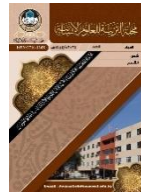




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# The Impact and Risks of the Oil Industry on Air Quality and Land Use in Koya District – Erbil - IRAQ Using Remote Sensin

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### Abstract

The oil industry is one of the most important sectors in Iraq, playing a significant role in developing and strengthening the country's economic infrastructure. Koya District has one oil field. Oil production in Koya has, of course, had a major impact on land use and air quality. Between 2003 and 2023, transformations in land use were primarily driven by the expansion of the oil industry. This sector has significantly influenced agricultural land conversion and accelerated urban growth in the region because of substantial changes in land use and air quality due to oil production activities in Koya District.

Using satellite image classification, we focused particularly on the northwest region of Koya, where the risks associated with crude oil production have strongly affected surface soils. In contrast, the eastern parts of Koya remain relatively unpolluted. Additionally, the southeastern area is characterized by extensive fish ponds, while urbanization has surged to 69.5%. Air pollution in Koya in 2021 was high—up to 65 molarity—but NO<sub>2</sub> levels dropped after oil production stopped in 2023, falling to 31 molarity. This study aims to analyze the changes in land use and air pollution in Koya District under the influence of the oil industry using remote sensing techniques.

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## مجلة التربية للعلوم الإنسانية

مجلة علمية فصلية محكمة، تصدر عن كلية التربية للعلوم الإنسانية / جامعة الموصل



### اثر ومخاطر صناعة النفط على جودة الهواء وإستخدامات الأراضي في قضاء

كويه - أربيل - العراق باستخدام الاستشعار عن بعد

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#### الملخص

#### معلومات الارشفة

تُعد صناعة النفط من أهم القطاعات في العراق، حيث تلعب دورًا هامًا في تطوير وتعزيز البنية التحتية الاقتصادية للبلاد. يوجد في قضاء كويه حقل نفط كبير، وبالطبع، فإن إنتاج النفط في كويه له تأثير كبير على استخدام الأراضي وجودة الهواء، فبين عامي ٢٠٠٣ و 2023، حدثت تحولات كبيرة في استخدام الأراضي، مدفوعة في المقام الأول بتوسع صناعة النفط. وقد أثر هذا القطاع بشكل كبير على تحويل الأراضي الزراعية وسرع النمو الحضري في المنطقة. وذلك بسبب التغيرات الكبيرة التي شهدتها استخدام الأراضي وجودة الهواء بسبب أنشطة إنتاج النفط في قضاء كويه. وباستخدام تصنيف صور الأقمار الصناعية، لا سيما في المنطقة الشمالية الغربية من كويه، حيث أثرت المخاطر المرتبطة بإنتاج النفط الخام بشدة على التربة السطحية. وعلى النقيض من ذلك، تظل الأجزاء الشرقية من كويه غير ملوثة نسبيًا. مع ذلك، تتميز المنطقة الجنوبية الشرقية بتربية أسماك واسعة، في حين ارتفعت نسبة التحضر لتصل إلى ٦٩.٥٪. وكان تلوث الهواء مرتفعًا في كويا في عام ٢٠٢١، لكن مستويات NO<sub>2</sub> انخفضت بعد توقف إنتاج النفط في عام ٢٠٢٣، وتهدف هذه الدراسة إلى تحليل التغيرات في استخدام الأراضي وتلوث الهواء في منطقة كويا تحت تأثير صناعة النفط باستخدام تقنيات الاستشعار عن بعد.

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الاستشعار عن بعد،  
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## **1-Introduction**

Economic growth depends on the development of the industrial sector, the development of the oil industry has directly affected the economic, social, and security situation in the region. Koya, as one of the cities of the Kurdistan Region, is not excluded from this. Especially during the research period, the legacy of the rapid development of the oil industry in all economic sectors has reflected and accelerated the direction of economic development. All these changes affect land use and land cover, especially soil erosion and biodiversity loss, which ultimately affect climate changes (Yohannes et al., 2020). all of which have had a big impact on land-use patterns in the area. The change in land use can play an main role in changing the environment at the local as well as global scale (Berihun et al., 2019). the last few years, people have been searching for natural resources to fulfill their needs for resource use. Discover the change in land use and land cover patterns is a very important tool to understand the relationship between human activity and environmental change (Liping et al, 2018). the rapid expansion of human activities, including city growth, population increase, industry, and production needs, has affected large-scale changes in land use and land cover patterns around the world. With a focus on developing countries, the fast changes in land use and land cover have been causing a lowering in main natural resources, such as water bodies, land use, and vegetation cover (Mishra, 2019). These human activities significantly alter the environment, impacting its physical, chemical, and biological properties, and driving climate change, It is defined as the physical bio-cover of the land. It is necessary to focus on natural resources and the mode of human intervention that modifies land use and land cover patterns in response to changing needs (Cheruto et al., 2016).

