqrt{[\,n\sum x^2 - (\sum x\,)^2][n\sum y^2 - (\sum y)^2]}}$$

n	Quantity of Information
Σx	Total of the First Variable Value
Σy	Total of the Second Variable Value
Σxy	Sum of the Product of & Second Value
Σx2	Sum of the Squares of the First Value

Correlation analysis was applied by means of the (SPSS) statistical program, and the NDVI vegetation data were compared with the rainfall data, as well as with the elevation, side, slope and delusion, and extracting the relationship between them.

Got spot analysis (HSA) technology provided by Arcmab 10.5 was used to extract the hot spot aggregates. This tool is used to identify the statistically significant spatial clusters of hotspot and cold spot. Hot spot analysis uses a set of weighted features and identifies statistically significant hot spots and cold spots (Mitchel, 2005). Using a statistic (Getis-Ord Gi *esri, 2020), this analysis presents the Z-Score and P-Value resulting from spatially high or low features pools (GIZ scores) and (GIP Values) as in figure (13). Through the tools of pattern analysis, it can be observed whether it appears as a pool or a scatter.

This tool also works by looking at each feature within the context of the adjacent features, the (GI) statistic that is retrieved for each parameter in the total data is (Z. Score), for the positive (Z) scores that are statistically significant, the higher the Z score, the higher the pool intensity values (Hot spot), while for negative Z scores with statistical significant, the smaller the Z scores, the higher the pool of low values (Cold spot). The Following figure shows a simplified process of the steps and methods that were followed in data instruction. Figure 13 and 14 illustrate the practical application of data analysis tools. These tools can help summarize and organize the geographic distribution, and identify spatially outliers and provide statistics for hot spot clusters and values for broad geographic patterns and trends over time.

Figure 13: p score and z value in a normal distribution (Source; URL3)

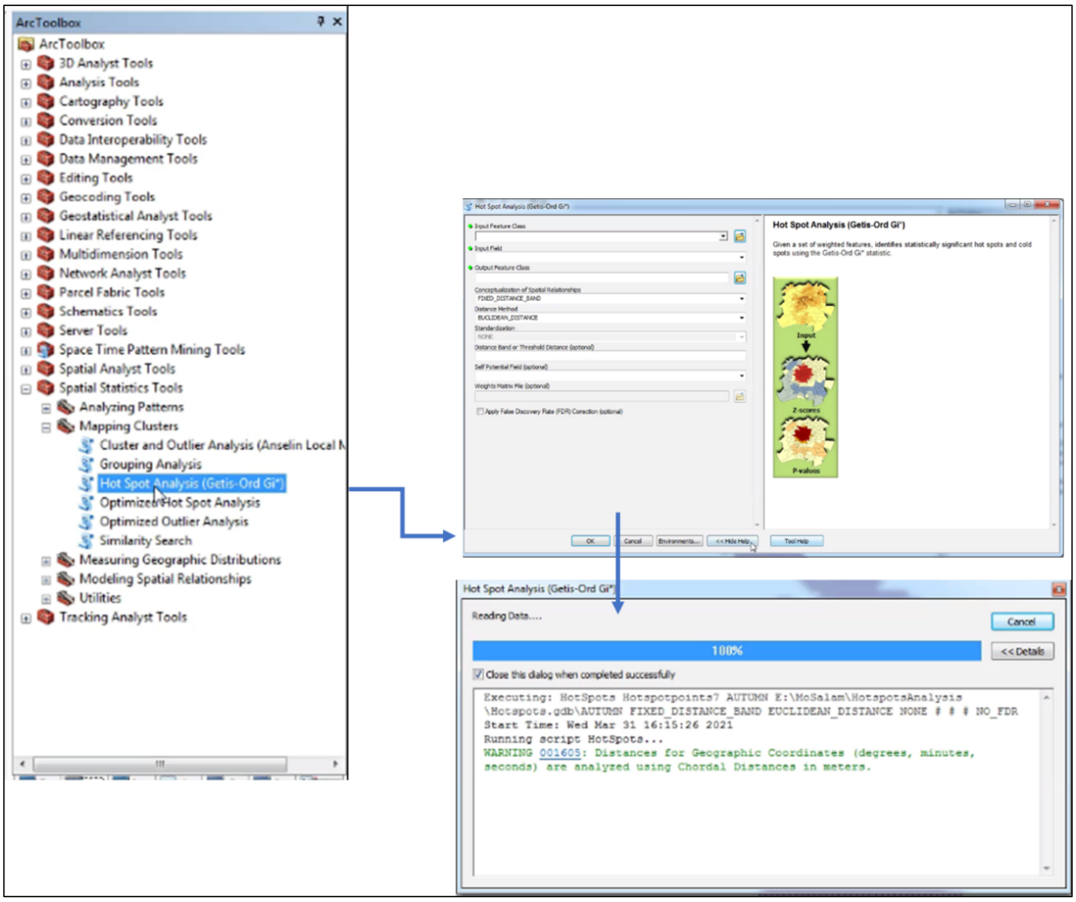


Figure 14: Hot spot analysis (getis-ordgi)

1.4. PREVIOUS STUDIES

Several studies have studied the land cover and the problems of desertification through remote sensing programs and satellite images.

Seboka, (2016) studied the problem of desertification in Ethiopia by NOAA-AVR for the period 1982-2006 by remote sensing to show rainfall trends where the satellite data showed that the majority of the study area didn't have a trend NDVI (p< 0.05) and it was concluded that more than 40% of the area witnessed positive trends in vegetation and 6% a decrease in vegetation.

Benedict et al., (2021) focused on monitoring vegetation effectively using remote sensing data and vegetation index (VI) for a time series in the US CONUS region where good quantity VIIRS and E MODIS were used for pixel elimination and drought monitoring was applied by means of tuned algorithms.

Yildiz et al., (2012) used SPOT 4 and SPOT 5 to analyze the temporal and spatial variance of plants in Turkey using the NDVI parameter. He explained that the plants in the country differ according to the different terrain and seasons, and indicated that satellite data can be used to monitor the earth, such as studying plant photosynthesis and analyzing drought factors.

AI-mamalachy, (2017) dealt with the phenomenon of agricultural drought and its impact on agriculture in Iraq, where MODIS indicators were used from 2003 until 2015. The study aimed to monitor hydrological drought and develop proposed solutions to address it. The study showed that 2008 was the driest year. It also showed that remote sensing helped in early warning of drought over the year and also helped in producing agricultural drought maps.

Fensholt & proud, (2012) conducted a study on the assessment of the global vegetation for the (GEMS and MODELS global NDVI) index for the period between 1982-2010, it also conducted an analysis of NDVI trends for arid regions with limited photosynthetic and correlational representation of 1% of the land cover. He noted that NDVI data constitute a strong basis for the long-term detection of arid, dry and humid regions of the world.

Jayanand, (2020) investigated the effect of unit time problem and vegetation detection that occurred between 2001-2016 in Nepal using monthly TERRA MODIS 13A3 data with 1 KM spatial resolution time interval on monthly basis. He emphasized that the data helped analyzing the pattern and trends of vegetation. The analysis showed that the average NDVI was higher during May to October in Nepal and lower during the rest of the months. While analyzing the data from 2001 to 2016, the NDVI was least in 2001 and highest in 2015.

Baio et al., (2018) linking the index (vegetation cover index of standard variation) to the diversity of the cotton yield for 9 seasons by analyzing LANDSAT satellite images and by tracking seasons. The study included 101 cotton production fields in western and central Brazil.

Karaburun, (2010) studied the soil erosion in Buyukcekmece, west of Islanbul), by means of the USER global soil loss equation. The aim of the research is to estimate the water accumulation factor and vegetation cover values using the NDVI index, which is derived from Landsat 5 ™.

Henik, (2011) studied the spatial variance of plant stress by NDVI index. The thesis dealt with the variation in maize yield where remote sensing can identify areas of low plant growth and compare it to other areas. Areas of higher yield can also be identified precisely and early in growth. The study recommended integrating technological developments with agricultural management.

Colditz et al., (2015) studied the time series of 15-year NDVI data from the MODIS Terra satellite. Annual indicators of drought and humidity were analyzed, and the study proved that the change in vegetation in Mexico has positive trends ($p < 0.05$) due to afforestation in northern Mexico.

Maranganti, (2009) the thesis attempted to analyze the vegetation change that occurred in India between 2000-2005 by remote sensing. Where TERRA MODIS data was used in the study. Using the NDVI Vegetation Indicator for image classification and using the Malkoff Probability Prediction Algorithm to predict five-year vegetation. The study emphasized better land use and vegetation cover management in the future to help prevent the loss of vegetation and agricultural cover.

Becker, (2014) studied the evaluation of the Iraq Marshes using MODIS data from 2003-2014. The results of the analysis showed expansion of the marshes area and recovery of its scope between 2003-2006 as a result of the opening of dams. Rain and human activities also played a big role in vegetation changes.

Cai et el., (2020) worked on the dynamic monitoring of Donting Lake in southern China for the period 2000-2019 using monthly LANDSAT data and remote sensing. The study focused on continuous monitoring of vegetation dynamics. A "cross-fusion" model of the MODIS data was applied with Landsat to extract the NDVI vegetation index at a resolution of 30 m. The results showed that the vegetation changes in Dong Ting lake wetlands varied spatially and temporally in the last two decades due to sever climatic conditions and human factors.

Naif et al., (2020) studied the city of Baghdad using Landsat images for the years (2008,2013,2019) and extracted the vegetation index (NDVI). The results indicated that the vegetation is healthy and dense. The results indicated that there are close correlations between climatic variables and the vegetation index during the growth seasons.

Ahmad S. Muhaimeed1, (2013) NDVI index account for cities (Mosul, Kirkuk, Salah al-Din) using modis images from 2000 to 2010 and monthly weather data for rainfall from 1980 to 2010, In 2001, the highest ndvi values were recorded at 0.33, 0.39, 0.20, and in 2008, the lowest values (0.10, 0.19 0.13), and the outcomes revealed the rainfall is closely linked to the NDVI index.

CHAPTER I

1. PHYSICAL GEOGRAPHY CHARACTERISTIC OF THE STUDY AREA

1.1. Geological and Geomorphological Properties of the Study Area

1.1.1. **Geological Settings**

The geological structure is one of the influential factors in determining the nature and growth of plants. The study area is geologically complex due to the diversity of the geological layers existing in the area according to figure 15.

1.1.1.1. Jurassic

This era represents the third phase of the Tethys marine sediment, known as the rocks of this era in many areas of northern Iraq as Sirwan valley, and is divided into three stages: (early Jurassic), (middle Jurassic), and the composition of Serjulo, and (upper Jurassic), represents the formation of Nikolican, northwest of Sulaimaniyah.

1.1.1.2. Cretaceous

The geological structure of the northern region shows rock formations that cover the surface of the region, where their chronological age starts from ancient eras until the modern era, as they were represented by types of igneous and metamorphic rocks such as granite, schist and flint, and they are concentrated in the complex mountainous areas in the northeastern part of the study area and it is located within the **High Folded Zone**, according to the physiographic distribution of Iraq (Al-Omari, 1977), and that most of the geologic structure that appears on the surface dates back to the Mesozoic period, the Second Geologic time.

1.1.1.3. Tertiary

The central region of Diyala includes rock formations, triple time formations, dating back to the lower, middle, and upper Eocene eras. The Eocene **Kolush formation** consists of shale stone and sandstone with clay. As for the middle Miocene, it is from al fat'ha formation. It consists of reddish clay limestone and muddy limestone. As for the late Miocene formations, it consists of the **Anjana formation**. And the formation of **Miqdadiyah and the formation of Bay Hassan**, as the table1 shows formations and their geological characteristics.

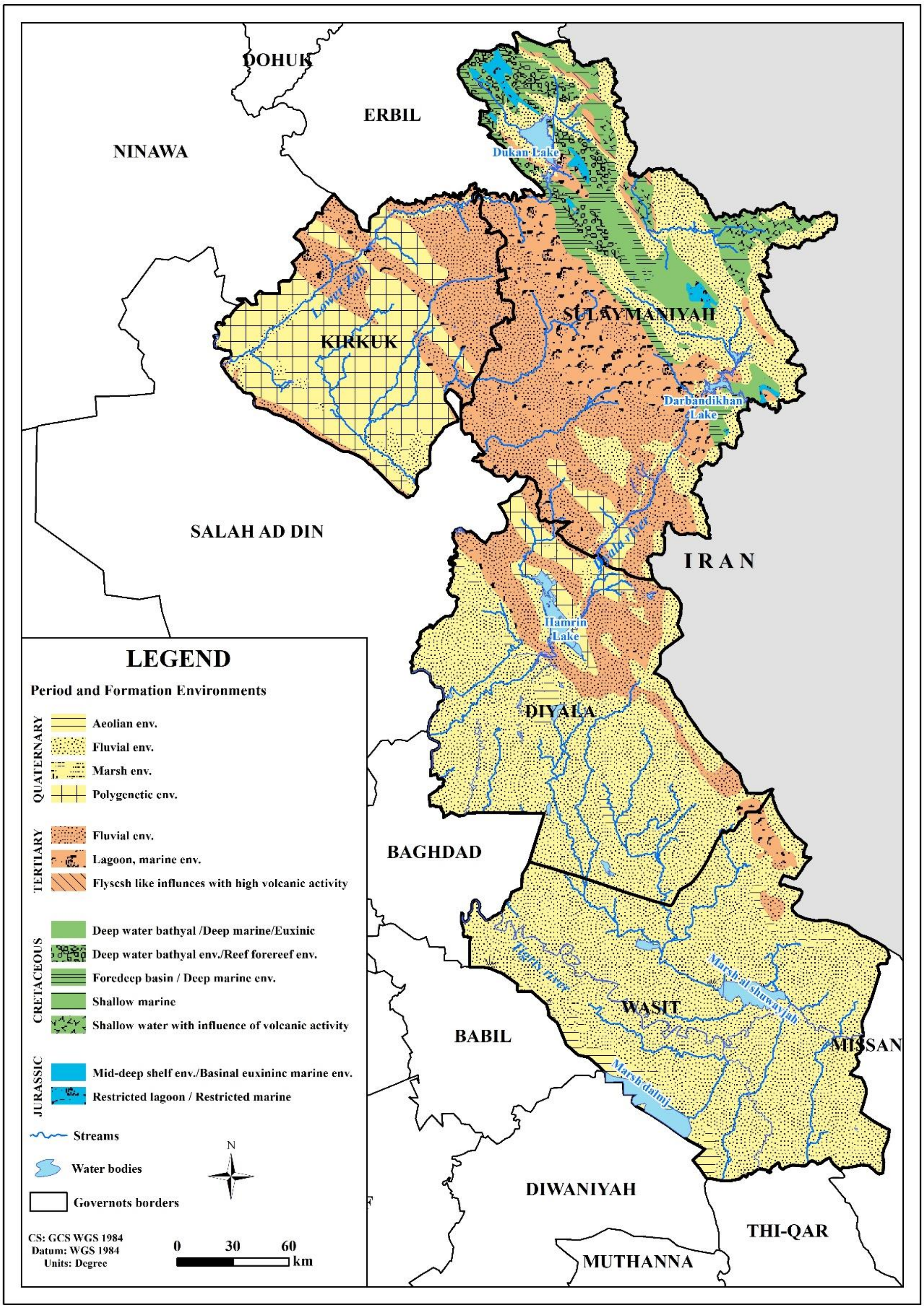


Figure 15: Geological map of the study area.

Sourse; Geological Map of Iraq Scale 1 : 1000 000 Sheet No. 1 National Library Legal Deposity No. 141, 2000, Baghdad, Iraq

Table 1: Geological era and formations of the study area

Era	Period		Formation	Description
Quaternary	Holocene	Recent sediment	Sedimentary deposits	alluvial sand
			valley deposits	alluvial sand gravel
			Sand Dune	Clay
	Pleistocene	Ancient sediments	Alluvial Fan	Gravel
				gravel sand
				Alluvium
				Clay
Tertiary	Pliocene		Bai Hassan& Al Muqdadiya	Sandstone Gravel
				Sandstone
				Mudstone
				siltsone
	Upper Miocene		Anjana	Mudstone
				Sandstone
				siltsone
				Mudstone
				limestone
	Middle Miocene		Fat'ha	clay
				limestone
				Gypsum
				Mudstone
Cretaceous	Mesozoie		Tanjiro&sheransh	sandstone rocks limestone
Jurasic	upper Jurassic		Naokelekan	bituminous limestone and dolomitic, coal horizon
	middle Jurassic		Sargelu	limestone, black shale, and marl

1.1.1.4. Quaternary

As for the western part of the study area, it shows in this part of the study area different rock formations from one place to another, where this difference is due to the ground movements since the ancient geologic ages. Where the region geologically dates back to **Pleistocene** and **upper Miocene** where the internal movements appeared at the latest of **Miocene** era and the area is located within the Folds sector characterized by many convex folds.

As for the southern part of the study area, the geological history of this region goes back to the Holocene, Pleistocene, and Tri-Miocene eras. It consists of the formations in the northern region, Al- Fat'ha Formation, Injana Formation, Alg Miqdadiya Formation and Bay Hassan.

1.1.2. Geomorphological Settings

The surface of Iraq is divided into fourth main sections (Al-Samak et al, 1985). Also, general morphography map of the study area presented in figure 16.

1.1.2.1. The first section: the region of the mountains:

It includes the northeastern region of Iraq with an area about 23500 km^2 with a percentage about 5% of the total area of Iraq as shown on figure 16. This region extends in an arc from the northwest to the southeast with a length of 360 km, where it is borded by the political borders of Iran from East and Turkey from North. The altitudes of this region vary from 1000-36000 meters (Al-Saadi, 2009).

1.1.2.2. The second section: the region of undulating lands (semi-mountainous):

This region occupies an area of 6700 km^2 which represents about 15% of the area of Iraq. The altitudes of this region range from the southeast to the northwest in the form of hills and mountains as shown in figure 16. (AL-Samak et al, 1985).

1.1.2.3. The third section: the region of the flood plain (the alluvial plain):

which extends in a rectangular shape with a length of 650 km in a northwest and southwest direction, with an area of 93,000 km^2 (AL-Saadi, 2009**).** This plain was the result of the sediments of the rivers that filled the concave torsion the region. But a large part of these sediments didn't fill the sedimentary plain, so depressions were formed from them covered by water resulting in water swamps and marshes, with a height of 100 meters above sea level.

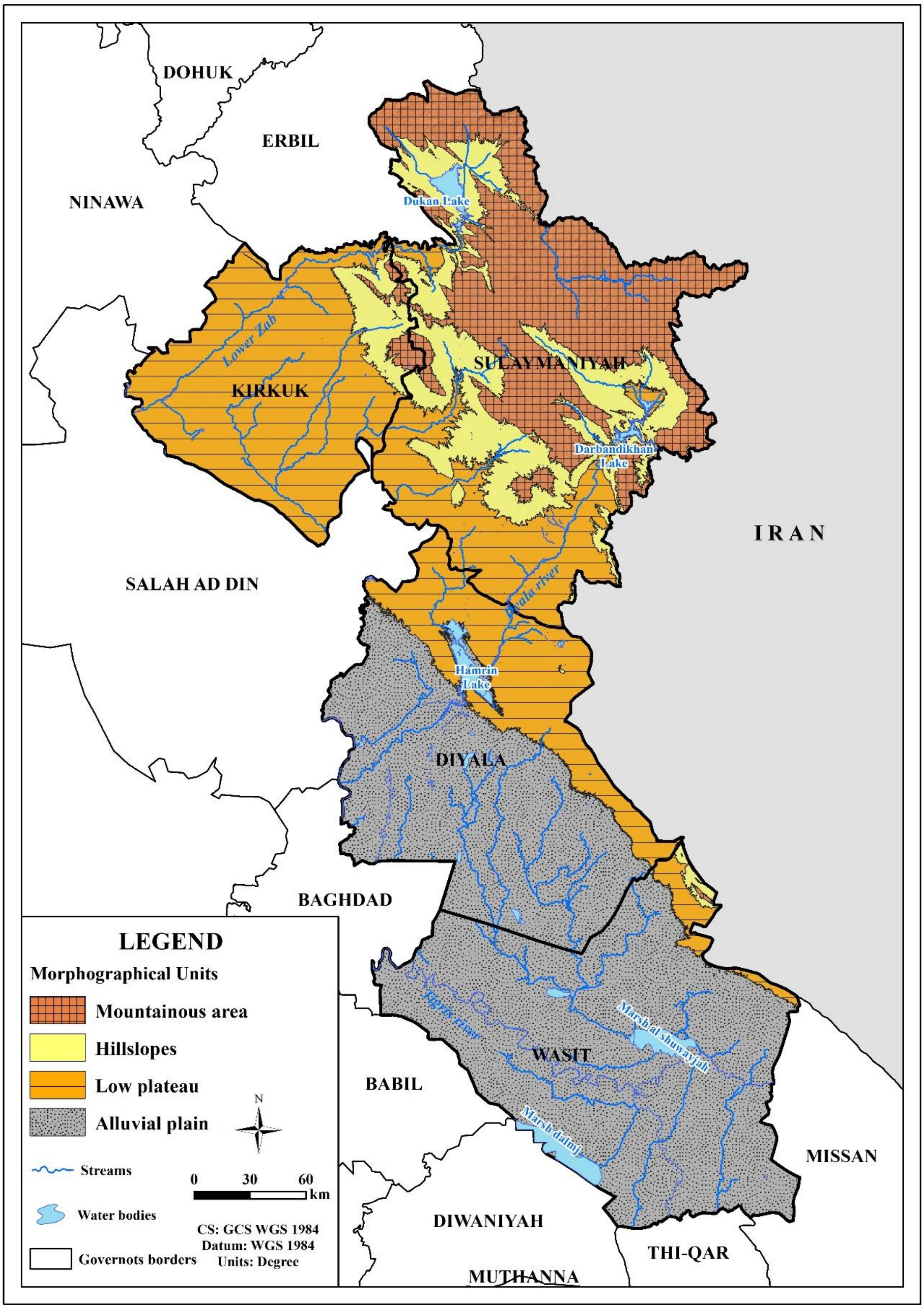


Figure 16: Morphography map of the study area.

1.1.3. Topographical Features of the Study Area

It is considered one of the surrounding conditions that affect the growth and spread of plant groups. Topography consists of the elements slope, aspect, elevation, extending from the mountains and the degree of terrain separation, and these three features effectively control the patterns and trends of vegetation in any area and these three factors determine the local climate and spatial distribution patterns of vegetation (Singh, 2018).

1.1.3.1. Elevation

The elements of altitude are one of the factors affecting the natural vegetation, especially in the region, where it constitutes an obstacle to the growth of plants in high-rise areas.

The nature of the surface of the region is characterized by diversity, as it is noted that the height of the ground level increases in the north and north-east, as shown in figure, where the height ranges from 750-3801 meters, and Sulaymaniyah city is surrounded by several mountains, including Mount Azmar from the east and north-east, with a height of 1709 meters, and the central region is 100-500 meters high. This part of the region is characterized by distant hills with feet of gradual slope as illustrated in figure 17.

The most prominent of these hills are the Hamrin hills, extending from the south of Khanaqin from the Diyala region, with a distance of 250 km and estimated to be the longest chain of hills in Iraq (Al-ssati et al., 1985). As for the southern part, it is with a height starting from 0-100 meters, except for some eastern parts.

When the spatial data of the region was examined, it was found that the least area covers 587 km² (1%), height from 2000 to 3018 m, 2021 km² (2%), height 1500 to 2000 m, 6489 km² (2%), 750 to 1000 m, 6,486 km² (7%), 11,049 km², 500 to 750 m² (11%), 29,447 (30%) and 41,610 km² less than 100 m² (43%). From the study area, the area between 0 and 100 meters covers most of the study area (Figure 18 and Table 2).

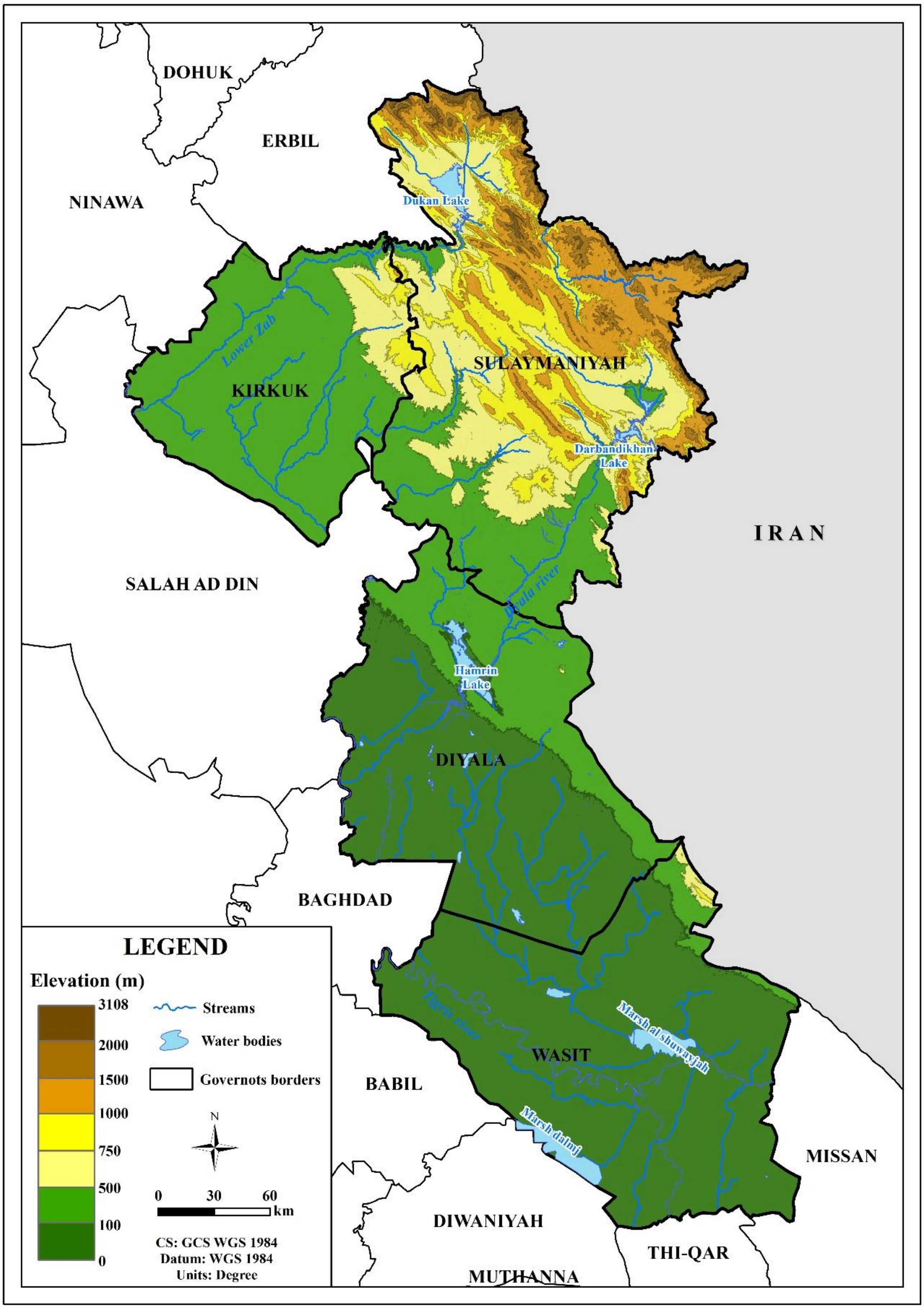


Figure 17: Physical map of the study area.

Table 2: The Study Area Site by Elevation (km²)

Elevation groups (m)	Area (km^2)	Percent
0-100	41610	43
100-500	29447	30
500-750	11049	11
750-1000	6486	7
1000-1500	6489	7
1500-2000	2021	2
2000-3108	587	1
Total	**97688**	100

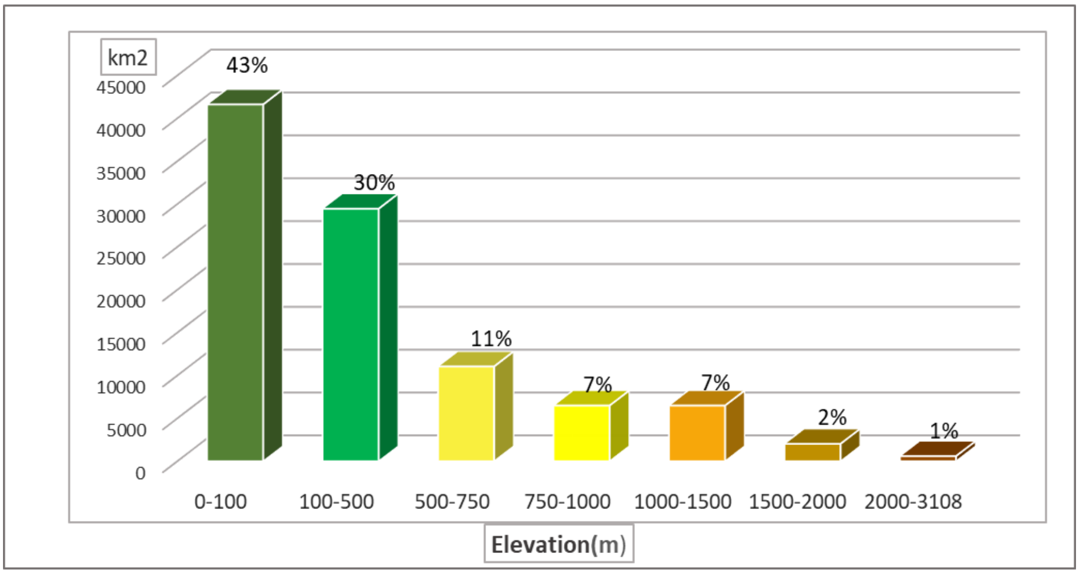


Figure 18 : Relative Distribution of elevation in study area.

