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Climate Change and Its Effect on Water and Vegetation Cover Over Shary Region Using GIS Techniques

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Abstract. The purpose of this study, identify and monitor changes that have occurred over land cover for different time periods using remote sensing and GIS techniques by analyzing satellite images for years (1990-2005-2018) to producing maps of water bodies and vegetation cover with studying the impact of climate factors (Temperature, Evaporation, and Rainfall) on them. The climate of study area is characterized by continental characteristics as it is warm, dry in summer, and cool in winter leading to significant differences in land cover in the region, hence the importance of research is to study these climatic elements and how they affected nature of the prevailing land cover. To execute this goal, three satellite images were used in this study, obtained from Landsat 5 - 8 satellites besides monthly average data of some climatic factors that have been adopted from European Centre ECMWF. The Supervised classification technique and spectral indices (NDVI and NDWI) were applied on satellite images using ArcMap10.6. The analysis shows clear changes in land covers during the study period which included changes in soils, vegetation, and water with the climatic factors, where the area of lake and rivers directly changed with rainfall except for the years 2018 was inversely, while inversely changing with temperature and evaporation either the area of grassland and orchards inversely changing with temperature and evaporation except for the years 2018 was directly where its area increases with a decrease in temperature and evaporation this is due to increased soil moisture which helps to germinate the natural grass.

INTRODUCTION

The negative change in climatic characteristics is an important factor directly affected by human activities such as destructive fires, tree cutting, soil erosion, desertification and emitted gases, which historically lead to air and water pollution and depletion of natural resources [1]. Climate change occurs due to different typical climatic conditions, either because of the dynamic processes of the earth or because of the industrial activity of humans, especially after the industrial revolution [2]. In the past decades, Iraq has faced successful waves of drought that have affected the water situation and mainly the water balance of the country, in addition to the great deterioration of the green areas, which has negatively affected water stocks and natural diversity [3]. The study area is considered one of the important areas in Iraq in terms of environment, economic and tourism, due to the exposure of this area during many years to environmental changes, one way to monitor the extent of change in the natural resources of land cover is to use satellite images so that, remote sensing techniques and GIS have been used as tools to follow the environmental changes of land covers - land uses in this region and evaluated, during the period (1990-2018) by classification techniques and spectral indices including Normalized difference Vegetation index, depending on the infrared spectral bands being useful in determining changes in vegetation because the brighter the pixel and the greater the brightness, the more healthy and abundant the amount of vegetation. Several ratios of the red and infrared bands of the satellite

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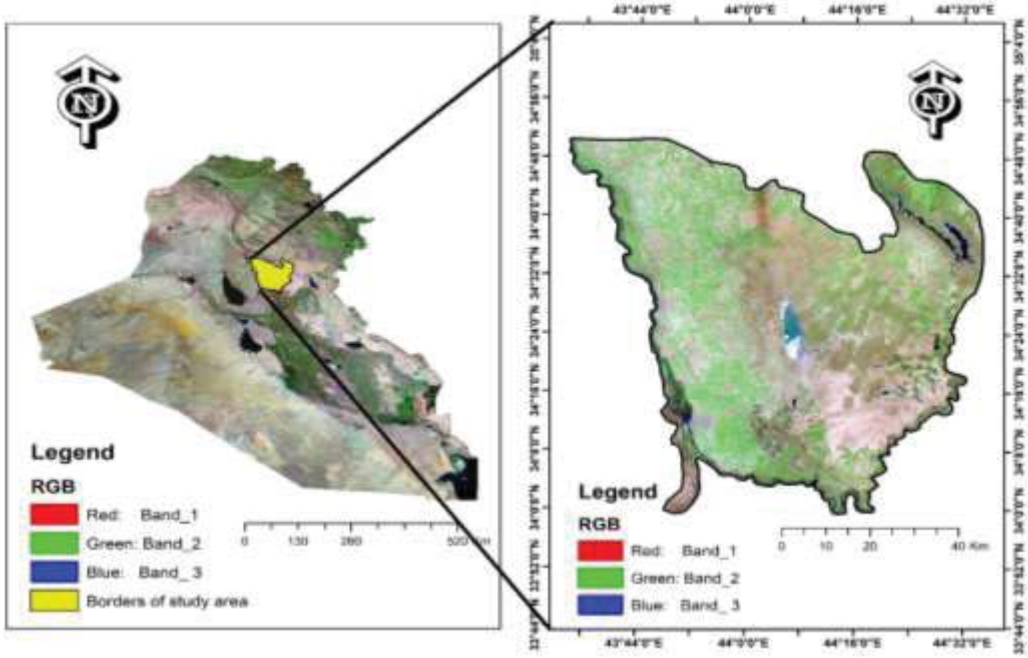
images were created to take advantage of this relationship. NDVI is a product based on the ratio of red and infrared. Because there are few denominations produced with NDVI value rating (-1 - +1). Normalized difference water index was used to diagnosing and determining the water bodies with the same principle (NDVI) where the spectral reflectance of water is high in the green wavelength range and low in the near-infrared range of the NDWI range values from (+1 to -1). Due to the high reflectivity of the plant and soil in the near-infrared range, the NDWI values make positive for water regions and thus appear bright. While green and built-up areas are dark and have negative or zero values.

