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Variations in Vegetation Cover in Al-Suwaira District during The period (2017-2023) Using Remote Sensing Data and Geographic Information Systems (GIS)

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Abstract

This research aims to determine the extent of change in the vegetation cover of the Al-Suwaira region in the period 2017-2023, as this region faces many problems, the most important of which are urban expansion at the expense of agricultural land, soil erosion, climate change, pollution. The region is located in southern Iraq, where water resources are scarce compared to the northern and central parts. The Support Vector Machine (SVM) classifier was applied to the seven scenes adopted in this work from Landsat 8 and Landsat 9 satellite data, and the area and percentage of each land cover category in the study area were calculated. The results indicated that the percentage of vegetation cover during 2017-2023 decreased by 1% annually using a graphical relationship between the percentages for each scene and the years. This decrease in the vegetation cover of the Al-Suwaira region is considered a dangerous indicator that threatens the ecosystem. Accordingly, the study recommends that the concerned authorities monitor the region's ecosystem and take the necessary measures and procedures to increase the water level in the Tigris River, reclaim lands, and encourage farmers to pay attention to agriculture.

Keywords: Support Vector Machine, Remote Sensing, GIS, Vegetation, land cover.

تباينات الغطاء النباتي في قضاء الصويرة خلال الفترة (2017 – 2023) باستخدام بيانات
الاستشعار عن بعد ونظم المعلومات الجغرافية (GIS)

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الخلاصة

يهدف هذا البحث إلى تحديد مدى التغير في الغطاء النباتي لمنطقة الصويرة في الفترة 2017-2023، حيث تواجه هذه المنطقة العديد من المشاكل، أهمها (التوسع الحضري على حساب الأراضي الزراعية، تآكل التربة، تغير المناخ، التلوث). تقع المنطقة في الجزء الجنوبي من العراق الذي تقل فيه الموارد المائية مقارنة بالأجزاء الشمالية والوسطى. تم تطبيق مصنف آلة المتجهات الداعمة (SVM) على المشاهد السبعة المعتمدة في هذا العمل من بيانات الأقمار الصناعية Landsat 8 و Landsat 9، وتم حساب المساحة والنسبة المئوية لكل فئة من فئات الغطاء الأرضي في منطقة الدراسة. أشارت النتائج إلى أن نسبة الغطاء النباتي خلال الفترة 2017-2023 انخفضت بنسبة (1%) سنويًا باستخدام علاقة بيانية بين نسب الغطاء النباتي لكل مشهد والسنوات. ويعتبر هذا الانخفاض في الغطاء النباتي لمنطقة الصويرة مؤشرًا خطيرًا يهدد النظام البيئي. وعليه، توصي الدراسة الجهات المعنية بمتابعة النظام البيئي للمنطقة واتخاذ التدابير والإجراءات اللازمة لزيادة منسوب المياه في نهر دجلة، كذلك استصلاح الأراضي وتشجيع المزارعين على الاهتمام بالزراعة.

1. Introduction

One of the most significant ecological problems in metropolitan regions worldwide is land cover change, specifically the growth of urban areas and related human activities at the expense of natural and semi-natural areas [1][2]. Interest in researching land cover classifications and phenomena, such as soil, water, vegetation, and urban areas, is a vital study. Show the magnitude of the changes that will occur in a specific area due to urban areas' expansion or decline at the expense of agricultural areas, or vice versa, or increase in the bare land compared to agricultural lands [3][4]. The advancement of remote sensing techniques and software for handling data packets or digital technologies has made it possible to control large areas to describe and diagnose the earth's formologies. These methods are now essential for researching natural phenomena on the planet, determining their origin and the interactions of the factors that affect them, and forecasting future changes by monitoring, analyzing, and comparing [5][6]. It is possible to study conditions and characteristics at the spatial and temporal level by taking advantage of the information and data provided by remote sensing techniques over several years. This allows us to monitor environmental changes, urban areas, and most human activities associated with land cover [7] [8]. This indicates that changes in land cover and land use are interconnected globally. Environmental changes and activities related to natural resource management can be better understood with the help of two essential elements [9][10]. Rainfall is another factor that significantly impacts land use patterns, and the direction in which rainfall falls is important for groundwater generation. There is a clear relationship between the amount of rainfall received throughout the growing season and the agricultural productivity achieved. This illustrates the importance of rainfall in agriculture [11] [12]. Rain is one of the essential climatic elements.

