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Using Remote Sensing Data to Study the Dynamics of Earth's Surface Temperature and its Response to Changes in Land Cover of Iraqi Marshes in the South Using GIS

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Abstract: Temperature levels are a crucial environmental indicator influenced by land cover and continuous changes. Therefore, extraction processes are the most suitable method for deriving Land Surface Temperature (LST). Remote sensing image techniques are used due to their continuous monitoring of the surface. To study the changes in land cover and temperature responses in the marshlands of southern Iraq, multispectral Landsat images from August (1986, 2000, 2014, and 2023) were used to estimate land cover changes and LST responses.

Differences were observed throughout the study period. The year 1986 had the lowest decrease in temperature compared to other years due to the rejuvenation of the area, while the highest increase was in 2000, resulting from forced drying processes in the region. In 2014, the temperatures were better than the previous year due to the return of water to the area. However, in 2023, the temperature increased compared to the previous year due to the closure of water outlets from upstream countries affecting Iraq in general and the study area specifically.

The impact of land cover on cooling and warming in the area depends on the type of cover and its percentage of area.

Keywords: Remote Sensing Data, Iraqi Marshes, GIS, Temperature.

Introduction

The temperature of the Earth's surface is one of the principal elements in the physics of the Earth's surface through its relationship to energy processes and water exchanges with the atmosphere. It represents an essential role in wide applications in water and environmental studies, climate change, and vegetation. Given the importance of this element, interest has increased in developing several methods. To measure surface temperature using remote sensing images, thermal images via satellite provide broad quantitative estimates of surface temperature by recording thermal energy emanating from the Earth's surface within atmospheric windows of the electromagnetic spectrum (1).

Thermal images with different spatial resolutions have been used to calculate the surface temperature, such as images of the moon (Land sat5, Land sat7, Land sat8). The calculation methods vary according to the characteristics of the spectral images and the special parameters for each satellite, as well as the factors related to the atmosphere and the surface. Many improvements have been made to the methods. Calculating the temperature to suit the diversity of the characteristics of the sensors used, and despite the complexity of the process of calculating the temperature via satellite images, it enables obtaining continuous spatial information on the ground about the distribution of temperature over large areas, and with various spatial resolutions.

The problem of study revolves around several questions:

How much has the surface temperature changed over the period (1986-2023)? Does drying have an effect on changing the surface temperature? What is the contribution of land covers (the standard difference index of water, vegetation cover, wetlands, and barren lands) to the surface temperature (2).

Its importance is highlighted by specifying the methodological steps for calculating surface temperature from space data that are not clarified in studies related to the subject, so that it can be a reference guide for similar studies, and that Land sat satellite images provide higher spatial accuracy in the thermal field compared to other satellites, and they are among the space data available to users.

The research aims to measure the surface temperature of the marshes in southern Iraq from remote sensing data, the variation in the effect of the marshes on the surface temperature, and to analyse the relationship between surface temperature and land covers (3).

Analysis the Data used in the study.

The research was based on a set of data, the most important of which was (satellite visualizations). Two space scenes were used that covered the study area for each of the sensor data (TM, ETM+, OLI) returning to the satellites (LAND SAT 5, LAND SAT 7, LAND SAT8). The space visualizations were chosen according to the suitability of the events. Which passed in the region from the natural state to the drying mechanisms and to the recovery operations, reaching the current situation of the region, which changed the hydrological situation, and in addition to that, data from the Ministry of Agriculture and the Department of Planning and Follow-up, the meteorological network of ground stations, for temperature data for agricultural stations in the region.

The marshes in southern Iraq represent a triangle extending from the city of Amara in the northeast, the city of Nasiriyah in the west, and the city of Basra in the south. They represent the alluvial plain and are located astronomically between latitudes (25.30 and 48.31) north and two arcs of longitude (31.46 and 00.48) east.