MATERIALS AND METHODS

Environmental Description of the Study Area

The study area is located in the north of central Iraq and follows the province of Salah al-Din. It is a natural region whose borders are located in the districts of Al-Dur, Samarra, Tikrit and Balad, It is bordered to the north and north-east by the northern Hamrin series, to the west and south by the Tigris River and to the east and southeast by the aleadeam River, The study area occupies an area (5363.4 km2) between 35.00°N and 33.50°N latitudes and 43.40°E and 44.30°E longitudes. The topography of the region is generally flat, interspersed with some valleys such as Wadi al-Sahl, Wadi al-Jammal and Wadi al-Mustaltun. The climatic characteristics of the region vary by location where it characterized by dry climatic conditions, rainfalls in the winter and spring from October to May, and the amount of rain falling on the area varies depending on the location. The average rainfall is between 250-300 mm / year in the area around the Hamrin series while rainfall in the western region to 150 mm / year, with variations in temperature and evaporation during the months of the year [4]. Figure (1) shows the location of the study area from Iraq.



(a) (b)

FIGURE 1. (a) Topographical map of Iraq with boundaries of the study area, (b) the Landsat image with spectral bandles (SWIR, NER-IR and RED) of Shary region shows the prevailing land cover.

Sources Data and Processing

Satellite Data

To following the temporal and spatial variability of the land coverings in study area, three satellite images were used during three time periods during the spring season for the purpose of minimizing the impact of abandoned or uncultivated land and its impact on the value spectral indices such as (NDVI and NDWI). That images taken from

Thematic Mapper (TM 4-5) and Operational Land Imager (OLI-8) sensors of Landsat Satellite adopted from (USGS) website https://earthexplorer.usgs.gov. as illustrated in table (1).

TABLE 1. The characteristics of Landsat image used in this study

ID	Sensors	Path - Row	Band	Spectral Resolution wavelength (µm)	Spatial Resolution (m)	Scene Cover Area (km²)	Acquisition date
1	TM 4-5 Thematic Mapper	169-36	1	0.45-0.52	30		**1990**
			2	0.52-0.60			**2005**
			3	0.63-0.69			
			4	0.76-0.90		185	
			5	1.55-1.75			
			6 Thermal	10.4-12.5	120		
			7	2.08-2.35	30		
2	OLI-8 Operational Land Imager	169-36	1	0.43–0.45	30		**2018**
			2	0.45–0.51			
			3	0.53–0.59			
			4	0.64–0.67			
			5	0.85–0.88			
			6	1.57–1.65	120		
			7	2.11–2.29	30	185	
			8	0.50–0.68	15		
			9	1.36–1.38	30		
			10 Thermal	10.60–11.19	100		
			11 Thermal	11.50–12.51			

Meteorological Data

The climate factor is one of the most influential natural factors in land cover, and its main role in soil composition, variety and fertility, as well as the impact on the stocks of surface water and groundwater. [5]. The most important elements of the climate that affect the vegetation and water cover are the temperature and the amount of rain as well as evaporation, the importance of each of these elements varies from place to place [6]. In this study, the annual mean was used for some climatic variables including (temperature, evaporation and rainfall). This climate information was adopted from European Center (ECMWF). The following table (2) and figure (2) shows the annual mean of climatic factor s during the extended period (1990-2018).

