Study (NDVI) in the Northern Wadi Araba Basin using GIS & RS

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Abstract— **With the significant decline and fluctuation of precipitation in southern Jordan in general, and to estimate the rates of change in the vegetation cover, the vegetation cover index (NDVI) was studied for the northern Wadi Araba basin, and this was generalized to other similar water basins. In order to achieve this, satellite visuals were used through remote sensing RS and analyzed through Geographic Information Systems GIS technology, and the USGS survey site was also used through satellite images taken from the Landsat 5, 7, and 8 satellites. In order to obtain several satellite visuals, it represented three time periods, the first 1987, the second 1998,2002, and the third 2014,2015. After calculating the NDVI and analyzing the satellite visuals, a significant decline was observed in the areas of forests, field crops, and pastures during the period 1987, 2002, and 2015, by rates of 28%, 47%, and 62%, respectively, and with increase in the proportions of barren lands in the basin**.

Index Terms—**Northern Wadi Araba Basin, remote sensing RS, Geographic Information Systems GIS NDVI.**

I. Introduction

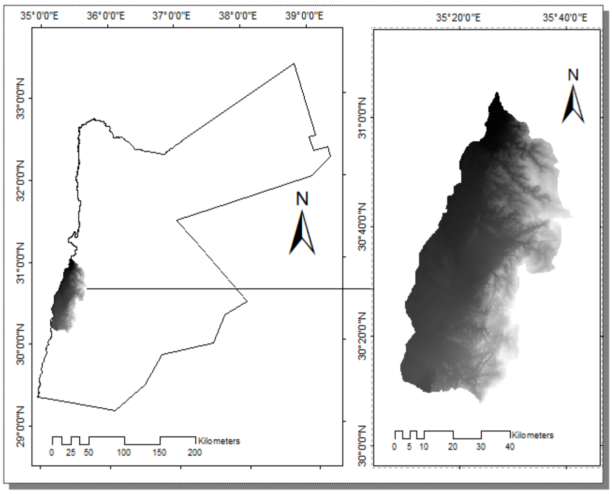
Geographic information systems are used in ever-increasing fields due to their ability to store information, analyze, integrate, display and analyze spatial, social, environmental and economic characteristics. It is also applied in different forms and functions to assessments of potential environmental impact and in all its stages. The use of GIS is not limited to producing maps and preparing reports only, but goes beyond that use due to the great potential for data modeling and analysis. Results, as these stages are done with great speed and accuracy, in addition to its ability to deal with higher levels of detail, thus increasing the accuracy of data processing operations.. It is also possible through GIS to update data continuously through spatial and temporal changes, and different scenarios for potential environmental impacts can be presented. For mining operations, in addition to putting several suggestions and options before the decision maker. Through GIS, it is also possible to display the environmental impact assessment through spatial analysis and three-dimensional analysis. This study seeks to clarify the importance of GIS in all spatial and environmental applications as a tool in environmental impact assessment due to the association of environmental elements.

Environmental systems represent a major challenge in many mines, as erosion of heaps of waste rock due to water runoff resulting from precipitation leads to the transfer of sediment from rock crumbs to other areas that may be far away, and thus mining causes a modification of the morphology of the flow by disrupting the channel and diverting the streams of the flowing streams, and changing the slope as well as changing the properties of its sediment, and this leads to a decrease in the water quality [6] To be taken into consideration during the mining process. The mining of copper and other minerals in the Dana Reserve has been the subject of great controversy between two parties. The first party defends the mining of these important minerals because of their economic impact on the local community and the residents of the region in particular and the Jordanian state in general, while adopting The other team defends the environment and its vital system, which includes a unique biodiversity in the world and the largest natural reserve in Jordan that extends within four vital and climatic regions, on the edge of the Great Rift Valley which is characterized by stunning landscapes and a pure healthy environment that is a pilgrimage for tourists and visitors to enjoy its beauty bewitching