## **1.Research problems**

A major limitation of this research is the lack of reliable oil production data, as well as insufficient population and agricultural growth statistics in the study area.

## **2. Importance of the research**

This research is vital for understanding how the oil industry is transforming land use in the Koya District. The use of remote sensing provides accurate, actionable insights for policymakers, environmentalists, and urban planners to support sustainable development in the region.

### 3. Research objectives

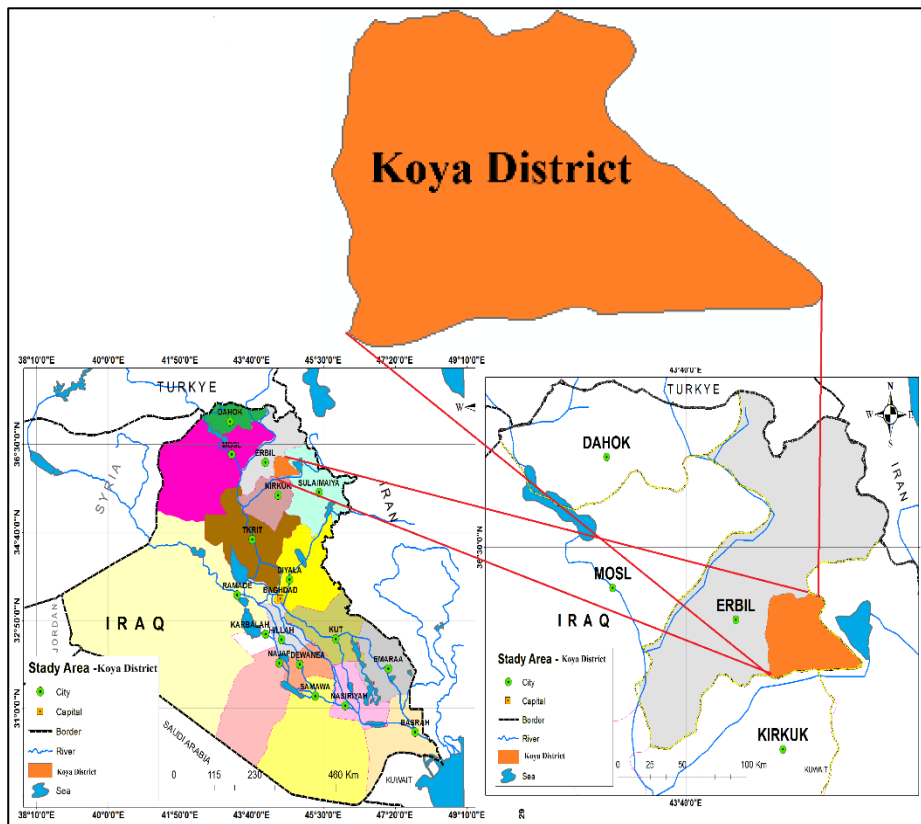
This study aims to present the changes in land use and air pollution of Koya district under the influence of the oil industry using remote sensing.

### 4. Research Hypothesis

These hypotheses can be tested using remote sensing techniques (Image classification) and GIS spatial analysis (oil fields and air quality). The findings will help determine the oil industry's role in land-use changes.

### 5. Study Area

The study area, Koya District, is located in northern Iraq, approximately 50 km southeast of Erbil Governorate (Al-Barzingy, 2009) (see Map 1).



Map 1, Location of Koya District in Iraq.

