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Environmental Impacts of Oil Fields on Agricultural Areas (Case Study, Al-Garraf Oil Field)

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Abstract

The Environmental change and Climate change are one of the most important challenges facing the world in the 21st century**.** The excessive use of natural resources, especially oil, and the multiplicity of extraction areas, especially within areas classified as agricultural areas. Changing the gender of the region from agricultural areas to industrial areas is a big challenge that increases the acceleration of climate and environmental change, when this industrial activity is accompanied by oil or gas residues (the burning of gas associated with the oil extraction process), burning gas can leave behind unburned heavy metals are toxic substances when present in the air or in combination with soil and water, which are the main source of food for plants. Which is a toxic element to both air, soil and agricultural. The purpose of the research to determine the change in vegetation and agricultural cover due to the presence of industrial oil areas by using satellite images of the Landsat 8 satellite for different periods of time and finding changes in the proportion of vegetation cover of the study area (Gharraf oil field and its adjacent lands) using the (ArcGIS 10.3) program and classifying the satellite images by the Normalized Difference Vegetation Index (NDVI).

Keywords: Environment, Remote sensing, NDVI, Satellite images classification, Al-Garraf oil field.

التأثيرات البيئية لحقول النفط على المناطق الزراعية (دراسة حالة حقل الغراف النفطي)

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الخلاصة

ان التغير البيئي وتغير المناخ من أهم التحديات التي تواجه العالم في القرن الحادي والعشرين. الاستخدام المفرط للموارد الطبيعية، وخاصة النفط، وتعدد مناطق الاستخراج، خاصة ضمن المناطق المصنفة كمناطق زراعية. إن تغيير جنس المنطقة من مناطق زراعية إلى مناطق صناعية يشكل تحديا كبيرا يزيد من تسارع التغير المناخي والبيئي، عندما يصاحب هذا النشاط الصناعي مخلفات النفط أو الغاز (حرق الغاز المصاحب لعملية استخراج النفط)، يمكن أن يترك الغاز المحترق وراءه معادن ثقيلة غير محترقة، وهي مواد سامة عند وجودها في الهواء أو مع التربة والمياه، وهي المصدر الرئيسي لغذاء النباتات. وهو عنصر سام لكل من الهواء والتربة والزراعة**.** هدف البحث إلى تحديد التغير في الغطاء النباتي والزراعي نتيجة وجود مناطق نفطية صناعية باستخدام الصور الفضائية للقمر الصناعي لاندسات 8 ولفترات زمنية مختلفة وإيجاد التغيرات في نسبة الغطاء النباتي لمنطقة الدراسة (حقل الغراف النفطي والأراضي المجاورة له) باستخدام برنامج (**ArcGIS 10.3**) وتصنيف الصور الفضائية بواسطة مؤشر الاختلاف النباتي الطبيعي (**NDVI**)**.**

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1. Introduction

Oil is the main source of economy in Iraq now and over the medium term. According to the World Bank Over the last decade, oil revenues have accounted for more than 99% of exports, 85% of the government's budget, and 42% of gross domestic product (GDP). Climate change could cut crop yields, especially in the world's most food-insecure regions. At the same time, agriculture, forestry, and land use change are responsible for about 25% of greenhouse gas emissions. The agriculture sector is core to addressing the climate challenge [1]. The danger of radiation exposure comes from natural sources such as cosmic radiation or the activity of natural interactions of heavy chain elements in nature, primarily uranium and thorium, and from other sources as a result of human activities such as mining and manufacturing industries, smelting plants, plumbing, chemical fertilizers and building materials quarries [2]. Iraq came second after Russia in the world for the fourth year in a row among the highest natural gas burning countries, as World Bank data indicates that in 2016 it burned a total of 17.73 billion cubic meters of gas, then it increased in 2019 to reach 17.91 billion cubic meters. The high rate of flaring of associated gas in Iraq is directly proportional to the increase in oil production, in light of the country's continued suffering from the wars it witnessed during the last four decades, which in turn led to the destruction of the associated gas investment facilities that Iraq had begun to build in the seventies of the last century.