The satellite visuals were downloaded from the US Geological Society (USGS) website. Two shots from the satellite (LAND SAT 5-7-8) covered the study area. A digital mosaic was made to make it a single image, then several equations were performed on it to reach the research goal through the program (ARC MAP) for the years of study (1986, 2000, 2014 and 2023). Data extracted from satellite visualizations were also compared to those measured in the field at several ground stations to analyse the relationship between air temperature and Earth's surface temperature in the study area.

Extracting temperatures from satellite images

Methodology for extracting LST from Landsat 5, 7 data for the years (1986, 2000) using band 6, which represents the temperature band of the moon and the sensor (TM, ETM+). The extraction was done for these two years according to the information attached to the visual in the meta data file and according to the following equations.

The first step: convert pixel values into radiance.

That is, converting the numerical values of the cells in the image in the thermal field into radiation values according to the following equation.

K2 (LN((K1/(((LMAX_LMIN)/(CAIMAX_CALMIN)) *(B_1) +1LMIN)) +1

The second step: extracting the temperature in Kelvin (4)

According to the following equation

BT=K2/LN (K1/TOAR (first equation of resulting layer**+1**)

The third plan: extracting the temperature in degrees Celsius.

According to the following equation

BT (CELSIUS) =BT _273.15

The methodology for extracting surface temperature from Landsat 8 data, which was used in the year (2014/2023), and the information attached to the metadata file was also used, according to the following equations:

First: Convert digital values into spectral radiation using the equation

TOA=L () =ML*BAND10+AL-oi

Second: Convert the temperature from Kelvin to Celsius using equation (5)

BT=K2/LN (K1/L () +1)-273-15

Third: Calculating the percentage of vegetation cover, which participates in heat emission, where the NDVI index is calculated according to the following equation

NDVI=(NIR-RED) \(NIR+RED)

Which is done by **PV= (NDVI-NDVI MIN) \ (NDVI MIX-NDVI MIN)**

Where min-max represents the vegetation index data for the maximum and minimum values in the image

Fourth: The emission index is calculated in the equation

E=0.004*PV+0.986

As in the figures (1) (2) (3) (4)

Fifth: Calculate LST according to the following equation

LST=PT/1+() *PT/C2) *LN(E))

Classification of land cover according to spectral indicators

Spectral indices use these special properties to derive specific information by applying calculations to at least two different wavelengths to which the feature is particularly sensitive. Most commonly, these calculations are based on the natural difference (A+B) (A-B). Natural indices have been used in processors. digital search

Natural plant indicator

It is one of the digital processors that is useful in detecting plants, which is built on the basis of the relationship between near-infrared rays and red rays, where the reflectivity of plants is high in the near-infrared range and low reflectivity in the visible red range, as it helps in creating the plant index (6), according to the following equation.

$$\boldsymbol{NDVI = \frac{NIR\ Band - R\ Band}{NIR\ Band + R\ Band}}$$

Water Standard Difference Index

This indicator is used to characterize the condition of water bodies on the ground surfaces, as water has a high reflectivity in the visible range of the electromagnetic spectrum and a low reflectivity in the near-infrared rays. Therefore, water appears in a dark colour in the near-infrared images (7), and the result is between (-1 and +1).) and according to the following equation.

$$NDWI = \frac{Band\ Green - Band\ nir}{Band\ Green + Band\ nir}$$

4-2-3-Spectral evidence of humidity

This indicator is used to determine the moisture content of soil and plants. This indicator depends on the wavelengths of near and short infrared rays. The values of the indicator according to the equation range between (-1 and +1), and through it can give a clear picture of the distribution of places exposed to water stress and lack of vegetation according to the following equation.

$$NDMI = \frac{Band\ NIR - Band\ TIR\ INFRARED}{(Band\ NIR + Band\ TIR\ INFRARED)}$$

-2-4-Bare soil indicator

It is defined as land degradation in arid, semi-arid, dry, and semi-arid areas as a result of many factors, including climate change and human activities, to different degrees. The bare soil index in the study area is inferred from the application of mathematical operations, which range between (-1 and +1), through which a clear picture can be given. About the places that are exposed to drought in region (8), according to the following equations.