This district consists of five sub-districts: Shorsh, Siktan, Ashti, Sikdkan, and Taktak. Koya District holds an important geographical position in Iraq and the Kurdistan Region. It covers an area of 2,050 square kilometers and lies at an elevation of approximately 620 meters above sea level. The district is surrounded by two mountains: Bawaji Mountain, which is 1,260 meters high in the north, and Haibat Sultan Mountain, which rises to 1,920 meters above sea level in the west. Additionally, Koya town is located between several mountains that border its eastern, northern, and western sides (Aziz, R. S., 2021). The southern part of Koya city consists of a vast plain, while some areas contain mounds. From an astronomical perspective, Koya District is situated between latitudes 35° 49' and 36° 16' N, and longitudes 44° 15' and 44° 57' E (Salem & Azez, 2015).

## **2. Methodology**

The dataset includes oil production data and other relevant information collected for this research, including satellite images. This data helps investigate land use and land cover changes over 15 years (2008–2023). A total of four Landsat and Sentinel satellite images were obtained for 2008-2023 (Table 1). The images were downloaded from Earth explorer and Sentinel Hub EO Browser (2024).

Table 1. Image Satellite used in this study (Earth explorer, 2024)

Andsat Scene ID	Date	Time	WRS Path	ROW	Map Projection	Datum
LT051690351989071501	03/07/2008	7:27Am	169	30	UTMZONE38	WGS84
LT051690361989071501	2107/2023	7:38Am	169	30	UTMZONE38	WGS84
Sentinel5P_NO2_Nitrogen_Dioxide	30/08/2021	----	169	30	UTMZONE38	WGS84
Sentinel5P_NO2_Nitrogen_Dioxide	24/08/2023	----	169	30	UTMZONE38	WGS84

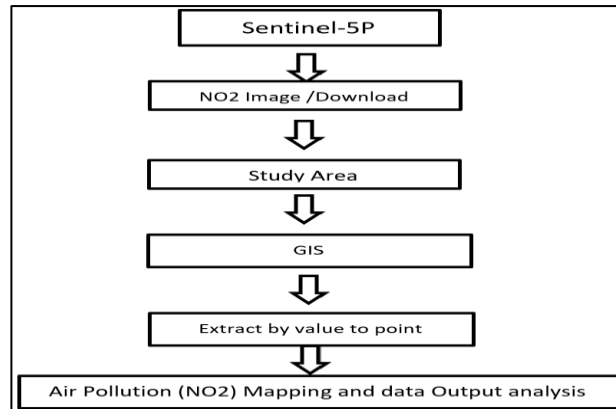


Figure1.Sentinel image process

The Sentinel-5P satellite image processing steps and the derivation of the air quality parameter for the tropospheric NO<sub>2</sub> column number density involved using GIS data analysis to extract mapping and data from pixel points. The system is designed to monitor the state of the atmosphere during the period from 2021 to 2024. The concentration of the gaseous substance, averaged over one hour, on the surface of the land at the point with coordinates X<sub>p</sub>, Y<sub>p</sub> is calculated according to the following formula:

$$S_{x,y} = \frac{E_g}{\pi \cup \sigma_y \sigma_z} - \exp\left(-\frac{y^2}{2\sigma_y^2}\right) \exp\left(-\frac{H^2}{2\sigma_z^2}\right) \times 1000 [\mu\text{g}/\text{m}^3]$$

E<sub>g</sub> [mg/s] is the maximum emission of the gaseous substance; x [m] is the component of the distance of the emitter to the point for which the calculations are made, parallel to the wind direction; y [m] is the component of the distance from the point for which calculations are made, perpendicular to the wind direction; σ<sub>y</sub> [m] is the coefficient of horizontal atmospheric diffusion; σ<sub>z</sub> [m] is the coefficient of vertical atmospheric diffusion; and u [m/s] is the average wind speed in the layer from the geometric height of the emitter h to an effective height of the emitter. (Wieczorek.B,2023). Recently the Supervised class is one of the techniques which might be the use of to land use land cover, this technique is operating to account and clear up getting ready information had to the spectral signatures for land cover lessons which can be divided into seven kinds of classes Table 2 shown taken.

