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Change Detection of Vegetation Cover by(Ndvi)Technique Using Geographic Information Systems (Gis) and Remote Sensing Technology in the Agricultural Region of Al_Wafra, Southern Part of Kuwait

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Abstract

This study aims to calculate the change detection method used NDVI in vegetation cover of agricultural crops in the Al-Wafra agricultural area using the main index, NDVI - Normalized Difference Vegetation Index. This index was used to measure the area of vegetation cover for field and protected agricultural crops grown under normal sunlight, in addition to measuring the soil-adjusted vegetation index (SAVI) and the transformed difference vegetation index (TNDVI). Al-Wafra agricultural area, located in the southern part of Kuwait, occupies approximately 32,755 hectares. The study used the NDVI index as the main indicator to measure the difference in agricultural land area between 1990 and 2020. The NDVI values (-1:1) in the study area over the 30-year period did not exceed 0.6. The TNDVI index reached 1.25 in 2020, while the SAVI index reached 0.7 in 2020. The annual growth rate of agricultural land area increased to about 7% annually between 1990 and 2020, but the rate varied between agricultural periods. The agricultural land area also varied across the 11 agricultural sectors of the Al-Wafra agricultural area

Keywords: NDVI, TNDVI, SAVI, Remote Sensing, and Growth Coefficients

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Introduction

Agricultural land is considered a strategic asset for nations due to its significant importance in providing food security. The COVID-19 pandemic has highlighted the importance of providing essential agricultural crops for the population, especially after the closure of airports and the disruption of imports. Therefore, the state's attention to the agricultural sector, especially in the Al-Wafra and Al-Abdali regions, has increased.

Al-Wafra agricultural area will be studied as one of the most important agricultural regions in Kuwait using remote sensing technology through the analysis of multi-spectral satellite imagery. This will calculate vegetation index values, including the standardized difference vegetation index (SDVI), which has become a standard for evaluating vegetation cover and crop health. NDVI and similar methods have been used for decades by the National Aeronautics and Space Administration (NASA). The Normalized Difference Vegetation index has become standard for vegetation and crop health assessment NDVI, and NDVI like methods, have been used for decades by the National Aeronautics and Space Administration (NASA).

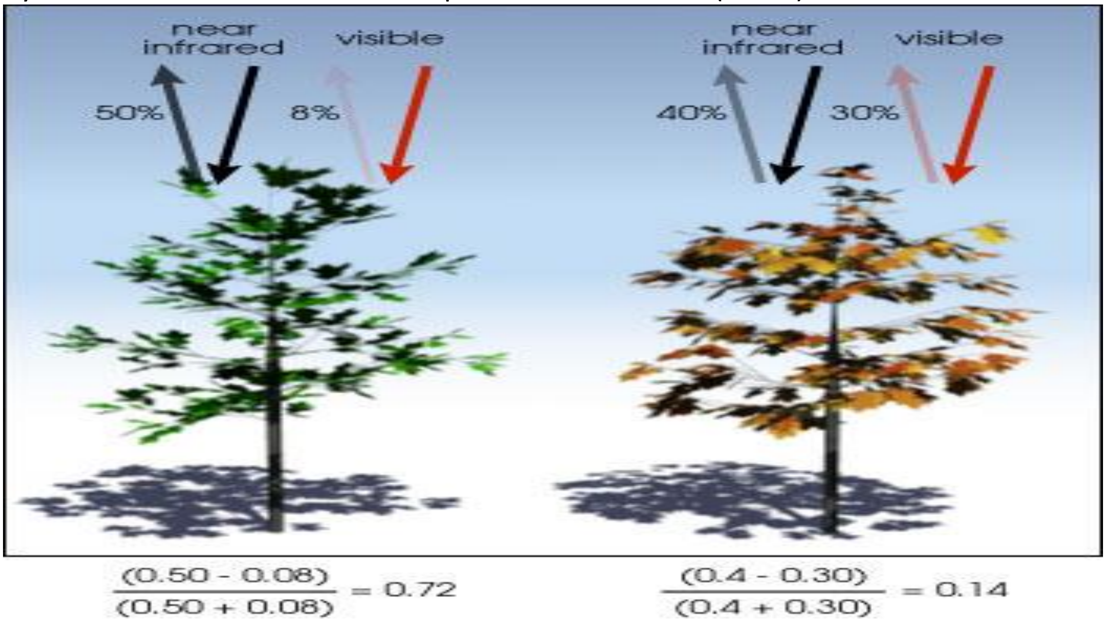


Figure (1): Measuring Vegetation (NDVI) (review: https://1.nasa.gov)

Two additional vegetation indices were used, namely the soil-adjusted vegetation index (SAVI) and the positive transformed difference vegetation index (TNDVI), for vegetation cover analysis. Multi-spectral satellite imagery will be analyzed using the ARCGIS10.7 software to obtain the best results for vegetation index values. The final output values will be converted from raster to vector to facilitate change detection calculations for the study period from 1990 to 2020.

Study Objectives

This study aims to measure changes in vegetation cover of agricultural crops in the Al-Wafra agricultural area using the main indicator, NDVI - Normalized Difference Vegetation Index. This index was used to measure the area of vegetation cover for field and protected agricultural crops grown under normal sunlight, in addition to measuring the soil-adjusted vegetation index (SAVI) and the positive transformed difference vegetation index (TNDVI) for vegetation cover analysis.

Study Significance

1. The novelty of using vegetation indices in studying the Al-Wafra agricultural area."
2. The use of ARCGIS 10.7 software for satellite imagery analysis and map production.
3. The use of SENTINEL-2 and LANDSAT (5,7,8) satellites, and applying vegetation index equations with different band ranges to calculate vegetation index values.

NAME OF BAND	LANDSATE (5,7)	LANDSAT8	SENTENIL2
RED	3	4	4
NIRINFRARED	4	5	8

Previous Studies

Several studies have addressed vegetation indices, particularly the Normalized Difference Vegetation Index (NDVI), which is considered one of the most important indicators for calculating changes in vegetation cover using geographic information systems, especially the ARCGIS 10.6 software. The researcher also benefited from studies comparing satellite reflectance, including the following key studies:

Studies that targeted vegetation cover indices:

The use of the Normalized Difference Vegetation Index (NDVI) as a plant indicator can be traced back to Tuecker and Miller (1979), who developed an index to distinguish between plants and soil. This index is based on excluding the soil effect on the total plant reflectance. Heute's study (1988) was a qualitative leap in the field of plant and soil discrimination, as he improved the NDVI index developed by Tuecker by adding a constant value to the result of the Tuecker index. This was done to improve the exclusion of the soil effect on plant clarity in areas with sparse vegetation cover, and the resulting index was called the Soil Adjusted Vegetation Index (SAVI).