TABLE 2. Annual mean of climatic factors during the extended period (1990-2018)

Month	Temperature(C°)	Evaporation (mm)	Rainfall (mm)
Jan	11.61	69.23	34.51
Feb	12.93	90.74	28.3
Mar	14.20	189.84	29.42
Apr	23.34	235.78	18.32
May	29.25	315.14	6.71
Jun	37.33	398.21	0.1
Jul	37.85	450.96	0
Aug	36.11	432.41	0
Sep	35.27	310.16	0
Oct	27.45	214.31	6.84
Nov	16.56	111.39	30.68
Dec	11.21	74.98	36.47

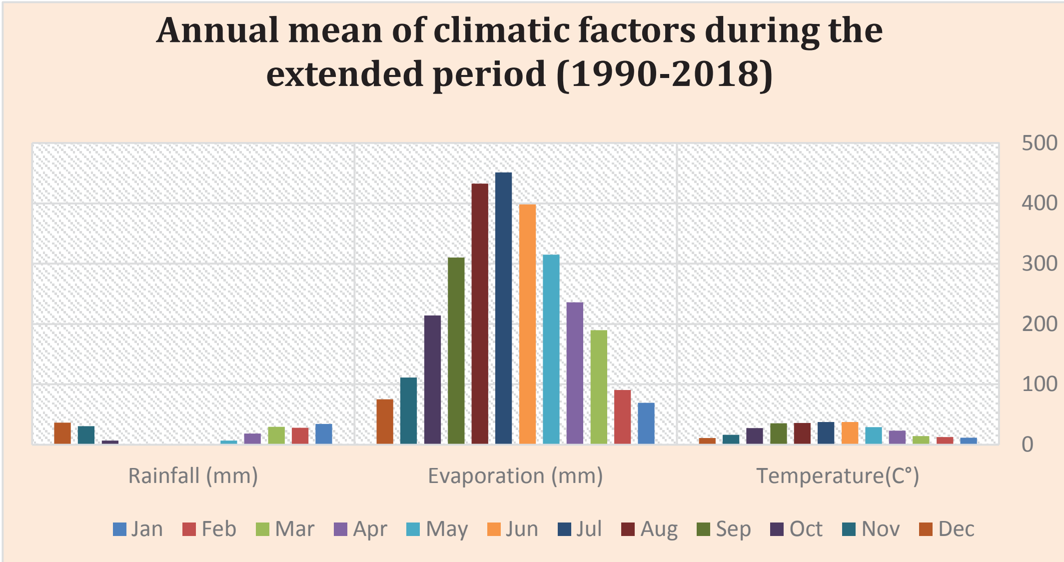


FIGURE 2. Annual mean of climatic factors during the extended period (1990-2018)

Preparing of Satellite Images

The conversion of satellite images from mere images to a clear thematic map accurately reflects the land cover of the study area some image processing and improvement should be performed to facilitate interpretation and classification; these processes was performed using GIS 10.6 as follows:

Geometric Correction

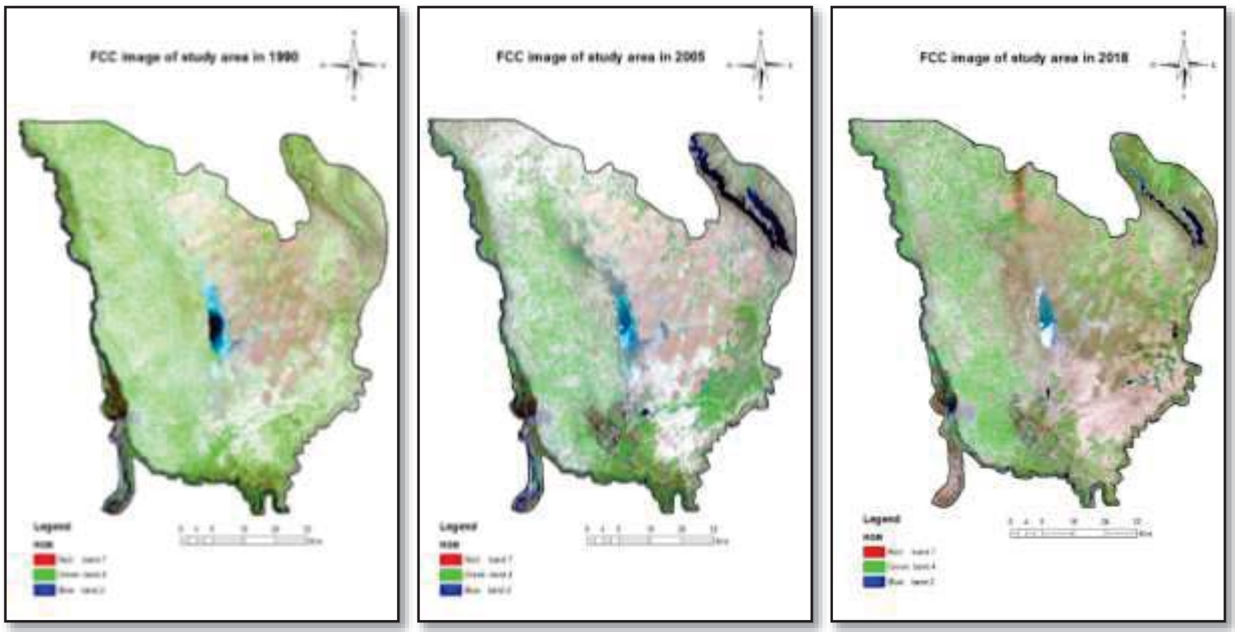
There are distortions caused by Earth curvature and rotation of the earth during the surveying, and these distortions are corrected by connecting the satellite images with ground control points according to known control equations. The basic purpose of engineering corrections is to remove these distortions so that the image is corrected and matched with the map projection system or reference image [7].