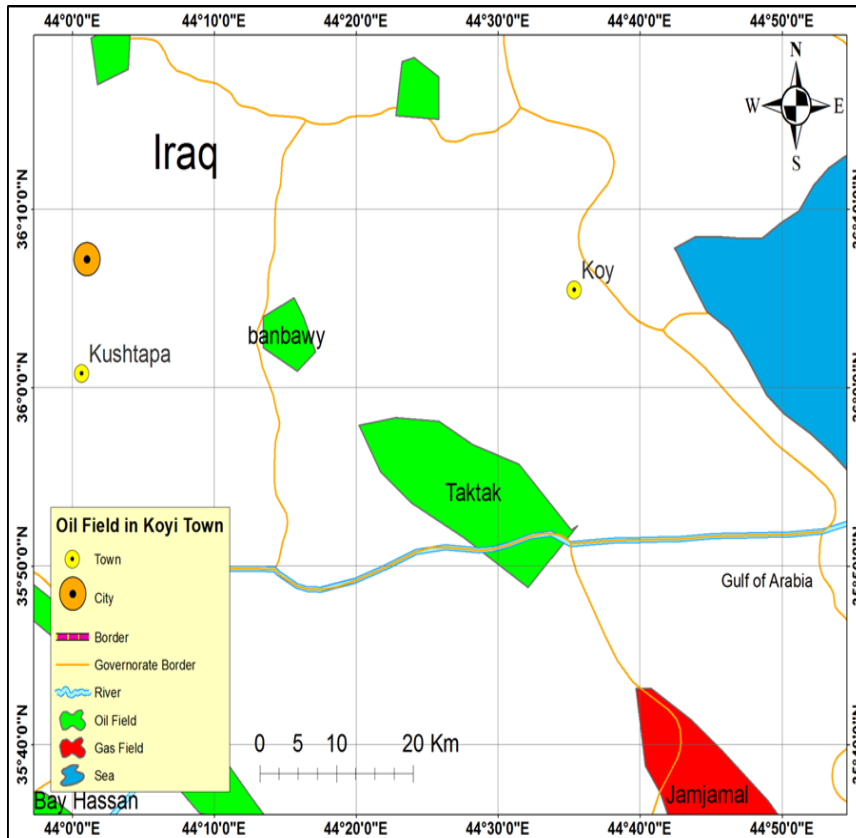
Table2.Land use and land cover classes in Koya District.

No	Class name	Description
1	Vegetation	Forest. Watermelon, Tomatoes, Cucumber, Vegetables
2	Fair area	Fair area
3	Mountainous Area	Rocky and Mounts, Soil Surface
4	Urban	location that have been human , building
5	Water	Water surface , River , Water project

ArcGIS 10.7 was used to analyze the images. Microsoft Excel was used for statistical and regression analysis, as well as for producing charts and graphs to evaluate the results and mapping. The main aim of this classified image was to assign the digital pixel values of satellite images to different land cover classes. Moreover, image classification can be an automated process that involves assigning pixels to specific groups of known classes based on analyst input and external data sources to identify each land class (GIS 10.7). In this case, to achieve the study objectives, supervised classification was employed to categorize land cover types. There are five types of land cover: urban, dense vegetation, sparse vegetation, agriculture, water, and other, illustrating the steps of supervised classification used in this study.

### 3. Results

The Taq Taq oil field is located 71 km northeast of Erbil city shows Map 2. Koya district of Erbil province. the length of this field is about 12 km, and the width is 11 km. The Taq Taq oil field was discovered by the Iraqi National Oil Company in 1978, and oil production began in 1994 (Amir,2013). The field contains 22 wells, with depths ranging from 3.9 km to 5.2 km. In 2015, oil production in the Taq Taq field was close to 150,000 Barrels per day, but production decreased to 7,000 barrels per day in 2023 (KRG, 2023).



Map 2 ,Taq Taq Oil Fields .

Mapping 2 and 3 shown that oil production in the Taq Taq oil fields in south Koya began in 1998, with a daily oil output of roughly 5 thousand barrels; nevertheless, daily oil production (5 to 45 thousand barrels) was relatively sluggish between 1998 to 2008 , however, after a new oil wells was discovered in Taq Taq in 2008, the proportion of oil output increased dramatically to 150 thousand in 2015 years , the Kurdistan region economy is heavily reliant on oil production and exported, moreover, oil is the most important strategic resource for KEG because it accounts for more than 98 percent of the KEG government budget from 2014 to 2023 , but after 2015 year, the oil production in the Taq Taq oil fields began to very low from city of Koya, Pushing production down from 2015 onward was the pronounced decline of the flagship Taq Taq field, which had been one of the largest producers in 2014. An increase in water production coincided with an oil production drop from 150,000 B in 2015 to 18,000 in 2017.