II. Procedure

A. Study area

Jordan contains 12 underground water basins, some of which extend to include lands from neighboring countries. These basins vary in terms of area, storage capacity, annual recharge quantities, and water quality. The lands of the Hashemite Kingdom of Jordan are divided into 15 surface water basins, whose characteristics vary according to the geographical and topographical location, which is reflected in the amounts of precipitation, and thus surface runoff, temperatures and evaporation [10],[11]. Among these surface basins is the northern Wadi Araba basin, which is located south of the Dead Sea, between latitudes 47 30° and 21 21° North and longitudes 57 34° and 36 35° East, as shown in Figure 1. The eastern part of the basin is represented by the mountains of Dana and Shoubak. And Petra, which reaches an altitude of 1734 m above sea level, which is part of the Sharah Mountains. While the western part drops below 400 meters below sea level, forming part of the Wadi Araba region, which is part of the Rift Valley Canyon. In addition to climatic diversity, the Mediterranean basin climate also prevails in the eastern highlands of the basin, where the temperature is moderate in summer, and cold and snow and rain fall in winter, which is reflected in its impact on the vegetation cover in general and pastoralism in particular, and the hot continental climate prevails in the Wadi Araba region.[2],[8].



Figer. 1 : Study area location, source USGS

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This study relies on collecting descriptive data from its primary sources of satellite visuals and cadastral data, and on the analytical approach through analyzing data derived from satellite visuals and topographic maps, studying the meteorological and hydrological elements of the study area and collecting the necessary data from the Meteorological Department, the Ministry of Water and the Ministry of Agriculture. In addition to the use of satellite visuals over different periods of time to know the change in land use, vegetation and land cover. And using the Digital Elevation Model (DEM) to determine the water dividing line of the northern Araba Valley and the subsidiary valleys within it. Finding the area of this basin and the sub-basins emerging within it, calculating the different ranks, knowing the lengths of the waterways, and the lower and upper levels of the sub-basins within it. In addition to calculating the circumference and the river bifurcation of the valleys and their lengths, number and ranks. And the use of the analytical approach for Interpreting and evaluating the data and technical information provided by the previous two phases and converting them into knowledge to make appropriate decisions to determine priorities in this basin, to develop proposals and recommendations to mitigate water pollution. The effects of natural disasters such as floods and droughts [1],[9] Studying and analyzing the satellite images of the study area over 30 years to find out the extent of change in land use and vegetation cover.

B. Technologies and software used in the study

GIS Geographic Information Systems

Through the use of GIS techniques in the hydrological field, the following points can be achieved:

Determine the basin and water division lines for the basin and know the hydrological and hydrogeological characteristics and the processes that occur in the basin from water runoff as well as sedimentation, to evaluate their impact on the changes that may occur in land uses. [1] you submit your final version, after your paper has been accepted, prepare it in two-column format, including figures and tables.

C. Remote Sensing

Remote Sensing was used to obtain satellite visualizations through the USGS visualization viewer. Six satellite visuals from the Rows 39 series and Path174 were downloaded from the Land Sat 5 & 7 & 8 satellites. [4]

D. DEM digital elevation model

The digital elevation model (DEM) represents the digital topographical data of the earth's surface. It is equipped with spatial references containing a single value for the area's height above sea level, according to the geographical coordinate systems WGS84 and the JTM coordinate system[1].

E. ENVI software

The program was used to process the satellite images downloaded from the American Survey Authority website, to classify land uses through a set of operations and procedures, which can be summarized as follows:

1- The satellite images captured on 4/18/2014 & 4/5/2015 & 4/7/2016 from the Landsat 8 satellite were used, and the visual packages were stacked with each other.

2 - Perform a radiometric calibration process within the multi-spectrum and convert it to the Tif extension to deal with it through the arc GIS program

3- Obtaining a multi-spectral satellite image, and cutting off the part that forms the northern Wadi Araba basin.

4- Conducting the Unsupervised Classification process by grouping cells or pixels into groups or clusters according to the distribution of numerical values in the visual after performing the (NDVI) process .

III. METHODOLOGY OF THE STUDY

A. Normalized Defference Vegetation Index (NDVI).

It is a numerical indicator that uses the visible and infrared bands of the electromagnetic spectrum. It analyzes remote sensing calculations and evaluates the land cover to determine and show its vegetation content. The vegetation cover in the stages of active growth absorbs more radiation than the visible spectrum falling on it, and reflects a large part of the infrared radiation. Inactive or withering vegetation reflects more visible spectrum radiation and less infrared radiation. Barren soils reflect moderate proportions of the visible red and infrared rays of the electromagnetic spectrum [3].