Radiometric Correction

The raw satellite images contain radiological distortions, as a result of the change in the speed of the survey, the change in the height of the satellite that carries the sensors, the refraction of the radiation in the atmosphere. These distortions are eliminated by applying mathematical formulas obtained by analysing the sources of these distortions [8].

2-3-3 Building composite images**:**

Building composite images with spectral bands (7,5,3) and (7,4,2) for Landsat-8 and Landsat 4-5 respectively to produce false colour that make the process of interpretation and analysis of images easier by providing many information on the prevailing land cover, where band (2) and band (3) shows the reflectivity of water and soil moisture and band (4) and band (5) shows the reflectivity of the ground cover, either the band provides information on geological and geomorphology. Color composite images (RGB) were obtained as shown in the figures below:



(a) (b) (c)

FIGURE 3. (a) False composite colour image (RGB) of study area in 1990, (b) False composite colour image (RGB) of study area in 2005, (c) False composite colour image (RGB) of study area in 2018

Analysis of Satellite Images

After conducting the processing required by the satellite images, we analyse these images to determine the prevailing land cover and the separation of vegetation and water cover from those covers.

Classification Process

The digital classification in remote sensing is the process of splitting multispectral image cells into classes based on the spectral patterns of these cells, which represent the reflectivity of the earth cover within spectral bands used in terrestrial imaging and then perform the supervised classification using GIS 10.6.

Spectral Indices

In this study, a number of spectral indices were used for the purpose of diagnosing and determining the nature of the land coverings, which reflect some of the manifestations of desertification in the study area. Some of them helped isolate some species from each other with high accuracy [9]. And the most important spectral indices are the following table (3):

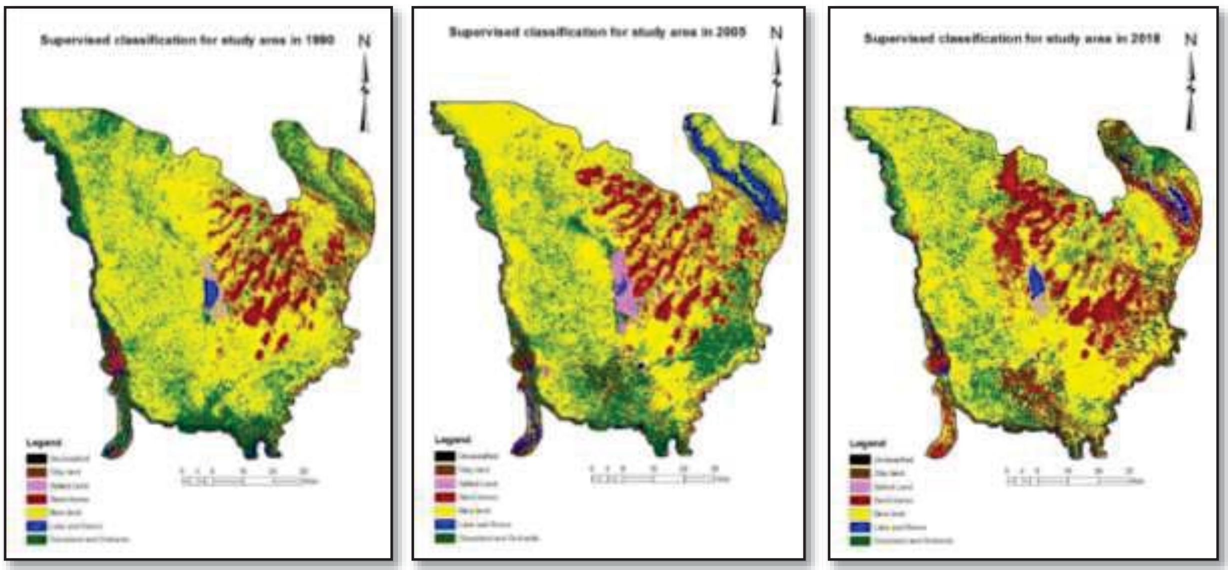
TABLE 3. The spectral indices used in the study