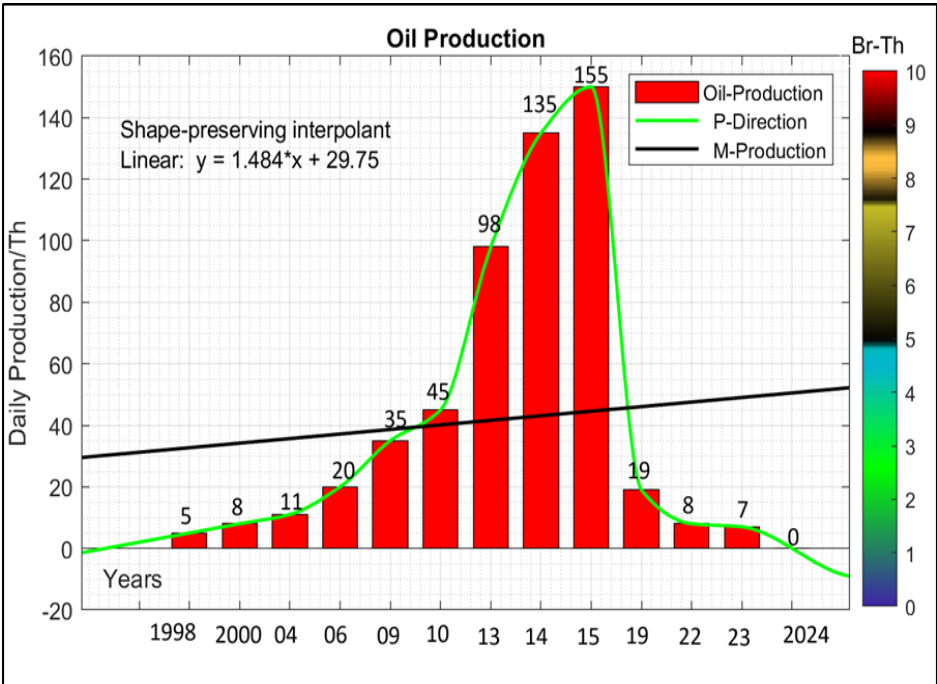
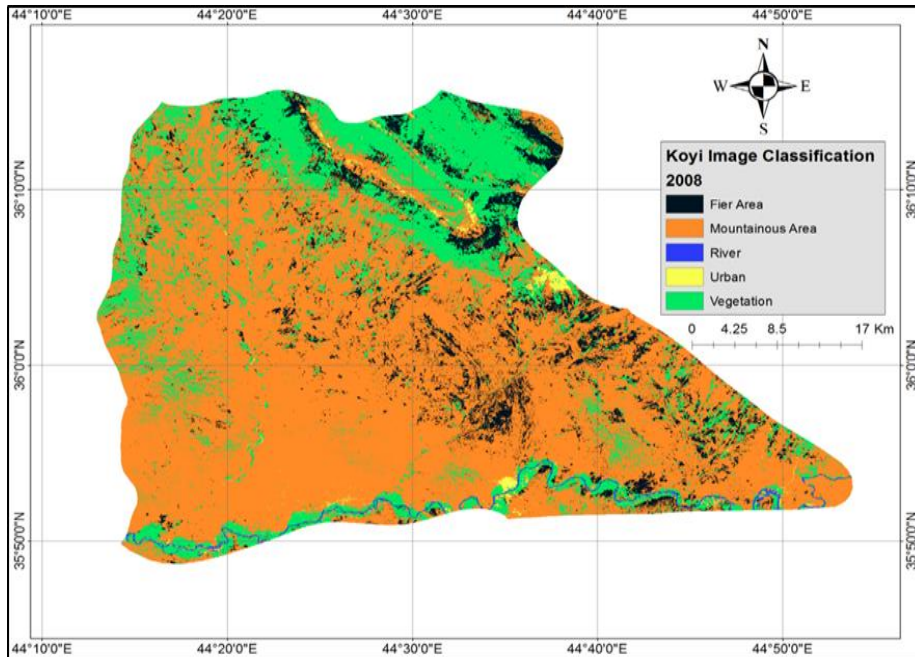