In the study by Mohamed El-Khazami Aziz (2007) on the effect of spatial variation on the ability to distinguish between plants and soil in Landsat imagery, a cartographic study was conducted on five models (Faleka Island, Al-Salimiya area, Al-Sulibiya area, Al-Wafra farms, and the Burgan oil field). The researcher relied on distinguishing between plants and soil through the analysis of Landsat 5 (TM) satellite imagery from February 1998, which represents the highest vegetation growth period. The Babd Composer (spectral composite 4, 3, 2) was used.

Marina, Nastsija, and Grajic (2017) utilized remote sensing and satellite imagery (Landsat 8, Sentinel 2) in the field of agriculture to detect chlorophyll quantity in crops, measure water quantity, detect pests, and create maps of vegetation cover indicators (NDVI, TNDVI, EVI2, GNDVI). Zuzana, Frantisek, and Jan (2007) classified vegetation cover and distinguished between mountainous herbaceous plants through aerial image analysis from 1960 to 2006 using the NDVI vegetation cover index. Igor, Victoria, Marlin, and Anna (2016) found that urbanization and urban areas lead to increased pollution and destruction of vegetation cover compared to the tundra forest areas. They studied vegetation cover in 28 urban areas over a 15-

year period from 2000 to 2014 and found that the NDVI index decreased in modern urban areas, while vegetation cover recovered in older areas.

In a study by NASA (2019), the objective was to train methods for finding plant indicators to determine plant health through the electromagnetic spectrum reflections of plants that absorb near-infrared radiation, which can only be seen through satellite imagery. The study was applied to Cambodia, analyzing vegetation cover from 2000 to 2015 using satellite images from Landsat 7, Landsat 8.

Clement and Prasad (2017) also presented a study aimed at comparing three different satellite sensors (Landsat 8, Landsat 7, Sentinel 2) to determine the NDVI vegetation cover index using different spectral bands from each sensor. They developed an equation for the NDVI index for each satellite sensor and applied it to Australia.

Methodology:

The researcher followed a systematic approach to study a specific topic, which is the change in vegetation cover area from 1990 to 2020, using several methods to address the study area. The applied methodology involved studying vegetation cover in the study area and highlighting the changes that occurred in the development of vegetation cover area in the Al-Wafra agricultural region.

Study Method:

- **The Cartographic Method**

The cartographic method was used to analyze satellite imagery and calculate the standard difference vegetation indices (NDVI, SAVI, and TNDVI) from 1990 to 2020 in the study area to determine changes in vegetation cover density. Several satellite images from different satellites and multiple years were processed, including Landsat 4, Landsat 5, Landsat 7, Landsat 8, and Sentinel 2, accessed through the USGS.gov website. Different equations were used to analyze the satellite imagery and calculate vegetation indices. The final maps were created using geographic information system software, with ArcGIS 10.7 and AutoCAD 2018 being some of the primary software used in the analysis.

- **The Quantitative method**

The study heavily relies on quantitative methods in data processing, including the use of mathematical equations to calculate vegetation indices and statistical analysis to determine the extent of changes that occurred in the vegetation cover in the study area from 1990 to 2020.

- **Data Presentation**

The data is presented in the form of maps resulting from satellite imagery analysis using ArcGIS 10.7 software and graphical figures illustrating the development of vegetation cover areas and values of various vegetation indices created from data analysis tables in Excel and ArcGIS software. Finally, a written text is used to evaluate the data and display the results achieved in meeting the study's objectives.

Study Terminology

- **NDVI**
- NDVI is calculated from the visible and near-infrared high reflected by vegetation The satellite sensors in light absorbed and reflected by green plants

(Kikita Marwha,2020)

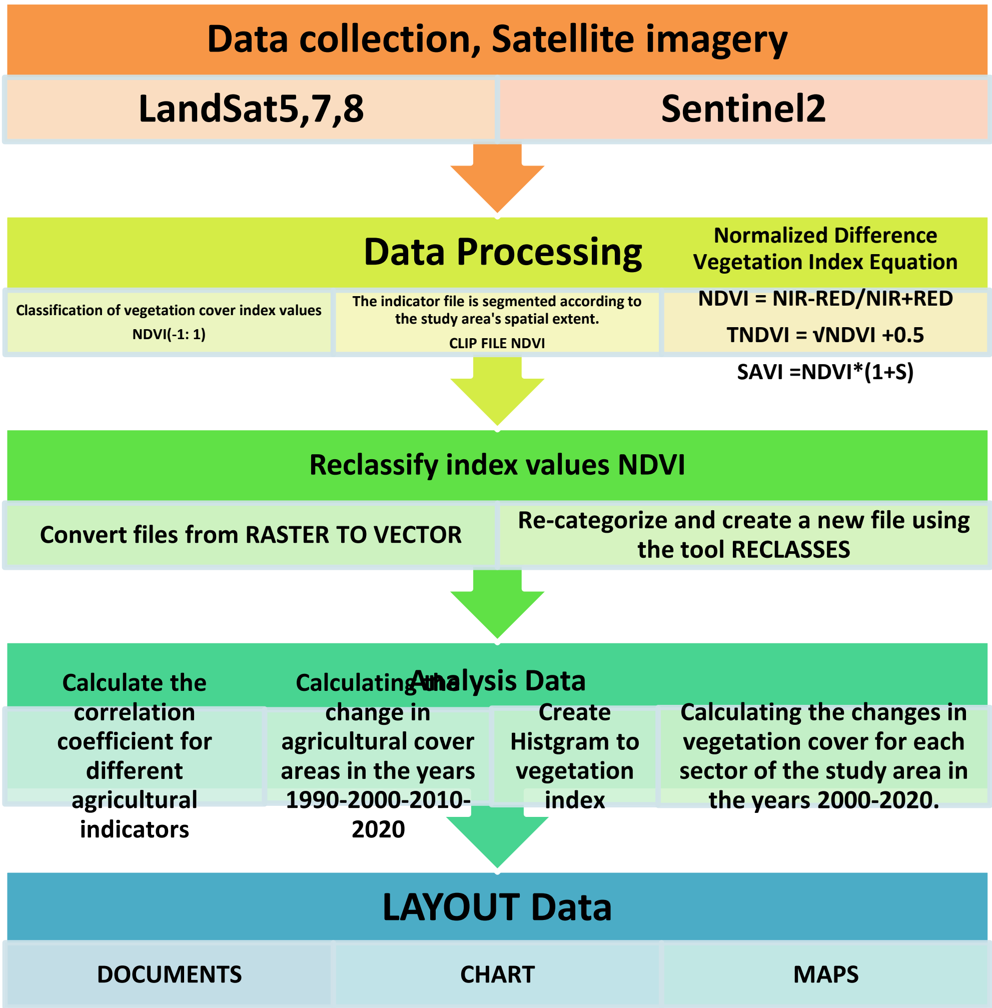
- **TNDVI**

Transformed Normalized Difference Vegetation Index is designed to have a higher coefficient of decisiveness which is the only difference between NDVI and itself (Research es Review DGTH, 2018).