Index	**Full name**	**Formula**
NDVI	Normalized Difference Vegetation Index	NIR - R \ NIR + R
NDWI	Normalized Difference Water Index	Green - NIR / Green + NIR

RESULTS AND DISCUSSION

Results of Supervised Classification

The supervised classification technology has been applied on satellite images using the visual interpretation of satellite images as well as the available field information on the nature of classes within the study area, five classes were identified within the study area representing three types of land coverings, (water, soil, plants) and land were classified into (Grassland and Orchards Lake and Rivers, Bare land, Sand dunes, Salted Land, and Clay land) And shown in figure (4)



(a) (b) (c)

FIGURE 4. (a) supervised classification of study area in 1990, (b) supervised classification of study area in 2005, (c) supervised classification of study area in 2018.

Table 4. Shows the numerical and descriptive results of the supervised classification process.

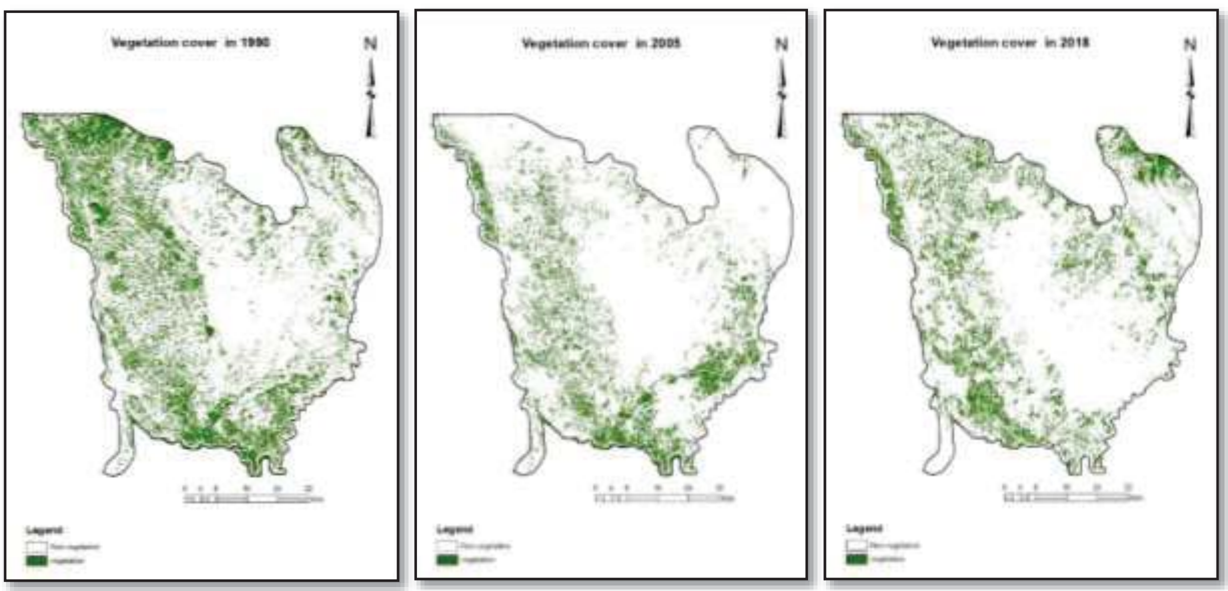
TABLE 4. Areas of land cover extracted from satellite images in (Km^2)

Date of image	Grassland and Orchards	Lake and Rivers	Bare land	Sand dunes	Salted land	Clay land
19/03/1990	1396.7	85.4	3084.9	620.8	94.9	80.7
07/03/2005	1282.5	147.8	2924.2	737.2	185.5	86.2
17/03/2018	1045.7	131.8	2967.9	955.3	61.9	200.9