Figure 3,Taq Taq Oil production between (1998 – 2024). \*M=Middle / p= Production

Genel Energy, a partner in the joint-venture operating company TTOPCO, attributed this decline to an initial overestimation of the porosity in one of the main reservoirs. Regardless of the cause, this highlights the challenges of predicting production in structurally complex fractured carbonate reservoirs in the Kurdistan Region of Iraq (Kurdistan-Region-of-Iraq, 2024). Koya is one of the main areas for crude oil production in Erbil Governorate and is well known for its large oil reserves. This area is heavily impacted by crude oil pollution (Masala, 2013). Oil wells contribute to soil pollution; some crude oil components leak directly into the soil, while others are released into the air as gases and mix with rain. The level of oil pollution may depend on the type and quantity of crude oil present on the land. The oil industry and human activities affect land use changes and air quality in the study area (Oyem, 2013).



map 4, Image Satellite Classification of Koya District in 2008.

map 4,shows.these impact negatively on land use and land cover, pollution is defined as a physical and chemical change in lands that impact of the environment the monitoring of oil pollution in the Koya between 2008-2023 by image satellite is very important to show land use changes , any change in the surface of the earth as a result of the unbalanced material in the soil can cause and affect the destruction and weakness of the soil cover. also, immense growth in the Koya city and created some new alleyways have made a huge change in the land use changes. Referring to the map 4 and 1, and based on the data and analysis control as a result of the classification of the area of our survey in July 2008, we find that the survey rate for classifying the green ratio of mountains, burned areas, urban areas and rural areas in the survey area is as follows. the greenery in the area has increased because of returning the people of the area to their lands and doing agricultural and animal husbandry.

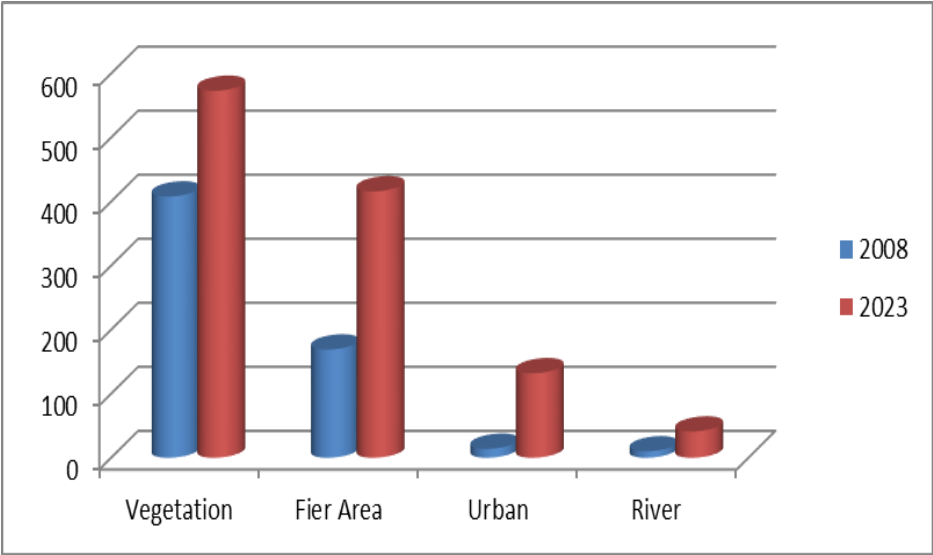
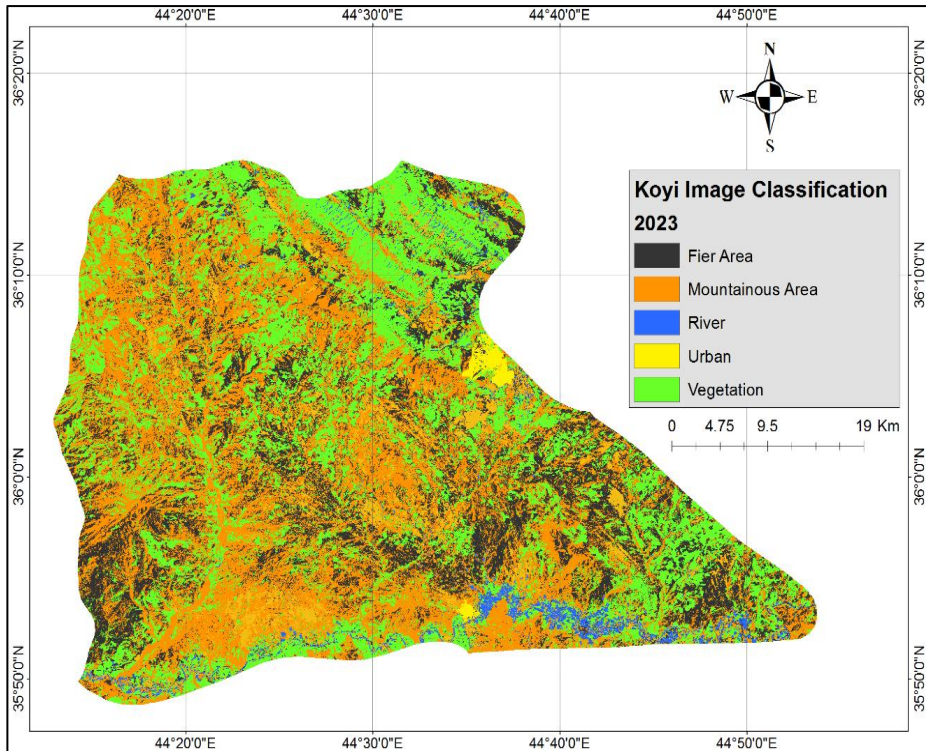