And through the electromagnetic spectrum, it is possible to know the behavior of plants from NDVI information and sensitive satellite bands that sense vegetation within the red and infrared bands. It can be calculated by the following equation:

$$NDVI = (NIR-Red)/(NIR+Red)$$

NIR: thermal infrared

Red: red rays

The range for NDVI is 1 to -1 , [5]

Water is represented by extreme negative values. around zero are represented by barren land and values greater than 0.6 are dense vegetation [7]. The following benefits can be achieved from NDVI:

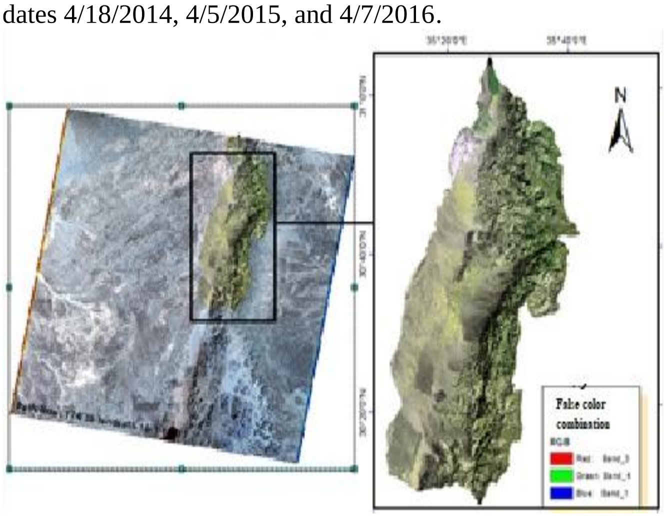
1- Shows the amount of vegetation cover and helps estimate its area, as well as the biomass and the percentage of vegetation cover.

2- Distinguish vegetation from soil and water.

3- Reduces the influence of terrain and atmosphere.

4- It helps in evaluating the cases of change in the vegetation cover because there is a strong correlation between the values of NDVI and the density of the vegetation cover [7]. (NDVI) was extracted from the satellite images captured during the evaluation periods. Band 3 representing the red rays and Band 4 for the thermal infrared rays were chosen to extract the NDVI images captured by 1987 & 1998 and 2002 from the TM & ETM sensors, while Band 4 representing the red rays and Band 5 representing the thermal infrared rays were chosen for the images captured from the OLI sensor of the Landsat 8 satellite.

Satellite visuals, which have become widely available since 1972, provide monitoring of the dynamics of land cover change, whether caused by human activity or urban expansion [13]. Or as a result of purely natural factors such as changing the natural vegetation cover, sand movement, and changing the area of water bodies. Thus, satellite visuals can be relied upon as an effective means for detecting changes in land cover and measuring rates of change. The integration of climatic information with geographic information systems and remote sensing enables the production of maps of the distribution of plants on ecosystems, the Earth's surface shapes, and the vital and climatic conditions. To study the change in the vegetation cover, satellite images from the USGS website were used as follows
1- A satellite image dated 4/24/1987 from the Landsat 5 satellite, Figure 2
2- Two satellite images dated 4/6/1998 and 4/9/2002 from the Landsat 7 satellite Table 1
3- Three satellite images from the Landsat 8 satellite on the dates 4/18/2014, 4/5/2015, and 4/7/2016.



Figer 2: The image captured on 4/24/1987 appears in false color composition

Table 1: The used spectral windows, wavelengths, and verified uses of each spectral window in the satellite image captured by the Landsat 7 satellite.