When the spatial graph of the search area is examined with intervals of 50 m, it becomes clear that the minimum area varies between 12 km^2 and 2800-3108 m. Its maximum area is between 41,610 km^2 and 0-100 meters, and according to the results, the average height of the search area is not as high as in the figure (Figure 19).

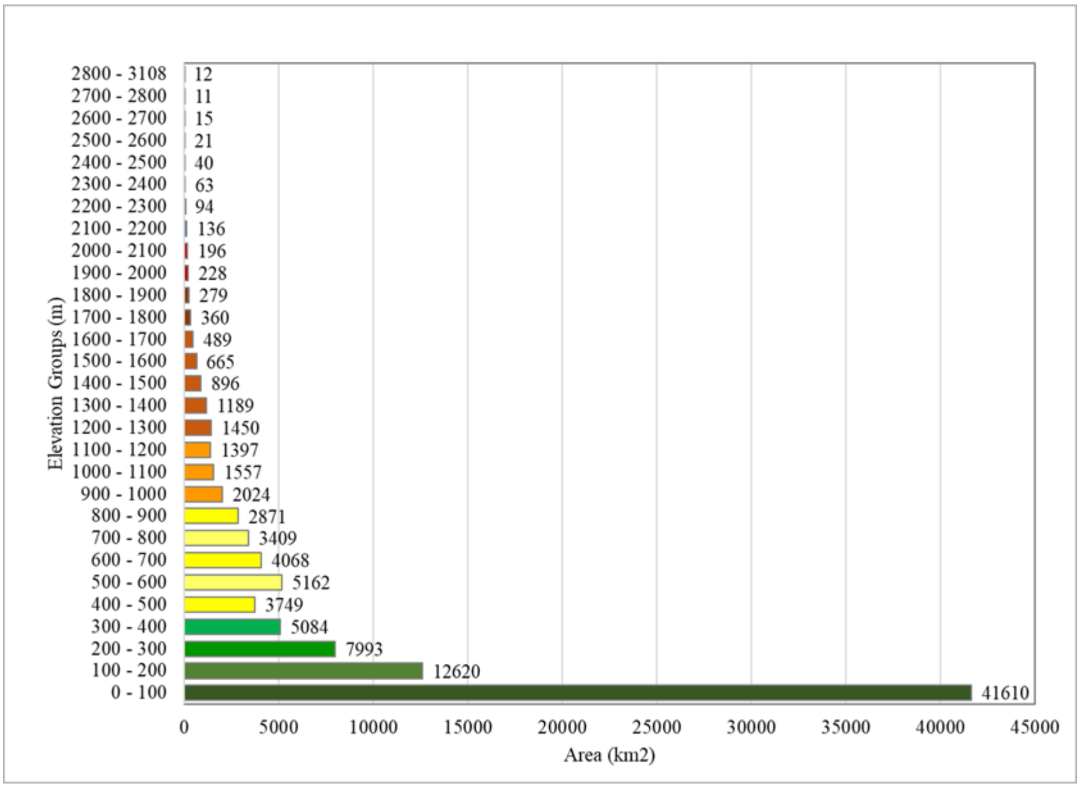


Figure 19: Altitude frequency histogram of the research area with 50-meter intervals.

1.1.3.2. Aspect

The aspect factor is related to the angle at which the sun's rays reach an area because It controls the distribution of vegetation by affecting the sunbathing and rainfall amount of the slopes. the temperature and humidity in any area (Coşkun, 2017). The elements of the Aspect were derived from the Digital Elevation Model (DEM), which is represented by (North, Northeast, East, Southeast, and West) as well as the direction value which is zero representing the flat surface (Figure 20).

As illustrated at the study area according to (Figure 5), it is possible to see that there are many areas with a flat surface with 16% (15508 km²) of the area, 9% in the north (1953 km²), 11% in the northeast (1358 km²), east 9% (9783 km²), southeast 10% (9843 km²), south 11% (10,925 km²), southwest 13% (12714 km²), west 11% (10,365 km²), while the total values for the northern sides were 46% and 54%, in the southern directions as in (table 3; figure 21).

Table 3: Spatial Distribution by aspect Steps

Aspect	**Area (km^2)**	**Percent**
Flat	15508	16
N	9153	9
NE	10358	11
E	8783	9
SE	9843	10
S	10925	11
SW	12714	13
W	10365	11
NW	10039	10
Total	**97688**	**100**

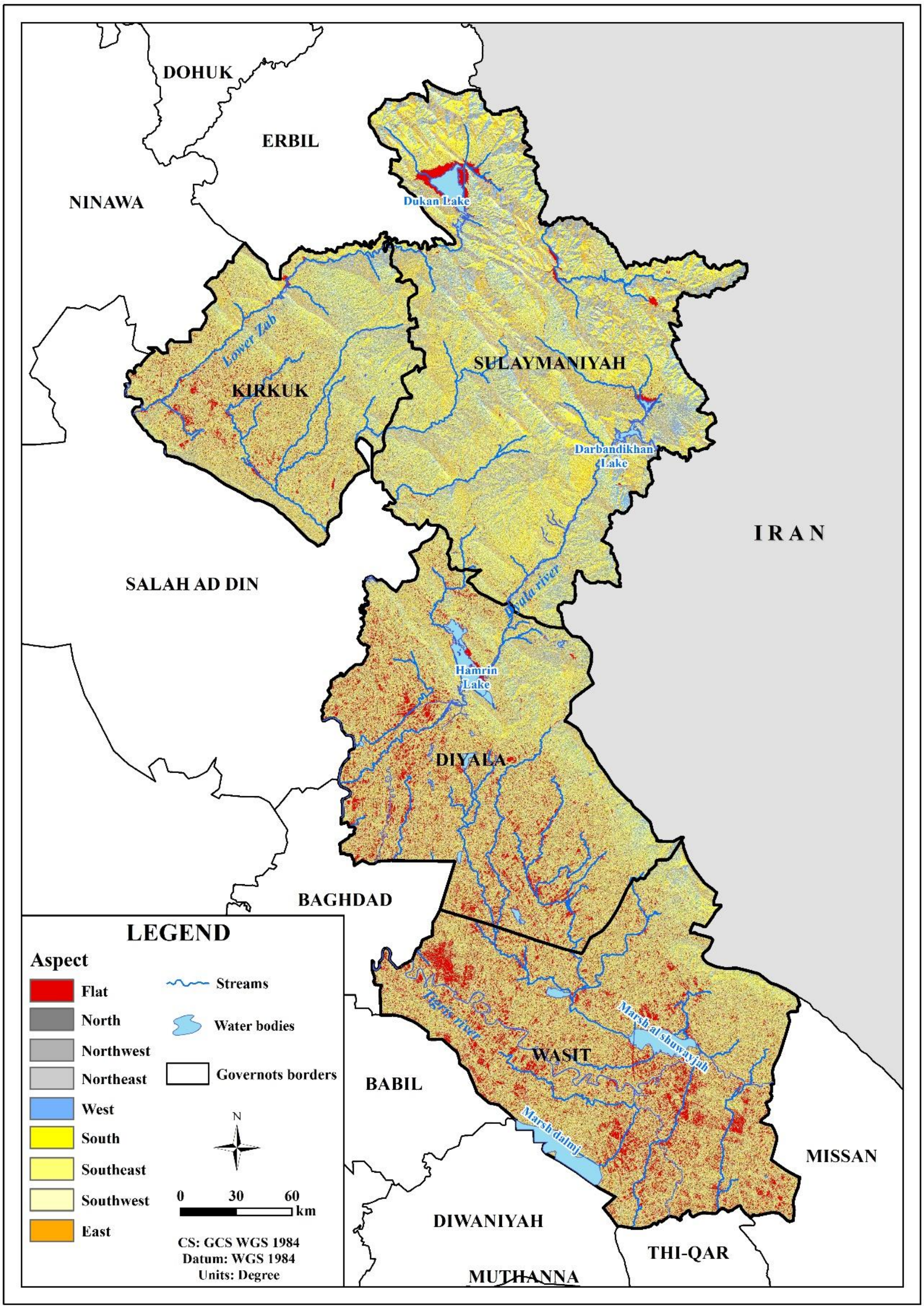


Figure 20: Aspect map of the study area.

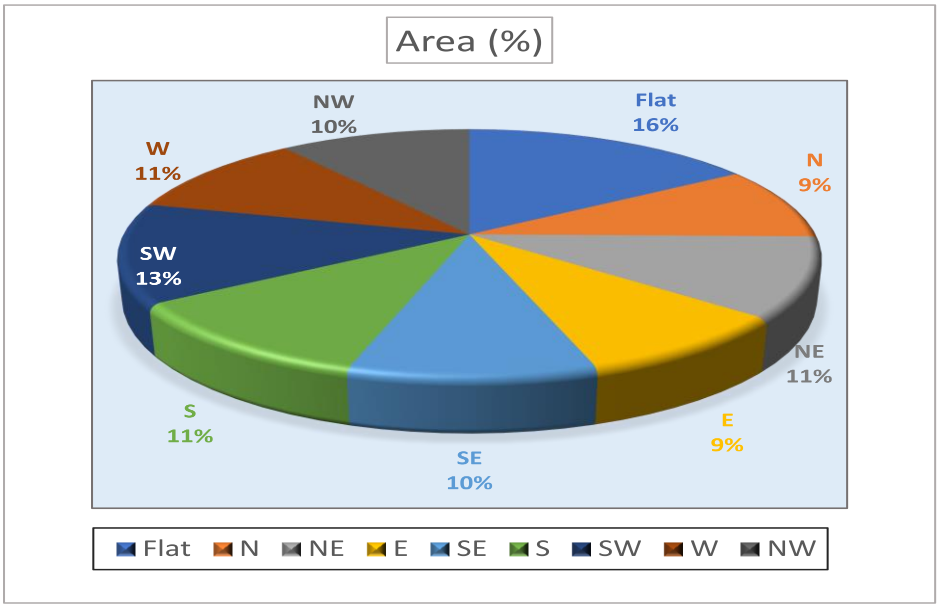


Figure 21: Proportional Distribution of Aspect Aspects of the Research Area.

Table 4: Spatial Distribution of North-South Aspects in the Research Area

Aspect	Area (km2)	Area%
N	9153.2	46
S	10924.7	54

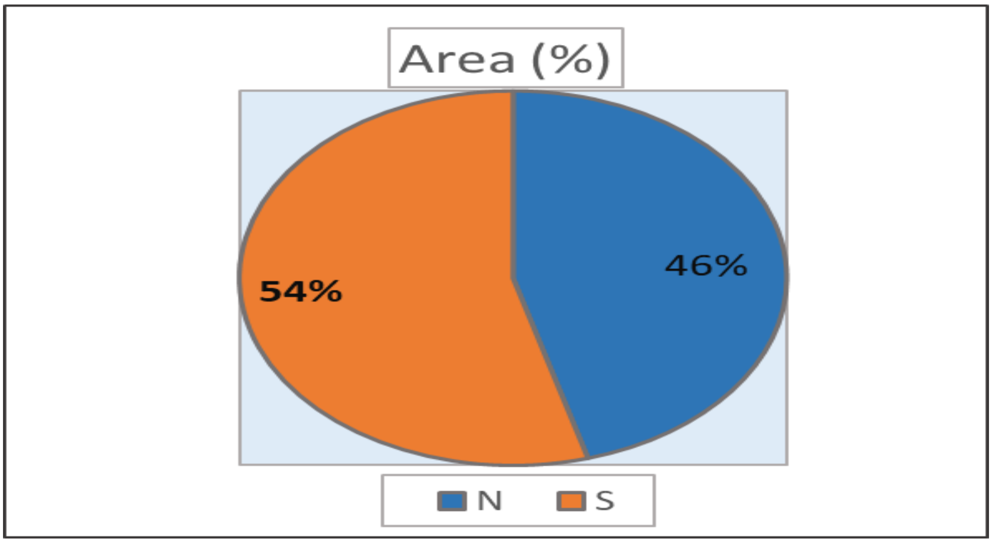


Figure 22: Proportional Distribution of North-South Aspects in the Research Area.

1.1.3.3. Slope

The diversity of plant groups in natural habitat conditions depends mainly on the shape of the land (Gerhardt and Foster, 2002). Slope is one of the most important factors that directly affect the water flow and its speed, and this affects the ability of the stems and roots of natural plant to stick to the soil especially in steep areas, the velocity of water flow increases, which affects the surface of the soil and its fragmentation and uprooting of plants from it. The slope increases from south to north (Figure 23).

Considering the distribution of slopes in the region, the area of flat regions covers a large percentage, which is 0-5% covers an area (76,861 km^2), lands with a slope of 5-10% cover an area (9961 km^2), and lands 10-15 %. 4329 km^2), and the land area is 15-20%, with an area (2910 km^2), and the lands with a slope of 20-25% (1,963 km^2), and the lands with an area of 25-30%, with an area, (1045 km^2). And lands with a slope greater than 30-70% (619 km^2), (Table 5; Figure 24).

Table 5: Spatial distribution by slope steps

Slope groups (degree)	Area (km^2)	Percent
0-5	76861	79
5-10	9961	10
10-15	4329	4
15-20	2910	3
20-25	1963	2
25-30	1045	1
30-70	619	1
Total	**97688**	**100**

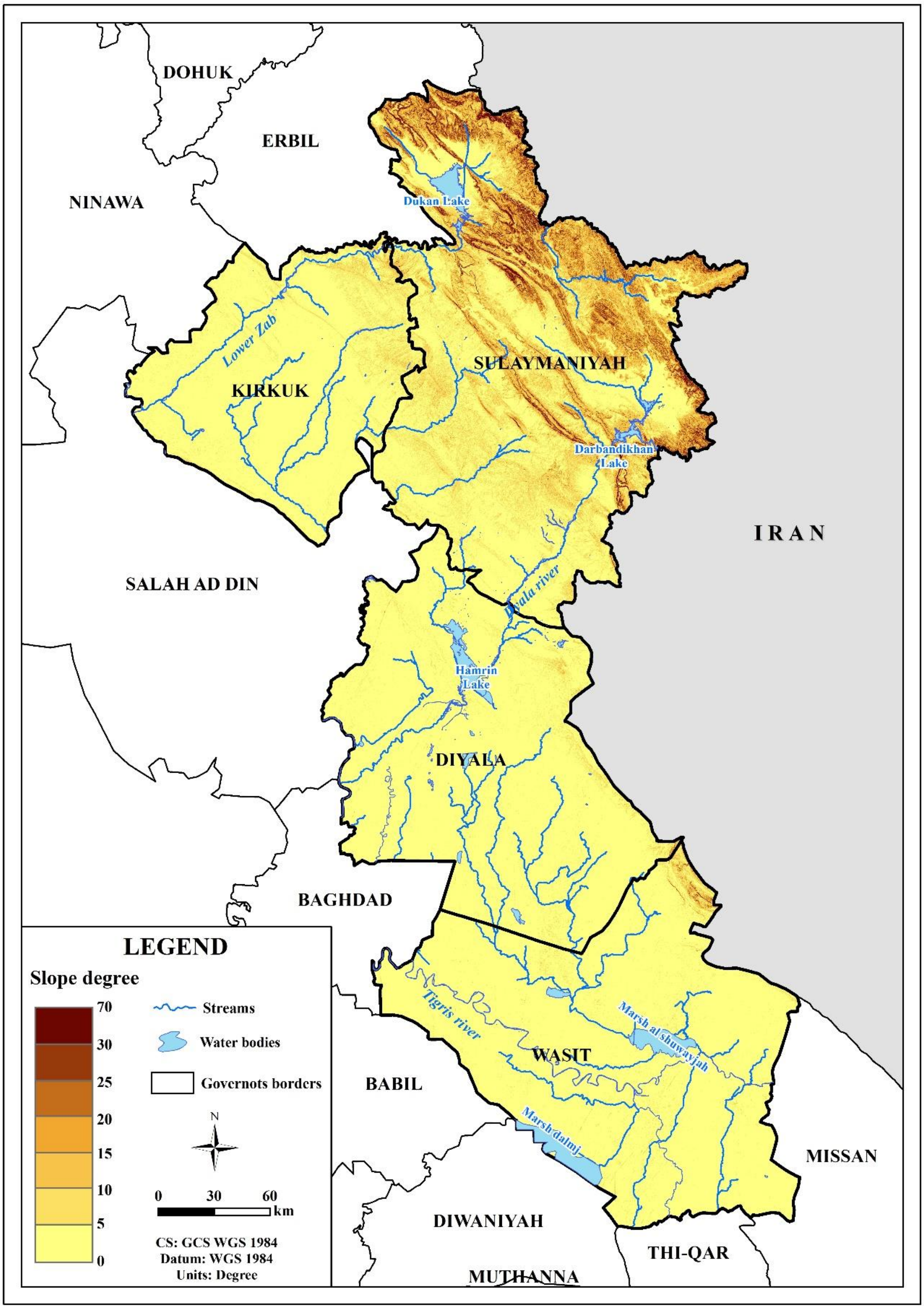


Figure 23: Slope map of the study area.

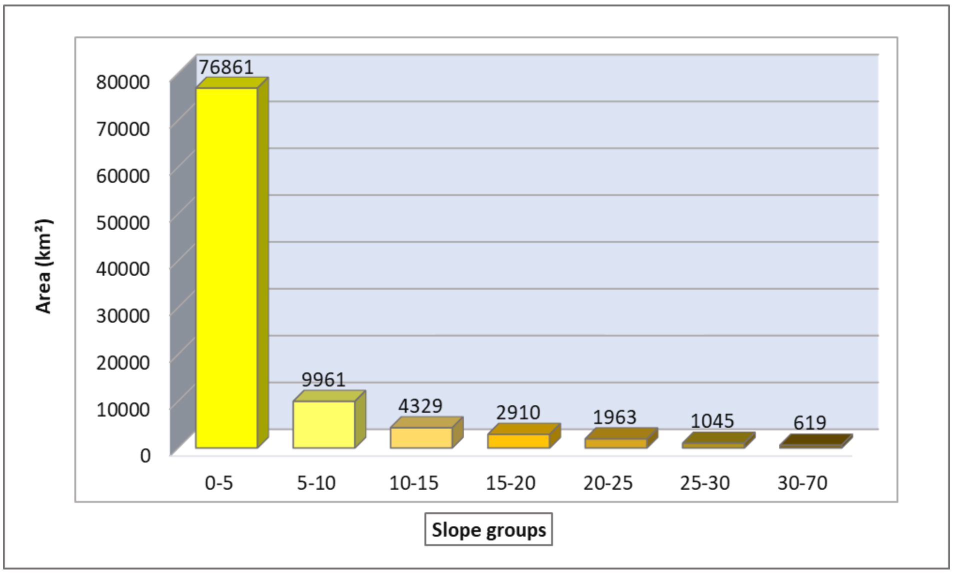


Figure 24: Spatial Distribution of Slope Groups in the study area.

1.1.4. Climatic Characteristic of the Study Area

This part covers climatic characteristics, temperature and precipitation, which directly affect the natural vegetation in the study area

1.1.4.1. Planetary Factors

Iraq is located in the northwestern part of the continent of Asia, which made its location acquire a semi-tropical continental climate, due to its distance from seas and water bodies, which made it acquire this characteristic (Al-anni, 1988), where its climate is characterized by hot and dry summers and cold rainy winters. Its climate is also characterized by characteristics such as extremes in temperatures and fluctuations in rainfall from year to year and season to season.

1.1.4.2. Geographical Factors

Geographical factors such as topography, proximity or distance from the seas and water bodies are formed by the formation of different climatic factors, especially that the study area is located between three climatic regions, which are humid, semi-humid and semi-arid, where the mountainous areas are characterized by a relatively mild climate in summer, unlike the areas that lies within the semi-arid region.

1.1.4.3. Climate Elements

The elements that make up the climate, humidity, pressure, wind, temperature and precipitation, and the variation of these elements has a direct effect on the plant, because these elements are related to each other. The change in these factors often leads to a difference in vegetation for some sites (Naif et al., 2020).

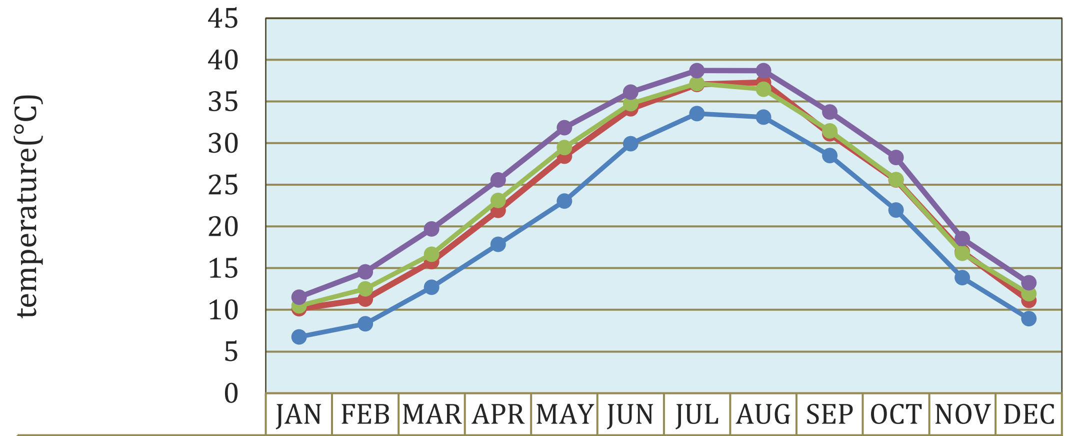
1.1.4.3.1. Temperature

Temperature is the most important environmental factor controlling the distribution of plants in an area (Coşkun,2021). The temperature in the study area is characterized by great variance as shown in table 6, where these values gradually rise at the end of spring, i.e. the month of May, until they reach their peak in summer.

Table 6: Monthly and Annual Average Normal Temperature (°C) (2000-2020)

	Months												
Metrology	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Yearly**
Sulymaniyah	6.8	8.3	13	18	23.1	30	34	33	29	22	14	8.9	**19.9**
Kirkuk	10	11	16	22	28.5	34	37	37	31	26	17	11	**23.4**
Diyala	11	13	17	23	29.5	35	37	37	32	26	17	12	**23.9**
Wasit	12	15	20	26	31.9	36	39	39	34	28	19	13	**25.9**

As illustrated in the figure (25 and 26), it is noted that the highest normal temperatures were recorded in Wasit station in August at a rate of (38.7 °C). The reason for this is due to the fact that the area is located in the dry desert region, which is characterized by low rainfall and low vegetation, in addition to the presence of the sand dunes which are scattered in this region in general and the area in particular.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SULYMANIAH	6,8	8,3	12,7	17,9	23,1	30,0	33,6	33,1	28,5	22,0	13,9	8,9
KIRKUK	10,1	11,3	15,8	21,9	28,5	34,1	37,1	37,3	31,1	25,6	17,0	11,1
DIYALA	10,5	12,5	16,7	23,1	29,5	34,8	37,2	36,5	31,5	25,6	16,8	12,0
WASIT	11,5	14,6	19,7	25,6	31,9	36,1	38,7	38,7	33,8	28,3	18,6	13,3

Figure 25: Monthly and Annual Average Temperatures of the Stations.

Where it is noted that the temperature is acceptable in Sulaymaniyah station, unlike the rest of the stations, as it is located in the cold semi-arid region, and the highest temperature was recorded in the month of August (°C33.1)

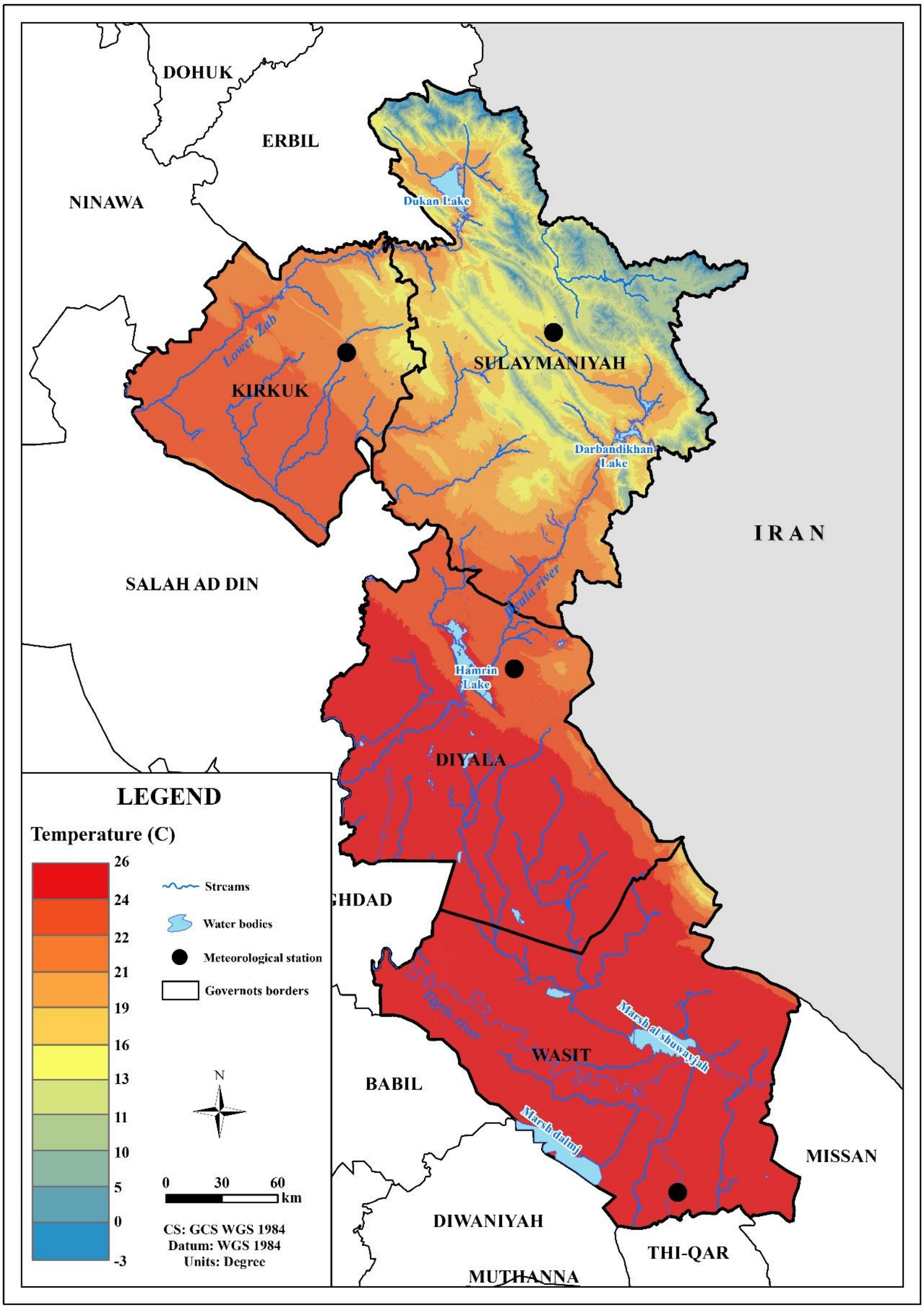


Figure 26: Annual mean temperature map of the study area.

1.1.4.3.2. Precipitation

The presence of water is very important for plant life, as it affects the distribution of plant life and plant formations in any area (Coşkun&Yüksel,2021).

Precipitation percentages were measured as shown in (Table 7; Figure 28, 29). The rainfall in the region is characterized by fluctuation, because the region is located between several climatic regions. The rainfall starts from October to the end of May, where the highest percentage of rain reached in Sulaymaniyah station for the months of December, January and February (117.1,120.4,101.2,mm), as for Kirkuk, the percentages were (49,69.7,53.5,mm), Diyala (39.7,45.4,29.3,mm), Wasit Station (19.5,21.9,11.6,mm). It is noted that the rates of rainfall increased in the northern parts of the study area, because the area is located in the humid region, where it was noted that the station recorded the highest total annual rainfall amounted to (681.3,mm), Kirkuk (318.4,mm), and Diyala (251.2,mm). While it is lower in the southern part, where Wasit station recorded the lowest total rainfall by (120.3,mm). Because the area is located in the semi-arid region, as in figure (27).