The results of the supervised classification showed differences in the area of the land cover during the duration of the study, where the area of grassland and orchards formed 1396.7 Km^2 in 1990 and decreased to 1282.5 Km^2 and 1045.7 Km^2 in 2005 and 2018 respectively, this ratio is increasing unless land reclamation is undertaken in the area. The area of lake and rivers formed 85.4 Km^2 in 1990 and increased to 147.8 Km^2 in 2005 and decreased to 131.8 Km^2 in 2018, This percentage depends on the water releases from Turkey and Iran in addition to the amounts of rain falling while the area of bare land, sand dunes and salted land depends on overlap between human and climatic factors, for example, lack of rain causes increased dryness of the soil because it reduces the possibility of growth of some plants, especially that depend on the precipitation and thus increase salinity. The area of clay land which can be cultivable when invested formed 80.7 Km^2 in 1990 and increased to 86.2 Km^2 and 200.9 Km^2 in 2005 and 2018 respectively. It is clear from the above that there is an increase in the area of bare land and salted lands and a decrease in the area of cultivated and water land. So, it can be said that the region is deterioration.

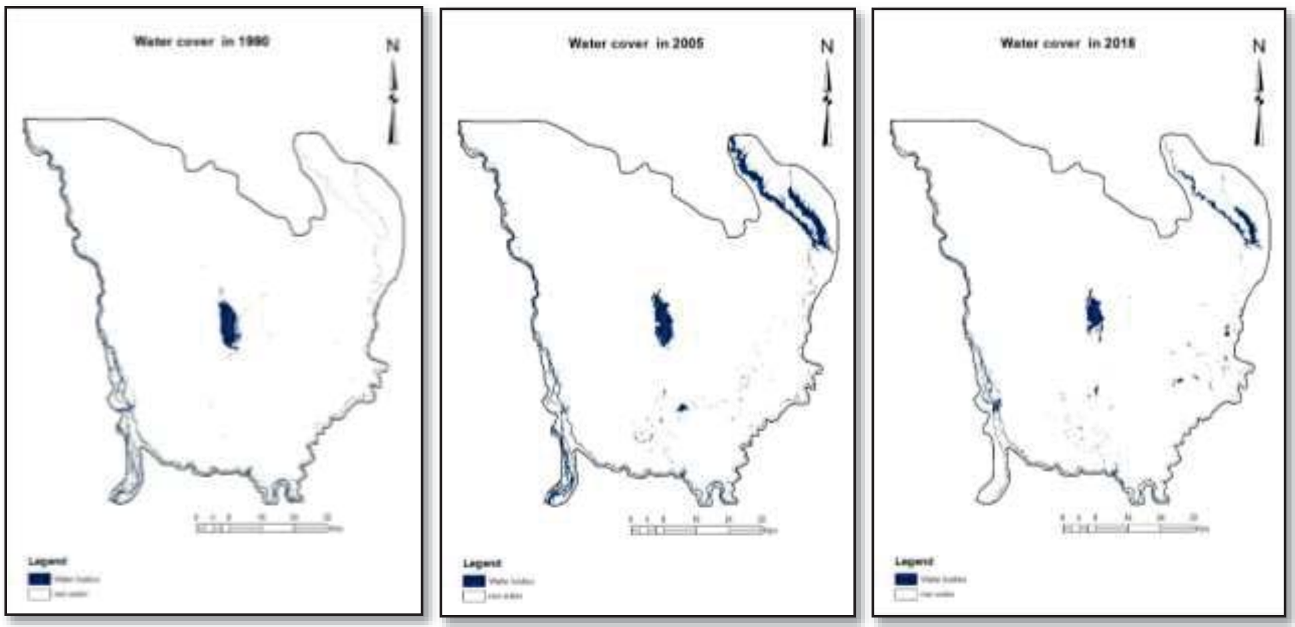
Results of Spectral Indices

Two spectral indices were used to diagnose and identify the types of land coverings prevalent in the study area, which reflect some aspects of desertification represented by both NDVI and NDWI. The values of each guide were calculated according to its own equation, which is included in the data and methods of work, the Normalized Difference Vegetation Index was calculated to diagnosing and determining the vegetation cover which values ranges from (+1 to -1). Negative values are an indicator of deterioration and decline of vegetation in the region, whereas positive values are an indicator of the existence of the vegetation cover. Either the Normalized Difference Water Index to accurately separate water bodies from other land cover and determine its area in the study area also its values range from (+1 to -1). Negative values are an indicator of deterioration and decline of water cover in the region, whereas positive values are an indicator of the existence of the water cover. The results in the following figure (5) and figure (6) show the spatial and temporal variation in the area of NDVI and NDWI.