Spectral bands	Wave length	resolution	uses
Band 1 : blue- green	0.45-0.52	30	bathymetric maps, distinguish soil from vegetation and deciduous trees
Band 2; green	0.52-0.61	30	shows peak vegetation cover, useful for assessing plant growth vigor.
Band 3: red	0.63-0.69	30	shows the state of vegetation
Band 4: Infrared reflex	0.76-0.9	30	shows biomass content and beaches
Band 5: Infrared reflected	1.55-1.75	30	characterizes the moisture content of soil, vegetation, and penetrating light clouds
Band 6: thermal	10.4-12.5	120	useful for heat mapping, soil moisture estimation
Band 7: Infrared reflected	2.08-2.35	30	Useful for mapping hydrothermal, rock-associated mineral deposits
Band 8: panchromatic	0.52-0.9	15	useful in multispectral images

IV. RESULTS AND DISCUSSION

Vegetation during the year 1987

The vegetation cover was studied in the northern Wadi Araba basin, which is characterized by a large variation in atmospheric elements, topography, and bio-cover, through analyzing the satellite image captured on 4-24-1987 Fig. 3. In view of the false color composition, the biological cover is concentrated over the eastern highlands of the basin, and through the use of the NDVI vegetation cover index of the satellite visual captured on the above date, which shows the forests located on the eastern highlands of the basin, in particular the Dana forests in Tafilah and Al-Hishah in the Shoubak, and the trees scattered in the waterways in addition to the irrigated farms within the population centers in the study area and the irrigated cultivations, especially in Wadi Araba, and to track the impact of potential climate change, a part of the Wadi Araba basin was dealt with, which is more than 330 meters above sea level, and because the areas that fall below this level are dry areas. Within 100 mm, it does not show a noticeable change.

From the study of the land cover in this area, the percentage of forest coverage was about 6.1% of the total area of this region, which covers 1308 km². Areas covered by various shrubs, in addition to field crops, accounted for 24.8% of the area of this area, pastures covered 44.9%, and barren lands 24.2%. This reflects the hydrological situation in the basin, and through observation of precipitation during the 1986/1987 rainy season, which amounted to 209 mm, which is less than the general average precipitation in the Shoubak region. And the distribution of precipitation during this season is irregular, as a quarter of the rainy season fell during the month of November, and the rain almost stopped during the months of December and January, and this retention has negative effects on field crops.

During the month of February, the percentage of precipitation was almost a quarter, while it approached half during the month of March. Table 2. This distribution led to an improvement in the pasture situation in the eastern part of the basin. Figures 4 show an increase in the percentage of pastures in the areas located at a hight more than 330 m. The distribution of rainfall during the rainy season has a significant impact on field and pasture crops. Ground recharge is also negatively affected in cases of irregular rainfall during the rainy season. And in the event that precipitation is in the months in which the rate of evaporation increases, the relationship is inverse with groundwater recharge.

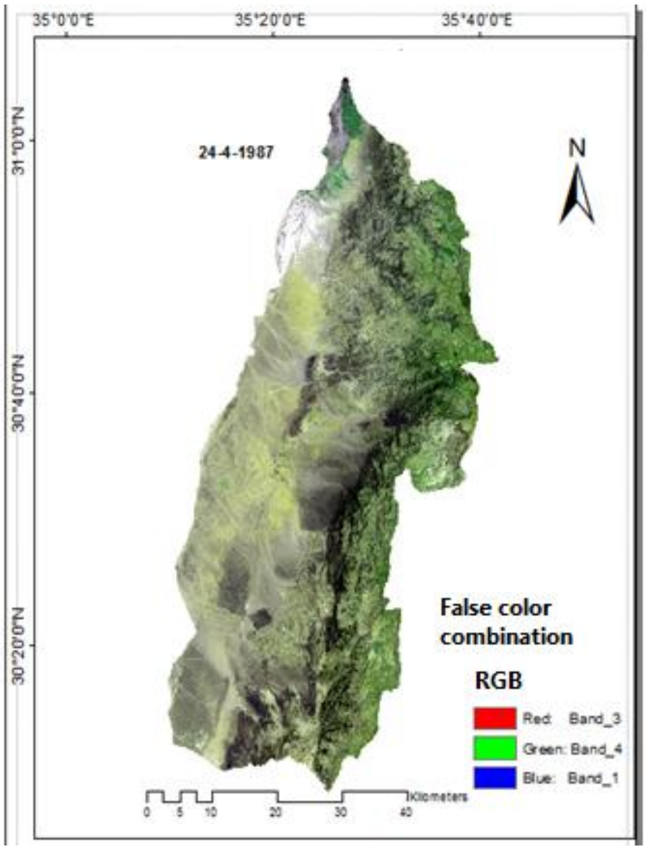


Fig .3 Distribution of vegetation cover through false color composition in the study area - the researcher's work based on (USGS)