Figure 5.mage Analysis 2008 and 2023.

In contrary, the amount of the burned lands in the research area occupies a large area, because of in these years this area is facing fire in the summer season. And the urban areas in the study area; if we are compared between the proportion of villagers and the center of the town and depending on aerial imagery and remote sensing, it becomes clear to us that the proportion of villagers is decreasing and the center of the towns; for example: Koya and Tak Tak; it goes in the direction of expansion. As for analysis, we are used land sad 8 for classification chart no1 by analyzing remote sensing data to explain, the aerial images of land cover have increased dramatically in August 2023 compared to 2008 since the expansion of agricultural land use in providing vegetation for animals.



Map 6, Image Satellite Classification of Koya District in 2023.

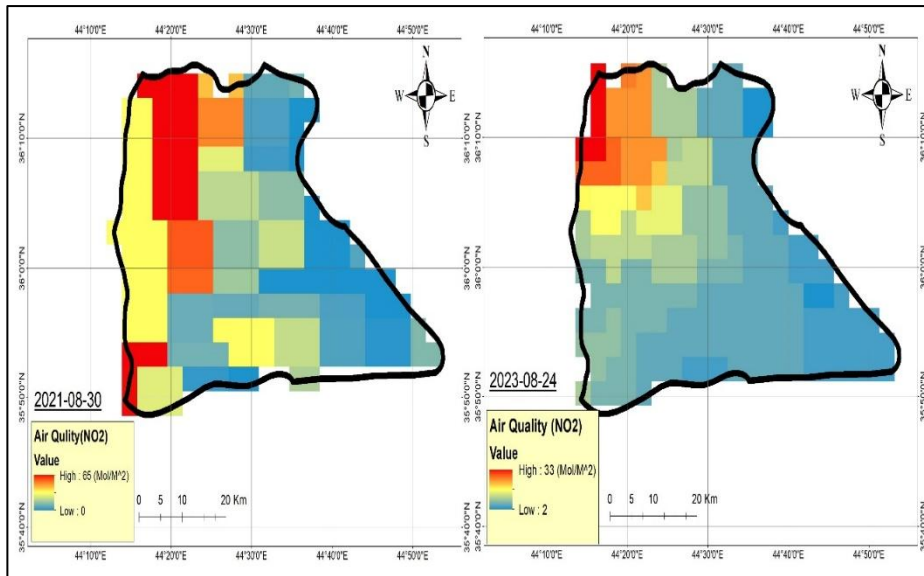
The images show that the proportion of burned areas has increased due to fires compared to 2008. Regarding the urbanization rate based on aerial images from Landsat 8 in 2023, it is clear that the rural population has decreased, while the population percentage in the city center and towns like Koya District and Taq Taq town has increased rapidly as a result of villagers migrating to these urban areas.