(a) (b) (c)

FIGURE 5. (a) Spatial distribution of vegetation cover in 1990, (b) Spatial distribution of vegetation cover in 2005, (c) Spatial distribution of vegetation cover in 2018



(a) **(b)** **(c)**

FIGURE 6. (a) Spatial distribution of water cover in 1990, (b) Spatial distribution of water cover in 2005, (c) Spatial distribution of water cover in 2018

The area of vegetation and water cover were calculated in each image taken and the table (5) shows the temporal and spatial variability of area during the years of study.

TABLE 5. Areas of vegetation and water cover extracted from NDVI and NDWI image in (Km^2).

Date of image	Area of vegetation cover in (Km2).	Area of water cover in (Km^2).
19/03/1990	1486.2	93.7
07/03/2005	1392.9	167.3
17/03/2018	1195.3	137.3

The results are shown in table (5) and figures (5 and 6) indicate a variability in the area of vegetation and water cover where the area of vegetation cover formed 1486.2 Km^2 in 1990 then decreased to 1392.9 Km^2 and 1195.3 Km^2 in 2005 and 2018 respectively. This variance the area of vegetation cover is the result of the degradation of agricultural land and its transformation into non-agricultural land, which increases the area of abandoned land as well as increasing the status of urban land. The area of water cover formed 93.7 Km^2 in 1990 and increased to 167.3 Km^2 and decreased to 137.3 Km^2 in 2018 this variance in the area of water cover depends on the water releases from Turkey and Iran in addition to the amounts of rain falling.

The Effect of Climate Factors on Land Covers Types

After the implementation of the classification process, the study area was classified into six types of land cover. The monthly averages of the climatic factors were calculated at the same date of capture the satellite images in order to determine and indicate their effect on the areas of the land coverings, as follows:

A- Temperature:

The figure (7) shows the effect of temperature in the area of land cover as follows:

- The area of grassland and orchards inversely changed with temperature.

- The area of lake and rivers inversely changed with temperature except for the years 2018 was directly.
- The area of bare land directly changed with temperature.
- The area of sand dunes inversely changed with temperature except for the year 2018 was directly.
- There is no relationship between areas of salted land with temperature.
- The area of clay land directly changed with temperature

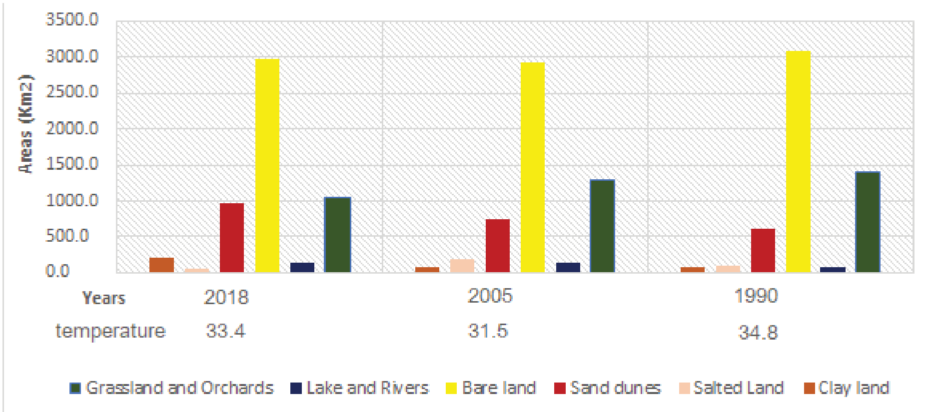


FIGURE 7. change the area of land cover with monthly average of temperature.

B- Evaporation:

The figure (8) shows the effect of evaporation in the area of land cover as follows:

- The area of grassland and orchards inversely changed with evaporation except for the years 2018 was directly.
- The area of lake and rivers inversely changed with evaporation.
- The area of bare land directly changed with evaporation.
- The area of sand dunes directly changed with evaporation except for the year 2018 was inversely.
- There is no relationship between areas of salted land with evaporation.
- The area of clay land inversely changed with evaporation.