$$BSI_{LB} = \frac{(Band_6 + Band_4) - (Band_5 + Band_2)}{(Band_5 + Band_4) - (Band_5 + Band_2)} Landsat\ 8\ OLI$$

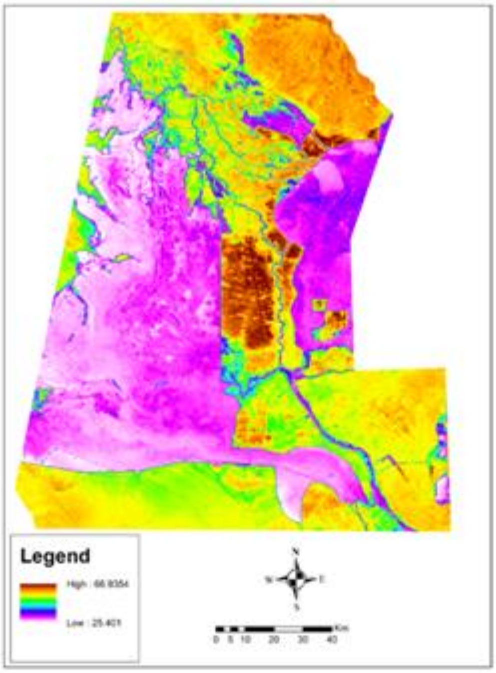
$$BSI_{LS} = \frac{(Band_5 + Band_3) - (Band_4 + Band_1)}{(Band_5 + Band_2) - (Band_4 + Band_1)} Landsat\ 5.7\ TM$$

Discussion and Results:

Analysis of changes in land cover for the period (1986-2023)

After the region was exposed to several changes in its hydrological and climatic environment during the years of the study (1986-2000-2014-2023), these changes were reflected in the nature of the region in terms of the state of drought and recovery that it experienced. The greatest impact of the spectral indicators (BSI NDWI-NDVI_NDMI_) emerged because they It is one of the most important and highly influential covers in the study area. We notice from Table (1) and Figure (6) a clear variation in the area of indicators for the study area. When comparing the ground covers extracted in the study, we find first that the standard water difference index varies from year to year. In the year (1986) The largest area of water coverage in the region was recorded, amounting to (4690 km2), due to the water feeding of the marshes from the outlets of the Tigris and Euphrates rivers due to the high levels of the two rivers and the current drainage of the region, that is, before the mechanisms of forced drying of the marshes, which constituted a percentage amounting to (23%), while in the year (2000) it reached The area for the standard water difference index (282 km2) constituted a percentage of (2%) of the study area. This is due to the fact that the marshes were suffering from water drought, which caused a decrease in the proportion of the water area, its division, and the closure of the water recharge outlets, as the researcher mentioned in the hydrological nutrition characteristics of the study area. Which caused the marshes to dry up completely after that.