Previous research investigated variations in vegetation cover in many cities around the world using a variety of methods, programs, and strategies, such as Pal and Mather (2006) [13] used the ML and ANN classification in two multi-class SVM experiments for central Spain and eastern England of Landsat-7 ETM+ data. They found that the SVM performs better than ML and ANN classifiers for limited training datasets and high dimensionality. Deilmai et al. (2014) [14] evaluated Multispectral data by MLC and SVM classifiers in Johor, Malaysia; Landsat Thematic Mapper identified urban areas, water, rubber, oil palm, and forests. They proved that the SVMs accurately classified land cover and outperformed MLC. Taghreed (2018) [15] studied the effect of vegetation indices technology on image segmentation to divide the image into homogeneous areas. She adopted three vegetation index techniques (DVI, PVI, WDVI) to detect and monitor the distribution and health of vegetation cover. She separated the vegetation areas from other land use areas and calculated their percentage area for 2001 and 2002 of (ETM+) scenes. She proved that separating agricultural areas from implementing the DVI index was better than other indices. Zahraa and Hussein (2020) [16] used SVM and MLC to classify land use for Hilla City. They showed the SVM performance superiority from MLC with an accuracy of 94.48%. Ahmed et al. (2022) [17] investigated the area covered by vegetation in Babylon,

central Iraq, every five years. They divided the vegetation area into high and low vegetation regions or low, moderate, and dense. They showed that the area covered by vegetation increased in 2021 from 803 km² and 280 km² to 990 km² and 406 km², respectively, for moderate vegetation and density or high vegetation. Sajan et al. (2023) [18] examined the changes in land cover and how they affected the normalized difference indicator of vegetation (NDVI) and land surface temperature (LST) in the Muzaffarpur district of Bihar, India. They discovered that vegetation and fallow land are important factors influencing the temporal and spatial variations in NDVI and LST compared to urban and water cover categories.

The study aims to analyze the variations of vegetation cover and calculate the areas of various land cover classes in the district of Al-Suwaira from 2017 to 2023, using remote sensing data and geographic information systems (GIS). These analyses will help understand the region's environmental changes and natural resources, contributing to planning vegetation management and biodiversity conservation decisions.

2. Materials and Methodology

Seven satellite scenes were used for the Suwayrah region to study the vegetation change in this region from 2017 to 2023. The following steps were performed to compare the results:

1. Perform the radiometric calibration and atmospheric correction.
 2. Select the eight training sets as the region of interest (ROI) for classification: trees, grass, clay soil, salty soil, sandy soil, building, deepwater, and shallow water of the study area indicated in Table 2.
 3. Implementing the Support Vector Machine (SVM) classifier to classify the Suwayrah region scene.
 4. Compute each class's percentage area and classification accuracy of the classified image.
- ENVI 5.1 and QGIS software were used to read the original scenes and clip the study area.

2.1 Study Site Description

The study site was clipped to cover an area of 1803 km², which represents the northwest of the Waist Province, located within a latitude of 33.40.0°N to 33.0.0°N and a longitude of 44.30. 0°E to 45.0.0°E. Table 1 lists the Landsat satellite data for path 168 and row 037, Figure 1. Landsat data was downloaded from (<https://earthexplorer.usgs.gov/>) [19][20]. The dominant features of the study are arable land and urban areas, along with other agricultural and dry areas, such as the Tigris River and fish lakes. Most plants are evergreen or plants that humans, not natural plants, planted.

Table 1: The available data

N0.	Date	Satellite
1	23 September 2017	Landsat-8 OLI
2	28 October 2018	Landsat-8 OLI
3	15 October 2019	Landsat-8 OLI
4	17 October 2020	Landsat-8 OLI
5	20 October 2021	Landsat-8 OLI
6	7 October 2022	Landsat-8 OLI
7	18 October 2023	Landsat-9 OLI-2