Converting the standard difference index of vegetation to obtain a higher body coefficient, which is the only difference between the NDVI and the same. In this indicator all numbers are positive and negative numbers disappear.

- **SAVI**

This index works to calculate vegetation differences in addition to soil reflectance, which includes the reflected portion of plant leaves and part of the soil (Haifa Ahmed Al-Mohammed et al., 2018).



Study Region

The study area is located in the agricultural area of Al-Wafra in the southern part of Kuwait, between latitudes 01° 36' 28" N and 00° 37' 28" N, and longitudes 49° 50' 47" E and 59° 09' 48" E (Figure 2). It is approximately 45 km west of the Arabian Gulf coast. Al-Wafra is situated in the southernmost part of Kuwait and is only 6 km north of the Kuwaiti-Saudi border. The total area of Al-Wafra is estimated to be 32,755

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hectares, and it is divided into 11 sectors with varying agricultural land areas in each sector (Figure 2).

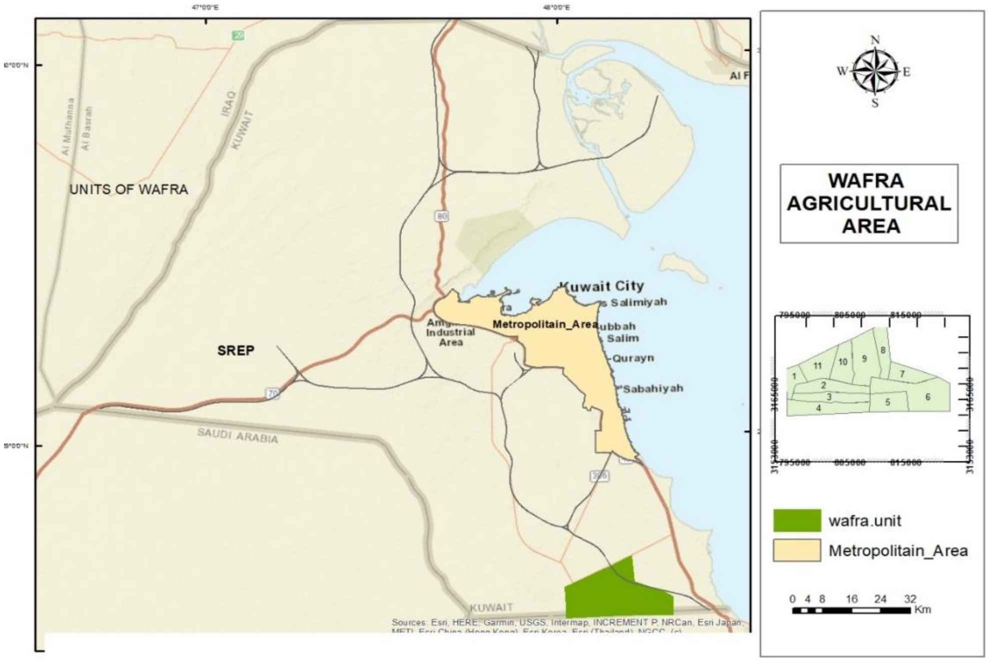


Figure (2): (Source: The researcher from the base maps of ArcGIS 10.3 and the Al-Wafra area from maps of the Public Authority for Agriculture Affairs and Fish Resources - Agricultural Plots Department (modified AutoCAD map)

Data Source

Satellite imagery was obtained from The USGS Earth Explorer website, including LandSat4, LandSat5, LandSat7, LandSat8, and Sentinel2 satellites. The data obtained from the satellite imagery was processed using ArcGIS 10.3 software to calculate the Normalized Difference Vegetation Index (NDVI).

Table (1): Landsat and sentinel2 images for both study areas

Year	Satellite	Sensors	Path/Row	Date	Number of Band
1990	Land Sat4	TM	165/40	12/6/1990	5
1995	Land Sat5	TM	165/40	8/10/1995	5
2000	Land Sat5	TM	165/40	21/10/2000	7
2010	Land Sat7	ETM	165/40	9/10/2010	7
2015	Land Sat8	UTM	165/40	15/10/2015	11
2020	sentinel2	UTM	EPSG Code 32639/72432	7/4/2020	13

Several equations were used to process the data and extract the values of the agricultural indicators.

Table (2) NDVI From NIR Infrared and RED Band

Year	Satellite	Formula
1990	Land Sat4	NDVI= (Band4-Band3)/(Band4+Band3)
2000	Land Sat5	NDVI= (Band4-Band3)/(Band4+Band3)
2010	Land Sat7	NDVI= (Band4-Band3)/(Band4+Band3)
2020	sentinel2	NDVI= (Band8-Band4)/(Band8+Band4)

NDVI - SAVI vegetation indices equations

Vegetation index	satellite	Formula
TNDVI	Land Sat sentinel2	(Sqrt (NDVI+0.5))
SAVI	Land Sat sentinel2	(NDVI*(1+S)
S= Soil Adjustment Factor (s (land sat =0.5)(sentinel2 =0.2)		
The growth coefficient GARG was used, where GARG = (Year 1 / Year n) ^(1/Period) = *(GARG = end/ start) ^ (1/periods		

After spatial data analysis of satellite imagery using ArcGIS 10.7 software, the study results showed that NDVI is calculated from the visible and near-infrared light reflected by vegetation, with different spectral fingerprints of green plants on the sensors of various satellite sensors (Kikita Marwha, 2020). The NDVI values range from 1 to -1, as shown in Tables 1 and 2.