Figure (1) Earth's surface temperature in the marshes of southern Iraq in 1986



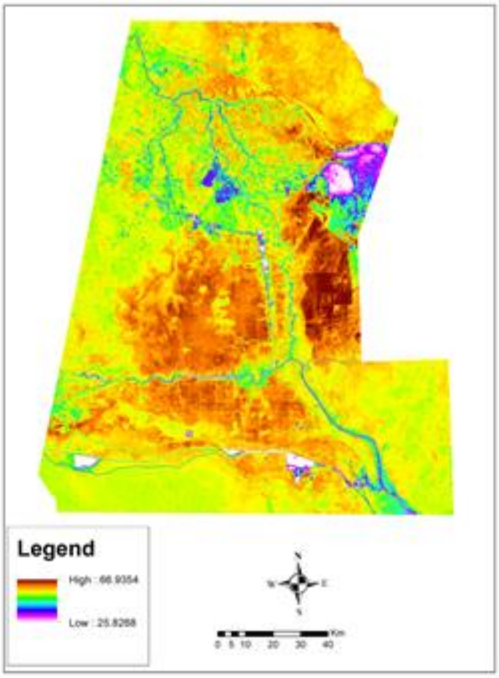
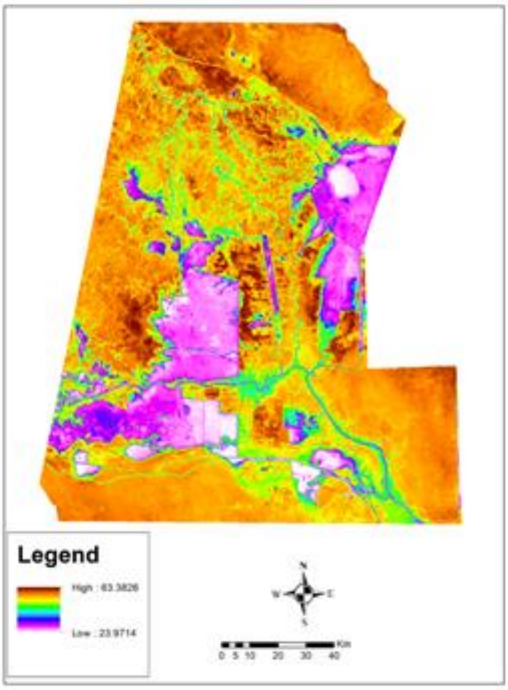


Figure (2) Earth's surface temperature in the marshes of southern Iraq in 2000



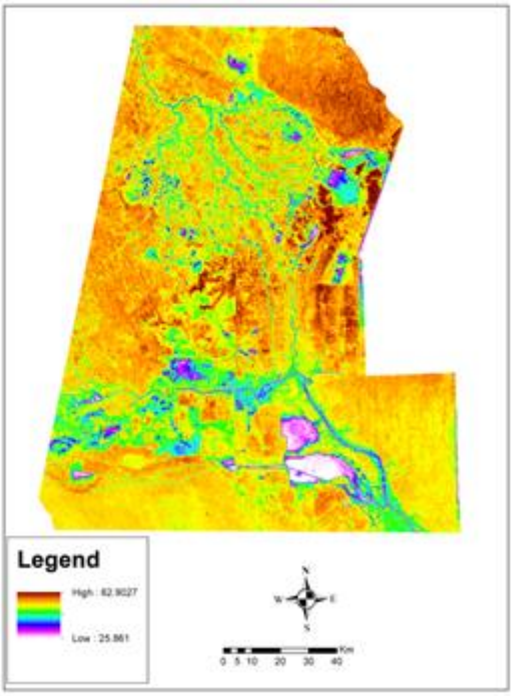


Figure (2): Earth's surface temperature in the marshes of southern Iraq in 2014.

Figure (4) Earth's surface temperature for the marshes of southern Iraq in 2023

Table (1) Area distribution and percentage of land cover in the study area

2023		2014		2000		1986		Item
Ratio %	Area km2	Ratio %	Area km2	Ratio %	Area km2	Ratio %	Area km2	
3	612	9	1904	2	282	23	4690	NDWI Water Standard Difference Index

9	1872	31	6170	6	1263	26	5190	Vegetation Index NDVI
	3014		8074		1545		9880	NDMI soil moisture index
88	17626	60	12036	92	18565	51	10230	BSI Barren Land Index
100	20110	100	20110	100	20110	100	20110	Total Study Area