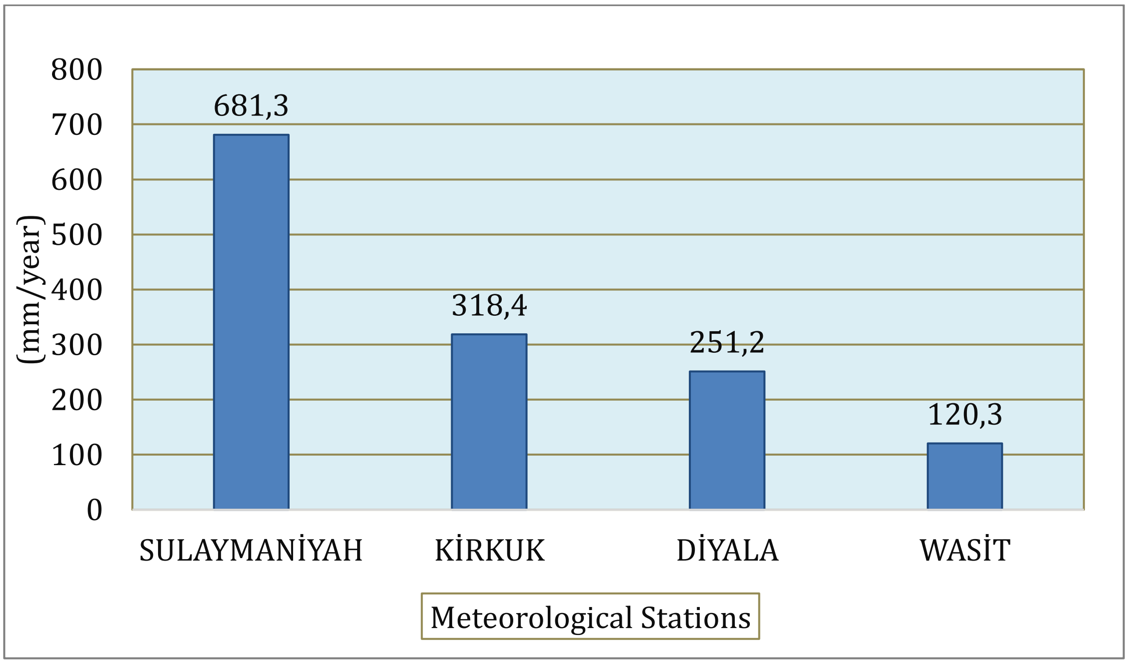


Figure 27: The annual total precipitation by mm (2000 -2020)

Table 7: Annual and Monthly precipitation (mm) For Period (2000-2020**)**

	Months												
Meteorology	J	F	M	A	M	J	J	A	S	O	N	D	**Yearly**
Sulaymaniyah	120	101	102	67	27	0	0	0	5	51	91	117	**681.3**
Kirkuk	69.7	53.5	44.5	37	14	0	0	0	1	16	34	49	**318.4**
Diyala	45.3	29.3	29	23	6.5	0	0	0	0	22	56	39.7	**251.2**
Wasit	21.9	11.6	17.6	15	5.8	0	0	0	0	4.4	24	19.5	**120.3**

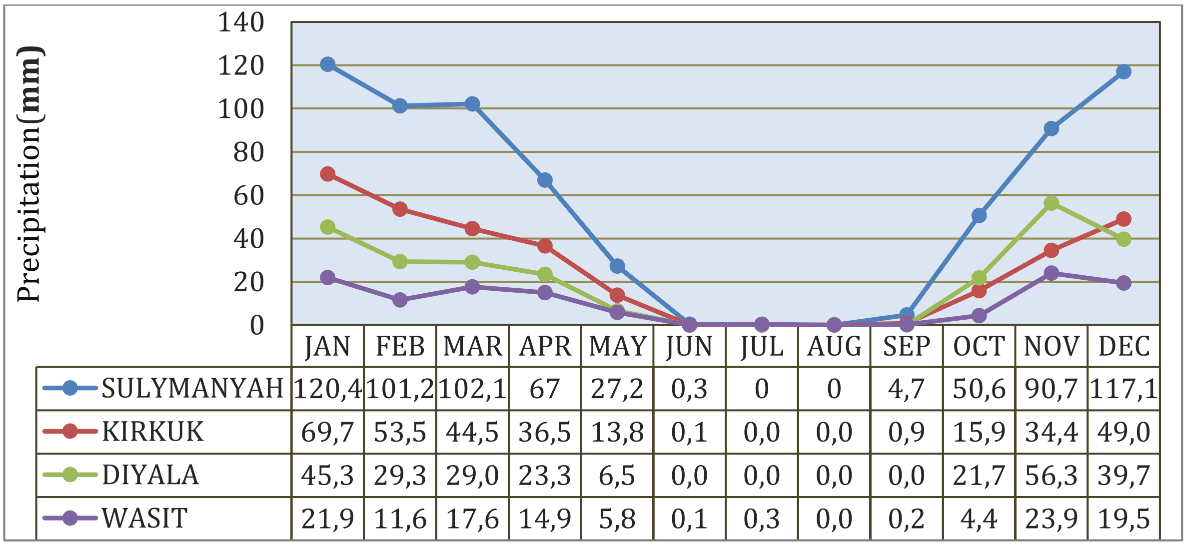


Figure 28: Average Monthly precipitation (mm) in Meteorological Stations (2000-2020)

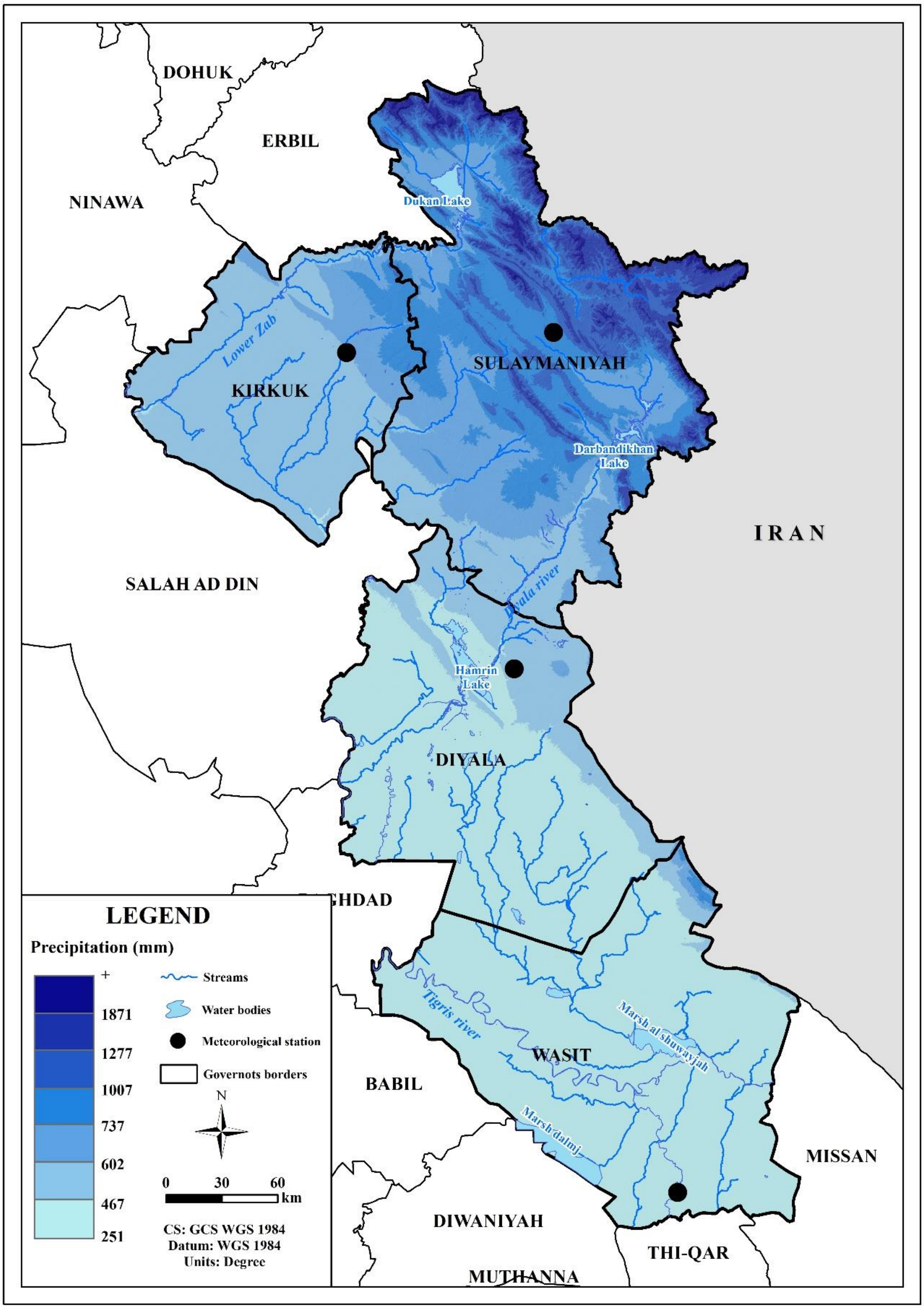


Figure 29: The annual total precipitation map of study area

When the relative distribution of precipitation was examined due to the measurement of the existing stations according to the seasons, the results showed that the highest percentage of precipitation was in winter with 49%, in spring by 27%, summer by 0% and autumn by 22% of the total rainfall in the region

While it is noted that Sulaymaniyah station receives the largest amount of precipitation in winter 49%, spring 29%, summer 0% and autumn 22%.

In view of the relative distribution of precipitation in Kirkuk station in winter 54%, spring 30%, summer 0% and autumn 16%. Diyala station receives 46% of rainfall in winter, 23% in spring, 0% in summer and 31% in autumn. As for Wasit station, the total precipitation for winter amounted to 44% of precipitation, spring 32%, summer 0% and autumn 24%. As shown in figure 30.

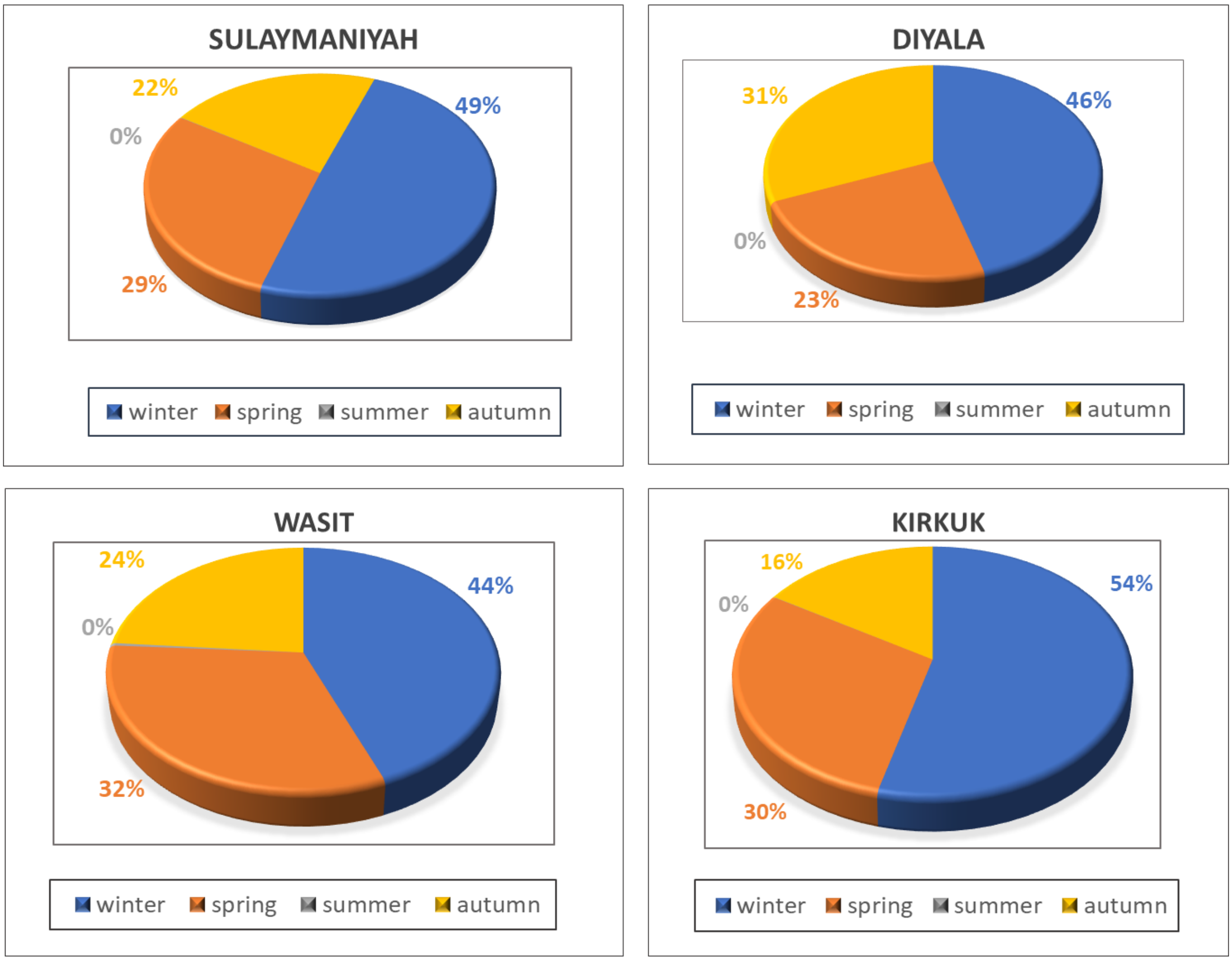


Figure 30: Seasonal Distribution of Precipitation.

1.1.5. Hydrographic Features of the Study Area

The water sources in the region have many ramifications, especially from the main sources and rivers from which many tributaries branch off. Given the (Figure 31), it consists in the northern part of the study area (Sulaymaniyah) of the Diyala River, which originates from western Iranian lands and has a length of 386 km (Sakar, 2015). It is joined by several tributaries, which are (Tanjiro) (Zalm)

The region is distinguished by its important lakes, namely Lake (Dukan) and Lake Darbandikhan, which are located in the eastern part of Sulaymaniyah Governorate. As for the western part of the study area (Kirkuk), it is located on three main rivers, which are from the north, the Zab River and covering its tributaries (especially Su, Tawook Su, and Waq Su)

As for the central region (Diyala), it consists of several rivers, the main river of Diyala, which shares with Sulaymaniyah, in addition to Lake Hamrin, which is located north of Diyala. The southern region (Wasit) includes the surface waters of the Tigris River, which passes through the region along the southwestern part, and its length is 308 km, as well as the Gharraf River. The area is also characterized by the presence of marshes, the most important of which are Al-Dalamj Marsh in the southwestern part, and Al-Shwija Marsh.

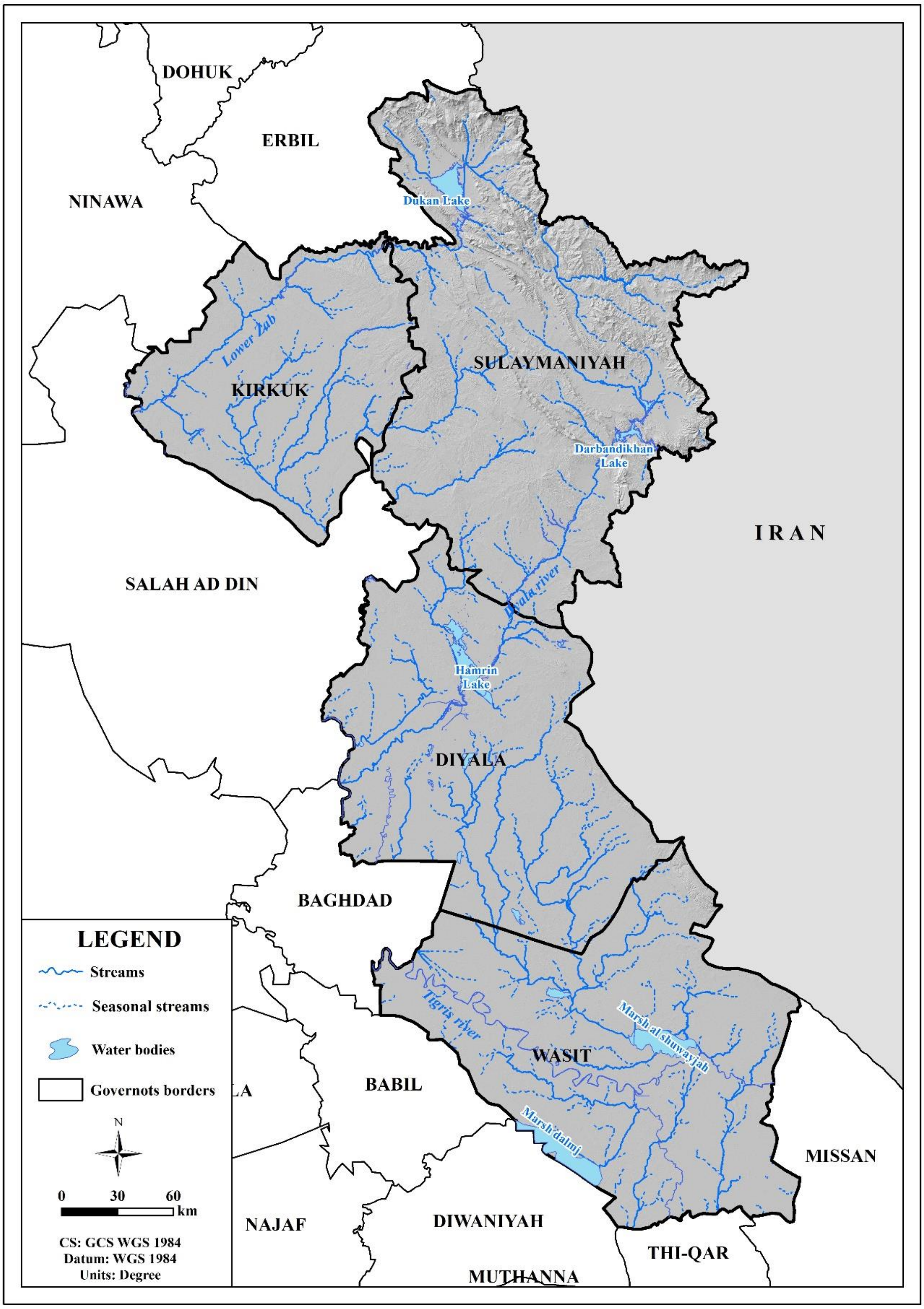


Figure 31: Hydrology map of the study area.

1.1.6. Soil Features of the Study Area

Soil is a decomposed layer that surrounds the outer part of the land surface with consists of a mixture of organic and inorganic substances, contains water and air in specific proportions, hosts a living environment in and on it, provides a resting place and a source of food for plants, and so on. It's characterized as a live, natural environment in which terrestrial plants thrive (Atalay, 2016). and also The importance of soil comes after climate in terms of plant growth (Oztekinci&Coşkun,2021).

The soil of the study area varies from one place to another depending on the different terrain (Figure 32). Soil represents an important role in determining the type of natural plant life. The soil of the study area is divided into several sections (Buringh, P.1957).

1.1.6.1. Mountainous soil

It covers large parts of the mountainous region and varies according to the height and slope variation also according to its exposure to erosion factors. It is shallow soil with rocks visible on the surface, the majority of which are lime and gypsum.

1.1.6.2. Rivers Levees Soil

This soil appears in the form of narrow bands adjacent to riverbeds, its surface undulates a little or a lot depending on its location in the rivers. It is characterized by its rough and medium texture and contains a percentage of gypsum and lime

1.1.6.3. Chestnut soil

It is located in the plains of the mountainous region, its valleys and terraces. It is fragile soil in its upper sections and its color is dark brown (Al-Saadi, 2009).

1.1.6.4. Chernozem soil

The presence of this type is limited to patches in the plains near the city of Sulaymaniyah, and due to the low slope of the land in these areas, the water velocity decreases and thus its sediments (which are of a dark gray color) deposits. (Sakar, 2015).

1.1.6.5. Flood Plain Soil

It is one of the modern, undeveloped soils that were formed by the seasonal floods of rivers, as they dumped their sediments on their banks with large bends, most of these sediments are of sand and clay which their sides decrease as moving away from the rivers' banks.

1.1.6.6. Soil of silted river basins

Covering the southern and central parts of the region.

1.1.6.7. Brown soil

It occupies the plain of Kirkuk and the northwestern part of the study area. It prevails a lot in the undulating plains of the region. Its color is dark brown and it is poor in organic materials (Al-Ssati et al., 1985).

1.1.6.8. Soil of sand dunes

they are located in the western and southwestern parts of the region, and the soil here is not sandy in general, rather its texture varies between alluvial and sandy clay, and its pores are large (Ibrahim Sharif 1985).

1.1.6.9. Marsh soil

This soil is found in the lower parts of the southern region of the study, which are filled with flood waters or from rain falling in the winter season, It is characterized by being soft in texture, with a high percentage of salts due to the accumulation of streams of water saturated with salts coming from the eastern highlands of the region.

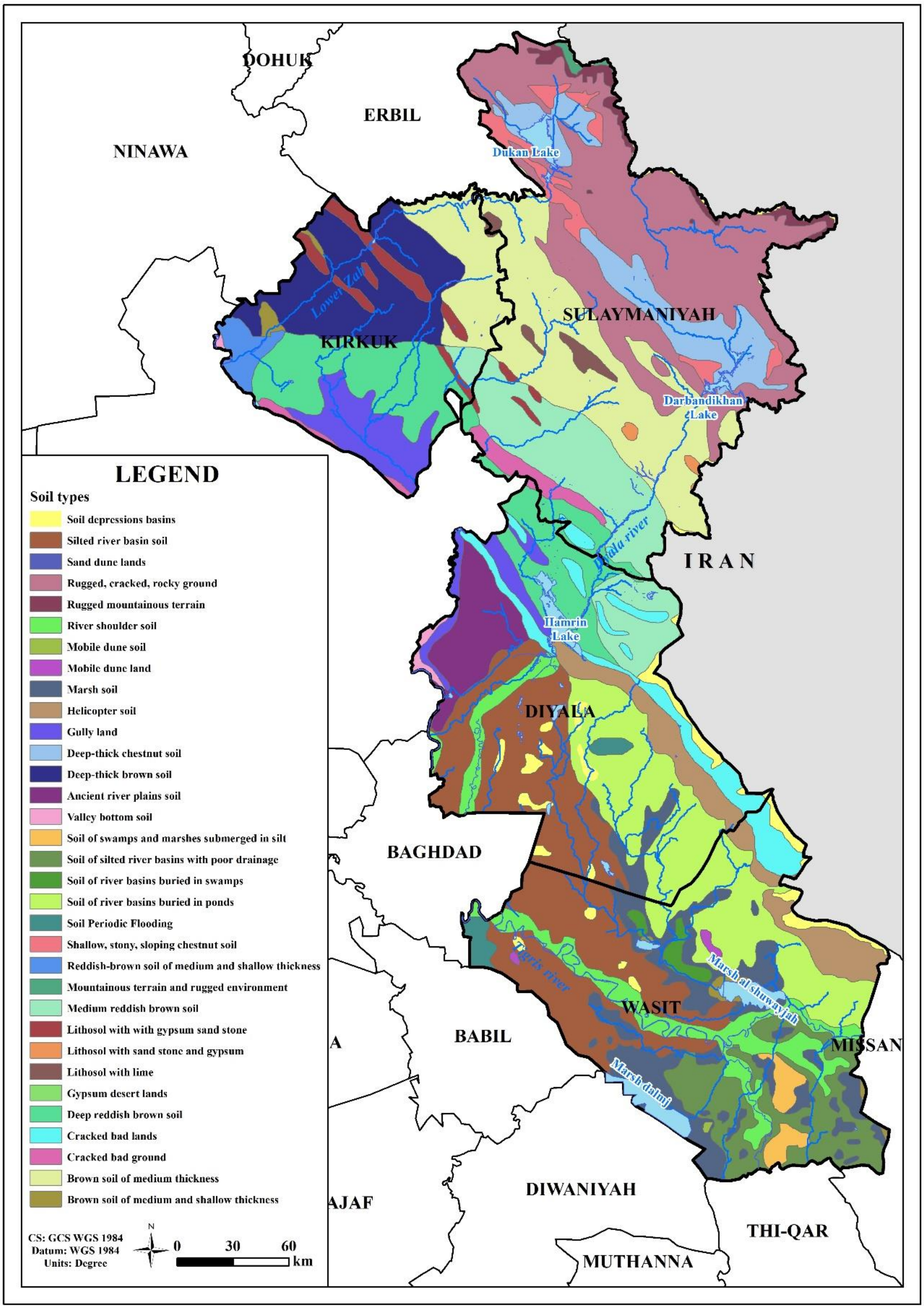


Figure 32: Soil Map of Study Area. source: By Dr. P. Buringh, 1957,Division Of Soils And Agricultural Chemistry Directorate General Of Agricultural Research And ProjectsMinistry Of Agriculture, Baghdad

1.1.7. General Vegetation Properties of the Study Area

Vegetation and its distribution in the climatic regions of the world is the product of a long series of variables. During the Ice Age in Northern Europe and the Alps, many types of plants that were growing in the third period managed to get rid of extinction by spreading south, where they found the appropriate environment and then spread to the south through Gibraltar and then to the heights of Maghreb, where the rains fall heavily. It also extended to the heights of Anatolia, and from there to the mountains of western Syria, Lebanon and Palestine, and then to the mountains of Madin, Asir and Yemen, all of which represent the amount of rainfall, capable of providing a suitable environment for the growth of many plant species (Gouda &Hassanein, 1999).

The plant in Iraq is divided into several sections or regions, which are:

1.1.7.1. The region of forests and mountain herbs

This range is located within the high mountains region above the 600 mm rain line, where there are forests and herbs, most of which are of perennial type that lasts for most days of the year. This range spreads in the northern and northeastern mountainous areas, confined between the Iraqi-Turkish-Iranian borders. The forest areas are estimated by an area of 60% of the total area of the mountainous region. The natural forests in Iraq include many types of trees, most of which belong to the oak genus, and walnut trees and common walnuts (Juglans regia), and there are also some types of pine trees, Pinus and Tannins (Quercus infectoria), and these trees are spread in the northern regions.

1.1.7.2. Steppe region Steppes

The plants of the steppe region occupy about 15% of the area of Iraq and are found within the borders of the semi-mountainous region and within the borders of the steppe region and it consists mostly of weeds and the rest of the bulbous and spiny plants. It is difficult to draw a line between this area and the desert areas, but there is no transitional area between them. The plants of this region can be divided into two parts.

1.1.7.3. Dry steppe plants

They are plants that are on the borders of the desert climate region and are similar to desert plants such as perennial spiny shrubs that are characterized by their resistance to drought season such as Prosopis farcta, Alhagi mauroram, Stipa tortelis, Alyssum desertorum and Haloxylon salicornicum as in the figure (33).

1.1.7.4. Wet steppe plants

They are plants that are more density, and sometimes in the form of small forests. The most prominent of these plants (Stipa tortelis, Alyssum desertorum) are spreading in SD, WD, K, PF and Su,as in Figure (34).

1.1.7.5. Desert plant areas

These plants occupy the western highlands and are famous for their tolerance of arid environmental conditions because they are different from other areas, have low density, and grow in different forms.

1.1.7.6. Riverside Plants Region

It includes plants that are found and abundant on the banks of rivers, where riverbank plants differ from steppe plants and forests, including reeds and sedge, where they spread in places of water swamps and rivers.

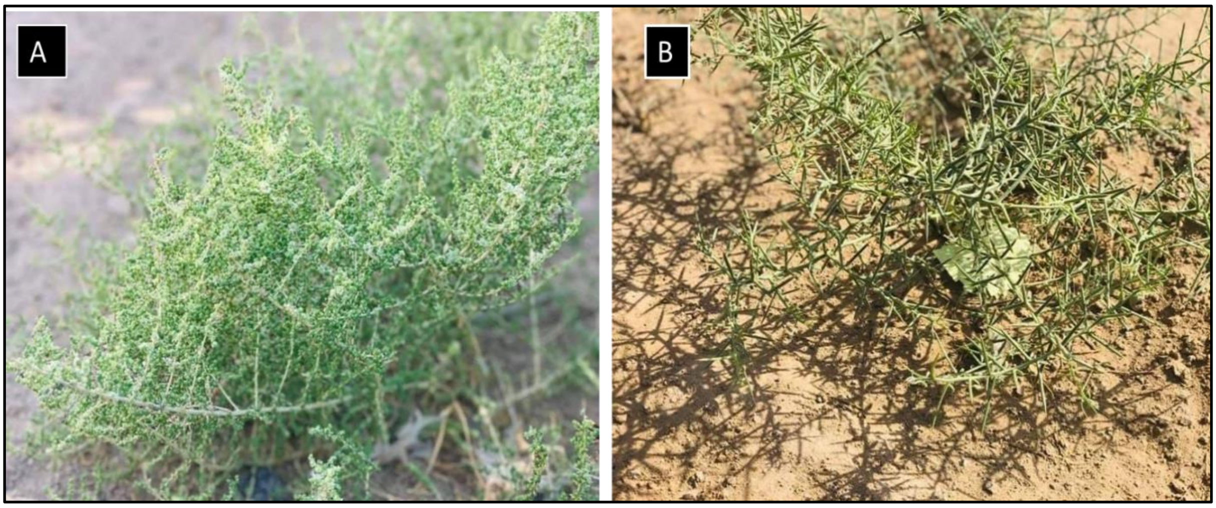


Figure 33: A. Represents the plant (Haloxylon salicornicum) and the figure B. Represents the plant (Alhagi mauroram), which covers all the desert parts of the study area.