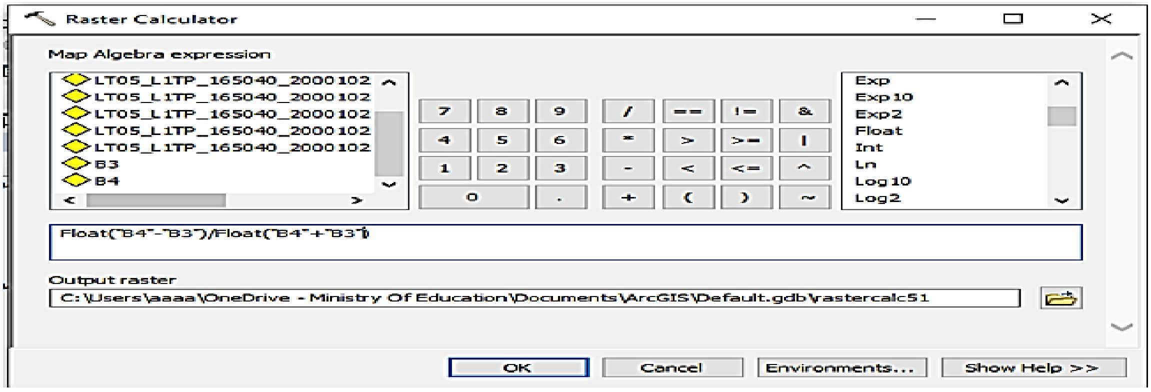
Processing NDVI requires separating the bands in satellite imagery taken from various remote sensing satellites with multiple spectra, and the value of the vegetation cover index varies, with values ranging from 0.1 to 1 (Merra Gandhi.G, et al., 2015).

NDVI indicators for the Al-Wafra region have shown values not exceeding 0.6 in different years, including the year 2020, for both cultivated and protected vegetation. The NDVI vegetation index sensor measures the absorption of chlorophyll in leaves (which gives them their green color) and uses the absorbed light in the process of photosynthesis. The NDVI sensor measures the reflection of light at two wavelengths, red and near-infrared (NIR). Chlorophyll absorbs most of the red wavelength (less reflection) and reflects most of the near-infrared wavelength. Low NDVI values indicate that chlorophyll absorbs less red light relatively. The decrease in NDVI values in protected agriculture in the study area depends on the type of protection. The most important specifications of protected greenhouse cover in the Al-Wafra region include:

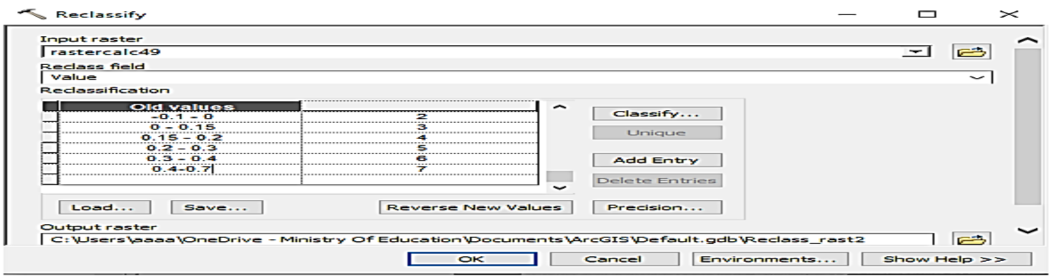
1. Plastic with a thickness of no less than 180-200 microns, characterized by light transmittance of 85-95%, resistance to ultraviolet rays, and lower transmittance for infrared rays to prevent loss of acquired heat at night.
2. Fiber glass: with light transmittance of 80-92%, resistance to cold and heat (40-140°C), and higher transmittance for the visible spectrum.

3. Glass: with lower transmittance for ultraviolet rays and higher transmittance for visible light (more than 90%) (public authority of agriculture affairs & fish resources

TOOLBOX → Spatial Analysis → Map Algebra → Raster calculator



TOOLBOX → Spatial Analysis → Reclass → Reclassify



were as follows:

The values of the vegetation indices were extracted using the equation in Table 2, and we observed differences in the index values from 1990 to 2020. The correlation coefficients for the NDVI-SAVI-TNDVI vegetation indices ranged from (0.97, 1, 0.96) in the periods (1990-2000), (2000-2010), and (2010-2020) in the study area, respectively. This indicates that the correlation coefficients are strong between the three indices. Therefore, we find that there is agreement with the graphical representation number (4) of the development of vegetation indices from 1990 to 2020.

The maps resulting from the vegetation cover indices and the corresponding histograms indicate differences in the standard deviation for each index of the vegetation indices from 1990 to 2020. The chart of the values of the vegetation indices shows an increase in the value of the vegetation cover reflection, where the standard deviation value increased from 0.06 in 1990 to 0.08 in 2020. Additionally, the average value of the NDVI vegetation index increased from -0.15 in 1990 to 0.10 in 2020.

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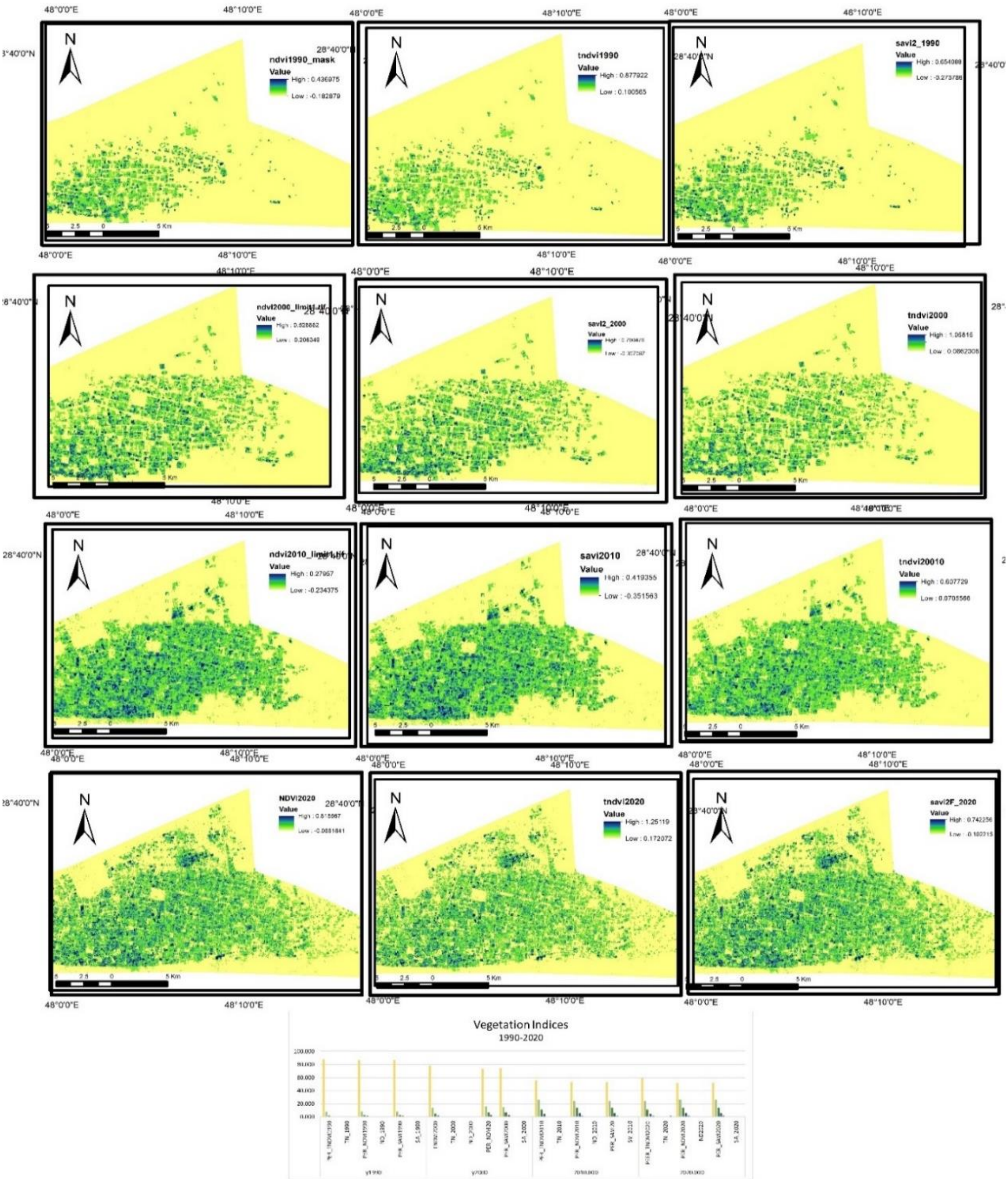