As for the green cover index of the study area, Najda occupies the largest area and percentage in the year (1986). Its area reached (5190 km2), and its percentage was (26%) as a result of the water nutrition that was prevalent in this year, which helps in the growth and density of natural plants in the region. In the year (2000), we find that the areas of vegetation cover had shrunk from before until they reached (1263 km2) and a percentage of (6%) for the same reasons, which are the forced drying of water in the region, which caused the death of plants, the drying up of agricultural lands, and the drying out of the natural vegetation in the marshes. Consequently, the area of vegetative cover declined as a result of the drought of the soil, and in the year (2014) an increase was recorded in the relative area of natural vegetation, as it constituted a percentage of (31%) in the region as a result of the recovery operations and the return of water in the marshes and swamps, where it reached (6170 km2) and the water returned to the agricultural areas. Which helped in the growth of plants that reached water and the restoration of plant life in the region, while the year (2023) recorded a significant decline in the green cover of the region compared to the previous one, as the area reached (1872 km2). We are heading towards the closure of water sources of nutrition by neighbouring countries on the Tigris and Euphrates rivers, which formed A percentage amounted to (9%), which had a negative impact on the plant life in the region.

The result of this was a significant decrease in the coverage of the vegetation index in the marshes in southern Iraq. When looking at the area of the soil moisture index during the years of study in the marshes, we find that it recorded the highest area in the year (1986), when its area reached (9880 km2), it was the wettest year in the region during the study as a result of water nutrition and the density of natural vegetation, especially reeds and sedges, more compared to other years. On the contrary, the year (2000) recorded the lowest area for the soil moisture index, as its area reached (1545 km2). For the same reasons as the water draining of marshes and swamps, which caused the soil to completely dry and harden, and the lands to crack, thus shrinking their wet area. As for the year (2014), soil moisture increased from the previous year as a result of the return of water to the area after the recovery operations. Water returned to the marshes and helped plants grow. Again, which was reflected in an increase in soil moisture, as its area reached (8074 km2), but in the year 2023, the area of soil moisture returned to decline, reaching (3014 km2) as a result of the current drought that Iraq is suffering from in general and the study area in particular due to the water policy of neighbouring countries. As for the barren lands index in the study area, we find that the lowest area recorded for it was in (1986) because it was a year of recovery in the region as a result of water recharge from the main rivers Tigris, Euphrates, and subsidiary rivers, and the rise in the levels of the two rivers, which works to fill the marshes and swamps with water, and thus plant density and increased soil moisture. It is working to reduce the number of decertified lands in this year, as the area of barren lands in this year reached (10,230 km2), which constituted a percentage of (51%), but in the year (2000) we find it higher than before for the same reasons as the forced drying operations that caused the decrease in the water area in The region, which was reflected in the hardening of the soil and thus increasing the dryness of the land and the desertification of the region. The area of barren lands this year reached (18,565 km2), and a percentage was recorded at (92%). However, in the year (2014), the percentage of decertified lands decreased less than before as a result of the return of nutrition. Water in the marshes due to the recovery operations conducted by the residents of the region at that time, which returned water to the marshes and swamps, as their area (12,036 km2) was swallowed, and its percentage was (60%). However, in the year (2023), the marshes returned to drought, and this is due to the water policy of the neighbouring countries, which It led to the closure of the water supply outlets of the two large rivers, and thus the percentage of barren lands increased, as their percentage reached (88%) in the region, and its area reached (17,626 km2).

Analysis of the change in Earth's surface temperature for the period (1986-2023)

The Earth's surface temperature was extracted using data from range (6) of the Landsat satellite (5-7) of the sensor (TM-ETM+) for both (8/19/1986) and (8/25/2000) and data from range (10,11).) for the Landsat 8 sensor (LIRS) satellite for both (8/16/2014) and (8/17/2023). The upper and lower temperatures were extracted by applying equations in the (ARC MAP GIS) program, as the researchers mentioned in the extraction methodology.