The data of the International Energy Agency indicated that the amount of gas that Iraq burns daily is sufficient to supply at least 3 million homes with electric energy, which post-2003 governments have been unable to address their problems so far. The natural reserves of Iraqi gas are estimated at 132 trillion cubic feet - according to the Organization of the Petroleum Exporting Countries (OPEC) - 700 billion cubic feet of it were burned as a result of the poor ability to exploit it, with its daily production of associated natural gas reaching 2.7 billion cubic feet, and it is targeted to reach 3.1 billion. Cubic feet, and it is estimated at 1.5 of the global reserves from OPEC, and 1.8 of the world reserves, and it ranks 11th in the world in terms of the international ranking.

In 2020, Iraq destroyed - according to international data - an estimated 18 million cubic meters of gas, and if this data transfer this amount to a barrel, it will destroy the equivalent of 62% of its gas production, which is equivalent to 196 thousand barrels of oil, which is equivalent to 45 billion dollars. almost a dollar. And after his recent announcement of investing 1.5 billion cubic feet of natural gas, Iraqi Oil Minister Ihsan Abdul-Jabbar suggested that his country's gas production would reach 4,000 cubic[3].

The Aim of Study, Determining the Area Change in vegetation and agricultural areas based on surface water and Identify the risks arising on the natural and agricultural areas near industrial oil site (Al-Gharraf oil field) that was established near cities or agricultural areas. Finding the connection between the establishment of industrial cities, especially oil, and changes in agricultural areas, and whether there is a direct impact on agriculture.

2. Impacts of Crude Oil and Natural Gas Production on the Study Area

Environmental impacts that occur during production of crude oil and natural gas would mostly occur from long-term habitat change within the oil and gas field, production activities (including facility component maintenance or replacement), waste management (e.g produced water), noise (e.g from well operations, compressor or pump stations, flare stack, vehicle and equipment), the presence of workers and potential spills[4]. These activities could potentially impact on the resources as explained below.

2.1.Razing of agricultural areas

The establishment of oil industrial areas leads to a change in agricultural areas and razing agricultural lands, green areas and construction of roads that contain asphalt to be the means of communication for these industrial areas. Thi-Qar District is particularly famous for its agricultural production. It is thought that Thi-Qar Governorate alone has the capacity to meet a high proportion of Iraq's rice needs; rice is produced along the areas next to the marshlands. The main arable crops and the respective areas of cultivation are outlined in Table 1[5].

Table 1- Crops and their areas of cultivation, [5]

Area	CROPS AREA
All over Thi-Qar	Barley and wheat All over Thi-Qar
All over Thi-Qar	Vegetables and fodder for
Al-Garaf sub-District	animals All over Thi-Qar
Suq Al-Shuyukh, Dawayah and Rafai	Corn Al-Garaf Sub-District
Chibayish , Shatra, Dawayah and Rafai	Rice

Environmental change and degradation has severely disrupted rural livelihoods in south of Iraq. Degradation, desertification and drought has been particularly acute over the last decade, as it coincided with a period of lack of rain and drought that only ended temporarily in 2019 with farmland, due to water scarcity, now mostly present near rivers or irrigation canals. Other factors negatively affecting agriculture activities include a lack of drainage systems and the high costs of fertilizers and seeds [6].

Thi-Qar District, with great oilfields potential for further extraction, hosts the Al-Nasiriya oil field , with oil reserves estimated at over 16 billion barrels. In 2019, oil production reached 200,000 barrels per day from the Al-Garraf and Al-Nasiriya oilfields. A promising plan was developed by the Ministry of Oil to increase the production from all oil fields in the governorate to reach 1 million barrels per day by 2025 and transforming Thi-Qar into a major oil-producing governorate, similar to Basra and Missan. Also, the Ministry has a plan to build a refinery in Thi-Qar at a production capacity reaching 300,000 barrels per day[7]. It's found During January, value concentration of sulphur dioxide reached its highest value due to the low temperature and low surface heating during the day By studying and analysing the sulphur dioxide concentration values near the surface during the months (January, April, July, October) for the year 2022 [8].