Figure (3): Visual representation of vegetation indices during the period from 1990 to 2020

VEGETATION INDICES (Histogram, Min, Max, Mean, Std. deviation)

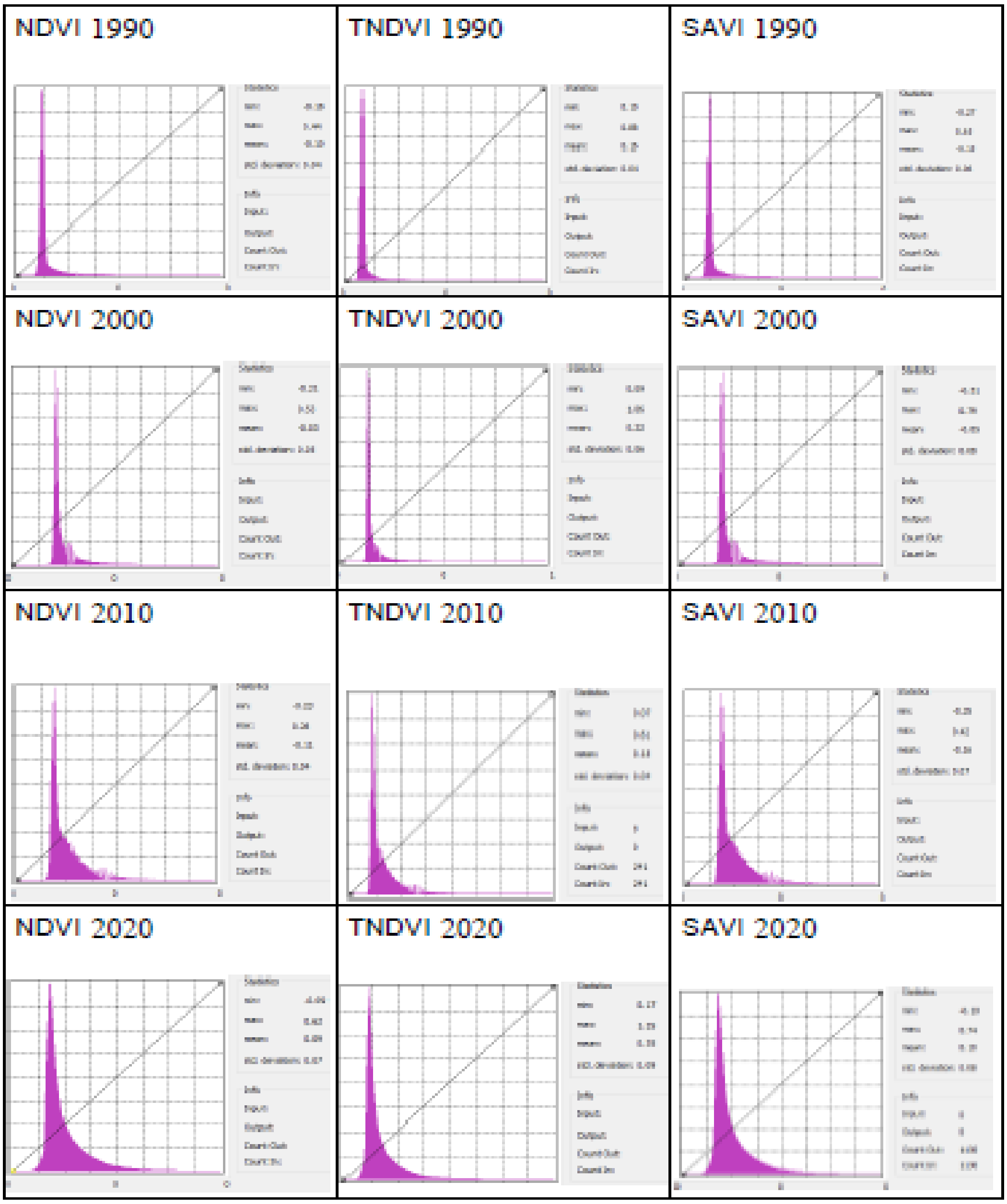


Figure (4): Vegetation Indices

Table (3) vegetation indices during the period from 1990 to 2020

Years	NDVI		TNDVI		SAVI	
	High	Low	High	Low	High	Low
1990	0.44	-0.18	0.8779	0.1	0.655	-0.2743
2000	0.53	-0.21	1.0582	0.1	0.79	-0.3071
2010	0.28	-0.23	0.6077	0.1	0.419	-0.3516
2020	0.62	-0.09	1.2512	0.2	0.742	-0.1022

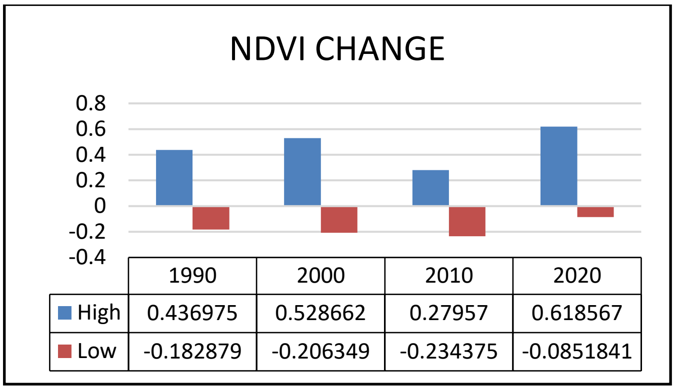


Figure (5)