The highest temperature in 1986 was recorded at 66 degrees for the month of August, and the lowest temperature reached 25 degrees, while the average temperature of the Earth's surface at that time reached 39 degrees. In the year 2000, maximum temperatures were recorded at 66 degrees across the thermal range, and a minimum temperature of 25 degrees, while the average temperature reached to 48°, and this difference is due to the reflection of the land covers in the region. In the first period, the marshes had wide water areas and dense vegetation cover, which is reflected in the increase in humidity in the region and the lack of decertified lands, while the reason for its rise in the second period is the drought to which the marshes were exposed, and this is what It is reflected in the death of plants after the water recedes from them, the salinization of the soil, and the increase in barren lands, which show an increase in the bare soil as a result of absorbing and reflecting more amounts of heat, and thus an increase in the temperature of the surfaces. As for the year 2014, a maximum temperature was recorded that reached 63 degrees, and the minimum temperature was 23, and its average temperature was 23 degrees. It reached 36°, and this thermal reflection of the surfaces of the study area is due to the submergence of the marshes with water as a result of lifting the earthen plugs from the dried area and opening nutrient streams on them. Water bodies are the focus of change in the region, so whenever they change, all other types of surface manifestations in the region change with them, whether negatively or positively, as it is. It is known that the drought of water in the year 2000 caused a decline in the area of the marshes in southern Iraq, and the water returned in 2014, thanks to international organizations and the population in the region at that time, to the marshes, which led to the revival of aquatic and plant life in the region. The axis of change returns to the region in the last year of the study, which is the year (2023).

The negative impact on the region as a result of the drought caused by the water policy of neighbouring countries when the water outlets were closed as a result of the dams built by them on the two large rivers, which was subsequently reflected in the dryness of the marshes in the study area. In the month of August, a maximum temperature was recorded that reached 62 degrees, and a minimum surface temperature was recorded. It reached 25, while its average temperature was 37 degrees. The value of the vegetation index was also extracted for the same two last periods, where (NDVI min) refers to the minimum value of NDVI at which pixels are classified as bare, and NDVI max represents the upper limit at which they are classified. The pixel units represent soil covered with plants, and the emissivity of the Earth's surface represents a measure of the effectiveness of the surface in emitting thermal radiation. It is a quantitative assessment of the emissivity of the surface's ability to emit heat via infrared radiation, as in Table (2).

Table (2) The Earth's surface and the standard deviation of temperature.

Years	Standard deviation	Average temperature	Lowest temperature	Highest temperature
1986	7	39	25	66
2000	4	48	25	66

2014	4	36	23	63
2023	2	37	25	62

The maps showed that the lands that had turned into barren areas as a result of the forced drought in the study area had increased in temperature and the marshes turned into barren lands devoid of water and plants, which was reflected in the warming. After the difference in average land covers was calculated for the standard difference index of water, vegetative cover, soil moisture and land. Desertification for several years, after using equations for spectral indicators (treatment) and calculating the area for each indicator on two types.

The marshes, which increased water drainage in the region, but in the year 2023, the surface temperature of the water standard difference index rose until it reached (30). This is a result of the water policy of the upstream countries in recent years. As for the vegetation cover in the region, it also differed during the years of the study as a result of It was affected by the same reasons for the water index, as it recorded a temperature in 1986 of (33), which was the least hot year as a result of hydrological nutrition at that time. As for the year 2000, the temperature of the green cover reached (41), this is due to the drought that caused the death and stiffening of the plant and its transformation to black colour, which was reflected in Consequently, the colour of the soil in the region became darker, which led to a higher absorption of sunlight. The drying mechanisms also led to the deterioration of agricultural lands, which in turn worked to reduce warming in the region. In 2014, its temperature reached (34) as a result of the recovery operations for the residents of the region.

Which brought the plants back to life again, and in 2023 the temperature of the vegetative cover reached (36) as a result of the decrease in the amounts of water coming into the region in particular and Iraq in general, and this had a negative impact on plant life. As for the wetlands index, it recorded a temperature of (31) in the year 1986, which is considered one of the hottest years. Humidity as a result of the state of recovery in the region at that time. As for the year 2000, a temperature was recorded that reached (37). As for the barren lands index, it was recorded in 1986. (45) In the year 2000, it was recorded (49), for the same reasons as the hydrological deterioration of the region, and in 2014, the temperature of the barren lands was recorded (39), and in 2023, it was recorded (38), and after multi-spectral remote sensing data was used to determine the types of land covers. And changes in the temperature of the Earth's surface. It was found that Landsat multispectral images and the maximum likelihood approach accurately extract the spatial patterns of the land cover and their potential implications on the thermal characteristics of the Earth's surface in the study area. The result of the classification of the land covers showed that the water bodies and agricultural lands were normal in the first years.