The Al-Garraf oil field is located in Rafai District, south of Iraq, around 265 km southeast of Baghdad DC, 85 km north of Nasiriya city. The approximate coordinates for the Gharraf oil field are around 31.1272° N latitude and 47.1332° E longitude. (Figure 1),[8]. Garraf oilfield located in al-Rafai district roughly 5 km northwest al-Rafai city. It was explored in 1984. The oil field is 17.5 km long and 5.5 km wide and holds between 860 million-1 billion barrels. The yield oil is kind of light oil, Garraf oil field was awarded to consortium led by Malaysian Petronas with Japanese Jappex as secondary partner in Second licensing round in December 2009. According to the deal the remuneration fee offered was $1.49 and the 'plateau production target' was 150,000 barrels per day [9].

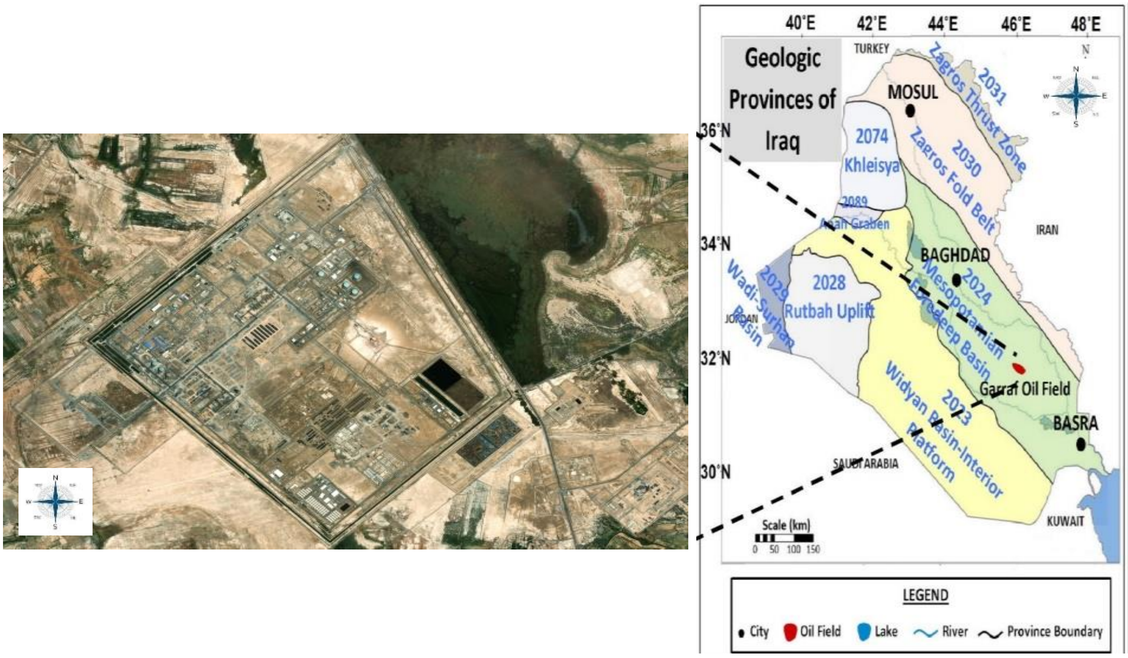


Figure -1 Shows Al-Garraf Oli field site

The impact of oil fields on the razing (clearing) of agricultural areas:-

1- Land use conversion: Establishing oil fields often requires a significant amount of land for drilling rigs, infrastructure, storage facilities, and other related activities. This can lead to the conversion of agricultural land into industrial or extractive use, resulting in the loss of fertile soil and reduced agricultural productivity [10].
2- Environmental impact: Oil extraction and production can lead to pollution of soil, water, and air. Spills, leaks, and emissions from oil facilities can contaminate nearby agricultural land, making it unsuitable for farming. Soil pollution can disrupt soil ecosystems and harm plant growth [11].
3- Water Scarcity: Oil production requires large amounts of water for various processes, including extraction and refining. In regions where water is already scarce, diverting water to oil operations can limit the availability of water for irrigation in agricultural areas, potentially leading to reduced crop yields [12].
4- Infrastructure Development: The construction of roads, pipelines, and other infrastructure associated with oil fields can fragment agricultural landscapes, making it harder for farmers to access and manage their land. It can also disrupt natural drainage patterns, leading to waterlogging or erosion in adjacent fields [13].
5- Displacement of Communities: Sometimes, the establishment of oil fields can lead to the displacement of local communities, including farmers. This not only affects their livelihoods but can also disrupt traditional agricultural practices and knowledge [14].
6- Economic Shift: in area heavily reliant on agriculture, the development of oil fields can lead to an economic shift away from farming. This can have social and economic implications for rural communities that traditionally depend on agriculture for their sustenance [15].