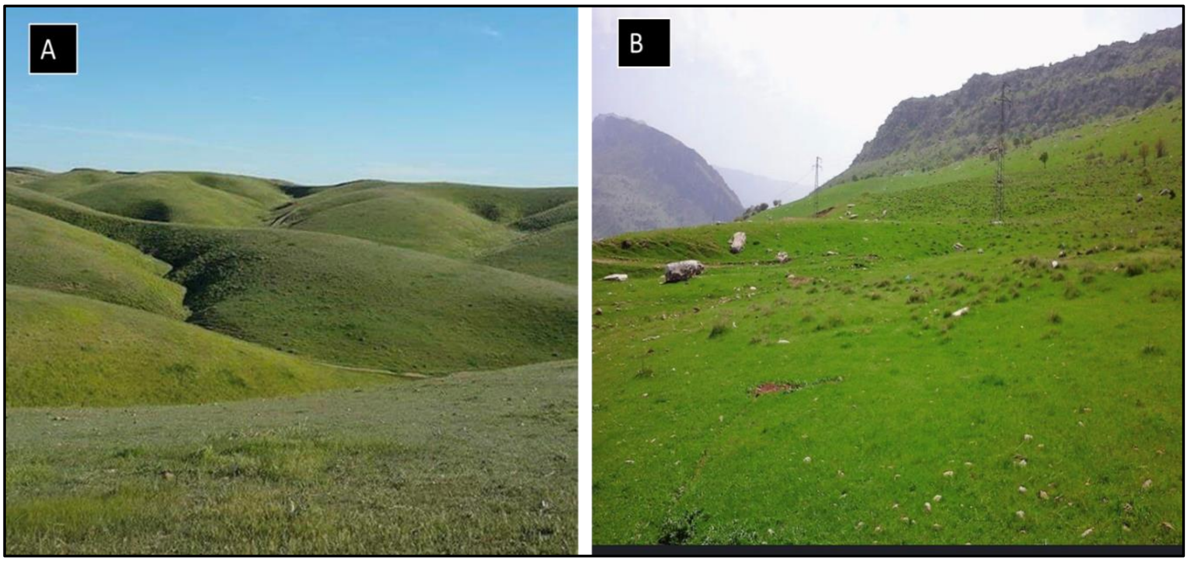


Figure 34: Figure A. represents the wet steppe plants of the type Stipa tortelis, in Kirkuk Governorate, photo date 2015 3-15, and Figure B. Wet steppe plants in Sulaymaniyah Governorate, photo date 21-3-2020.

CHAPTER II

THEORETICAL FRAMEWORK ABOUT RS and GIS

2.1. Remote sensing

Remote sensing is defined as the process of obtaining specific information for a target on the Earth's surface through sensors installed on aircraft or in satellites without touching or contacting (Figure 35). Where it is possible to see, identify and measure targets on the surface of the earth with the help of light energy in the atmosphere, which is called electromagnetic radiation (Maranganti, 2009). Satellites capture images through the devices carried on them without stopping and with different temporal and spatial resolutions (Huang et al., 2018). In recent times, a new generation of satellites with high spatial resolution has appeared, which is able to provide satellite images with high spatial and spectral accuracy and which allowed to conduct spatial analysis at a local level, which has been used in land cover research and environmental studies (Aplin & Aplin, 2005).

The history of remote sensing goes back to aerial photography. In 1858, the French photographer (Gaspar Felix) took the world's first aerial photograph of Paris (Khorram et al., 2016). However, the real beginning of remote sensing was through satellites in the early sixties. After that, the concepts and technology of remote sensing have gradually developed in the last decade until they reached the stage of unmanned aircraft (Huang et al., 2018).

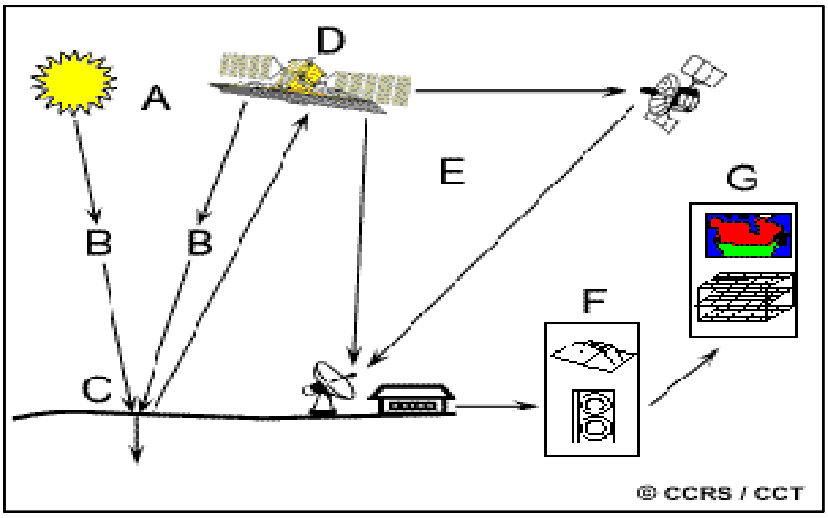


Figure 35: Elements of remote sensing. (Source;Voute, 1982).

Components and mechanism of action of remote sensing

Remote sensing consists of a set of basic components for using as shown in figure (6) (Voute, 1982), which were addressed as follows:

Energy source: The power source is the first requirement of the sensing process, as remote sensing depends on energy sources through light or what is called (electromagnetic radiation). This energy is transmitted in the atmosphere from the sun to the surface of the earth in the form of waves such as radio waves, ultraviolet rays, X-rays and heat rays. The electromagnetic wave can be described through 3 parameters: (λ) is the wavelength, (f) is the frequency of the wave, and (c) is the speed of the frequency.

The wave can be measured by the following equation

$$\boldsymbol{c = f\ \lambda}$$

λ= wavelength

f= frequency

c= velocity

The magnetic spectrum contains a group of short electromagnetic wavelengths such as gamma rays, x-rays, radio waves, and the visible spectrum that can be seen by the eye, which contains the primary colors which are red, green and blue. In addition, the electromagnetic spectrum contains near, medium, and far heat waves and ultraviolet waves, as shown in figure (36, 37).

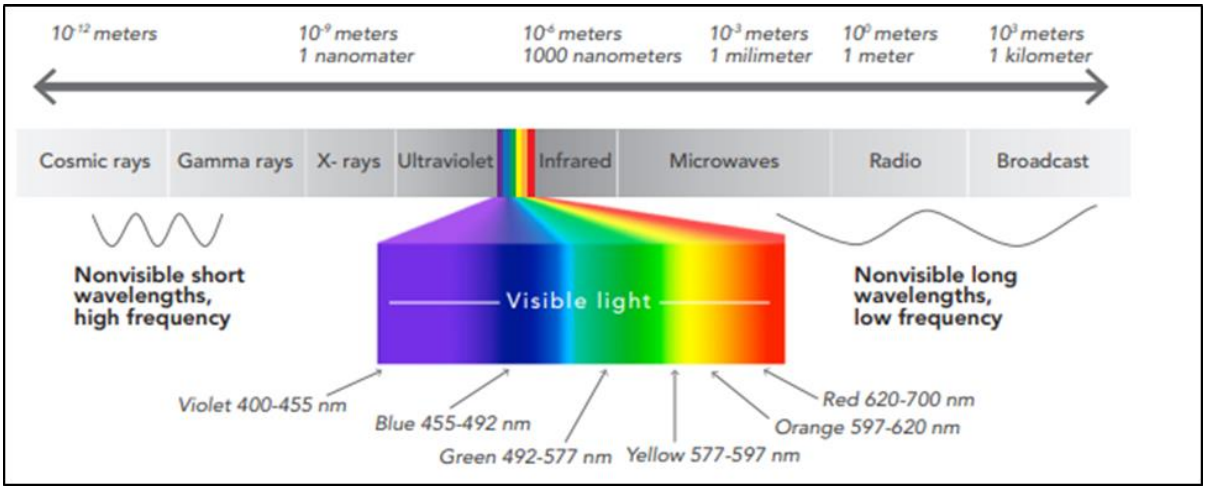


Figure 36: The electromagnetic spectrum. (Source; ESRI, 2018)

Interaction with the atmosphere: The energy emitted from the source reaches the target through the atmosphere, which contains obstacles such as smoke, clouds and fog, which in turn reflect, scatter, or deliver energy to the Earth's surface.

Interaction with the target: When energy reaches the surface of the earth, electromagnetic radiation interacts with the targets through three ways (dispersion, absorption and reflection).

Energy recording by sensor: This is done by recording the energy reflected from targets on the surface of the earth by sensors.

Reception and processing: The recorded energy is sent through the sensor, which is often in the form of electromagnetic, to a receiving and processing station on the surface of the Earth. Electromagnetic energy is converted into electrical signals and then into digital numbers then into digital visuals that are stored in the computer. After data is recorded, it is processed to remove errors and transformed into final images and sent to the ground data dissemination station.

Interpretation and analysis: This visually or digitally produced visual is interpreted in order to extract information about the target that has been sensed.

Application : Where satellite visuals and their data are used in many fields that help in solving problems.

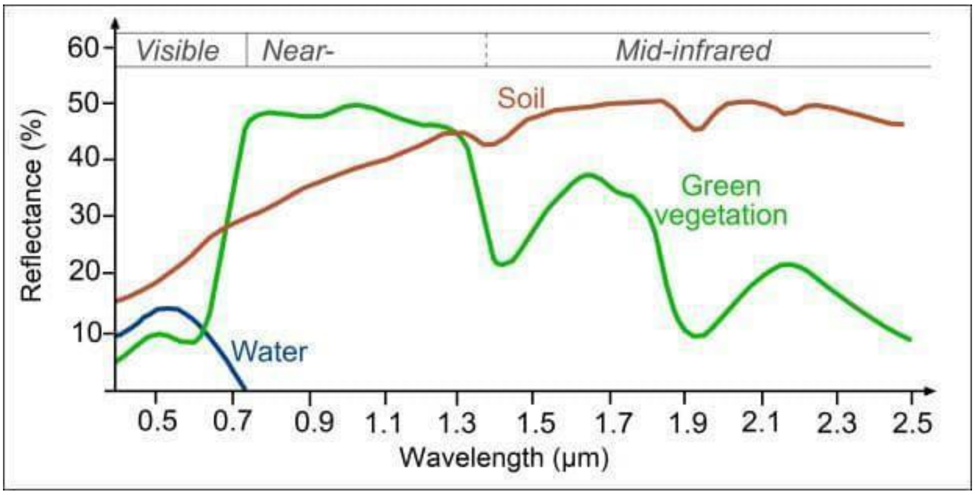


Figure 37: Spectral reflectance signatures of vegetation, soil, water. (Source; URL4).

Most remote sensing systems capture electromagnetic energy emitted or reflected by objects from great distances through aircraft-borne sensors and hundreds of kilometers through satellite-borne sensors (ESRI, 2018). This is because the sensors collect reflected information such as soil, water and vegetation, where the space- borne imaging sensor takes simultaneous samples at different ranges simultaneously and over a large area. After proper processing of the captured data, each pixel in the resulting image contains a specific spectrophotometric measure of reflection (show & Burke, 2003).

The spectral response of objects on the surface of the earth varies according to the target, such as soil, vegetation and water. Depending on the spectral response or the spectral content of the targets that were recorded, these digital images can be easily interpreted by the computer (Campbell & Wynne, 2011).

Figure (8) shows the spectral variation of reflections for terrestrial targets such as soil, water and vegetation. The figure also shows the spectral signals in the visible infrared (NIR) for the average of reflectance curves of the mentioned elements. Green plants have a spectral signature of about 0.7 to 1.3 µm due to the reflection of their surface compared to the blue and red color due to their absorption of chlorophyll.

Types of remote sensing

There are two types of remote sensing systems which are called active and passive systems. In the passive system, the sun is the energy source for the remote sensing system. The passive remote sensing system depends on recording. sunlight and thermal radiation in the visible and infrared rays of the electromagnetic spectrum reflected from the Earth as shown in Model A, of figure (38).

On the other hand, the positive sensors are the main provider of their electromagnetic energy. It directs the energy towards the target objects. One of the most important features of positive sensors is their ability to obtain data at any time (Voulte, 1982). Model B from (figure 38) shows the work of the positive (Active) sensors.

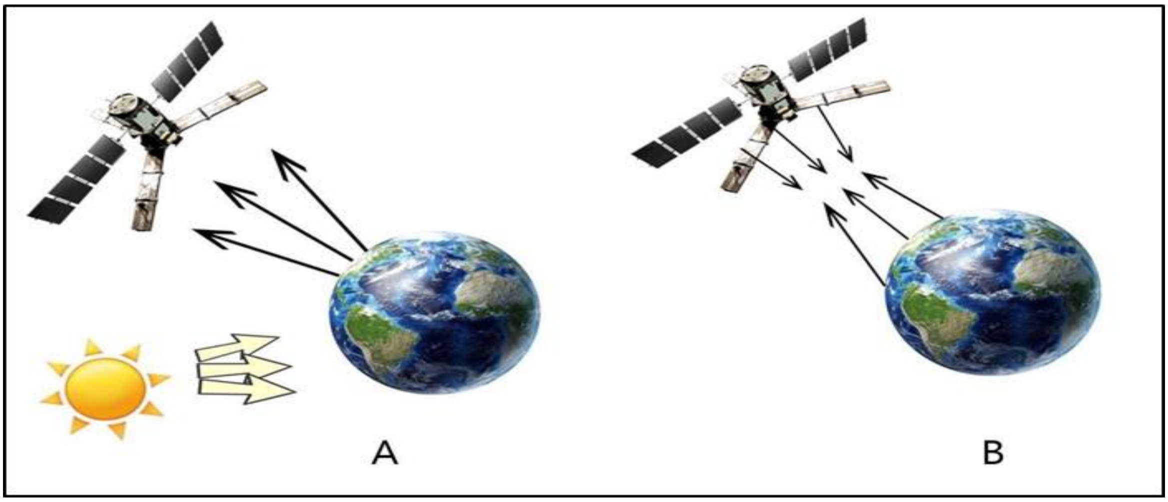


Figure 38: Passive vs. Active Sensing

Satellites:

What is meant by a satellite is a vehicle that orbits around the Earth's surface. The first artificial satellite began to operate in space since the mid-nineteen century, which was launched by the Soviet Union into space in 1957 (URL,5). The satellites can be classified into three groups (D, Gomaa M., 2013) as follows:

Navigational satellites: their main objective is to provide accurate techniques and means for air, sea and space navigation operations, such as the GPS system.

Communications satellites: These satellites help in transmitting data such as television and radio broadcasts and distributing them over large parts of the Earth's surface.

Satellites dedicated for studying the Earth's surface resources: including satellites dedicated for studying the seas and the characteristics of the atmosphere and climate.

In the recent period, a new generation of advanced sensors and satellites with high spatial accuracy has emerged, providing images at sufficient levels to conduct spatial analysis at a local scale, which allows the use of space visuals in environmental research, analysis, study and tracking of vegetation changes (Aplin & Aplin, 2005).

Due to the continuous developments in remote sensing, there is a long group of platforms that provide remote sensing data through a group of satellite systems that collect images and distribute them to a large number of users (McHaffie at al., 2018) such as:

French SPOT satellite: This system was launched from System Pour L`Observation de la Terre (SPOT) and operated by the (French consortium) in 1985. These SPOT satellites carry to high resolution sensors (HRV) in multi-color spectra. These satellites produce a digital image with a special resolution of twenty meters. This series 1 continued into the sixth version SPOT 6, which was launched in September 2012 and it provides an accuracy of 1.5 m data (McHaffie at al., 2018).

The American satellite Landsat: The ASTER-1 satellite was launched in 1972, and later on, NASA approved a renaming of it to Landsat-1,which continued to operate until 1978. Then Landsat-2 was launched in 1975, which continued to operate until1983. After that the series of Landsat satellites continue to launch until LANDSAT-8, which was launched in February 2013.

(Mopitt): It is used to major atmospheric pollution in the troposphere and to monitor its interaction with the Earth's atmosphere and oceans. (URL,6)

(Aster): The Radiation Reflectance and Heat Emission Meter delivered through space options high-resolution images from 15-90 square meters per pixel, and is used to create detailed maps of planet surface temperatures, emission and reflectance.

(Ceres): This sensor provides cloud characteristics estimates that enable scientists to assess the role of clouds in radiation flux.

(Misr): It is considered an important material for understanding the Earth's climate, determining how it changes, knowing the sunlight scattered in different directions in natural conditions, observing the seasonal and monthly trends of clouds and aerosols, whether natural aerosols or those caused by human activities. Figure (39) shows the characteristics of terra tools

MODIS: It is one of the satellites concerned with measuring the processes of the atmosphere, land and oceans, including surface temperature, land and vegetation, the characteristics of clouds and oceans, their colors and climate elements such as temperature and humidity (Kit at al., 1999). MODIS provides a comprehensive set of measurements that scientists need to make informed decisions about managing natural resources from season to another and provides land map data that alerts scientists and decision-makers about the importance and state of vegetation, whether the area is vegetated or not. In addition, it provides information on the type of vegetation that grows there, it can also separate deciduous and coniferous forests, grassland and agricultural lands, and plant classes (Salomonson, 1990).

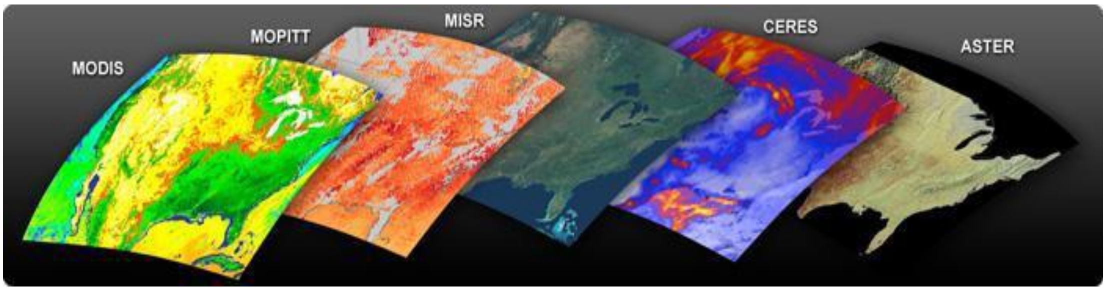


Figure 39: The operation of the sensors mounted on the terra vehicle (Source; URL7)

MODIS sensor records the data reflected from the targets, where this data is collected in the form of images obtained as a result of electromagnetic energy reflected, scattered or emitted from visible blue to invisible infrared in 36 spectral bands as in (Table 8) and these lengths range from 0.405 and 14.385 micrometers (Main, 2007)

MODIS provides corrected and virtually distortion-free data covering approximately 2.330 km. MODIS makes it possible to provide accurate cloud-free images of the vegetation index over a specified time. In addition to the possibility of accurately distinguishing between the temporal changes of the vegetation (Huete et al., 1999)

Table 8: MODIS Sensor Characteristics (Source; URL8)

sensour	resolution	wavebands	swath	website
MODIS	250m (Band 1 – 2) 500m (Band 3 – 7) 1km (Band 8 – 36)	36 bands 1-9 = 0.405-2.155 20-36 =3.66-14.28 micrometer	2330 km	https://modis.gsfc.nasa.gov/

2.2. Geographical Information system (GIS)

GIS has emerged as an effective tool for solving complex problems due to its ability to integrate, visualize and analyze geographical data in many fields and disciplines (Nielsen, 2014). GIS is defined as a computer system capable of capturing, storing, analyzing and displaying geographic information. In recent years, the number of users of this software has increased significantly due to the ability of this software to process, display and analyze geographical or spatial information (Folger, 2011).

By defining geographical information systems as, being able to enter, store, retrieve, extract and analyze information, and through applying this broad definition, it can be distinguished that geographical information systems are capable of statistical analyzing, drawing and producing thematic maps by computer.

Geographical information systems can also be defined as the system that uses a spatial data base to provide answers to inquiries of a geographical nature (Cowen, 1990).

The strength of this system lies in the ability to integrate geographical and spatial information in distinct ways by means of layers (Folger, 2011). The use of GIS offers various advantages that can be summarized in three elements: high efficiency, improved services, and high-quality decisions. Table 8 shows the advantages of using GIS.

Table 9:Advantages of using GIS.

Efficiency	Improving services	High quality decisions
• Automated processing • Faster data visualization • Standered work procedures • Coordinated development	• Faster processing • Higher data reliability • Additional services • Higher transparency	• Collect data from different institutions • Using a large set of data in addition to archived data • Integrated planning

The integration of remote sensing data with GIS is very important for users to interpret and analyze this data. In the past two decades, many methods such as machine learning and deep learning have been developed, which have provided amazing results in data analysis. It provides the possibility of better extraction of geographical information from remote sensing's data and images (Huang et al., 2018). Geographical data bases (geo data bases) have also been developed within work environment of geographic information systems such as (File geo data base), which provides the ability to manage large spatial data, and deal with its various uses. Applications are developed in order to analyze and interpret large amounts of physical, biological, social, statistical, spatial and temporal data in order to provide a variety of results for the required information products in the form of images and maps.

Geographical information systems are the main component of the information management system. The benefit of GIS is that its ability to carry out effective functions such as the ability to query data by making hypotheses, and processing, separating and organizing data (Sombroek & Antoine, 1994). Figure 40 shows different set of GIS applications in processing and analyzing different data and their applications.

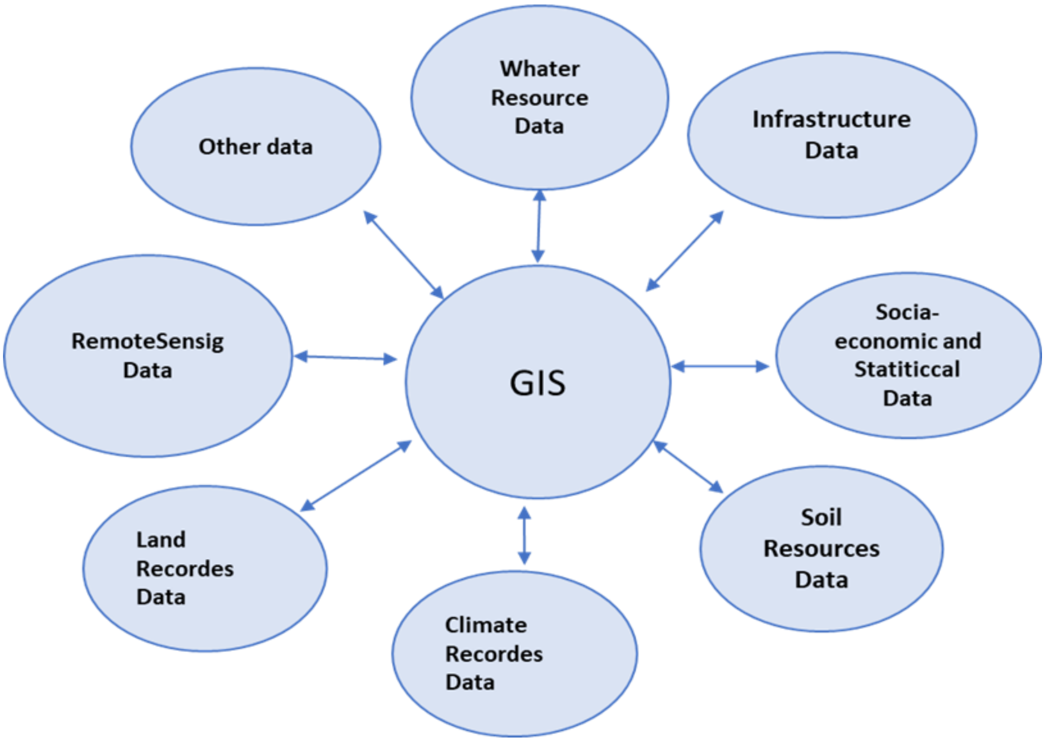


Figure 40: GIS applications in processing and analyzing various data and their applications

2.3. The importance of remote sensing and GIS in the study of land cover

The strength and benefit of remote sensing and geographic information system techniques lies in their ability to detect temporal changes that occur over large areas of the Earth's surface (Main, 2007). Remote sensing has features that is provided in order to monitor the vitality of crops through the feature of visual imaging record and seeing invisible wavelength in the near infrared. The near- infrared wavelength are very sensitive to crop health and their data can be used to detect crop damage and stress.

Remote sensing provides an image of the spatial overview of the state of the land, where recent developments in methods of information transfer, technology and information systems have enabled farmers to monitor crops by means of various images in order to make timely decisions about field management. Where remote sensing helps in analyzing crop diseases and determining the factors affecting them such as drought, humidity, or weather (Sombroek & Antoine, 1994). The vegetation can be monitored during the annual or seasonal seasons by means of several captured images, which provides an effective and reliable way to collect information about the health of the vegetation and thus can be measured and monitored. Geographical information systems can be employed in order to interpret and map these data in conjunction with remote sensing (Voute, 1982).

By collecting data, remote sensing systems enable rapid and effective monitoring of changing land use. The two systems also provide different fields of applications such as: land use planning, land degradation assessment, assessment of land suitability and productivity, monitoring of land resource development, and environmental impact assessment.

CHAPTER III

FINDINGS

Many satellite-borne sensors measure red light and infrared waves near the Earth's surface, Therefore, scientists use mathematic equations (algorithms) to convert initial satellite data for these light waves into indicators of vegetation. The Vegetation Index is an index that describes the greenness (relative density and health of vegetation) for each image element or pixel in a satellite image. Although there are many vegetation indicator, one of the most widely used is the vegetation index (NDVI). NDVI values range from 1.0 to -1.0 (USGS), positive values divide vegetative areas and negative values provide non-vegetative areas.

The detection of change in vegetation is the process of determining the differences that occur in it by observing them at different times. The information about the area can be extracted by comparing the images obtained at different times. And the aim of detecting changes is to compare the spatial representation of the study target over time (Lu et el., 2004).

3.1. Spatiotemporal variation analysis in the vegetation

The time period of the study area between 2000 and 2020 was studied monthly to facilitate the data display. The study was conducted for the following periods: the first phase starts from 2000-2004, the second phase starts from 2005-2009, the third phase starts from 2010-2015, and the fourth phase starts from 2016-2020. As in (Figure 41), it appears The NDVI time series from 2000-2020 for all area.

As illustrated in the figure 39, the time series for all study periods shows that the year 2001 showed a high density of vegetation cover in Diyala, Kirkuk, and Sulaymaniyah (0.28, 0.23, 0.29) and that 2008 was the least dense year of vegetation cover for all regions with a rate of (0.13) except for Sulaymaniyah with a rate of (0.18). The year 2019 recorded the highest NDVI rates for Sulaymaniyah (0.30), Kirkuk (0.31), Diyala (0.24), and Wasit (0.22).

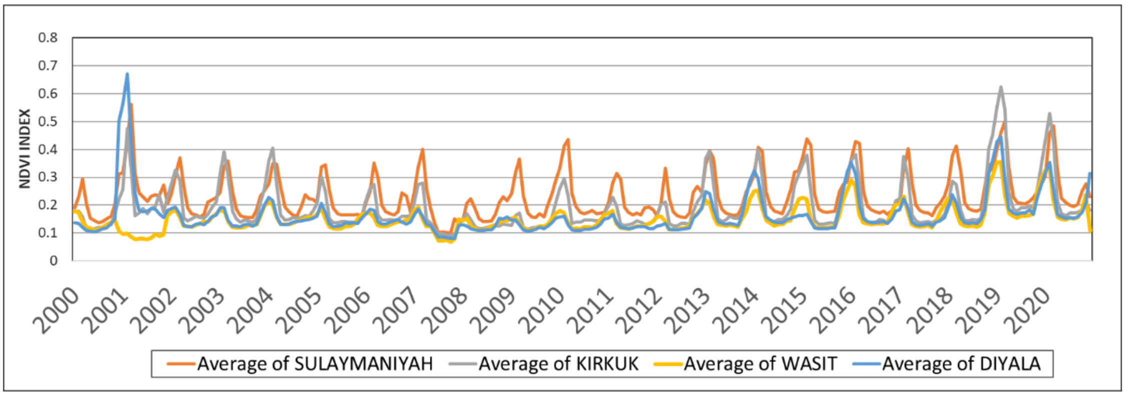


Figure 41: NDVI changes according to the provinces borders with all time series.