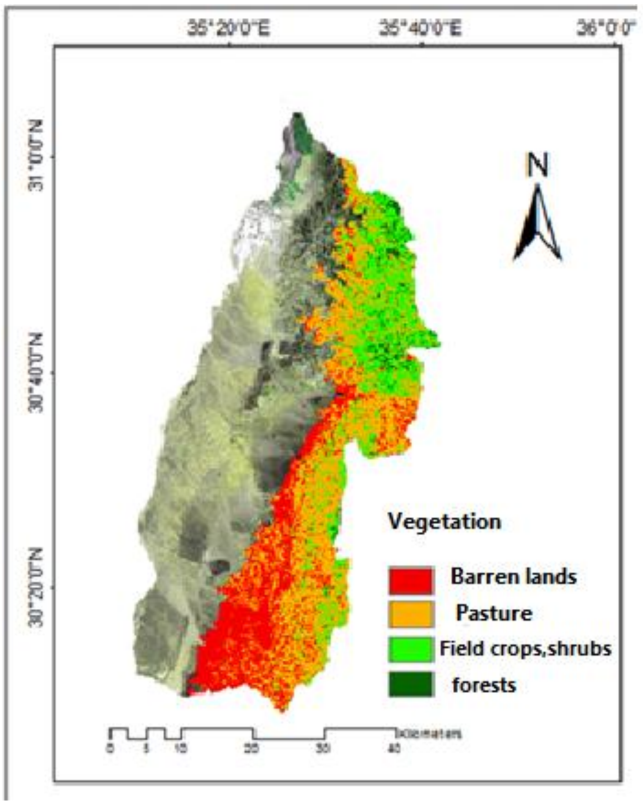


Fig. 4 vegetation cover through NDVI showing the area with an elevation of more than 330 m - the researcher's work based on (USGS) data

Table .2 Average monthly precipitation (mm) during the study years recorded at the Shoubak Meteorological Station

year	Rainfall	October	November	December	January	February	March	April	May
1986/1987	209	0	50.3	14.3	6.9	49.7	88.2	0	0
1997/1998	274	18	0.3	55.7	92.3	56.3	45.3	5.4	0
2001/2002	224	0	20.8	17.7	89.8	63.6	11.6	22	24
2013/2014	189	0	5.8	66.4	14.9	12.2	44.6	0	45
2014/2015	258	11.2	30.9	8.3	91	83.6	14.9	18.6	0
2015/2016	290	43.3	10.8	2.4	43	83.1	63.8	43.9	0

Table.3 percentage of vegetation cover at a hight above 330 m as shown through NDVI

year	Barren lands	Pastures	Field crops and small shrubs	Forests and irrigated crops
1986/1987	24.2%	44.9%	24.8%	6.1%
1997/1998	23.2%	56.4%	17.6%	2.6%
2001/2002	52.1%	28.2%	17%	2.6%
2013/2014	66.8%	21.1%	9.8%	2.3%
2014/2015	52.3%	32.4%	13%	2.3%

Rainfall is seen to be important in Shoubak and Tafilah regions and the eastern heights of the basin in general, where the amount and distribution of snow and rain during the year has a significant impact on the vegetation cover and the hydrological situation in the basin and its impact on surface and groundwater sources. since the largest part of the basin area is located in the western part of the basin it has low rainfall rates to less than 100 mm, and therefore its impact on the hydrology of the basin is limited. The flood water resulting from rainfall on the eastern elevations is the main determinant and important source of water in the western part of the basin, in addition to the base water resulting from the flow of spring water through the valleys spread in the basin. Different types of trees and shrubs grow, and irrigated farms spread in many areas in the basin.