2.2 Landsat 8 satellite Bands

Landsat 8 and Landsat 9 both carry similar sets of spectral bands. Landsat 9 is the successor to Landsat 8 and continues the tradition of collecting data in the same spectral ranges. However, it's essential to note that sensor capabilities can vary slightly [16].

1. Coastal/Aerosol (Band 1): (0.43 - 0.45) µm.
2. Blue (Band 2): (0.45 - 0.51) µm.
3. Green (Band 3): (0.53 - 0.59) µm.
4. Red (Band 4): (0.64 - 0.67) µm.
5. Near Infrared (NIR) (Band 5): (0.85 - 0.88) µm.
6. Shortwave Infrared (SWIR1) (Band 6): (1.57-1.65) µm.
7. Shortwave Infrared (SWIR2) (Band 7): (2.11-2.29) µm.
8. Panchromatic (Band 8)-(0.50-0.68) µm (Higher spatial resolution compared to the other bands.
9. Cirrus (Band 9): (1.36 - 1.38) µm.
10. Thermal Infrared (TIRS) 1 (Band 10): (10.60 - 11.19) µm.
11. Thermal Infrared (TIRS) 2 (Band 11): (11.50 - 12.51) µm.

3. Material and Methodology

3.1 Bands Composite

Creating a band composite in Landsat 8 imagery involves combining multiple bands to create a single image that highlights specific features or characteristics of the Earth's surface. Landsat 8 has 11 spectral bands. For a true-colour RGB image follows

- Band 4 (Red) / (1.64-0.67 µm)
- Band 3 (Green) / (0.53-0.59 µm)
- Band 2 (Blue) / (0.45-0.51 µm)

Natural Colour Composite: Combines the Red (Band 4), Green (Band 3), and Blue (Band 2) to create a single true-colour image with difference time as showing the Figure 2.

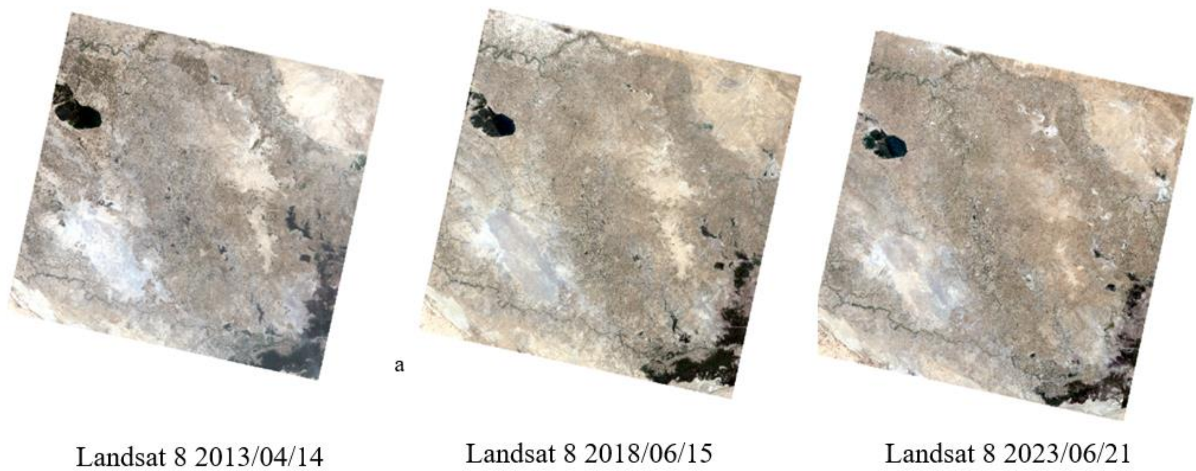


Figure -2 Shows the Landsat satellite images (composite bands) in different time.