3.1.1. The first period 2000-2004

In the year 2000 in March, significant increases were recorded for Sulaymaniyah city, as shown in figure (42) where the increase was estimated at 0.29 for March, 0.20 for April, and 0.15 for May. After this period, the vegetation gradually begins to recede. As for Kirkuk city, the NDVI ratios were similar to Sulaimaniyah city, where the months of March, April and May were recorded at rates (0.15 0.11 0.11) until the decline stage. As for Diyala city, the ratios were low (0.13 0.11 0.10). In Wasit city, the ratios of greenness index were (0.14 0.11 0.12.).

Figure (43) shows the geographic distribution of vegetation density for the year 2000. Where (a) represents winter, (b) spring and (c) summer. The increase in the density of vegetation is clearly visible in Sulaymaniyah city during March until the beginning of the summer.

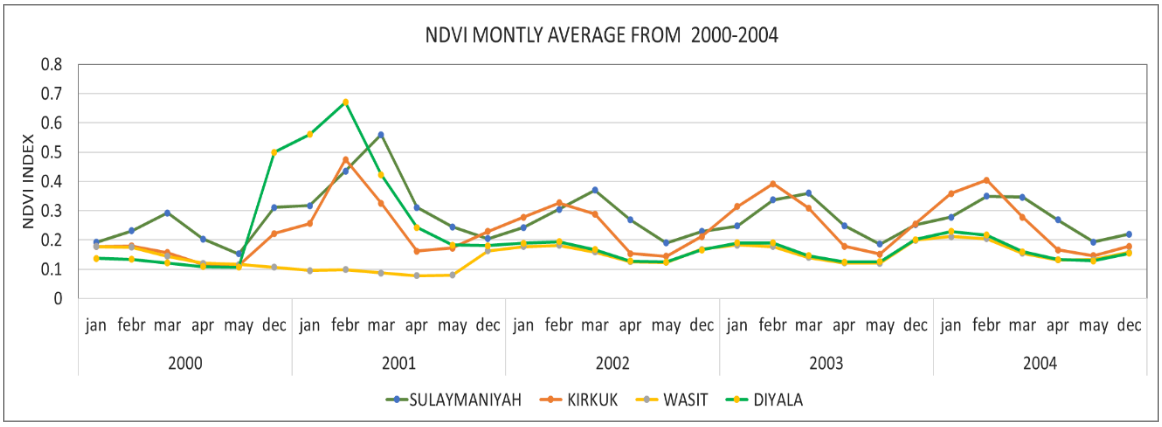


Figure 42: Vegetation index for the period 2000-2004

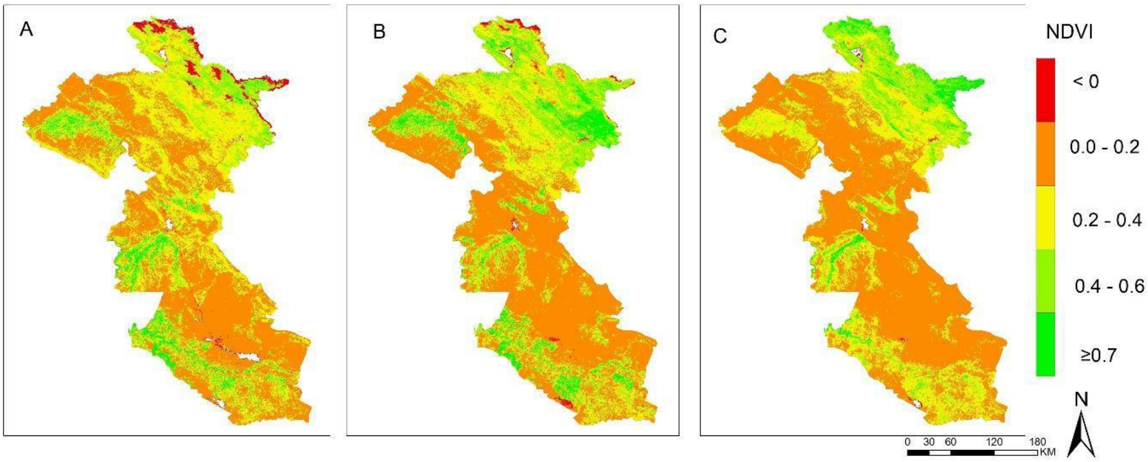


Figure 43: Represents the vegetation for the year 2000

The year 2001 recorded the highest percentage in this period. Where Sulaymaniyah recorded (0.56 0.3 0.24) as for Diyala, it witnessed significant increase in the vegetation index, as it started in March, where it recorded (0.42), and the index fell in April until it reached 0.24, while in May it reached 0.18 until its decline. In Kirkuk the percentage for the months March, April, May were (0.33 0.17 0.16), which increased significantly from the previous year. In Wasit the percentages were very low (0.08 0.08 0.09) compared to the rest of the regions as shown in figure (44).

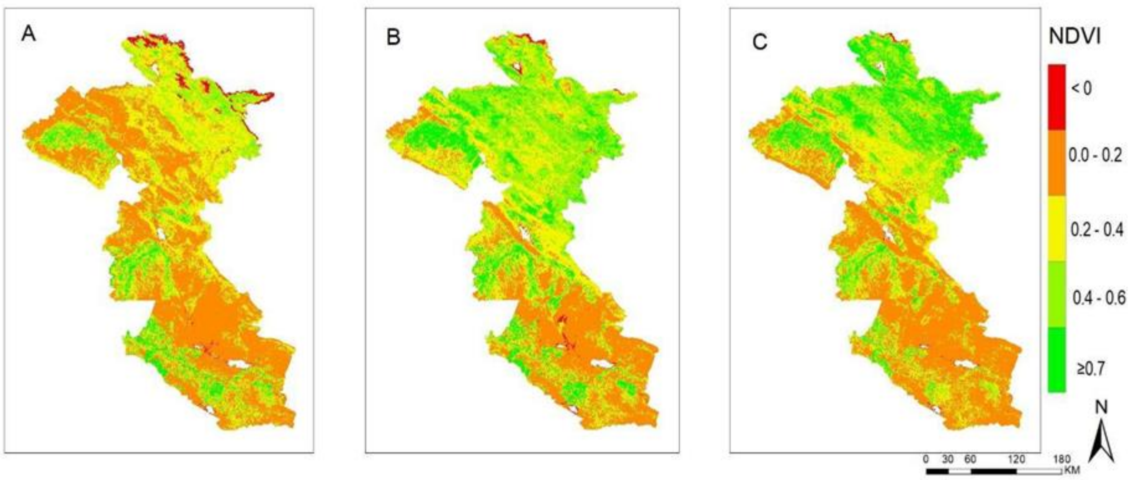


Figure 44: shows the natural plant level for the year 2001

As for the year 2002, as shown in figure (45), the results of the indexes of the greenness months were higher in Sulaymaniyah city. Where the mentioned months recorded simple percentage compared to the previous year. The percentages for Sulaymaniyah city for the months of March, April and May were (0.36 0.30 0.26). In

Kirkuk, the percentages were (0.29 0.15 0.14). And in Diyala the percentages were very low (0.16, 0.12). In Wasit, the indexes were different from the previous years (0.13, 0.16 0.12).

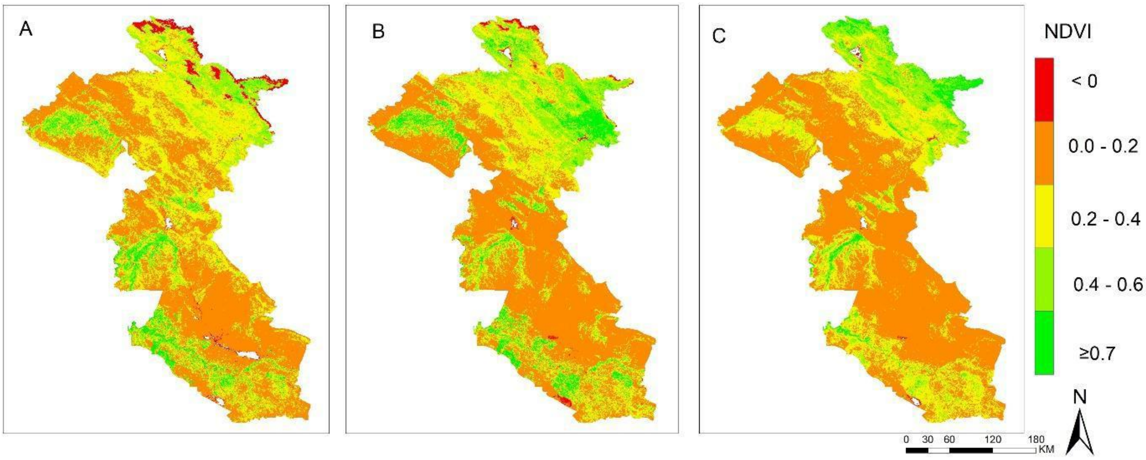


Figure 45: Shows the natural plant level for the year 2002.

In the year 2003, as shown in figure (46), Sulaymaniyah recorded the highest NDVI values for March (0.36, 0.25, 0.16), while Kirkuk was at rates of (0.31 0.18 0.1), followed by Diyala with rates of (0.15 0.12 0.13), where there were increases compared to the previous year. The indexes of greenness months of Wasit fell slightly compared to the previous year (0.14, 0.12, 0.12)

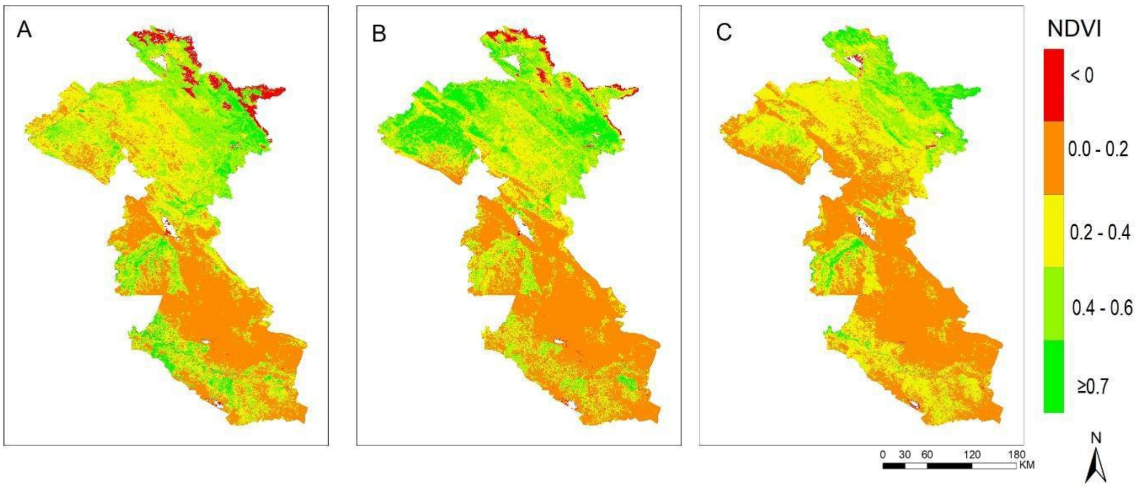


Figure 46: The level of natural plant for the year 2003.

In the year 2004, there was a relatively significant progress for Sulaymaniyah city compared to other cities in March. Where the NDVI index was in March

(0.35),April (0.27) and May (0.19), followed by Kirkuk with rates of (0.28 0.17 0.15). As for Diyala and Wasit, the percentages were similar (0.15 0.13) as shown in figure (47) areas of dense vegetation.

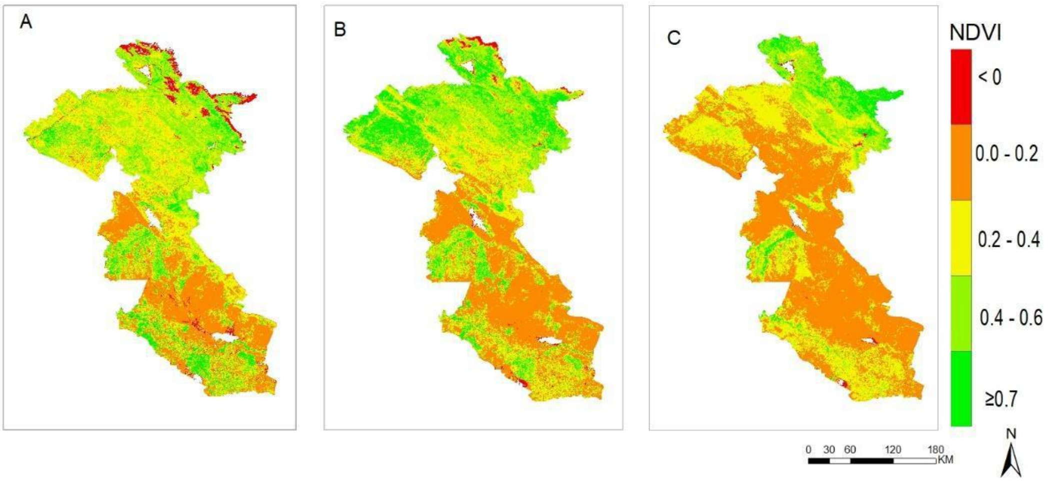


Figure 47: The level of natural plant for the year 2004

3.1.2. Second period 2005-2009

This period started from the year 2005 until the year 2009, as shown in figure (48) where there was a decline in the rates of vegetation compared to the previous period. The NDVI indexes for the year 2005 recorded for Sulaymaniyah during the greenness months of March, April and May (0.34 0.26 0.19). Kirkuk recorded percentages of (0.25 0.15 0.14), followed by Diyala with low percentages (0.17 0.15 0.12) and Wasit with very low percentages (0.16 0.12 0.12).

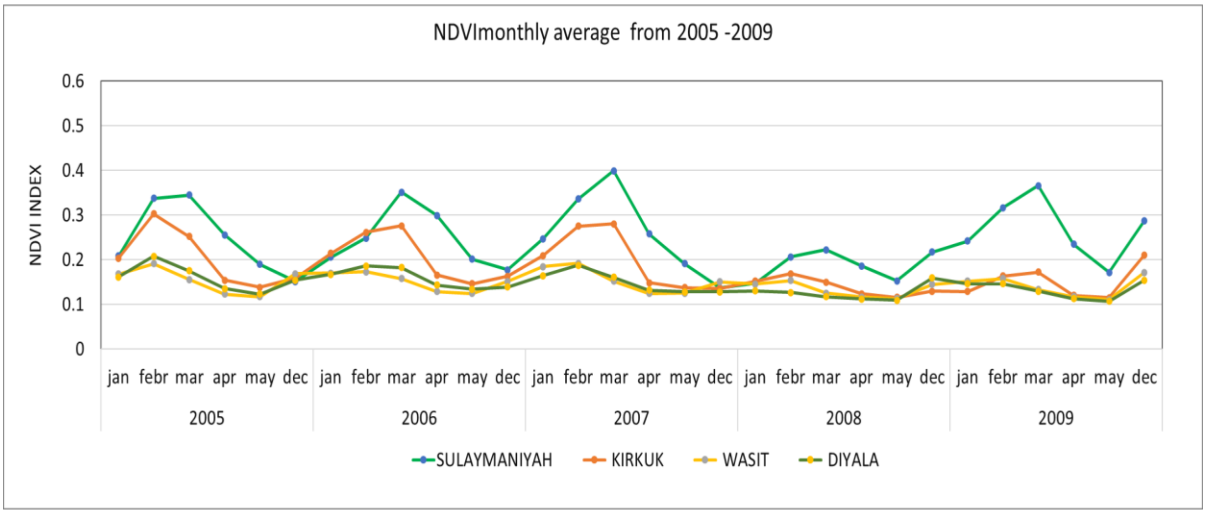


Figure 48: Vegetation index for the period 2005-2009

Figure (49, 50) shows the geographic distribution of vegetation density for the year 2006. It shows the rate of deterioration of vegetation in the study area. The ratios of the indexes of Sulaymaniyah city were (0.35 0.30 0.20), while for Kirkuk, the percentages were close to the previous year with rates of (0.28 0.17 0.15). As for Diyala the rates of vegetation for the greenness months increased slightly from the previous year (0.18 0.14 0.13). As for Wasit, there was an increase of one degree over the previous year for the month of April (0.16 0.13 0.12)

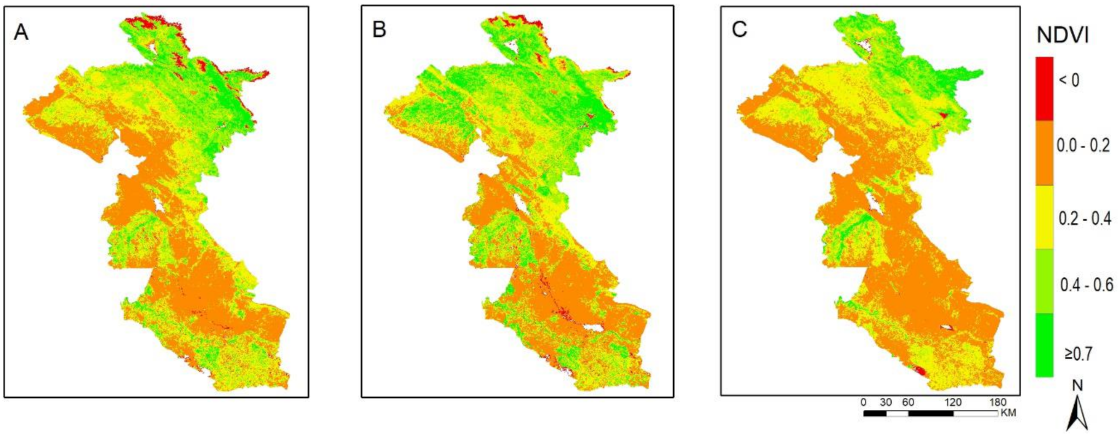


Figure 49: Vegetation density for the year 2005

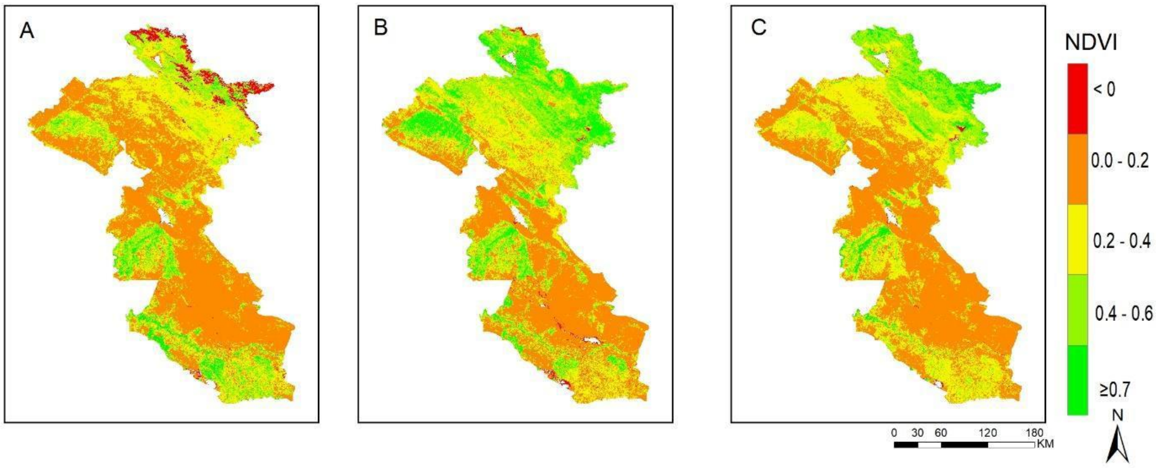


Figure 50: Vegetation density for the year 2006

In 2007, as show in figure (51), this year recorded a decline in the percentage of vegetation indexes in Sulaymaniyah city, where it was (0.40 0.26 0.19) for the greenness months. The big difference can be seen in this year by comparing the regions' indexes. Kirkuk recorded (0.28, 0.15, 0.14), which witnessed decreases in April and May compared to the previous year, followed by Diyala which was at lower rates than the previous year (0.16 0.13, 0.13). As for Wasit, the NDVI rates were (0.15 0.12 012).

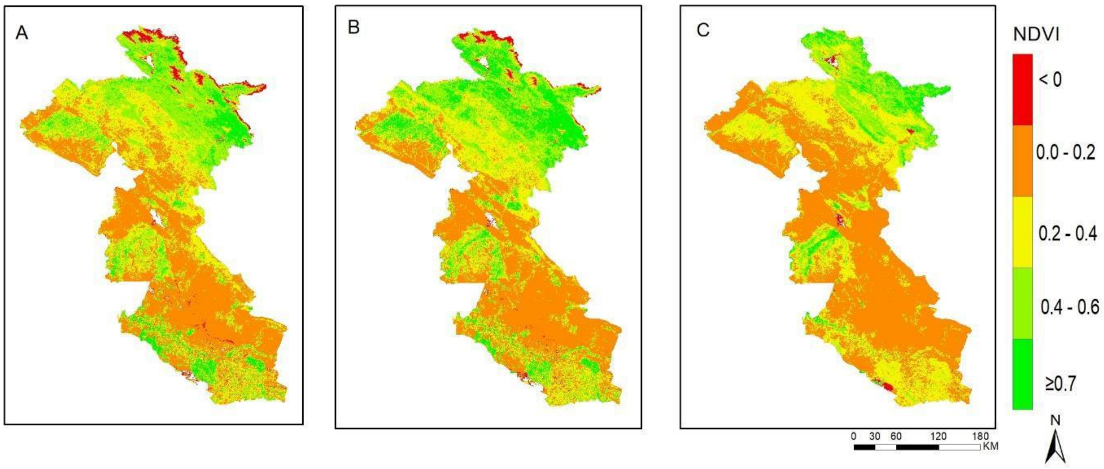


Figure 51: Vegetation density for the year 2007

As shown in figure (36) for the time period, the results of NDVI showed that the year 2008 witnessed the lowest rates of vegetation in this period, where significant decreases were recorded compared to previous years for all areas included in the study. The NDVI indexes fell in Sulaymaniyah city during the greenness months, where the rates of March decreased from 0.40 in 2007 to 0.22 for this year, and the months of April and May were (019 0.15). While in Kirkuk the rates decreased (0.15 0.12 0.12), as well as Diyala, where the months of March, April and May were (0.12 0.11 0.11). As for Wasit city, the rates were (0.13 0.12 0.11). Figure (52) shows the decrease in the percentage of vegetation compared to the previous figures.

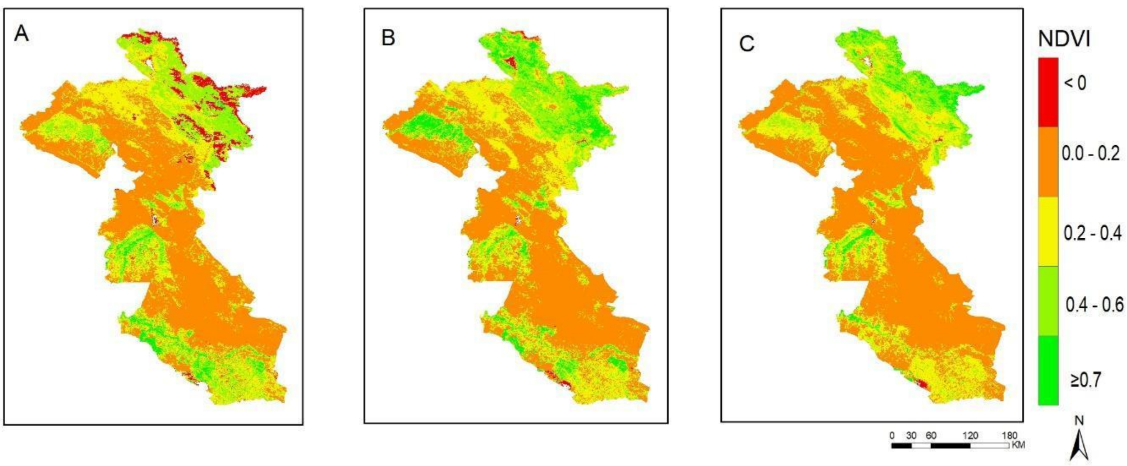


Figure 52: Land cover density for the year 2008

Through Figure (53), the NDVI data for the year 2009 is better for the northern region compared to the previous year, where indexes of greenness months recorded ratios of (0.37 0.23 0.17) for Sulaymaniyah city, and Kirkuk (0.17 0.12 0.11), and for Wasit and Diyala the percentages were close to the previous year, where the percentages ranged from (0.13 0.11 0.11) for Diyala and (0.13 0.12 0.11) for Wasit. Figure (53) shows the density of vegetation for this year.

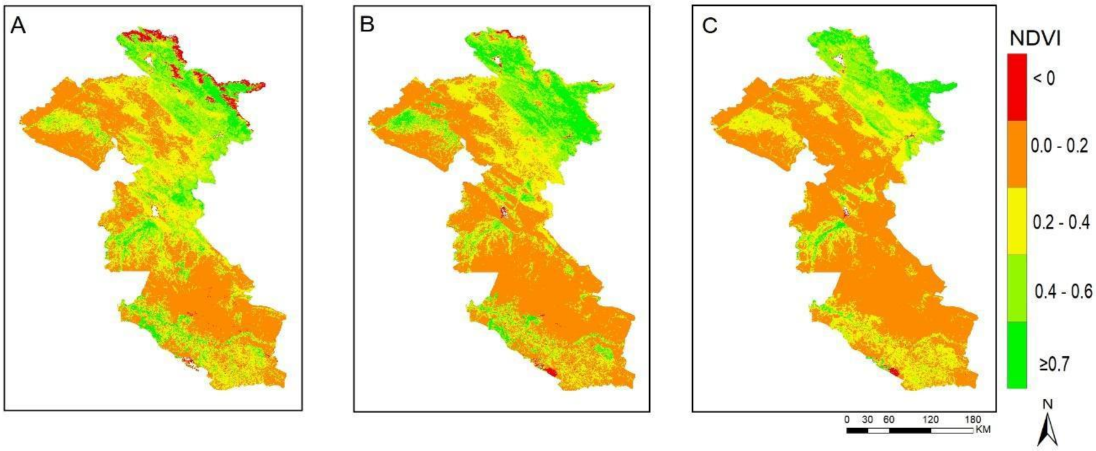


Figure 53: Land cover density for the year 2009

3.1.3. Third period 2010-2014

This period witnessed noticeable increases in the NDVI Vegetation index in Kirkuk and Sulaymaniyah, as shown in figure (54). The period began in 2010, where the increase in NDVI values for Sulaymaniyah was (0.44 0.24 0.19) for March, April and May. As for Kirkuk, the rates were (0.24 0.14 0.14) followed by Diyala with rates similar to the previous year (0.11 0.11 0.13), and in Wasit there was a slight increase in March (0.14 0.12 0.12) as shown in figure (55).