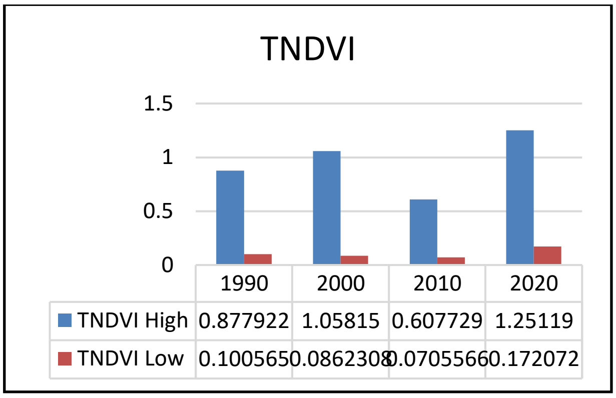
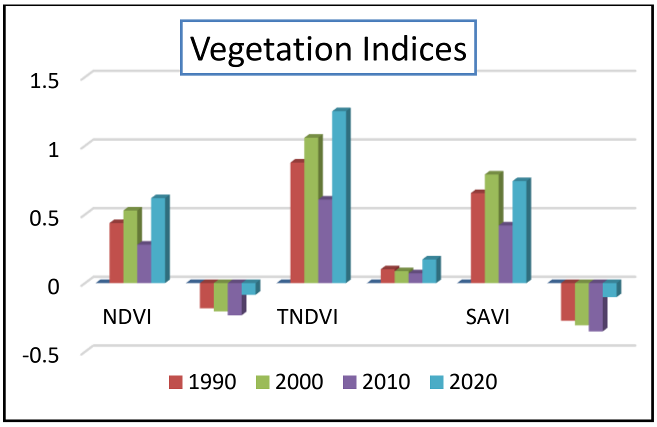


Figure (6)



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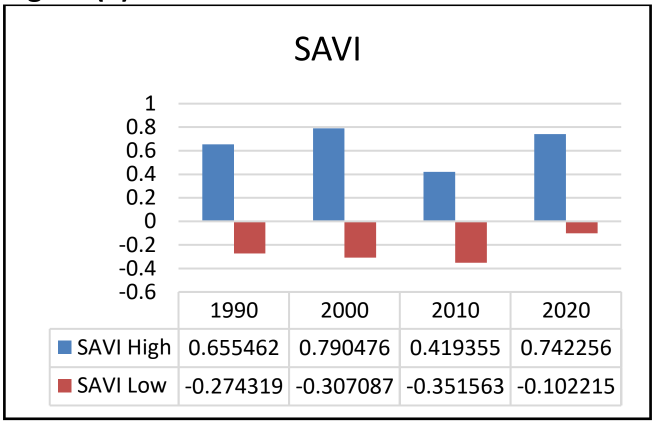


Figure (8)

It is evident from figures (5, 6, 7, 8) and Table (3) that:

Firstly, the results of the NDVI vegetation index values

The results of the NDVI vegetation index values showed a significant difference in vegetation cover in the study area. The lowest value was around -0.18 in 1990, and the highest value was 0.4, while the NDVI vegetation index reached 0.5 in 2000, indicating an increase in vegetation cover density during this period. However, the index decreased in 2010, reaching a value of -0.23 to 0.28. The decrease in the index during this year can be attributed to several reasons, the most important of which is the spread of agricultural protection zones. The low NDVI values indicate that chlorophyll absorbs less red light relatively, and the decrease in NDVI values in protected agriculture can be observed in satellite imagery, as we explained earlier. Then, the index increased again in 2020, reaching a value of 0.6. The increase in the vegetation index is due to an increase in the area of agricultural land in the study area, with differences in the spatial resolution of satellite imagery.

Secondly, the results of the TNDVI vegetation index values

The results of the TNDVI vegetation index values, which have positive values, differ from the main NDVI index. TNDVI values are calculated by taking the square root of the NDVI vegetation index value multiplied by 0.5. The highest TNDVI values ranged from 0.1005 in 1990 to 1.058 in 2000, then decreased in 2010 to 0.607 and then increased again to 1.25 in 2020.

The results of the SAVI vegetation index values showed values that are close to the NDVI vegetation index values, but with a slight increase. The increase in SAVI values is due to its calculation of both the soil reflectance and vegetation differences. The SAVI range was (-0.273 to 0.654) in 1990, then increased in 2000 to (-0.307 to 0.79), then decreased again in 2010 to (-0.35 to 0.419), and then increased in 2020 to (-0.1022 to 0.74).

By analyzing satellite imagery and calculating the development of vegetation cover areas from 1990 to 2020, maps were created to show the development of vegetation cover in the Al-Wafra agricultural area.

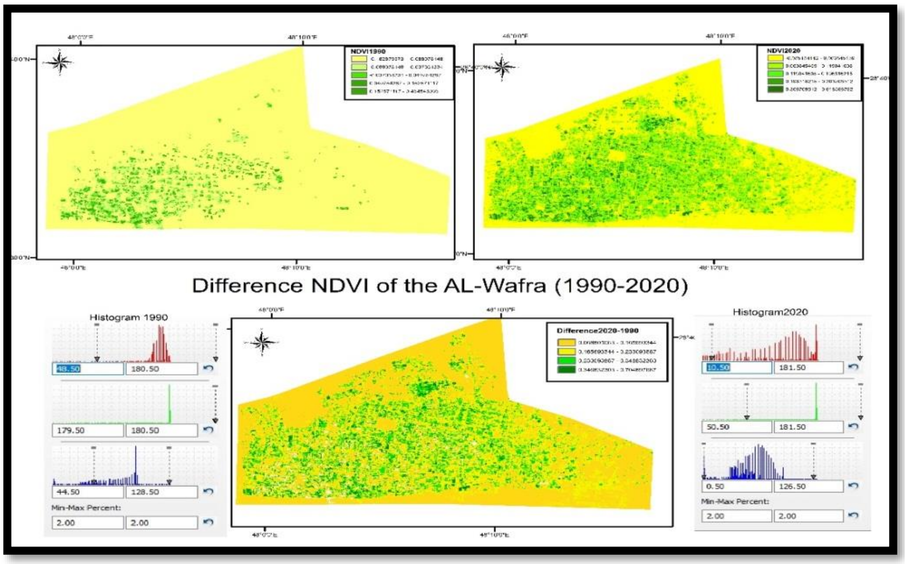


Figure (9)