The study (1986) decreased in the following year of the study (2000) and then recovered again in the year (2014) and returned to drought in the last year of the study (2023) as a result of several political and economic factors and reasons. The study showed that the value of the Earth's surface temperature It varies according to the land cover categories. In bare, bare soil, dead zones, and decertified lands, the radiation temperature increases. The study indicates that the rise in nutrient levels and the return of water to the marsh areas has led to a decrease in the value of radiation temperature as a result of the increase in agricultural land and the growth and density of vegetative cover, which works to reduce Thermal radiation.

Table (3) Difference in average land covers in the study area

2023	**2014**	**2000**	**1986**	Item
medium LST	medium LST	medium LST	medium LST	
30	27	31	29	indicator NDWI
36	34	41	33	indicator N DVI
35	33	37	31	indicator NDMI
38	39	49	45	Indicator BSI

The relationship between air temperature and Earth's surface temperature

After extracting temperatures from satellite visuals of the study area, obtaining the daily temperature (available) from the agricultural stations of the study area, and acquiring the visuals used in the study, the PEARSON correlation law was used to determine the relationship between the two variables (air temperature and land surface temperature (LST)) (9)

$$= \frac{n\sum X_i y_i - \sum X_i \sum y_i}{\sqrt{n\sum X_i^2 - (\sum X_i)^2}\sqrt{n\sum y_i^2 - (\sum y_i)^2}}$$

The proportional area to the type of land cover

After applying the equation to the study area, the thermal contribution (LST) of each type of land cover was determined, and the temperature difference of the area during the study years in the month of August was revealed, which indicates that the depth and abundance of water has a significant impact on thermal reflection and that water is the most important factor in influencing other types. In the region, the drying up of marsh water is reflected in the death of plants, the lack of moisture in the soil, and the increase in the expansion of decertified lands. This explains the high contribution of the temperature of species during the drought period, and thus the high surface temperature of the region as a result of the reflection of the indicators affected by drought, which shows a higher contribution during the years of drought from the study. It was recorded in the year (2000 and 2023) The contributions were greater than other years as a result of the drought situation in the region at that time. However, when the marshes recovered, the thermal contribution was different in the region, which indicates a lower thermal contribution than other years during the year (1986 and 2014).

Conclusions

1. Multispectral remote sensing data from the Landsat series of sensor satellites (TM. ETM+ TLRS) were used. OIL.) In determining land cover changes and the dynamics of the Earth's surface temperature during the period (1986-2023), the study showed that the Earth's surface temperature (LST) varies according to the types of land cover. It decreases in areas of water bodies, vegetation lands, and wetlands in general, while it increases. In the bare, barren soil
2. It became clear that the ma(Ins have a major role in changing the surface temperature of the region, as it was concluded through research that the water cover and vegetation in the region have a major role in the thermal effect, as the thermal contribution of water in 1986 reached (-3.2) and in 2000 the thermal contribution of water reached (In 2014, the water contribution reached (-0.81), and in 2023 it reached (-0.21). As for the contribution of green cover, in 1986 it reached (-1.5), in 2000 it reached (-0.42), and in 2014 it reached (-0.6). In 2023 it reached (-0.09)
3. It became clear through the research that it is possible to extract Earth's surface temperatures from space visualizations, and it became clear that the relationship between the surface temperature extracted from space visualizations and that measured at ground stations is a very strong correlation, as the degree of correlation reached (0.97), which indicates the importance of this mechanism in extraction.

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