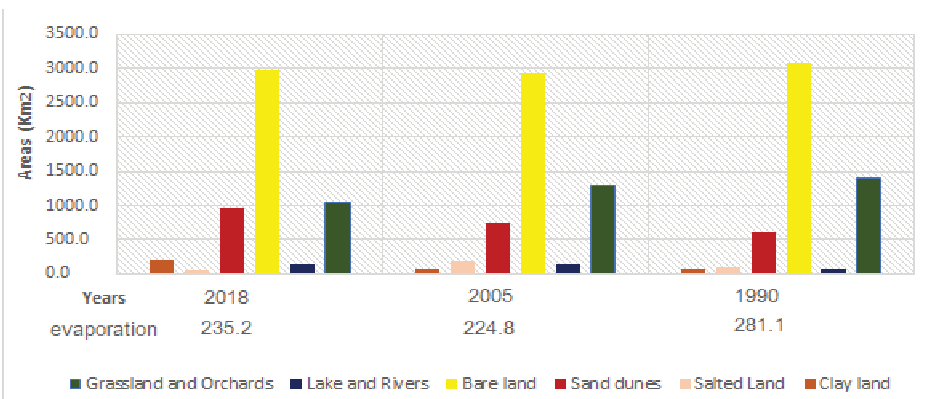


FIGURE 8. change the area of land cover with monthly average of evaporation.

C- Rainfall:

The figure (9) shows the effect of rainfall in the area of land cover as follows:

- The area of grassland and orchards directly changed with rainfall.
- The area of lake and rivers directly changed with rainfall except for the years 2018 was inversely.
- The area of bare land inversely changed with rainfall.

- The area of sand dunes directly changed with rainfall.
- There is no relationship between area of sand dunes with rainfall
- The area of clay land directly changed with rainfall.

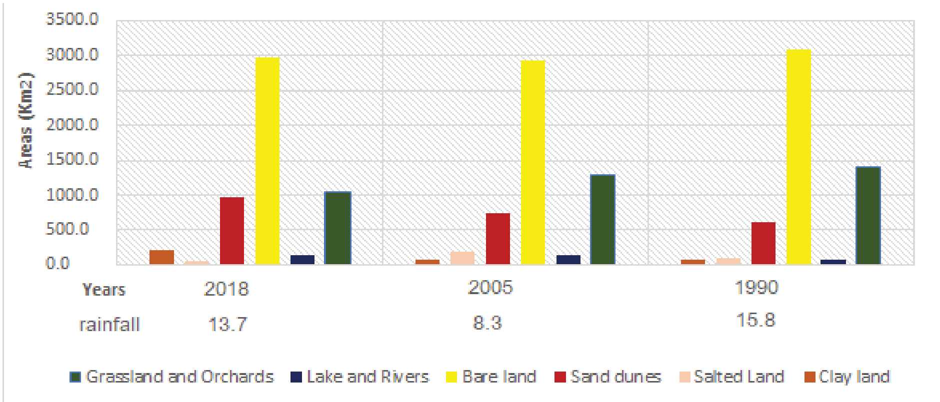


FIGURE 9. change the area of land cover with monthly average of Rainfall.

CONCLUSIONS

- Monitoring and identifying changes in land cover using satellite image classification techniques and spectral indices are important in monitoring changes that occur in land cover and determining the factors that affect them, including climate change.The results of the supervised classification showed differences in the area of the land cover during the duration of the study, where we notice a deterioration in the area of vegetation cover and this ratio is increasing unless land reclamation is undertaken in the area.
- Climatic factors have an effective role in forming sand dunes, especially dry climatic conditions, as most sand dunes are located in areas where a climate prevails, characterized by a long period of drought, lack of rain, high temperatures in summer.
- The area of water cover formed 93.7 Km2 in 1990 and increased to 167.3 Km2 and decreased to 137.3 Km2 in 2018 this variance in the area of water cover depends on the water releases from Turkey and Iran in addition to the amounts of rain falling
- the area of bare land, sand dunes and salted land depends on overlap between human and climatic factors, for example, lack of rain causes increased dryness of the soil because it reduces the possibility of growth of some plants, especially that depend on the precipitation and thus increase salinity.
  The land degradation for the year 2018 compared to the year 2005 is due to several reasons, the most important of which is the presence of modern irrigation methods and innovative agricultural methods, and by making use of thousands of dunums as agricultural fields such as wheat, maize, barley as well as palm orchards, fruit trees and others, not a natural plant such as alhagi maurorum, Schanginia aegyptiaca, and Cressa critica, which we mentioned previously depends on rain and soil moisture in order to it grows with lower temperatures.

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