For more accuracy we can apply Pan-sharpening which is a technique where the panchromatic band has a higher spatial resolution (15 meters for Landsat 8), is used to enhance the spatial resolution of the multispectral bands (30 * 30 meters). This process creates a new multispectral image with improved spatial details. While it can provide a higher-resolution appearance, it doesn't change the actual spatial resolution of the individual bands. Landsat 8, the panchromatic band has a higher spatial resolution (15 meters), and the multispectral bands have a lower spatial resolution (30 meters). Pan-sharpening involves merging the higher-resolution panchromatic band with the multispectral bands to create a composite image with improved spatial resolution for the multispectral data. This technique is commonly used to enhance the visual quality and spatial details of satellite imagery. For this technic must do the following steps.

1- **Acquire Data:** Obtain the panchromatic and multispectral bands from the satellite sensor. for Landsat 8, the panchromatic band has a higher spatial resolution (15 m), while the multispectral bands have a lower spatial resolution (30 m).
2- **Check Band Alignment:** the bands must be correctly aligned and have the same geographic coordinates.
3- **Resample Multispectral Bands**: because of panchromatic band has a higher spatial resolution, must apply resample for multispectral bands to match the spatial resolution of the panchromatic band.
4- **Apply Pan-Sharpening Algorithm:** There are many methods for pan-sharpening algorithms.
    - Brovey Transform for this research apply this technic
    - Principal Component Analysis (PCA)
    - Intensity-Hue-Saturation (IHS) Transform
5- **Validate and Assess Quality:** Assess the quality of the pan-sharpened image. Compare it with the original multispectral data and evaluate whether the enhanced spatial resolution must meets specific requirements. The attention to spectral distortions that may be introduced during the pan-sharpening process.

3.2 Area of interest (AOI)

Creating a satellite image clip using ArcGIS, for Rafai District and exporting the clipped image for our research by download the map of all Thi-Qar government to extract a portion of a satellite image based on a defined boundary.

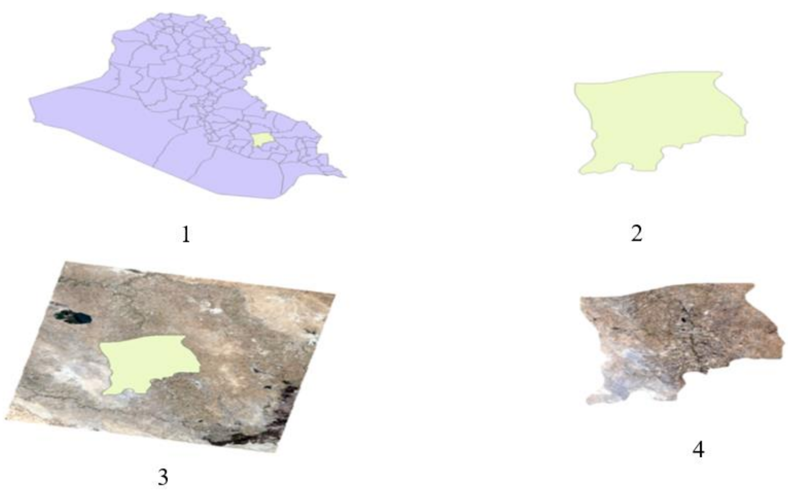
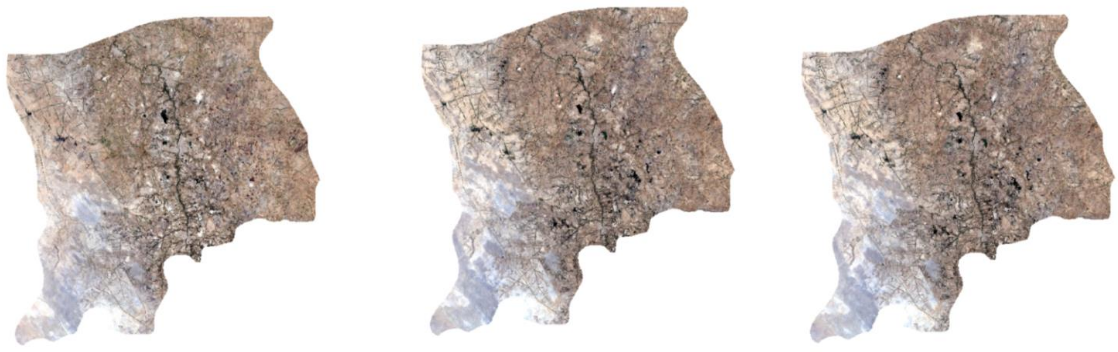