During the second phase of the evaluation, which includes the years 1998 and 2002, and tracked the rainfall rates at Al-Shoubak station and their distribution during the months of precipitation, they were 274.9 mm and 224.5 mm, respectively. The distribution of precipitation during the months of the 1997/1998 rainy season was regular Table 2. It resulted in a clear increase in vegetation cover and a significant increase in irrigated and rainfed field crops, as the vegetation cover appears within the infrared spectrum band and through the false color structure, which shows the significant increase in irrigated crops, field crops, shrubs, and pastures. Rainfall has been distributed in mm/month - according to Data of meteorological stations in Shoubak and Tafila - during the months of December, January, February, March 55, 92, 56, and 45 respectively. This regular distribution of precipitation in these appropriate quantities encouraged farmers to plant field crops and explains the significant increase in these crops Fig 5.

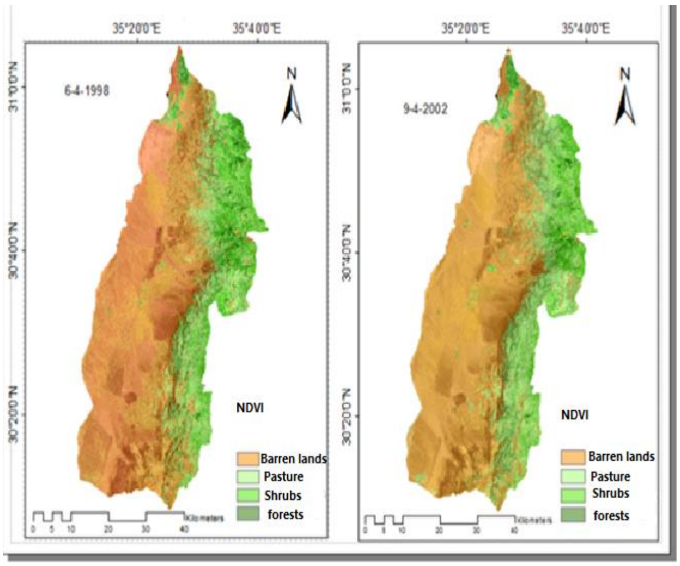


Fig.5 Distribution of vegetation cover as shown by the NDVI vegetation cover index

In order to shed light on the critical area, which is affected by the efficiency of rain and snow, and whose height exceeds 330 m, the percentage of forest cover was 2.6% of the area and the same percentage for the rainy year 2001/2002. It also decreased sharply compared to the percentage of forest cover during the rainy year 1986/1987, which amounted to 6.2% of the area of the region whose altitude exceeds 330 meters.

The percentage of shrub cover and field crops decreased to 17.6% and 17%, respectively, during the two rainy seasons 1997/1998 and 2001/2002. Compared with 24.8% during the rainy season 1986/1987 at Al-Shobak station, despite the regular distribution of rain during the rainy season 1997/1998, there is a cumulative decrease during the previous years, Figure 6. This regular rainfall was also reflected in the pastures, which increased to 56.4% compared to 44.9% during the year 1986/1987.

When studying the rainy situation during the year 2001/2002, the average rainfall was 224.5 mm, distributed over the months of precipitation extending from November 2001 to May 2002, at a rate of approximately 20 mm/month, except for the months of December and February, in which the amount of precipitation reached 90 & 63 mm, respectively. Because of the heterogeneous distribution of precipitation, the amounts of pastures decreased sharply to reach 28% of their area, which rises to more than 330 m in the basin, and the barren lands constitute an increasing rate that exceeds 52%.

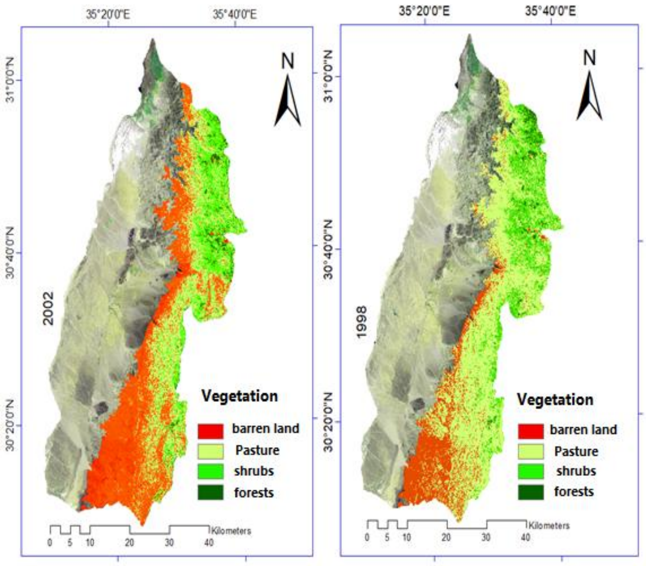


Fig .6 Distribution of vegetation cover as shown by NDVI in the northern Wadi Araba basin higher than 300m