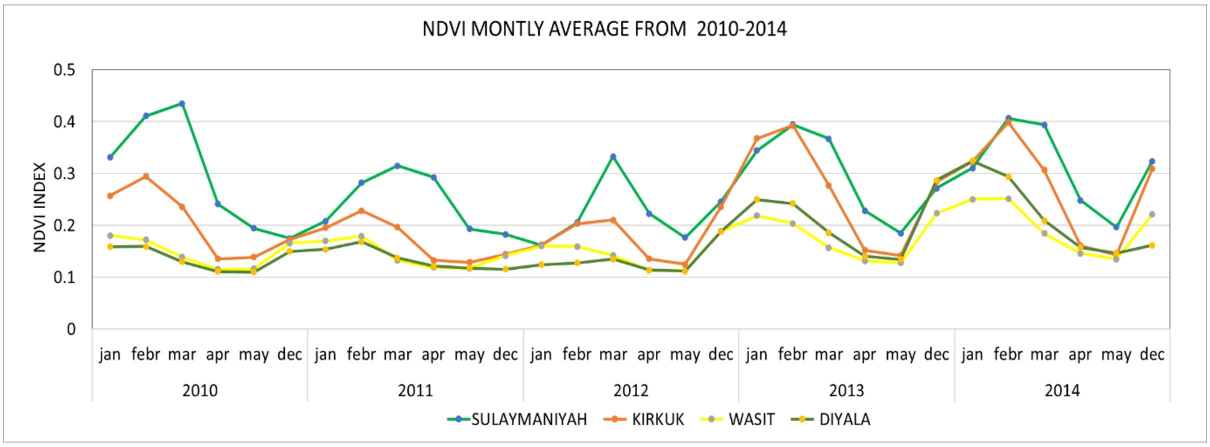


Figure 54: Vegetation index for the period 2010-2014

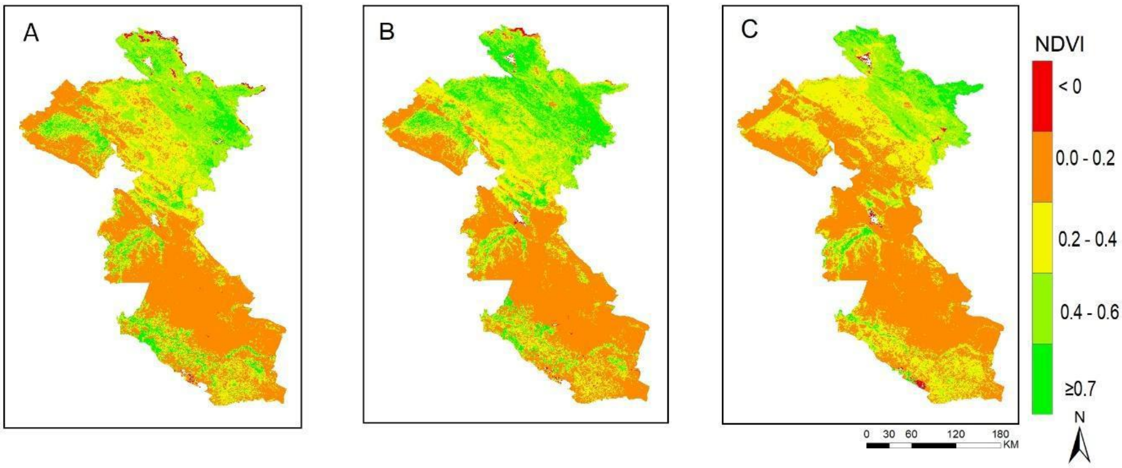


Figure 55: The density of vegetation for 2010

The results of NDVI indexes., m/mn, m for the year 2011 indicate that there was a decrease in the average for March, as it declined to 0.31, April 0.29 and May 0.19. As for Kirkuk, the rates also decreased in this year for the months March, April and May (0.20, 0.13, 0.13). In Diyala the indexes increased slightly (0.14, 0.12, 0.12), followed Wasit at similar rates (0.13 0.12 0.12). Figure (56) shows the density of vegetation of the region for the year 2011.

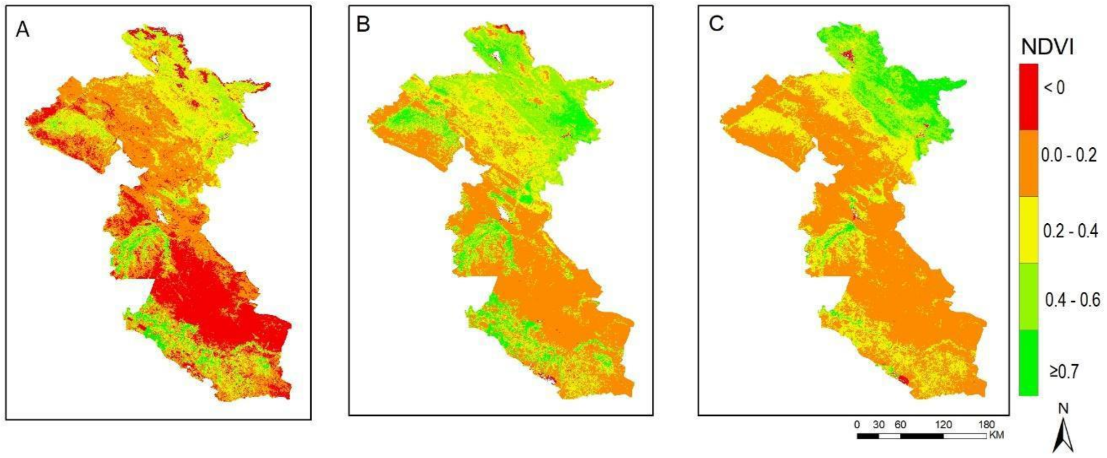


Figure 56 : The density of Land cover for 2011.

According to Figure (57), the year 2012 recorded the results of a slight increase over the previous year in the city of Sulaymaniyah, where the percentages were (0.33, 0.22 0.18) and in Kirkuk the rates were (0.21 0.14 0.13). As for Diyala, there was a decline in the monthly rates (0.13, 0.11, 0.11), and the rates of Wasit Governorate indicated similar indicators for the city of Diyala (0.14, 0.11, 0.11). Figure 57 shows the density of land cover in this year.

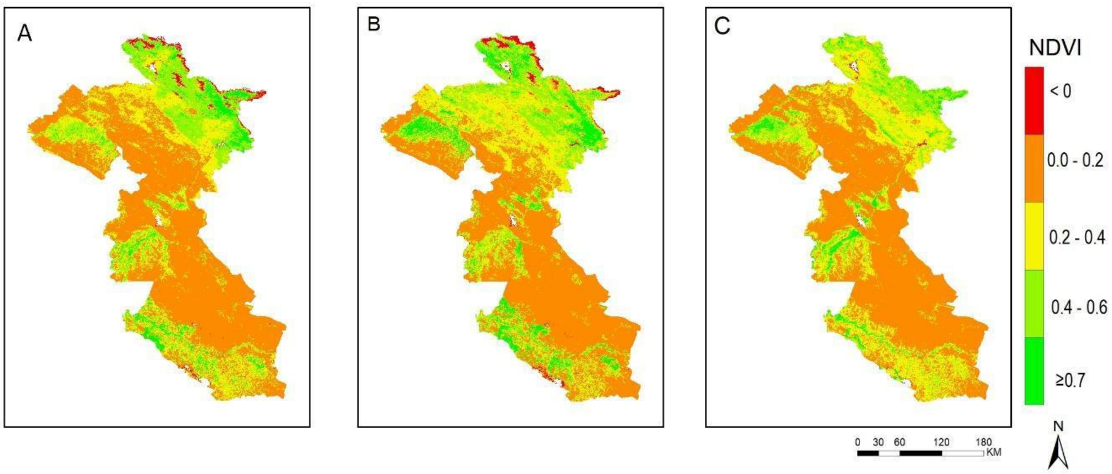


Figure 57: The density of land cover of the year 2012.

As for the years 2013 and 2014, significant increases were recorded in the vegetation cover indicators for the cities of Kirkuk and Sulaymaniyah compared to the previous years for the third period, according to Figure (54). The percentage recorded for the city of Sulaymaniyah was (0.19 0.23 0.37). As for the city of Kirkuk, it was (0.14 0.15 0.28), and in Wasit, the rates were (0.13 0.13 0.16). As for the city of

Diyala, increases were recorded (0.13 0.14 0.19). As for the year 2014, the results were slightly higher than the year 2013, where the NDVI rates for the city of Sulaymaniyah (0.20 0.25 0.39) and Kirkuk (0.14 0.16 0.36). Where the increase in the city of Kirkuk can be observed in the month of March. As for Diyala, the indicators were (0.15 0.16 0.21), followed by the city of Wasit with indicators (0.13 0.18 0.15). Figure (58) and (59) show the density of vegetation cover for the year 2013-2014.

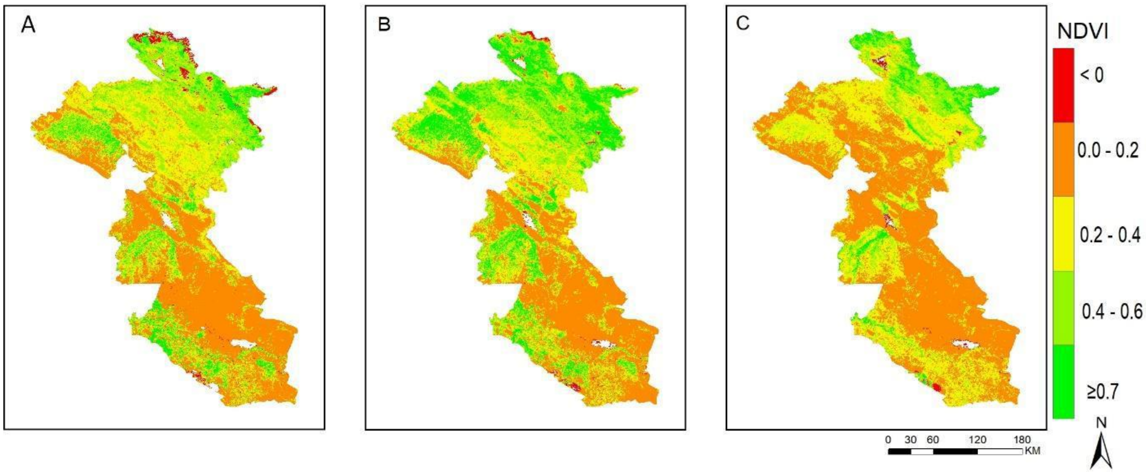


Figure 58: Land cover density for the year 2013

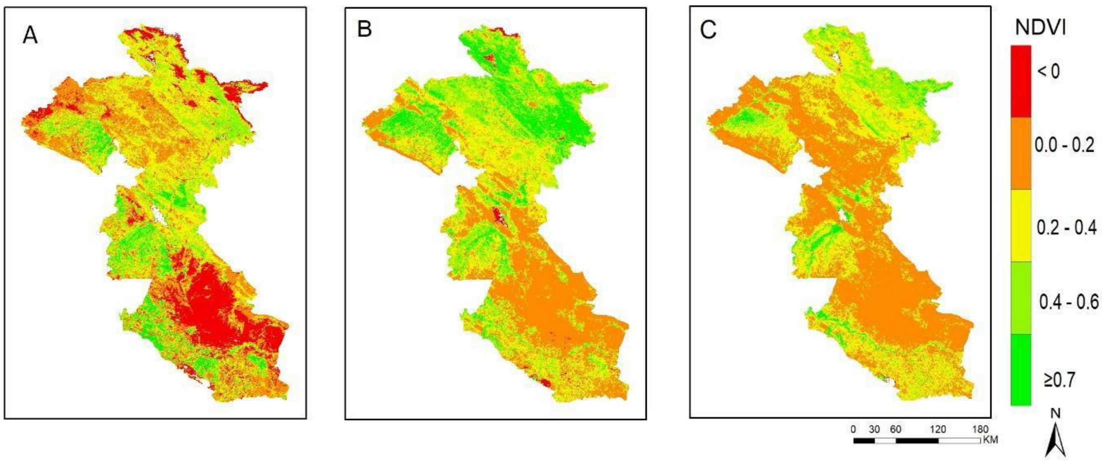


Figure 59: Land cover density for the year 2014

3.1.4. Fourth time period 2015-2020

This period is considered better compared to the rest of the previous series, where the results of the NDVI recorded significant increases in the green seasons for the years 2019-2020 and for all studied regions according to Figure (60). Where this period began in 2015 and the NDVI indicators for the city of Sulaymaniyah recorded (0.41 0.24

0.19), where there was a noticeable increase for the month of March. As for the city of Kirkuk, the ratios were between (0.25 0.15 0.13) for the months of March, April and May, while Diyala was at rates (0.14 0.12 0.12) followed by Wasit city (0.15 0.12 0.12) as shown in Figure (61) which shows the density of vegetation for 2015.

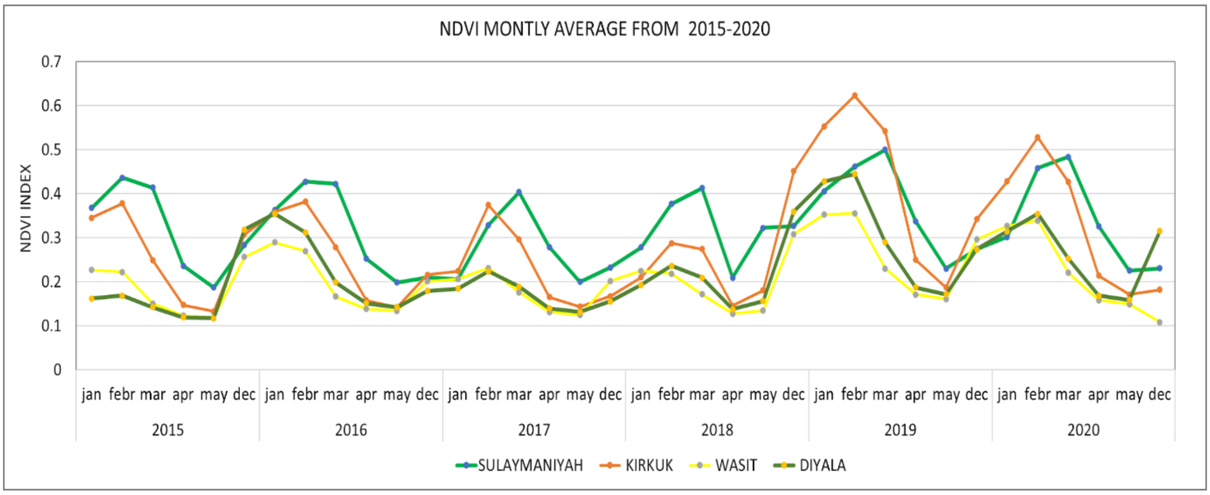


Figure 60: Vegetation cover index for the period 2015-2020

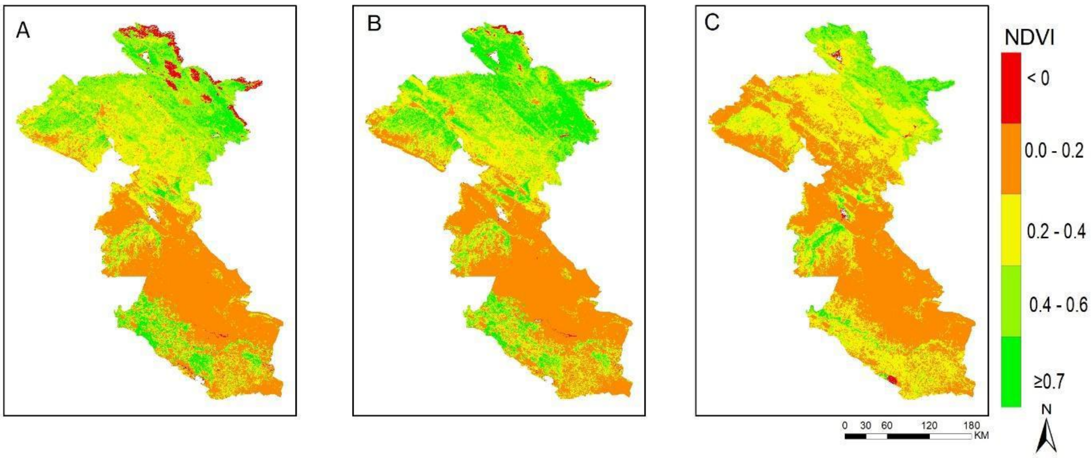


Figure 61: Land cover density for 2015

The years 2016 and 2017 recorded the results of NDVI close to the study area as in Figure (60) and (61), where the indicators of the city of Sulaymaniyah were (0.42, 0.25, 0.20) for the months of March, April and May, while for Kirkuk, the indicators recorded a slight increase for the greenness months (0.28, 0.16, 0.14), while in Diyala (0.20, 0.15, 0.14). As for Wasit city, indicators were (0.17, 0.14, 0.13). In 2017, the indicators of Sulaymaniyah city indicated (0.40, 0.28, 0.20) and Kirkuk, there was an increase in the month of March (0.30, 0.17, 0.14), followed by Diyala (0.19, 0.14, 0.13).

As for Wasit the indicators were (0.18 0.13 0.12) Figures (62) and (63) show the density of vegetation.

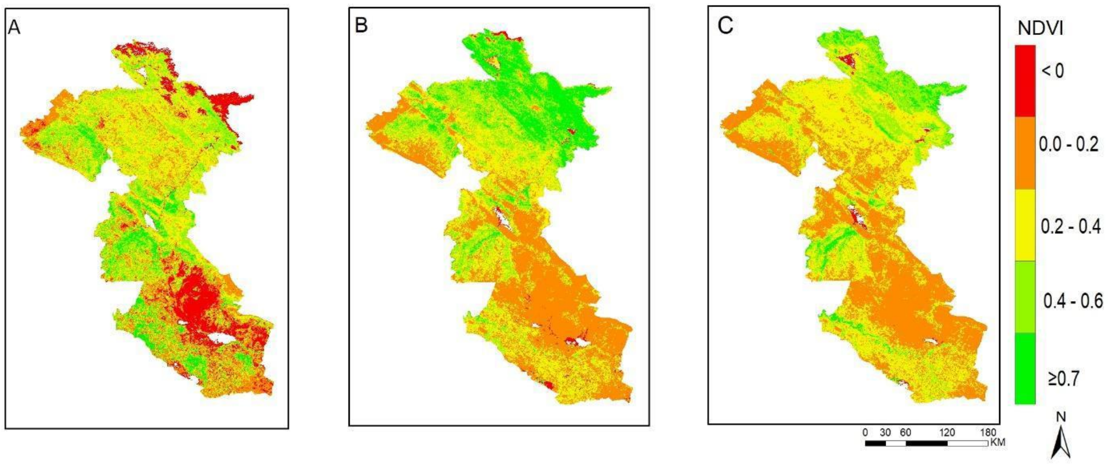


Figure 62: Land cover density for 2016

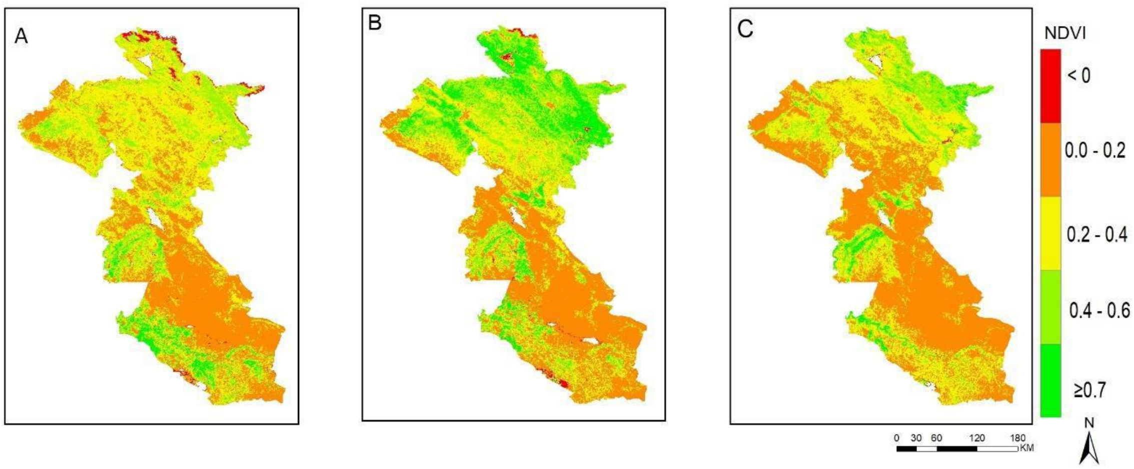


Figure 63: Land cover density for 2017

The year 2018, as shown in Figure (62), was not significantly different from the previous year, where the extracted NDVI indicators recorded equal values, where the results recorded for the city of Sulaymaniyah were (0.41, 0.32, 0.21), while for Kirkuk, the monthly averages for the greenness season were (0.27, 0.18, 0.14), where the index fell for March by a noticeable percentage. As for the city of Diyala, rates were (0.21, 0.16, 0.14). As for the city of Wasit, it recorded a slight decrease in March from the previous year, and the rates were (0.17, 0.13, 0.13). Figure (64) shows the density of vegetation for the year 2018.

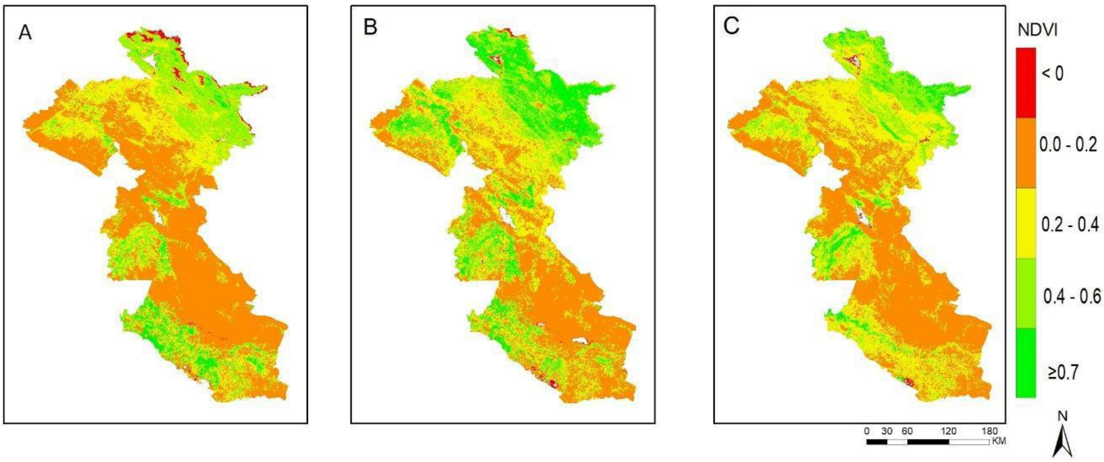


Figure 64 : The density of land cover for 2018

In Figure (60), the years 2019 and 2020 recorded the highest values of the NDVI index for the studied region compared to all the years studied. The city of Sulaymaniyah recorded noticeable indicators for March in 2019, where the rates reached (0.50 0.34 0.23), while Kirkuk recorded the highest results, which were (0.54 0.25 0.19). There were also increases in the central and southern regions of the study area. Diyala city rates reached (0.29 0.19, 0.17), while in Wasit city, there were also increases in indicators, which were (0.23 0.17 0.16) for March, April and May. Figure (65) shows the density of vegetation for 2019.

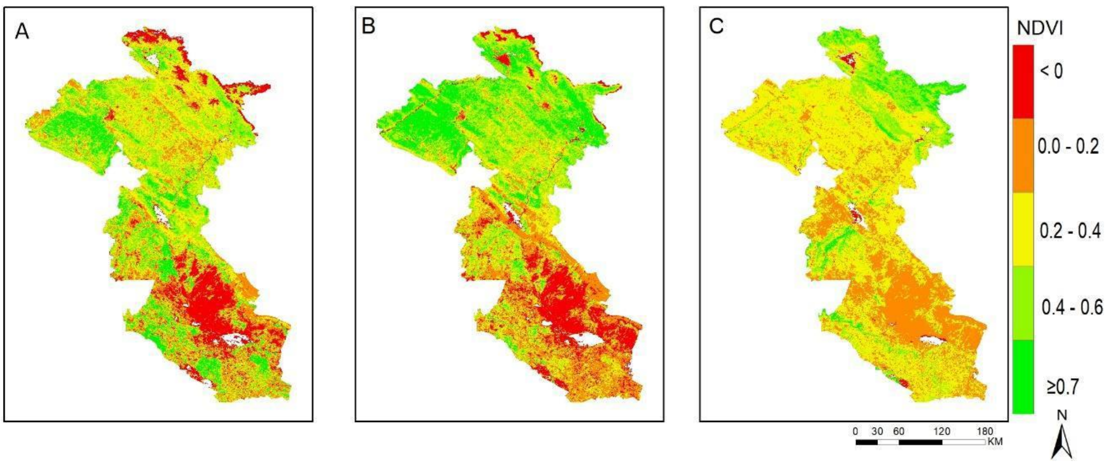


Figure 65: Land cover density for the year 2019

As for the year 2020, the results of the NDVI for the months of March, April and May indicate a slight decline in the city of Sulaymaniyah, which was (0.48 0.33 0.23). As for Kirkuk, the indicators declined in March from the previous year by rates (0.43

0.21 0.17). As for Diyala, the rates indicated (0.25 0.17 0.16) and Wasit city recorded slight declines from the previous year (0.22 0.16 0.15). Figure (66) shows the density of vegetation for the year 2020.

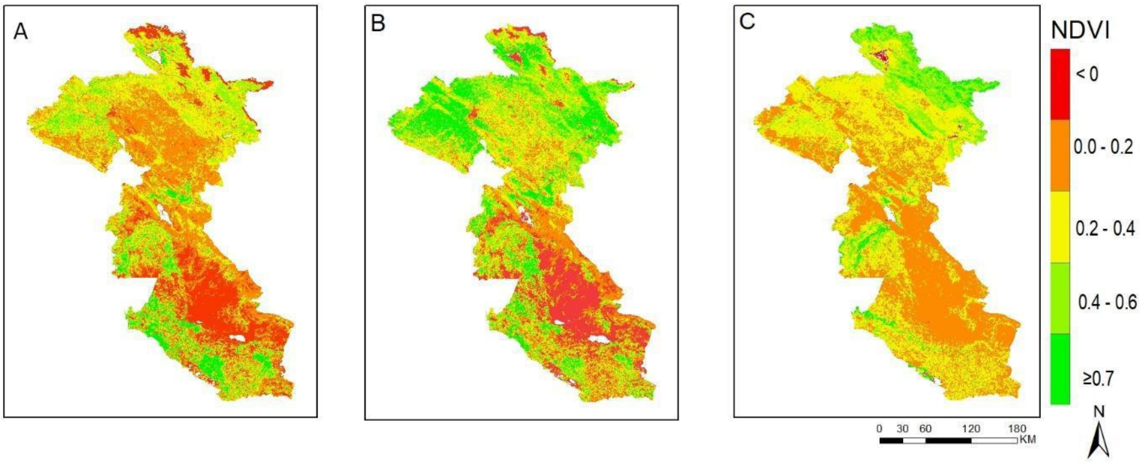


Figure 66: Land cover density for the year 2020

By analyzing the time periods, it is noted that there are differences and fluctuations in the land cover indicators for the time periods and study areas. The first period was represented in the years (2000- 2001- 2002- 2003- 2004), where 2001 recorded the highest rates of NDVI in this time period compared to other years for the same period. As for the second time period, it was represented in the years (2005- 2006- 2007- 2008- 2009), where this period witnessed a decline in the levels and rates of vegetation for all study areas. The year 2008 recorded a decline in the rates and percentages of vegetation, due to the drought that swept the region in the same year (Almamalachy, 2017).

During the third period of time which represented by (2010- 2011- 2012- 2013- 2014-2015) there was stability in the rates of vegetation in the study areas, where the levels of vegetation are somewhat better than the rates of the first and second periods.

The fourth time period represented by the years (2016- 2017- 2018- 2019- 2020) and this period is considered the best period of time in terms of the density of vegetation for, as there were increases in the NDVI indicators for all years of the period, especially the year 2019, which witnessed a great boom in the density of vegetation.

3.2. The effect of rainfall rates on the density of vegetation

Climate influences such as rainfalls are mainly considered one of the largest climatic variables that play a major role in the growth, density and productivity of vegetation (Naif et al., 2020). The data of the annual average rainfall was obtained by calculating the average monthly data for each year during the study period. Figure (67) shows the change in NDVI values with the change in the amount of annual precipitation, in the stations of the study area (Khanaqin, Kirkuk, Sulaymaniyah, Al-Hayy), for the period (2000- 2020). It can be observed from Figure (67) that there are significant changes or increases in precipitation rates and NDVI rates for the year 2001 in the stations of Sulaymaniyah, Khanaqin, Kirkuk, except for Al-Hayy station (Wasit), where the lowest percentage was recorded in this year. There is also a similarity in the values of NDVI and precipitation in the Sulaymaniyah station for the years 2002, 2003 and 2004.

There is a correlation for the values of NDVI for the year 2008 with all stations, where the lowest percentages of vegetation recorded less than 0.14, except for Sulaymaniyah, which was 0.18. It can be seen that there is a correlation with the values of precipitation and the NDVI index for each of the Sulaymaniyah and Kirkuk stations for the years 2010, 2011, 2012, in contrast, there are decreases in the stations of the Al-Hayy (Wasit) and Khanaqin (Diyala) in the NDVI indicators in these years. As for the year 2013, the NDVI rates were reasonable for all stations, and there was a consensus of the NDVI values for Kirkuk and Khanaqin stations for the years 2013, 2014 and 2015. The years 2018 and 2019 recorded the highest percentages of NDVI values for all study stations and over the 21 years studied. The reason for the increase in vegetation cover in 2019 is the abundance of rain in this year, as well as the scarcity of grazing animals in it due to the security conditions.