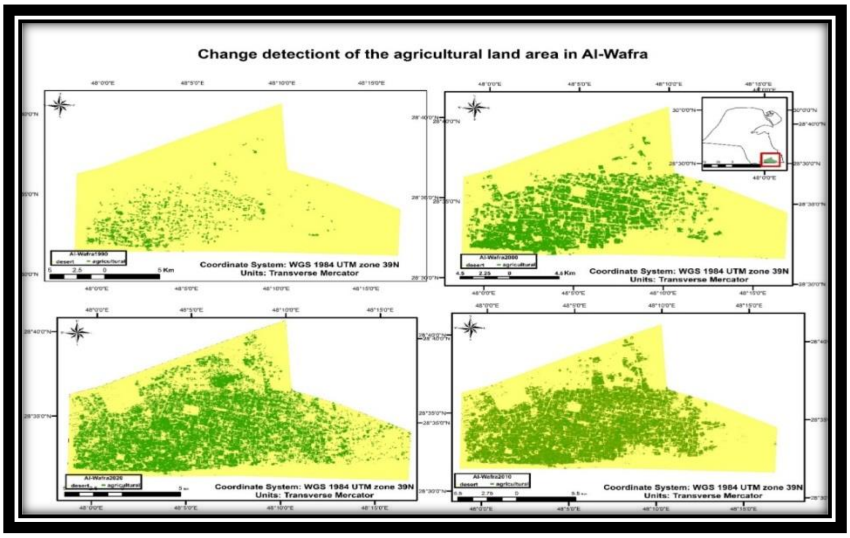
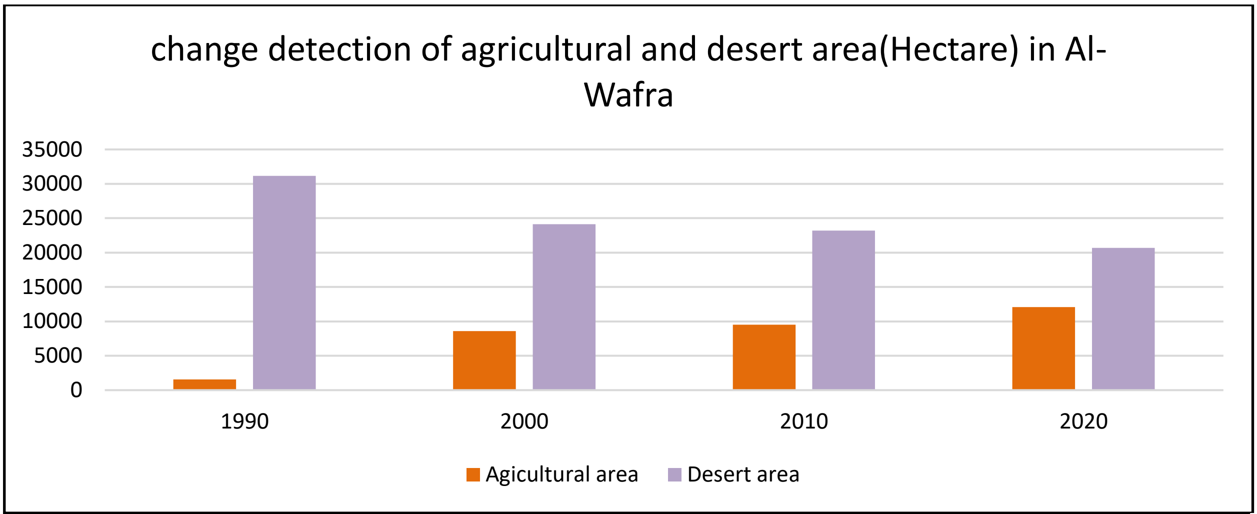


Figure (10)

Table (4) change detection of agricultural from 1990 : 2020

Year	Agricultural area	Desert area	%Agriculture	%Desert	change%
1990	1570	31178	5.0%	95.0%	
2000	8604	24141	26.0%	74.0%	19%
2010	9536	23209	29.0%	71.0%	1%
2020	12074	20669	37.0%	63.0%	2%



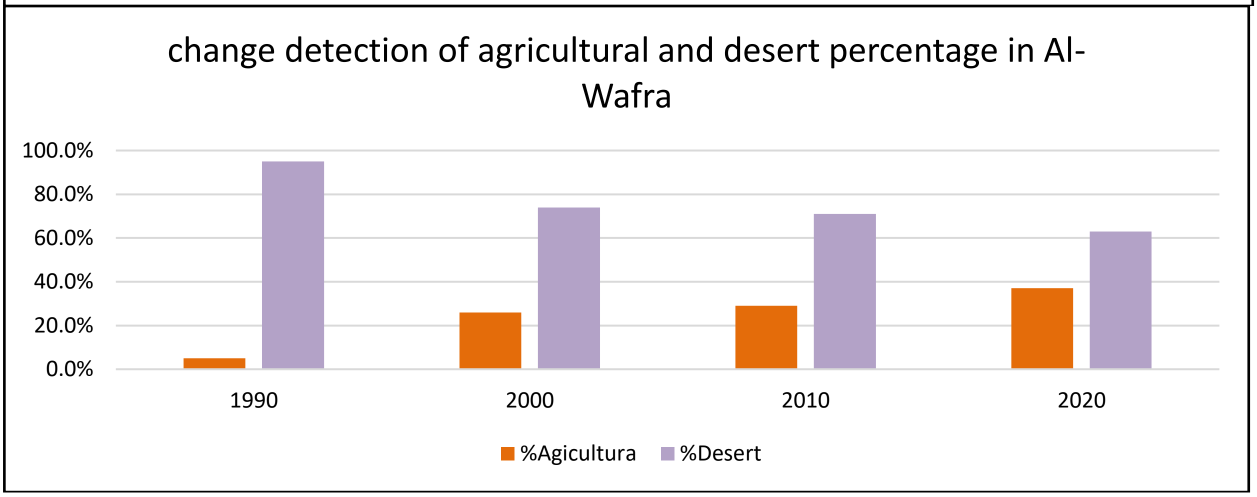


Figure (11)

It is evident from Table (4) and Figures (9, 10, 11) that:

1. The agricultural land area in the Al-Wafra area increased from 1570 hectares, which is approximately 5% of the total area in 1990, to 12074 hectares, which is approximately 37% of the total area in 2020.
2. The agricultural land area for crops in the Al-Wafra area increased from 1570 hectares in 1990 to 8604 hectares in 2000 with an annual growth rate of 19%.
3. The agricultural land area in the Al-Wafra area increased from 8604 hectares in 2000 to 9536 hectares in 2010 with an annual growth rate of 1% during this period.