**Table -3 Geographic of population distribution from Koya district between rural and urban areas (2009-2023)**

Years	Number of Population Koya City	Urban population	Population of Koya District	proportion of urban Population in Koya Urban	proportion of urban Population in Koya District
2009	53031	73264	95281	%72	%55.6
2015	74317	85950	122225	%86	%60.8
2020	95186	111975	148852	%85	%63.9
2023	81777	91148	131097	%62.3	%69.5

Kurdistan Regional Government, Erbil Governorate, Statistics room,2024.

The urban population has increased significantly, while the rural population has declined. In 2009, Koya had a population of 73,264, with 72% living in urban areas. This percentage is high compared to the previous year, due to city expansion and the formation of new urban areas such as Taq Taq, Shorsh, and Sekertkan, (Zhear,2016,12) ,table (3) shows percentage of urban population in 2023 compared with 2009 has changed to (131,097), while the percentage of rural population has changed compared to last year from 36.1% to 30.5% due to the expansion of cities and the increase in urban population, regarding the amount of water in the study area; aerial images, data analysis, classification, and depending on analysis of images from 2008 to August 2023 indicate that the area of water has expanded extremely fast especially on the little Zab, which it has led to the creation of a large fish ponds in the area, and it has resulted that a large number of people raising fish , Taq Taq, located in the Koya District , has been a significant hub for fish farming, with over 1,200 fish farms operating in the area, these farms have played a crucial role in local employment and food production(Krg,plannig,2024).



Map 7, Air quality mapping.

The oil industry risk is demonstrated and its impacts on land use and land cover from Koya by using satellite classification with air quality data. Map 7 depicts land use changes that cause crude oil spill risk and oil spread dangers in the Koya oil fields area. The red and yellow-colored region indicates the impact of an oil industry, which is important in planning and preparing to avoid dangerous oil industry reactions and reduce oil production risk. In the 2021 year, the crude oil production risk shows on the land use and land cover changed and air quality in some parts in the north and west of the Koya region are polluted. The green and blue-colored region indicates no impact of an oil industry, but impacts of the crude oil production process risked on the surface soils in the west-north of the Koya region are very strong, as shown in Map 7, Air quality mapping. However, satellite image data analysis and recording from the Koya area shows the effects of oil production on air pollution, land changes, and vegetation cover will be very low, because oil production is stopped in the Taq Taq field and the Bani field (Aljazeera, 2023).

Table.3 Distribution of the average NO<sub>2</sub> Values in Koya between (2021 to 2023)

In	No <sub>2</sub>	Middle Data		Minimum Data		Maximum Data		the
	Area	2021	2023	2021	2023	2021	2023	
	North	32	18	16	11	65	33	
	South	4	4	32	2	54	10	
	West	6	8	6	2	11	5	
	East	36	12	27	10	42	18	

Koya region the percentage of nitrogen dioxide in the atmosphere has gradually increased, after 2006 years has begun to cover large area because of oil production increased in this region, as oil exports have increased in 2015 years and the export quantity has reached 155 thousand barrels per day (Rebin,2018), you can see table. (3), the level of nitrogen dioxide in 2021 years is high in the big area in the northwest - southwest of the Koya region, because oil fields the place, and the percentage of nitrogen dioxide in the atmosphere from the oil industry areas compared to other areas is very high, about 45 degrees Molarity above non-oil industry areas, Table3. Distribution of the average NO<sub>2</sub> values in Koya shows Maximum Data from north Koya area in 2021 years 65mol, and south parts 54mol, but west 11mol, the eastern regions of Koya are unpolluted and have a very low degree of pollution, however, the percentage of NO<sub>2</sub> from Koya in 2023 year is changed, because oil production has stopped.

## CONCLUSION

- Nowadays, the images of the satellites have a great and important role in the determination ‘analysis ‘and comparison of the changes in use of the earth's surface. The oil industry risked is demonstrated and impacts on the land use and land cover from Koya, by use image satellite classification with air quality data.
- The impact of oil industry which is important in planning and preparing to avoid dangerous oil industry reactions and reduce oil production risks, in the 2021 the crude oil production risked shows on the land use and land cover changed and air quality in some parts in north and west of the Koya region are polluted.
- The impact of crude oil production process risked on the surface soils in the north - west from Koya region are very strong, but from eastern regions of Koya are Non polluted, because after 2015-year Daily oil production in Taq Taq field (%95) decreased

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