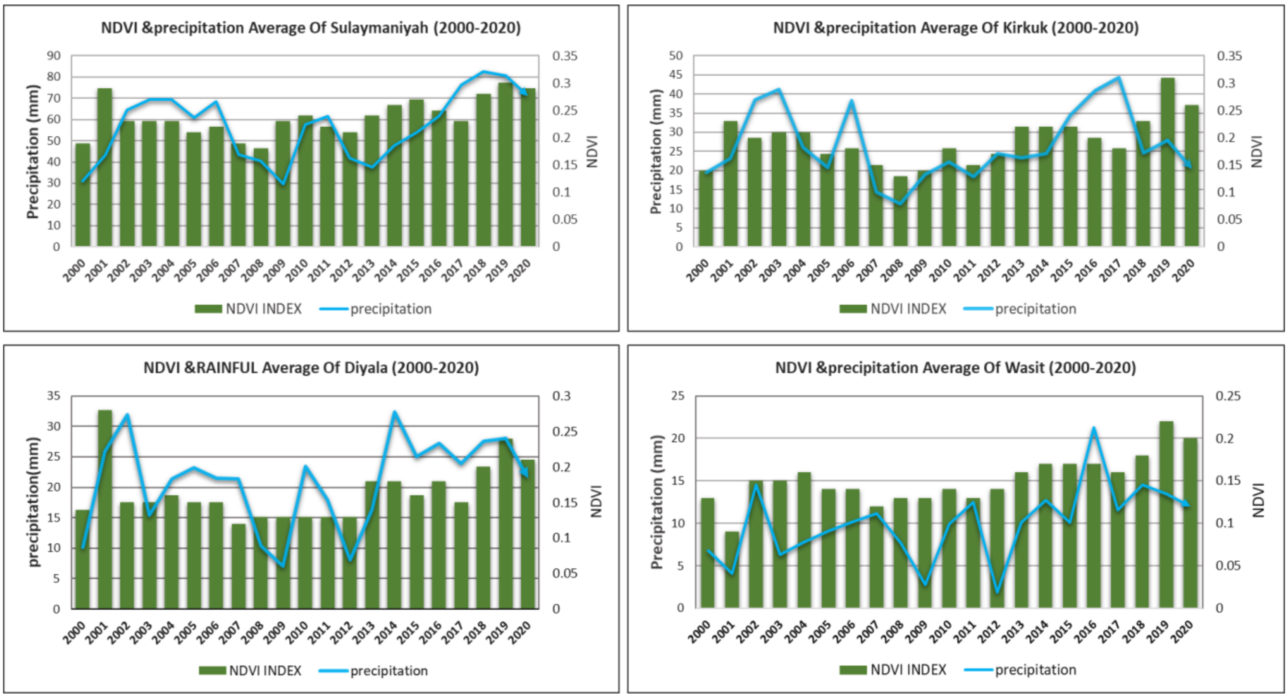


Figure 67: The annual averages of rainfall and NDVI for the study stations of Khanaqin, Kirkuk, Sulaymaniyah, Al-Hayy, for the period 2000-2020.

Based on the statistical analysis of the data, the results of the Pearson correlation test indicated that there is a positive medium correlation between the vegetation index and annual precipitation, where the value of the correlation in Sulaymaniyah Governorate was (R= 0.458) and the value of the statistical significance was at (P = 0.11). While in Al-Hayy station, there is a medium positive relationship between the two variables at a result of (R= 0.544) and a value of (P= 0.11). It is followed by Khanaqin station with a medium direct relationship with a value of (R= 0.490) and a value of (P= 0.24). And the signs of the Kirkuk station have a weak direct relationship, where the value was (R= 0.303) and (P= 0.182), and all relationships have a statistical significance at the level of (0.05). Figure (68) shows the results of the correlation between precipitation rates and vegetation data.

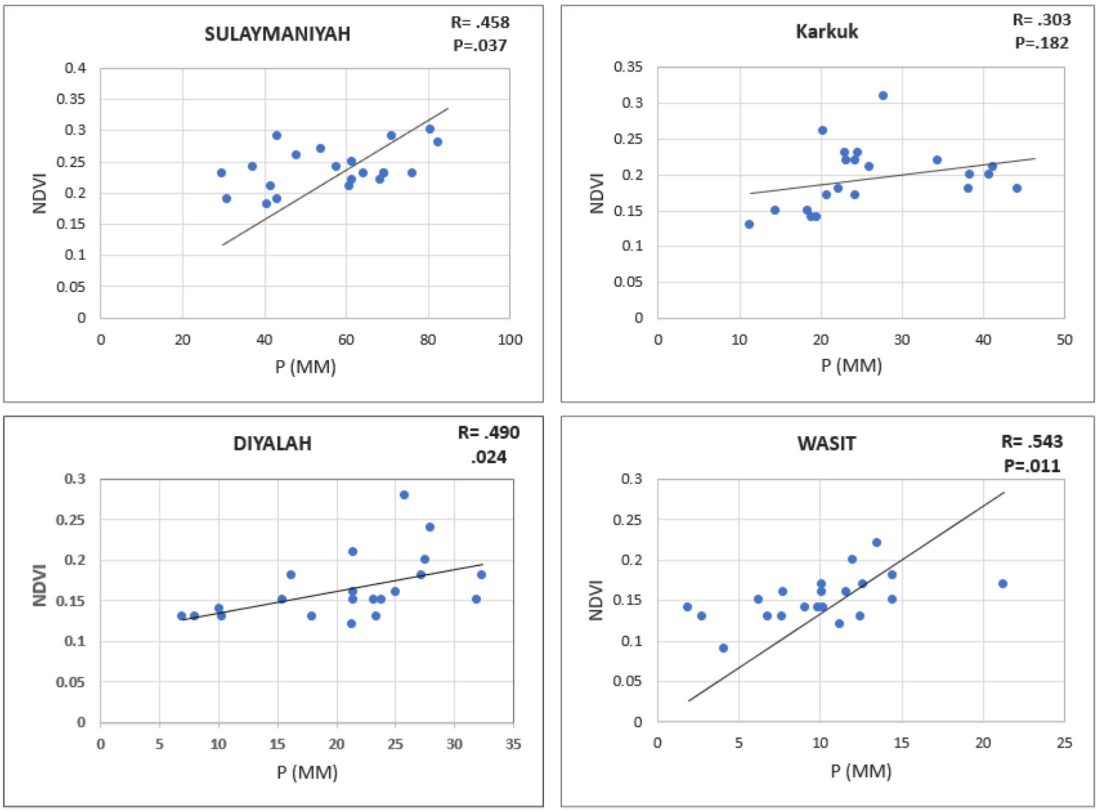


Figure 68: Correlation between NDVI and precipitation

3.3. The effect of topographical factors on the density of vegetation

Just as there is an influence of climate elements on the vegetation, the topographical factors also have a role in the distribution of plants. In this light, a digital elevation model (DEM) was prepared and terrain elements (Hill Shade, Slope, Aspect, elevation) were derived using the Dem digital elevation model in order to measure the correlations between the NDVI values of 2019 and the terrain elements of the study area.

The correlations between the NDVI and the topographical elements in the study area were examined for the seasons through (table 9). The correlations between NDVI and altitude were shown in the order of spring season, autumn season and summer season. There were weak direct relationships except for the winter season, which was a strong inverse relationship, and the reason for this is due to the low temperatures and the accumulation of snow, which has a role in preventing the growth of vegetation cover in high areas. This concludes that topography has a major role in the distribution and growth of vegetation. In addition, no correlation was found with the direction of the Earth's surface and gradient.

Table 10: Correlation coefficients between NDVI and terrain factors topography

Seasonal	variable	Hill Shade	Slope	Aspect	Elevation	NDVI
WINTER	Hill Shade	-				
	Slope	.997**	-			
	Aspect	.920**	.913**	-		
	Elevation	.514**	.535**	.479*	-	
	NDVI	-.007	-.012	.009	-0.75**	-
SPRING	Hill Shade	-				
	Slope	.997**	-			
	Aspect	.920**	.913**	-		
	Elevation	.514**	.535**	.479*	-	
	NDVI	-.018	-.009	.000	0.387**	-
SUMMER	Hill Shade	-				
	Slope	.997**	-			
	Aspect	.920**	.913**	-		
	Elevation	.514**	.535**	.479*	-	
	NDVI	.000	.006	.027	0.171**	-
AUTUMN	Hill Shade	-				
	Slope	.997**	-			
	Aspect	.920**	.913**	-		
	Elevation	.514**	.535**	.479*	-	
	NDVI	-.002	.003	.030	0.127**	-

Note: *P <.05, **P <.01, two-tailed

3.4. Spatial statistical analysis of vegetation assemblies

Spatial Statistics Tools in GIS have been used to prepare spatial distribution maps for pools of similar areal values of vegetation, represented by maps of Hot and Cold Spots (Hot spot Analysis: Getis-Ord Gi maps). The GI statistic for each item in the data table has a Z score and a Z+ score. Where it indicates the pools of high values (hot spots), meaning that the agglomeration value is high, and the negative (Z) value indicates the pools of low values (cold spots), and the degree (Z) close to zero indicates that there is no apparent spatial pool.

In order to conduct a quantitative spatial analysis of the vegetation for the summer and spring seasons, the tool Hot Spot Analysis: Getis-Ord Gi* was used.

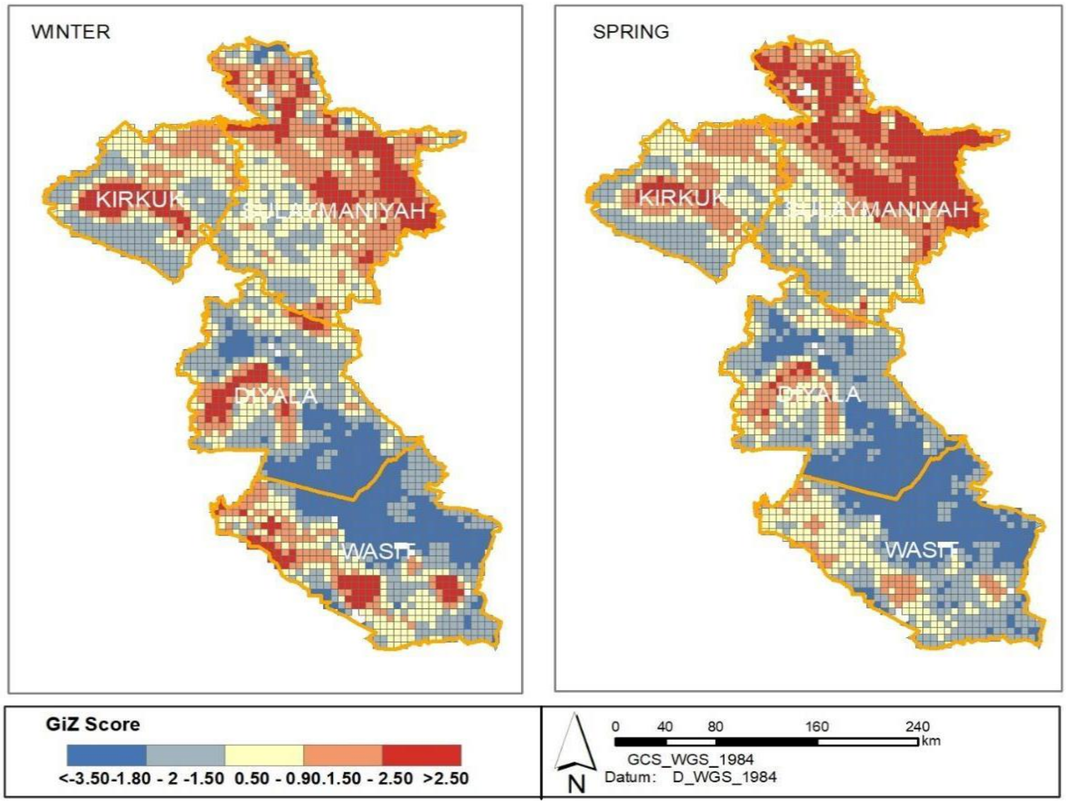


Figure 69: High and low values of vegetation for the winter and spring seasons

Positive (GiZScore) values represent: the appearance of hot spots in the spatial unit pool with high values for green lands and indicated in red as in Figures (67) and (68). It is noted that there are hot spots in small areas in the northern parts of the study area, and they increase in the northern and eastern areas of the study area and some western parts. They are lightly in the winter season and hot in the spring season.

Negative (GiZScore) values: As shown in the figure (the two maps), the cold spots show the locations of agglomerations of low values of spatial units of low density of plants, and they are shown in the southern, eastern and central parts of the study area and indicated in blue as in Figure (69) and (70).

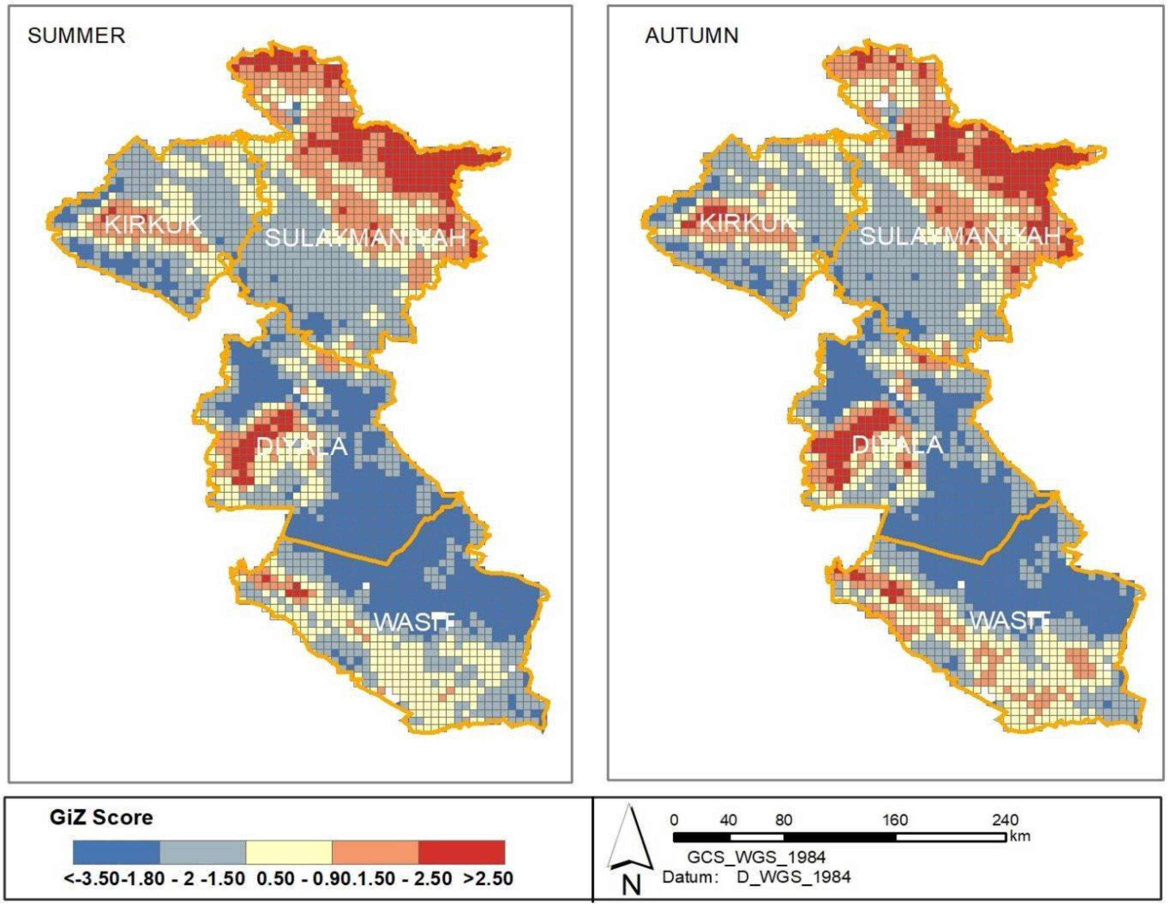


Figure 70: High and low values of vegetation for the summer and autumn seasons

The point of using hot and cold spots is to show where the natural vegetation is concentrated, as indicated by the largest values on the map. Hot spots or places with higher values are shown in red, while areas with lower values are represented in blue. This model was used in the study to identify and highlight the difference between hot regions with higher values and cold regions with lower values. According to the region's area, the distance separating them, and the juxtaposition of values, the northern regions were identified with the highest vegetation values, although there is a density of vegetation in Diyala and Wasit.

CHAPTER IV

RESULTS, DISCUSSION AND RECOMMENDATION

4.1. Results and Discussion

The use of remote sensing techniques and geographic information systems provided a lot of effort, time and cost in determining the values of the density of vegetation cover in the study area, and the visual interpretation method indicated good results in determining the change in vegetation according to the apparent color grades illustrated by the satellite images which were captured for the selected study area and vegetation density was calculated using the Normalized Difference Vegetation Index (NDVI).

The aim of the study was to detect and assess the natural vegetation by remote sensing and geographical applications by satellite sensor images (MODIS13q1250,M) during the time period 2000-2020 with an interval of 16 days**.** This study covered the northern, central and southern parts to show the extent of the change taking place in the region. Despite the lack of studies related to the study of vegetation in the study area, they proved the ability of GIS and remote sensing in studying vegetation and producing accurate maps.

It was used to detect the vegetation cover for the months of the vegetative period, which is represented in March, April and May, as these months represented the peak stages of plant growth in the study area, where there were seasonal and monthly differences between the regions and there were differences in the indicators extracted from the MODIS data, where the year 2001 witnessed significant increases in the values of vegetation for all study areas.

The statistical relationships between rain on the one hand and the diversity of vegetation on the other hand showed that there are moderate direct relationships between rain and the NDVI indicators, where the relationships were direct and moderate in the cities of Sulaymaniyah, Diyala and Wasit, while for Kirkuk, the relationship was positive and weak. There were medium positive relationships between rainfall indicators and NDVI values in the stations of the region during the study period, as the relationship amounted to (0.458) in Sulaymaniyah station, while in Khanaqin station, the relationship was moderately direct, as the relationship amounted to (0,490) and in the Al-Hayy station it was a medium positive relationship with an amount of (0.544), as for the Kirkuk station, the relationship of rainfall with NDVI was weak, so the relationship reached (0,303).

There is a decrease and deterioration in the values of vegetation in the region, where the values of vegetation rates decreased in 2008 and 2012, where the lowest rates of annual vegetation were recorded. And the lowest rates were for Wasit and Diyala, which ranged from (0.13) to (0.14) and this is due to the lack of rain rates in 2008, where it is considered One of the driest years in the region.

The year 2019 recorded the highest values of NDVI rates along the studied time series and included all studied regions, where the indicators of Kirkuk city with an index of 0.30, followed by Sulaymaniyah with an index of (0.28), then Diyala with a rate of (0.24) and Wasit with an index of (0.22).

The different prevailing climatic elements affected the four governorates, which vary in natural vegetation and. It is noted that the Sulaymaniyah governorate, which enjoys the Bsk regions, has the spread of dense vegetation, trees, forests and vegetation that continues until the summer season, and this is a reflection of the region's favorable climate, while we find the central region is characterized by a hot, dry desert climate, in which plants do not persist until the month of April.

The study proved that the terrain height have a role in hindering the growth of vegetation, especially in the winter season, where there were strong inverse relationships between height and vegetation, as reached (-0.75).

The study demonstrated the ability of spatial statistical analysis tools in detecting the density of vegetation for seasons through hot and cold spots.

In order to analyze the vegetation chain, the study employed a 21-year record of MODIS NDVI.time-series to detect significant temporal trends of vegetation in A part of Iraq Sulaymaniyah, Kirkuk, Diyala, Wasit, The results were divided into four periods of time. The results of the study conform with (Nail et al., 2020)that the changes in climatic elements of the plants affect it at the growth period. As well as they conform with the study of (Ahmad S. Muhaimeed 1, 2013), that the year of 2008 was the least according to the the density of vegetation as it recorded the least value of NDVI of kirkuk.

4.2. Recommendations

After completing the study in accordance with the scientific methods that the researcher concluded through the chapters of the study based on the geographical and statistical techniques that were used in managing and processing data statistically and geographically, in order to draw conclusions, the study reached a set of recommendations that he considers necessary to address this problem and determine its future impact, address it and reduce its effects on the study area is:

-Conducting more academic studies on the- relationship between climatic variables and vegetation and their possible effects in the future.

-Benefiting from the research methodology and the method of detecting and monitoring changes in vegetation during monthly and seasonal periods of time due to the accuracy and speed of this method and saving effort and money.

-Using different data of some satellite images to study the vegetation such as landsat and sentinel, as they provide periodic monitoring

-The necessity of establishing scientific centers specialized in geographic information systems and remote sensing in all governorates in order to permanently monitor the changes that occur in the vegetation and to provide databases and monthly and annual reports on the changes that occur in various regions of Iraq.

APPENDIX

years	Average monthly precipitation (mm)in the study area				Average monthly NDVI values in the study area			
	Sulaymaniyah	Kirkuk	Diyala	Wasit	Sulaymaniyah	Kirkuk	Diyala	Wasit
2000	31.08	19.53	10.16	6.8	0.19	0.14	0.14	0.13
2001	43.29	23.08	25.88	4.1	0.29	0.23	0.28	0.09
2002	64.37	38.47	31.92	14.5	0.23	0.2	0.15	0.15
2003	69.46	41.3	15.43	6.3	0.23	0.21	0.15	0.15
2004	69.46	26.01	21.43	7.8	0.23	0.21	0.16	0.16
2005	60.8	20.79	23.22	9.1	0.21	0.17	0.15	0.14
2006	68.31	38.22	21.49	10.2	0.22	0.18	0.15	0.14
2007	43.4	14.43	21.33	11.2	0.19	0.15	0.12	0.12
2008	40.63	11.26	10.36	7.7	0.18	0.13	0.13	0.13
2009	29.78	18.92	7	2.8	0.23	0.14	0.13	0.13
2010	57.67	22.27	23.47	9.9	0.24	0.18	0.13	0.14
2011	61.45	18.48	17.95	12.5	0.22	0.15	0.13	0.13
2012	41.71	24.34	8.1	1.9	0.21	0.17	0.13	0.14
2013	37.4	23.26	16.28	10.1	0.24	0.22	0.18	0.16
2014	47.88	24.35	32.35	12.7	0.26	0.22	0.18	0.17
2015	54.11	34.47	25.05	10.1	0.27	0.22	0.16	0.17
2016	61.46	40.8	27.25	21.3	0.25	0.2	0.18	0.17
2017	76.38	44.34	23.88	11.6	0.23	0.18	0.15	0.16
2018	82.67	24.61	27.58	14.5	0.28	0.23	0.2	0.18
2019	80.74	27.86	27.97	13.5	0.3	0.31	0.24	0.22
2020	71.19	20.39	21.51	12	0.29	0.26	0.21	0.2

Appendix 1: Monthly and Annual of ndvi and (mm\Y) along the last 21 years

The monthly Average NDVI Of Sulaymaniyah from Year 2000-2020												
months / years	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
2000	0.19	0.23	0.29	0.20	0.15	0.14	0.14	0.14	0.15	0.16	0.20	0.31
2001	0.32	0.43	0.56	0.31	0.24	0.23	0.21	0.23	0.24	0.23	0.27	0.20
2002	0.24	0.30	0.37	0.27	0.19	0.17	0.16	0.16	0.17	0.21	0.22	0.23
2003	0.25	0.34	0.36	0.25	0.19	0.16	0.16	0.15	0.16	0.18	0.23	0.25
2004	0.28	0.35	0.35	0.27	0.19	0.18	0.17	0.16	0.20	0.24	0.22	0.22
2005	0.21	0.34	0.34	0.26	0.19	0.17	0.17	0.17	0.16	0.17	0.17	0.15
2006	0.21	0.25	0.35	0.30	0.20	0.18	0.17	0.17	0.18	0.24	0.23	0.18
2007	0.25	0.34	0.40	0.26	0.19	0.14	0.10	0.10	0.10	0.10	0.15	0.14
2008	0.15	0.21	0.22	0.19	0.15	0.14	0.14	0.14	0.17	0.21	0.23	0.22
2009	0.24	0.32	0.37	0.23	0.17	0.16	0.16	0.17	0.16	0.20	0.24	0.29
2010	0.33	0.41	0.44	0.24	0.19	0.17	0.17	0.17	0.18	0.17	0.17	0.17
2011	0.21	0.28	0.31	0.29	0.19	0.17	0.17	0.17	0.16	0.19	0.19	0.18
2012	0.16	0.21	0.33	0.22	0.18	0.16	0.16	0.16	0.17	0.25	0.27	0.25
2013	0.34	0.39	0.37	0.23	0.19	0.17	0.17	0.16	0.17	0.20	0.25	0.27
2014	0.31	0.41	0.39	0.25	0.20	0.18	0.17	0.17	0.21	0.26	0.32	0.32
2015	0.37	0.44	0.41	0.24	0.19	0.18	0.17	0.18	0.18	0.25	0.27	0.28
2016	0.36	0.43	0.42	0.25	0.20	0.18	0.18	0.17	0.18	0.17	0.18	0.21
2017	0.21	0.33	0.40	0.28	0.20	0.18	0.17	0.17	0.16	0.19	0.21	0.23
2018	0.28	0.38	0.41	0.32	0.21	0.19	0.18	0.18	0.19	0.26	0.35	0.33
2019	0.41	0.46	0.50	0.34	0.23	0.21	0.21	0.20	0.21	0.23	0.25	0.27
2020	0.30	0.46	0.48	0.33	0.23	0.21	0.20	0.20	0.20	0.25	0.28	0.23

Appendix 2: The Monthly Average of NDVI of sulaymanyah from 2000-2020.