4. The agricultural land area in the Al-Wafra area increased from 9536 hectares in 2010 to 12074 hectares in 2020 with an annual growth rate of 2% during this period.

Table (5) Percentage of agricultural land area in the agricultural sectors of the Wafra region

AL-Wafrah Units	Area	2000	2020
1	37802994	5%	27%
2	27731277	29%	67%
3	24169067	37%	68%
4	27598385	33%	46%
5	22086149	4%	27%
6	39373097	7%	26%
7	25069309	8%	27%
8	21646703	5%	18%
9	44241948	14%	44%
10	24141555	14%	39%
11	37802994	5%	19%

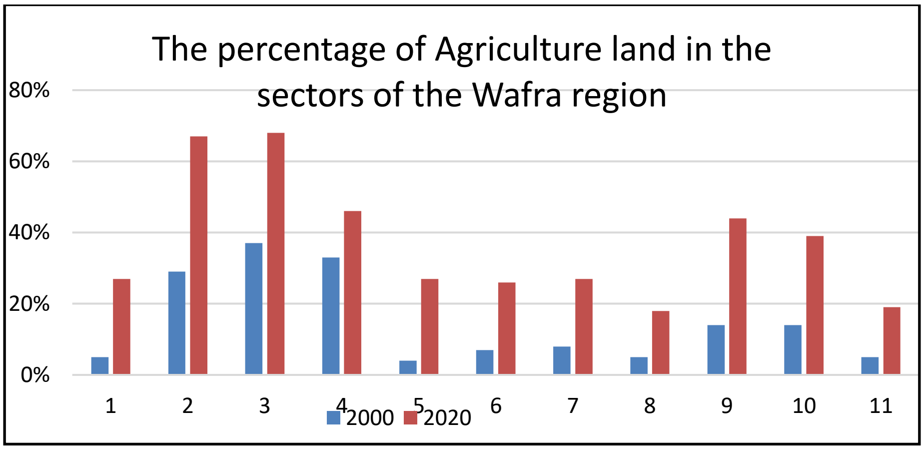
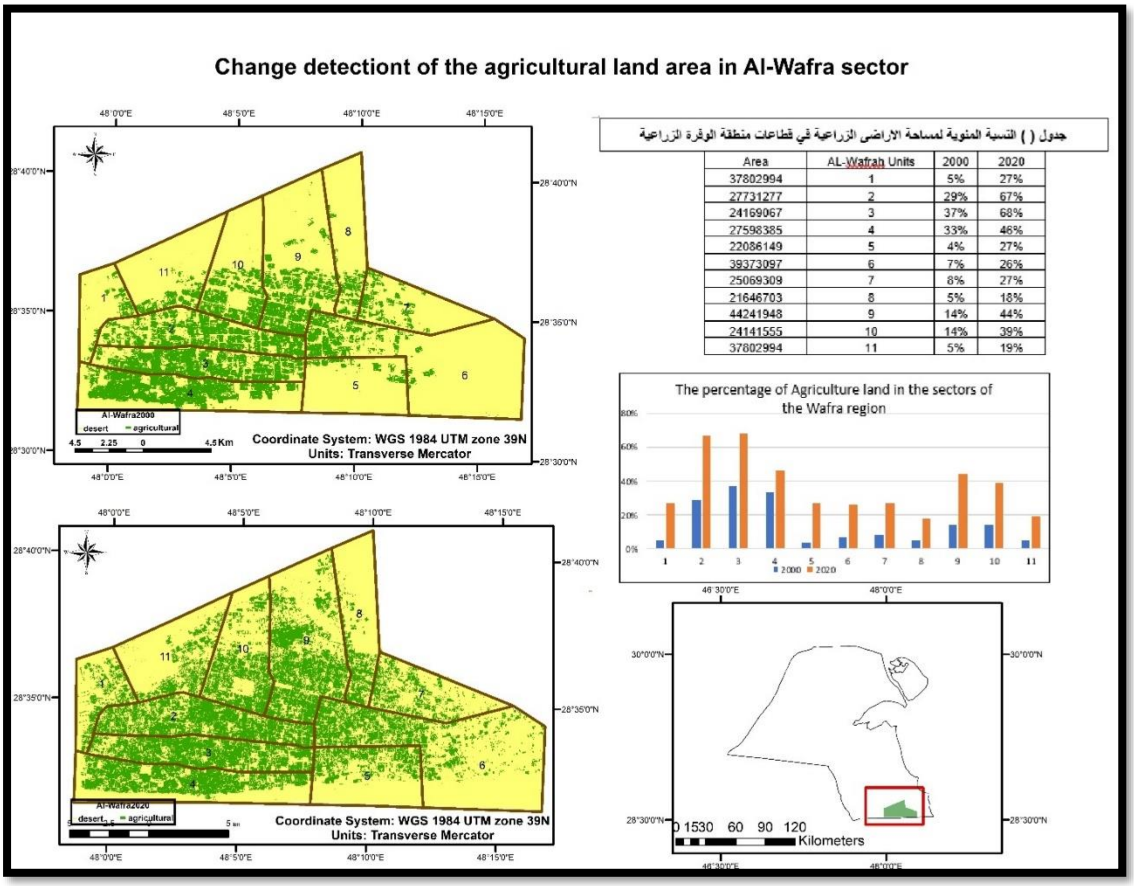


Figure (12)



Area	AL-Wafrah Units	2000	2020
37802994	1	5%	27%
27731277	2	29%	67%
24169067	3	37%	68%
27598385	4	33%	46%
22086149	5	4%	27%
39373097	6	7%	26%
25069309	7	8%	27%
21646703	8	5%	18%
44241948	9	14%	44%
24141555	10	14%	39%
37802994	11	5%	19%

Figure (13)

The agricultural land area in the Al-Wafra agricultural area varies across the region, with 11 agricultural zones.

There is a high vegetation area in the southeastern, southwestern, and central parts of the Al-Wafra area (Figures 12, 13 and Table 5). The estimated agricultural land area in sectors (2, 3, 4, 9, 10) is approximately (67%, 68%, 46%, 44%, 39%) of the total area in the sector for the year 2020. The agricultural land area in sectors (1, 5, 6, 7) is estimated to be approximately (27%, 27%, 25%, 27%) of the total area in the sector for the year 2020. The agricultural land area in sectors (8, 11) is estimated to be approximately (18%, 19%) of the total area in the sector.

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