Figure -3 Shows the process of clipping (AOI) Rafai District.

3.3 Satellite Image Change Detection

Satellite image change detection is a process involves comparing two or more satellite images taken at different times to calculate, identify and analyse changes in the landscape or features over time. This process is valuable for various applications, including urban planning, agriculture, environmental monitoring, and disaster management. For this research the satellite images taken in 2013/04/14, 2018/06/15 and 2023/06/21.



Landsat 8 Landsat 8 Landsat 8

Figure -4 Shows Landsat 8 composites bands with (AIO) Rafai District

3.3.1 Normalized Difference Vegetation Index(NDVI)

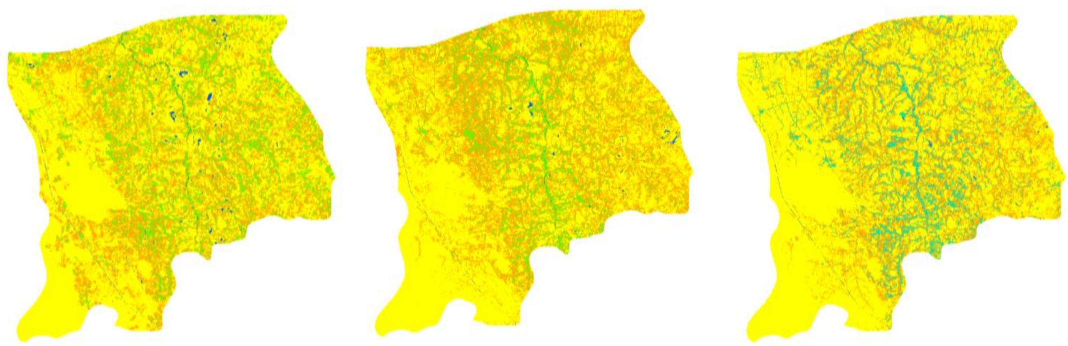
The NDVI technic used to quantify vegetation greenness and useful in understanding vegetation density and assessing changes in plant health. The Standardized Vegetation Index emphasizes the difference between the visible band of Red and that of near infrared.
NDVI Calculation Equation:

$$NDVI = \frac{PIR-R}{PIR+R}$$

In Landsat 8,

$$NDVI = \frac{B5-B4}{B5+B4}$$

Using ArcGis10.8 program to calculate the equation above we need to download Landsat 8, satellite image for the Rafai District for different time periods in our research the periodic time was 10 years from 2013 to 2023[17].



Landsat 8 2013/04/14 Landsat 8 2018/06/15 Landsat 8 2023/06/21

Figure -5 Shows NDVI image classification of Rafai District

Table 2- The percentage of water, soil, clay and vegetation for each year

Year	2013 %	2018 %	2023 %	Total area Km^2
Water	0.003748186	0.002194393	0.003842174	3496.34973
Soil	0.800680633	0.821953814	0.570237793	3496.34973
Clay	0.173126107	0.164140884	0.341441143	3496.34973
Vegetation	0.022445073	0.011710911	0.084478891	3496.34973