			The monthly Average NDVI Of Karkuk from Year 2000-2020									
months / years	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
2000	0.18	0.18	0.16	0.12	0.11	0.12	0.12	0.12	0.13	0.13	0.17	0.22
2001	0.26	0.47	0.33	0.16	0.17	0.19	0.17	0.19	0.20	0.24	0.17	0.23
2002	0.28	0.33	0.29	0.15	0.14	0.15	0.16	0.15	0.15	0.17	0.19	0.21
2003	0.31	0.39	0.31	0.18	0.15	0.14	0.15	0.14	0.14	0.15	0.21	0.25
2004	0.36	0.40	0.28	0.17	0.15	0.15	0.16	0.15	0.16	0.16	0.16	0.18
2005	0.20	0.30	0.25	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.16
2006	0.21	0.26	0.28	0.17	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16
2007	0.21	0.27	0.28	0.15	0.14	0.12	0.10	0.10	0.09	0.09	0.10	0.14
2008	0.15	0.17	0.15	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13
2009	0.13	0.16	0.17	0.12	0.11	0.12	0.12	0.12	0.12	0.13	0.16	0.21
2010	0.26	0.29	0.24	0.14	0.14	0.14	0.15	0.15	0.15	0.14	0.15	0.17
2011	0.20	0.23	0.20	0.13	0.13	0.13	0.14	0.14	0.14	0.13	0.13	0.14
2012	0.16	0.20	0.21	0.14	0.13	0.13	0.13	0.13	0.13	0.18	0.21	0.24
2013	0.37	0.39	0.28	0.15	0.14	0.15	0.16	0.15	0.15	0.17	0.24	0.28
2014	0.32	0.40	0.31	0.16	0.14	0.14	0.15	0.15	0.16	0.19	0.27	0.31
2015	0.35	0.38	0.25	0.15	0.13	0.13	0.14	0.14	0.14	0.20	0.26	0.31
2016	0.36	0.38	0.28	0.16	0.14	0.14	0.14	0.15	0.15	0.13	0.17	0.22
2017	0.22	0.37	0.30	0.17	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.17
2018	0.21	0.29	0.27	0.18	0.14	0.14	0.15	0.15	0.15	0.22	0.40	0.45
2019	0.55	0.62	0.54	0.25	0.19	0.18	0.19	0.19	0.20	0.19	0.26	0.34
2020	0.43	0.53	0.43	0.21	0.17	0.16	0.17	0.17	0.17	0.18	0.21	0.18

Appendix 3: The Monthly Average of NDVI of karkuk from 2000-2020

The monthly Average NDVI Of Diyala from Year 2000-2020												
months / years	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
2000	0.14	0.13	0.12	0.11	0.11	0.10	0.11	0.12	0.12	0.13	0.15	0.50
2001	0.56	0.67	0.42	0.24	0.18	0.18	0.18	0.19	0.19	0.17	0.16	0.18
2002	0.19	0.19	0.17	0.13	0.12	0.12	0.13	0.13	0.13	0.14	0.16	0.17
2003	0.19	0.19	0.15	0.12	0.13	0.12	0.13	0.13	0.13	0.13	0.16	0.20
2004	0.23	0.22	0.16	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15
2005	0.16	0.21	0.17	0.14	0.12	0.12	0.13	0.14	0.14	0.14	0.14	0.15
2006	0.17	0.19	0.18	0.14	0.13	0.13	0.14	0.14	0.15	0.14	0.13	0.14
2007	0.16	0.19	0.16	0.13	0.13	0.11	0.09	0.09	0.08	0.08	0.08	0.13
2008	0.13	0.13	0.12	0.11	0.11	0.11	0.11	0.11	0.13	0.15	0.15	0.16
2009	0.15	0.15	0.13	0.11	0.11	0.11	0.11	0.12	0.12	0.13	0.14	0.15
2010	0.16	0.16	0.13	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.13	0.15
2011	0.15	0.17	0.14	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
2012	0.12	0.13	0.13	0.11	0.11	0.11	0.11	0.12	0.12	0.15	0.17	0.19
2013	0.25	0.24	0.19	0.14	0.13	0.13	0.13	0.13	0.13	0.16	0.23	0.29
2014	0.32	0.29	0.21	0.16	0.15	0.14	0.14	0.14	0.15	0.15	0.16	0.16
2015	0.16	0.17	0.14	0.12	0.12	0.12	0.12	0.12	0.12	0.19	0.26	0.32
2016	0.35	0.31	0.20	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.15	0.18
2017	0.18	0.22	0.19	0.14	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.16
2018	0.19	0.24	0.21	0.16	0.14	0.14	0.14	0.13	0.15	0.18	0.31	0.36
2019	0.43	0.44	0.29	0.19	0.17	0.17	0.17	0.17	0.18	0.17	0.23	0.27
2020	0.31	0.35	0.25	0.17	0.16	0.15	0.16	0.15	0.16	0.17	0.21	0.32

Appendix 4 : The Monthly Average of NDVI of diyala from 2000-2020

			The monthly Average NDVI Of Wasit from Year 2000-2020									
months / years	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
2000	0.18	0.18	0.14	0.12	0.12	0.11	0.12	0.12	0.13	0.14	0.15	0.11
2001	0.10	0.10	0.09	0.08	0.08	0.08	0.08	0.08	0.10	0.09	0.09	0.16
2002	0.18	0.18	0.16	0.13	0.12	0.12	0.13	0.13	0.14	0.14	0.16	0.17
2003	0.18	0.18	0.14	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.16	0.20
2004	0.21	0.20	0.15	0.13	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16
2005	0.17	0.19	0.16	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.15	0.17
2006	0.17	0.17	0.16	0.13	0.12	0.12	0.13	0.14	0.14	0.14	0.15	0.15
2007	0.18	0.19	0.15	0.12	0.12	0.10	0.07	0.07	0.08	0.07	0.08	0.15
2008	0.15	0.15	0.13	0.12	0.11	0.11	0.12	0.12	0.13	0.14	0.15	0.14
2009	0.15	0.16	0.13	0.12	0.11	0.11	0.12	0.12	0.12	0.13	0.16	0.17
2010	0.18	0.17	0.14	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.15	0.17
2011	0.17	0.18	0.13	0.12	0.12	0.11	0.12	0.12	0.12	0.13	0.13	0.14
2012	0.16	0.16	0.14	0.11	0.11	0.11	0.12	0.12	0.13	0.16	0.17	0.19
2013	0.22	0.20	0.16	0.13	0.13	0.13	0.13	0.13	0.12	0.15	0.18	0.22
2014	0.25	0.25	0.18	0.15	0.13	0.13	0.13	0.13	0.14	0.14	0.19	0.22
2015	0.23	0.22	0.15	0.12	0.12	0.12	0.12	0.12	0.13	0.16	0.22	0.26
2016	0.29	0.27	0.17	0.14	0.13	0.13	0.13	0.13	0.13	0.14	0.17	0.20
2017	0.21	0.23	0.18	0.13	0.12	0.12	0.12	0.13	0.12	0.15	0.18	0.20
2018	0.22	0.22	0.17	0.13	0.13	0.13	0.13	0.12	0.13	0.17	0.28	0.31
2019	0.35	0.36	0.23	0.17	0.16	0.16	0.16	0.16	0.16	0.17	0.25	0.30
2020	0.33	0.34	0.22	0.16	0.15	0.15	0.16	0.15	0.16	0.18	0.24	0.11

Appendix 5: The Average Monthly of NDVI of wasit from 2000-2020

months / years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2000	38.7	2.7	29	3.2	0	0	0	0	0	0	28.8	19.5
2001	31.9	44.2	59.7	7.7	1.7	0	0	0	0	11	0	154.4
2002	105.8	41.6	55.3	61.5	0	0	0	0	0	1.4	59.3	58.1
2003	44	16.8	24.6	24.6	0	0	0	0	0	1.2	18.6	55.3
2004	89.9	21	4.4	9	20.1	0	0	0	0	7.6	39.5	65.6
2005	57.4	34	85.7	19.9	0.8	0	0	0	0	0	59.1	21.7
2006	57.4	65.4	8	35.8	0	0	0	0	0	0.8	73.7	16.8
2007	89.4	57.3	10.8	83	4	0	0	0	0	0	7.4	4
2008	52	16.8	8.3	0	0	0	0	0	0	16.9	17.7	12.6
2009	16.1	18	23.1	21.3	1	0	0	0	0	0	0	4.5
2010	19.4	30.7	37.9	40.3	19.6	0	0	0	0	78.5	37.8	17.4
2011	31.9	5.2	14.7	38.6	1.1	0	0	0	0.7	16.5	50.6	56.1
2012	11.3	45.9	25.6	4.3	3.8	0	0	0	0	0.5	2.4	3.4
2013	72.7	6.7	0.9	6.3	25.7	0	0	0	0	18	54.3	10.8
2014	52.1	12.1	49.1	3.8	8.9	0	0	0	0	29.8	170.4	62
2015	10.4	48.2	26.3	0	3.5	0	0	0	0	0	181.1	31.1
2016	24.6	38.3	44	44.4	4.6	0	0	0	0	43.9	54.9	72.3
2017	31.8	26.7	28.4	19.7	9.6	0.0	0.0	0.0	0	51.9	90.2	28.3
2018	37.9	30.1	29.8	25.3	11.5	0	0	0	0	57.6	95.4	43.4
2019	40.2	33.3	26.5	27.2	12.5	0	0	0	0	62.4	81.4	52.1
2020	35.4	20.4	16.4	14.3	8.6	0	0	0	0	58.5	60.2	44.3

Appendix 6 : The Average Monthly precipitation of Diyala from 2000-2020.

months / years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2000	85.4	14.7	11.4	6.4	5.6	0	0	0	0.1	10.3	28.8	71.6
2001	48.8	26.7	66.4	12.3	6.3	0	0	0	2.2	4.7	28.8	80.8
2002	104.7	17.2	81.1	31.3	9.2	0	0	0	0	14.7	22.9	180.5
2003	72.9	45.6	78.4	42	12.8	0.2	0	0	0	33.5	120	90.2
2004	125	52.7	8.6	49.9	4.9	0	0	0	0	1	43	27
2005	83.3	63.5	54.1	27.7	7.5	0.1	0	0	6.4	0.1	2.6	4.2
2006	65.3	192	0.2	98.3	37.7	0	0	0.1	0	38.4	14.7	11.9
2007	34.3	65.7	25.2	34.3	8.3	0.001	0	0	0	0.8	0.1	4.5
2008	49.001	27.502	26.104	0.1	4.6	0.1	0	0.1	0.2	17.2	5.8	4.4
2009	6.201	6.202	49.6	34.6	0.2	0	0	0	0.201	37	55	38
2010	22.5	56.9	64.4	29.2	56.7	0	0	0	0	1.5	0	36
2011	59.6	21	16.9	71.8	3.6	0	0	0	0	9.2	2	37.7
2012	52.4	31.1	49.3	12	3.9	0	0	0	0	6.7	93.7	43
2013	65.4	53.2	67.5	12.2	0.5	0.1	0	0	0	5.2	11.4	63.6
2014	84	22.3	42.3	2.6	23.1	0.1	0	0	0.1	37.5	28.3	51.9
2015	73.4	88.7	49.8	47.5	12.7	0	0	0	0	8.5	71.7	61.3
2016	86.3	92.5	87.6	21.6	13.9	1.2	0.1	0.1	0	11	70.9	104.4
2017	125.1	42.6	40	120.4	37	0	0.1	0	8.2	76.9	58.1	23.7
2018	130.2	38.7	26.7	37	28.5	0	0	0	0	0.1	13.5	20.6
2019	64	56.21	47.53	36	13.31	0.13	0.19	0.04	0.83	16.93	44.95	54.21
2020	26.7	107.7	41	39.6	0.3	0	0	0	0	3.2	6.8	19.4

Appendix 7 : The Average Monthly precipitation of kirkuk from 2000-2020

months / years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2000	147.2	45.8	37.9	32.9	31.9	0	0	0	0	13.6	4.2	59.4
2001	82.6	83.9	81.9	35.3	12.6	0	0	0	0	6.7	51.2	165.3
2002	204.4	64.6	134.2	131.6	27.2	0	0	0	2.7	28.2	31.4	148.1
2003	127.2	173.8	131.5	65.6	18.7	0	0	0	3.7	21.8	42.9	248.3
2004	272	103	12.5	74	95.6	0	0	0	0	57	58.2	161.2
2005	143.8	123.3	144.5	55.8	25	0	0	0	0	43.4	129.1	64.7
2006	141.6	276	3	133	86	0	0	0	0	13.7	116.4	50
2007	52.4	146	82	161.1	21.7	1.8	0	0	0	0.5	36.3	19
2008	59	121.1	48.3	17.5	0.9	0	0	0.2	0	81	41	118.6
2009	39.5	76.2	78.1	97.6	2.9	2.6	0	0	0	35	4	21.5
2010	69	161.9	93.2	77.1	80.8	0	0	0	2.5	96.8	12.4	98.3
2011	146.3	44.6	60.7	214.8	38.3	3.7	0	0	10.1	23	136.4	59.5
2012	109.2	94.6	175	19.6	34.8	0	0	0	0	0.6	1	65.7
2013	171.5	54.4	15	22.1	30.3	0	0	0	0.2	26.6	48.7	80
2014	80	12	174.8	56.9	8.5	0	0	0	0	17.9	37.8	186.6
2015	119.6	82.1	112.9	29.5	20	0	0	0	0	0.5	166.4	118.3
2016	110.2	91.5	156.8	69.8	5.5	0	0	0	0	64.4	153	86.3
2017	109.8	91.3	155.7	29.5	5.3	0	0	0	12.4	132.6	194.1	185.8
2018	115.4	95.2	163.2	31.6	6.6	0	0	0	23.1	128.5	240.2	188.2
2019	115.5	90.2	150.2	30.5	9.1	0	0	0	26.2	155.5	221.5	170.2
2020	112.5	95.2	133.5	21.5	11.2	0	0	0	19	115.5	180.4	165.5

Appendix 8: The Average Monthly precipitation of sulaymanyah from 2000-2020

months / years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2000	38.8	9.3	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	32.0
2001	12.5	2.0	19.5	4.8	1.6	0.0	0.0	0.0	0.0	0.0	0.3	8.6
2002	32.6	3.9	26.1	59.5	0.0	0.0	0.0	0.0	0.0	6.3	25.5	19.5
2003	31.3	10.7	22.3	0.9	0.2	0.0	0.0	0.0	0.0	0.0	6.6	4.0
2004	36.0	12.8	3.0	5.5	1.0	0.0	0.0	0.0	0.0	5.2	5.7	24.6
2005	41.9	5.8	21.8	8.0	1.5	0.0	0.0	0.0	0.0	1.7	9.9	18.6
2006	38.4	31.1	14.1	23.5	0.7	0.0	0.0	0.0	0.0	0.3	13.6	1.2
2007	13.7	3.3	13.9	14.1	0.0	0.0	0.0	0.0	0.0	0.0	26.0	63.0
2008	45.3	2.2	0.0	14.1	3.5	0.0	0.0	0.0	0.0	1.8	6.5	19.5
2009	0.0	4.1	5.7	23.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	1.4	26.2	2.1	10.2	20.2	1.3	0.0	0.0	4.7	3.1	14.7	35.4
2011	50.1	19.4	7.7	34.1	5.4	0.0	0.0	0.0	0.0	10.3	6.4	16.4
2012	5.7	1.0	2.6	2.7	3.3	0.0	0.0	0.0	0.0	0.8	1.7	5.0
2013	28.7	5.4	0.0	0.1	51.5	0.0	0.0	0.0	0.0	1.4	1.7	31.8
2014	46.9	5.0	35.8	23.7	0.2	0.0	0.0	0.0	0.0	1.0	32.8	7.0
2015	2.9	22.9	13.9	0.7	4.6	0.0	7.3	0.0	0.0	0.4	63.7	4.4
2016	6.0	25.4	35.2	43.6	6.7	0.0	0.0	0.0	0.0	36.4	45.9	56.9
2017	1.9	3.1	34.8	0.7	6.2	0.0	0.0	0.0	0.0	8.1	77.3	6.6
2018	11.4	21.5	37.6	2.4	5.1	0.0	0.0	0.0	0.0	9.1	65.1	21.5
2019	5.4	16.7	33.2	21.3	6.3	0.0	0.0	0.0	0.0	3.5	57.3	18.3
2020	8.3	12.3	40.3	20.3	4.5	0.0	0.0	0.0	0.0	2.1	41.4	14.5

Appendix 9 : The Average Monthly precipitation of wasit from 2000-2020

REFERENCES

Abujayyab, S. K. M., & Demiral, E. (2019). *Makine Ö ğ renmesi Yöntemini Kullanarak NDVI Zaman Serisi Verileri ile Bitki Örtüsü Tahmini / Vegetation cover prediction using NDVI time series data and machine learning Makine Öğrenmesi Yöntemini Kullanarak NDVI Zaman Serisi Verileri ile Bitki Örtüsü Ta*. April.

Ahmad S. Muhaimeed1, A.-H. M. (2013). Evaluation of long-term vegetation trends for northeastern of Iraq: Mosul, Kirkuk and Salah al-Din. IOSR Journal of Agriculture and Veterinary Science, 5(2), 67–76. https://doi.org/10.9790/2380-0526776

Al-anni, K. (1988). geography,land population and economic resourse. collge of education,(In Arabic) Baghdad University.

AL-azawi, amaar M. (2019). Analyzing the effect of seasonal changes in climate elements on the severity of drouhts in iraq. university tikrit.

Al-Omari, F. (1977). Geology of Northern Iraq(In Arabic) ,.Printing and Publishing, Mosul.iraq.

Atalay, I. (2016) " *Soil Formation, Classification and Geography*.(in turkish)," 5. Printing, MetaPrint, Izmir.

Al-saadi, A. (2009). iraqs geography the natural framework and economic activity ,(In Arabic).University of baghdad.

Al-samak, M., Al-ssati, B., Al-ganabi, S., Ghalib, S., & AL-tamimi, A. (1985). Iraq,Regional Study.(In Arabic) ,part1.Baghdad.iraq.

Al-ssati, B., Al-samak, M., Al-ganabi, S., Ghalib, S., & AL-tamimi, A. (1985). Iraq,Regional Study.(In Arabic) ,part1.Baghdad.iraq.

Ali, F., & Jamal, S. (2012). Geographical information systems and remote sensing principles and applications ,(InArabic)Brant Press, Fez. Morocco.

Almamalachy, Y. (2017). Utilization of Remote Sensing in Drought Monitoring Over Iraq. https://pqdtopen.proquest.com/pubnum/10283891.html%0A

Aplin, P., & Aplin, P. (2005). Aplin, P., & Aplin, P. (2005). Progress in Physical Geography Remote sensing : ecology.

https://doi.org/10.1191/030913305pp437prProgress in Physical Geography Remote sensing : ecology. https://doi.org/10.1191/030913305pp437pr

Baio, F. H. R., Neves, D. C., Campos, C. N. da S., & Teodoro, P. E. (2018). Relationship between cotton productivity and variability of ndvi obtained by landsat images. Bioscience Journal, 34(6), 197–205. https://doi.org/10.14393/BJ-v34n6a2018-39583

Baldwin, K. A., Chapman, K., Meidinger, D., Uhlig, P., Allen, L., Basquill, S., Faber-Langendoen, D., Flynn, N., Kennedy, C., Mackenzie, W., Major, M., Meades, W. (B. ., Morneau, C., & Saucier, J.-P. (2019). The Canadian national vegetation classification: principles, methods and status.

Becker, R. H. (2014). The stalled recovery of the Iraqi Marshes. Remote Sensing, 6(2), 1260–1274. https://doi.org/10.3390/rs6021260

Benedict, T. D., Brown, J. F., Boyte, S. P., Howard, D. M., Fuchs, B. A., Wardlow, B. D., Tadesse, T., & Evenson, K. A. (2021). Exploring viirs continuity with modis in an expedited capability for monitoring drought-related vegetation conditions. Remote Sensing, 13(6). https://doi.org/10.3390/rs13061210

Bhandari, A. K., Kumar, A., & Singh, G. K. (2012). Feature Extraction using Normalized Difference Vegetation Index (NDVI): A Case Study of Jabalpur City. Procedia Technology, 6, 612–621. https://doi.org/10.1016/j.protcy.2012.10.074

Buringh, P. (1957). Directorate General of Agricultural Research and Projects–Ministry of Agricultural, Baghdad, Iraq.

Campbell, J. B., & Wynne, R. H. (2011). Introduction to remote sensing. New York,USA: Guilford Press.

Chalil, K. (2020). Self Instructional Study Material Course : Statistical Methods for Development Correlation U N I T – 3 : C O R R E L a T I O N. April, 1–21.

Chaves, M. E. D., Picoli, M. C. A., & Sanches, I. D. (2020). Recent applications of Landsat 8/OLI and Sentinel-2/MSI for land use and land cover mapping: A systematic review. Remote Sensing, 12(18). https://doi.org/10.3390/rs12183062

Colditz, R. R., Ressl, R. A., & Bonilla-Moheno, M. (2015). Trends in 15-year MODIS NDVI time series for Mexico. 2015 8th International Workshop on the Analysis of Multitemporal Remote Sensing Images, Multi-Temp 2015, Vi, 8–11. https://doi.org/10.1109/Multi-Temp.2015.7245766

Cowen, D. J. (1990). GIS versus CAD versus DBMS: what are the differences? Introductory Readings in Geographic Information Systems, 54(11), 52–61.

Coşkun, S. (2017). *Vegetation Ecology and Classification of Karabuk Environment*(inTurkish),Karabuk:.pp.42.https://iksadyayinevi.com/wpcontent/uploads/2020/12/KARABUK-CEVRESININ-VEJETASYON-EKOLOJISI-VE-SINIFLANDIRILMASI.pdf

Coşkun, S. (2021). *Ovacik and Its Surroundings in terms of Vegetation Geography* (in Turkish), Ankara: Iksad Publishing House.pp.60-74

Coşkun, M., & Yükel, S. (2021). *Devrek Çayi Havzasinin Vejetasyonu Ve Hidrografyasi*.(in Turkish), Ankara: Iksad Publishing House

Dawod, G. (2013). An Introduction to aerial photographs and satellite images (A Book in Arabic) مقدمة في الصور الجوية و المرئيات الفضائية. https://doi.org/10.13140/RG.2.1.4614.5764

Dawod, G. (2015). Fundamentals and Applications of Remote Sensing (in Arabic). https://doi.org/10.13140/RG.2.1.3205.5525

Didan, K., Munoz, A. B., Solano, R., & Huete, A. (2015). MODIS Vegetation Index User 's Guide (Collection 6). 2015(May), 31.

Edwards, D. P. (2014). An Introduction to Statistical Methods and Data Analysis. In Journal of the Royal Army Medical Corps (Vol. 160, Issue Suppl 1). https://doi.org/10.1136/jramc-2014-000309

Faber-Langendoen, D., Keeler-Wolf, T., Meidinger, D., Tart, D., Hoagland, B., Josse, C., Navarro, G., Ponomarenko, S., Saucier, J.-P., Weakley, A., & Comer, P. (2014). EcoVeg: A new approach to vegetation description and classification. Ecological Monographs, 84, 533–561. https://doi.org/10.1890/13-2334.1

Fensholt, R., & Proud, S. R. (2012). Evaluation of Earth Observation based global long term vegetation trends - Comparing GIMMS and MODIS global NDVI time series. Remote Sensing of Environment, 119, 131–147. https://doi.org/10.1016/j.rse.2011.12.015

Folger, P. (2011). Geospatial information and geographic information systems

(GIS): Current issues and future challenges. Geospatial Information and GIS: Background and Issues, 1–34.

Henik, J. (2011). Utilizing NDVI and remote sensing data to identify spatial variability in plant stress as influenced by management. Graduate Theses and Dissertations, 54. http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=3348&context=etd

Huang, Y., Chen, Z. Xin, YU, T., Huang, X. Zhi, & Gu, X. fa. (2018). Agricultural remote sensing big data: Management and applications. Journal of Integrative Agriculture, 17(9), 1915–1931. https://doi.org/10.1016/S2095-3119(17)61859-8

Iraqi Ministry of Environment. (2018). No TitleNational Action Program to Combat Desertification in Iraq برنامج العمل الوطني لمكافحة التصحر. http://moen.gov.iq/Portals/0/sixth/Strategies and Plans/National Action Program to Combat Desertification in Iraq.pdf

Jayanand Bhatti, M. A. (2020). TEMPORAL NDVI CHANGE DETECTION OF NEPAL USING MODIS IMAGERY. Sigma Journal of Engineering and Natural Sciences Sigma Mühendislik ve Fen Bilimleri Dergisi Research, 38(2), 927–943.

Karaburun, A. (2010). EstimatioKaraburun, A. (2010). Estimation of C factor for soil erosion modeling using NDVI in Buyukcekmece watershed. Ozean Journal of Applied Sciences, 3(1), 77–85. http://ozelacademy.com/OJAS_v3n1_8.pdfn of C factor for soil erosion modeling using NDVI . Ozean Journal of Applied Sciences, 3(1), 77–85. http://ozelacademy.com/OJAS_v3n1_8.pdf

Khorram, S., van der Wiele, C. F., Koch, F. H., Nelson, S. A. C., & Potts, M. D. (2016). Principles of Applied Remote Sensing. Springer International Publishing. https://doi.org/10.1007/978-3-319-22560-9

Kit, P., Steitz, D., Diller, G., Ainsworth, D., & Neiman, M. (1999). Terra : Flagship of the Earth Observing System. November.

Kottek, M., Grieser, J., Beck, C., Rudolf, B., & Rubel, F. (2006). World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift, 15(3), 259–263. https://doi.org/10.1127/0941-2948/2006/0130

Lu, D., Mausel, P., Brondízio, E., & Moran, E. (2004). Change detection techniques. International Journal of Remote Sensing, 25(12), 2365–2401.

https://doi.org/10.1080/0143116031000139863

Lunetta, R. S., Knight, J. F., Ediriwickrema, J., Lyon, J. G., & Worthy, L. D. (2006). Land-cover change detection using multi-temporal MODIS NDVI data. Remote Sensing of Environment, 105(2), 142–154. https://doi.org/10.1016/j.rse.2006.06.018

Main, R. (2007). A Remote sensing change detection study in the arid Richtersveld region of South Africa [(MSc research in english),Uinersity of the Western Cape]. http://etd.uwc.ac.za/xmlui/handle/11394/2411

Maranganti, S. (2009). Vegetation Change Detection in India Using MODIS Satellite Images.

Massei, G., Rocchi, L., Paolotti, L., & Boggia, A. (2016). Monitoring natural and rural ecosystems using the NDVI anomaly: an application to the Umbria Region. PeerJ PrePrints, 4, 2–4. https://doi.org/10.7287/peerj.preprints.2191

McHaffie, P., Hwang, S., & Follett, C. (2018). Introduction to Remote Sensing and GIS. GIS: An Introduction to Mapping Technologies, 239–270. https://doi.org/10.1201/9780429441028-9

Mitchel, A. (2005). The ESRI Guide to GIS analysis, Volume 2: Spartial measurements and statistics. In ESRI Guide to GIS analysis. ESRI press.

Naif, S. S., Mahmood, D. A., & Al-Jiboori, M. H. (2020). Seasonal normalized difference vegetation index responses to air temperature and precipitation in Baghdad. Open Agriculture, 5(1), 631–637. https://doi.org/10.1515/opag-2020-0065

Nielson, D. (2014). Geographic information systems (GIS): Techniques, applications and technologies. https://novapublishers.com/shop/geographic-information-systems-gis-techniques-applications-and-technologies/

Öztekinci,M.,Coşkun, M., (2021).Yenice Sicak Nokasi:Ekolojisi Ve Sürdürülebilirği(In Turkish), Ankara.

Pereira, L., Allen, R., & Smith, M. (2015). Crop evapotranspiration estimation with FAO56: Past and future. Agricultural Water Management, 147, 4–20. https://doi.org/10.1016/j.agwat.2014.07.031

Purevdorj, T., Tateishi, R., Ishiyama, T., & Honda, Y. (1998). International Journal of Relationships between percent vegetation cover and vegetation indices. International Journal of Remote Sensing, 19(September 2012), 3519–3535.

Rouse, J. W., Haas, R. H., Schell, J. A., Deering, D. W., & others. (1974). Monitoring vegetation systems in the Great Plains with ERTS. NASA Special Publication, 351(1974), 309.

Sakar, M. (2015). Agricultural Development in Sulaymaniyah Governorate in the Kurdistan Region of Iraq (A Geographical Study).(unpublished Phd theses in arabic) of Art in the Department of Geography. Cairo University.

Salomonson, V. V. (1990). The moderate resolution imaging spectrometer (MODIS). 28th Aerospace Sciences Meeting, 1990. https://doi.org/10.2514/6.1990-166

Schott, J. R. (2007). Remote sensing: the image chain approach. Oxford University Press on Demand.

Schowengerdt, R. A. (2007). Remote Sensing, Third Edition: Models and Methods for Image Processing (3rd ed.). https://2u.pw/pBTXh

Seboka, G. N. (2016). Spatial Assessment of NDVI as an indicator of desertification in Ethiopia using remote sensing and GIS (Issue 51).

Sharif, Ibrahim Shalash, A. H. (1985). Soil Geography.

Singh, S. (2018). Understanding the role of slope aspect in shaping the vegetation attributes and soil properties in Montane ecosystems. Tropical Ecology, 59(3), 417–430. www.tropecol.com

Sombroek, W. G., & Antoine, J. (1994). The use of geographic information systems (GIS) in land resources appraisal. Outlook on Agriculture, 23(4), 249–255. https://doi.org/10.1177/003072709402300403

Studies, S., Sciences, B., & Vol, S. (2014). Using The Normalized Difference Vegetation Index (NDVI). 4(36).

Venancio, L. P., Filgueiras, R., da Cunha, F. F., dos Santos Silva, F. C., dos Santos, R. A., & Mantovani, E. C. (2020). Mapping of corn phenological stages using NDVI from OLI and MODIS sensors. Semina:Ciencias Agrarias, 41(5), 1517–1534. https://doi.org/10.5433/1679-0359.2020v41n5p1517

Voute, C. (1982). Remote sensing. ITC Journal, 1982–1, 37–44. https://doi.org/10.1175/amsmonographs-d-16-0015.1

Walker, M., Kadhem, A., Asaady, A., Office, Z., & Almuazm, B.-B. (2018). Climate of Iraq Written by: Deposit number in the Book and Documentation House in Baghdad 244 of 2017 مناخ العراق-ولكر مالكوم تأليف ترجمة أ.د علي عبد الزهرة الوائلي أ.د الوهاب االسدي عبد كاظم رحيم هللا سعد فراس م. https://www.researchgate.net/profile/Miqdam-Chaichan/publication/322665025_Iraq_Environment_Translated_Book/links/5a6781004585159da0d9f158/Iraq-Environment-Translated-Book.pdf

Westen, C. Van. (2013). Remote sensing and GIS for natural hazards assessment and disaster risk management. Treatise on Geomorphology, 3(2004), 259–298. http://www.charim.net/sites/default/files/handbook/datamanagement/3/3.3/Background paper Spatial data for hazard and risk assessment.pdf

Yildiz, H., Mermer, A., Ünal, E., Akbaş, F., & Bitkileri Merkez Araştırma Enstitüsü Müdürlüğü, T. (2012). Türkiye Bitki Örtüsünün NDVI Verileri ile Zamansal ve Mekansal Analizi. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi, 21(2), 50–56. https://dergipark.org.tr/tr/pub/tarbitderg/136983

INTERNET RESOURCES

URL-1 https://bit.ly/3rivxQt Access Date: (15/January/2021).

URL-2 https://bit.ly/3AAiRc2 Access Date: (26/March/2021) .

URL-3 https://bit.ly/3Kdpbua Access Date: (26/may/2021) .

URL-4 https://bit.ly/3A4OmKP Access Date: (11/May/2021).

URL-5 https://go.nasa.gov/3FAxqwN: (16/May/2021).

URL-6 https://go.nasa.gov/3tqHKoV Access Date: (17/January/2021).

URL-7 https://go.nasa.gov/321VmeV Access Date: (27/April/2021).

URL-8 https://go.nasa.gov/33eeHu9 :Access Date: (14/May/2021).

FIGURES LIST

TABLES LIST

SUPPLEMENTARY DATA LIST

CURRICULUM VITAE

Mohammed salam received his elementary education from Abdullah ibn Rawaha School in tuz. He completed his middle school from then the secondary education at Ibn Sina School in Then he obtained his bachelor‟s degree from the Faculty of Arts and Education, Department of applied Geography, Tikrit University in the academic year 2017-2018. study In Turkey in September 2019. Finally, in 2021 he completed master his study at Karabük University, Department of Geography, specializing in Physical Geography.