Irregularity in precipitation during the rainy season causes a defect in the growth of vegetation cover, and by looking at the amounts of vegetation cover - forests, irrigated crops, rainfed crops, and pastures - during the third evaluation period, and analyzing three satellite images for the same period in April and tracking the rain situation during These three rainy seasons in which annual and monthly rainfall totals varied. During the rainy season 2015/2016, the amount of rain was 290 mm, but the distribution of vegetation cover according to the NDVI vegetation index was somewhat similar to the vegetation distribution of the rainy season 2013/2014, where the amount of precipitation was 190 mm Fig.7.

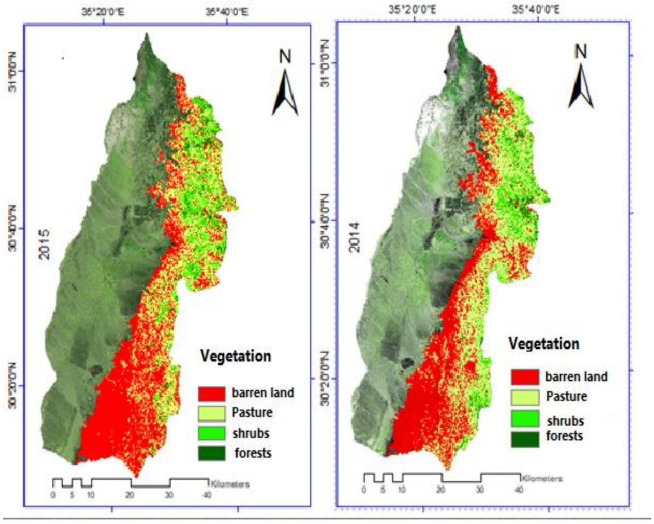


Fig.7 Vegetation distribution during the period 2014, 2015 through NDVI

V. Conclusion

By tracking the monthly totals of rainfall and vegetation cover during the three evaluation periods, we note the following:

1- During the rainy season 2013/2014, 66.4 mm fell, representing a third of the amount of precipitation for this year in December, in Al-Shoubak, which is characterized by extreme cold in the eastern part of the basin, and the high precipitation during December and January enhances opportunities for groundwater recharge, since degrees Heat and solar radiation are as low as possible at this time of the year in this region, and thus evaporation rates are lower and groundwater recharge opportunities are greater, especially if precipitation is in the form of snow.

2- Precipitation concentrated in Shoubak during three months, which are December, March and May, with precipitation amounts of 66.4, 44.6 and 45.6 mm, respectively. This indicates an irregularity in rainfall during the months in which evaporation rates are high, and thus the use of it in groundwater recharge is small, while rain falls during these months over a short period of time, and thus the rate of runoff and evaporation is high.

3- As a result of the irregular distribution of rain during the 2013/2014 rainy season in Al-Shoubak, and about half of it fell during the months of March and May, its impact did not reflect positively on the vegetation cover due to the delay in rainfall during the season, and thus does not help the growth of new vegetation cover, and it negatively affected the pastures. whose percentage decreased in areas with a height of more than 330 m to reach 21% of this region, and the percentage of shrubs and field crops decreased, due to the delay in the onset of precipitation, which leads to the reluctance of farmers to cultivate their lands with rain-fed field crops.

4- There is a sharp decline in the percentage of forests from 6.1% during the first assessment period 1986/1987, decrease to 2.6% during the second assessment period 1997/1998-2001/2002, and to decrease to 2.3% during the third assessment period 2013/2014-2014 / 2015, and this is consistent with the trend of decreasing the average annual amount of rain during the past thirty years 1985-2015

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