Table 3- The area (km), water, soil, clay and vegetation for each year

Year	Water(km^2)	Soil(km^2)	Clay(km^2)	Vegetation(km^2)
2013	13.10497	2799.46	605.3094	78.47582
2018	7.672365	2873.838	573.8939	40.94544
2023	13.43358	1993.751	1193.798	295.3677

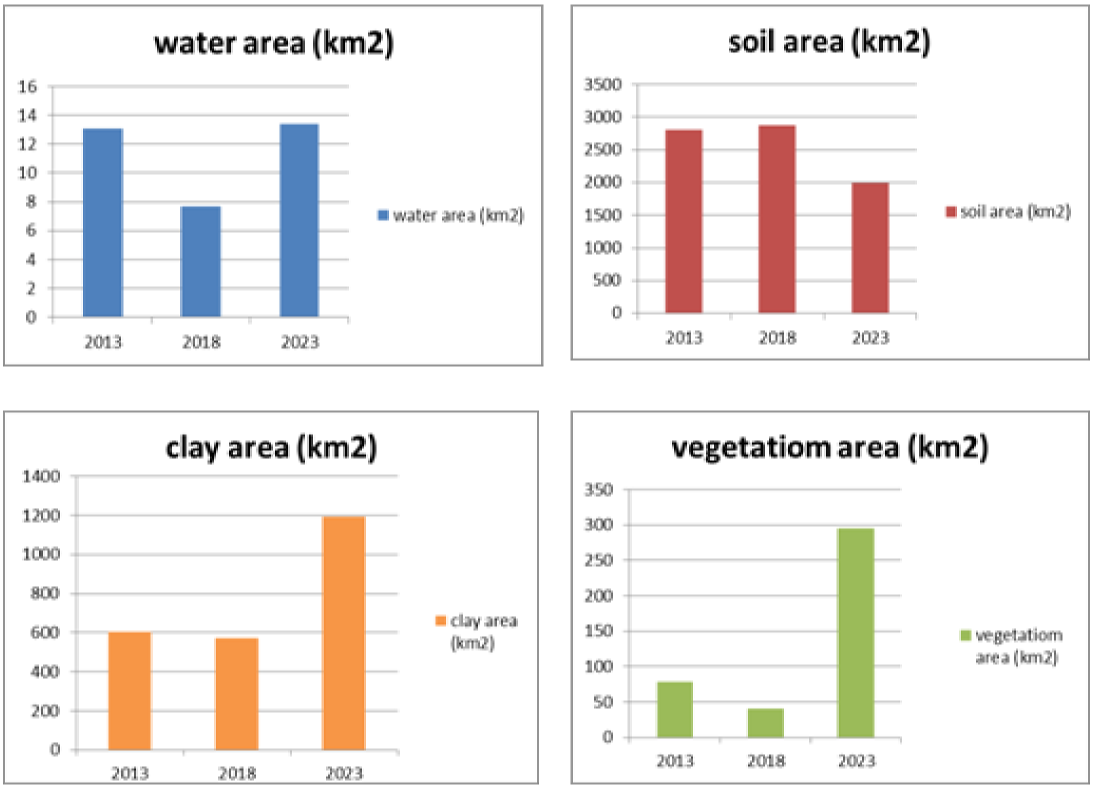


Figure -4 Shows the frequency percentage of water, soil, clay and vegetation for each year.

The result of the NDVI for each image gave difference percentage area and the amount of vegetation depends on the water surface area o in each satellite image, and that the change resulting from the construction of the Gharraf oil field is minimal.

4. Conclusions

The impact of the Al-Gharraf oil field on agricultural areas during 10 years was very small and almost non-existent. The Establish of industrial cities and oil fields in agricultural areas has a bad impact on the environment. But when the research is studying the changes in agricultural areas in Al Rafai District, it was noted that the impact of oil sites is not of high value. The change in agricultural areas depends mainly on the rate of rainfall and the surface water. So the percentage of water content in 2018 is very low compared to the years 2013 and 2023. Therefore, the agricultural areas or vegetation cover of the study area was very small. But, the abundance of surface water area in 2023 has increased the cultivated area. This means that the impact resulting from the establishment of industrial and oil zones at the present time on cultivated areas is very small.

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