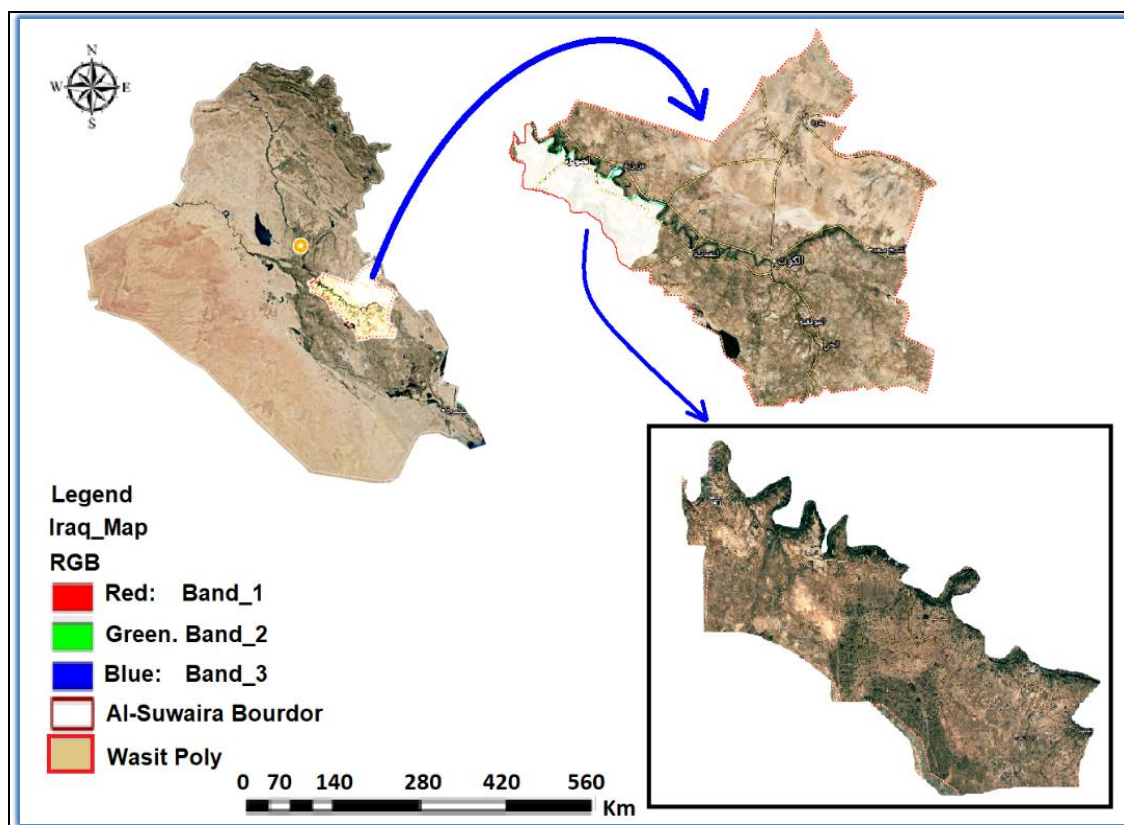


Figure 1: Waist Province location of the Iraq map and the natural band combination (Red, Green, Blue) of Landsat_8 OLI scene for Al-Suwaira District, the study area

2.2 Support vector machine classification (SVM)

SVM is a supervised learning method for regression analysis and LULC classification. The hyperplane, an optimal decision boundary created by this algorithm, separates the training data based on the minimum number of misclassified pixels. SVM used an iterative approach to create the best hyperplane to distinguish between the patterns in the training dataset [21]. The mechanism depends on the dataset's size, making SVM unsuitable for massive data due to its training difficulty. However, because of its kernel approach, SVM is beneficial for complex data [21]. This method uses a kind of SVM classification based on training samples to sort the image into the training courses. The user must choose a region of interest that functions as a classifier and categorizes every pixel in the image in supervised classification [22] [23]. The resources' type, the application's character, and the availability of data all influence the classification technique selection. Therefore, this study applies a statistical learning-based classifier, the non-parametric rule of support vector machines, to the pixel-based supervised classification technique. The decision to use this method is based on research studies showing that SVM outperforms other classification methods in accuracy [24][25].

3. Results and Discussion

To study the land cover of the studied area, four main training sets (ROI) were selected: plants, soil, urban, and water. Eight sub-training sets were determined within these main training sets. The colors used to discriminate the various training sets in the study area were demonstrated in the key colors (Table 2). The approved scenes in this work were selected for October, when the season of most of the plants that grow naturally ends due to rainfall, and only evergreen trees and plants that humans cultivate remain.

Table 2: Training sets and key colors.









No.	Main Class	Sub-class	Color
1	plant	Trees	
2		Grass	
3	Soil	Clay soil	
4		Salty soil	
5		Sandy soil	
6	Urban	Buildings	
7	Water	Deepwater	
8		Shallow water	

Figure 2 The natural scenes of the study area for the adopted years (2017 to 2023) in this study.

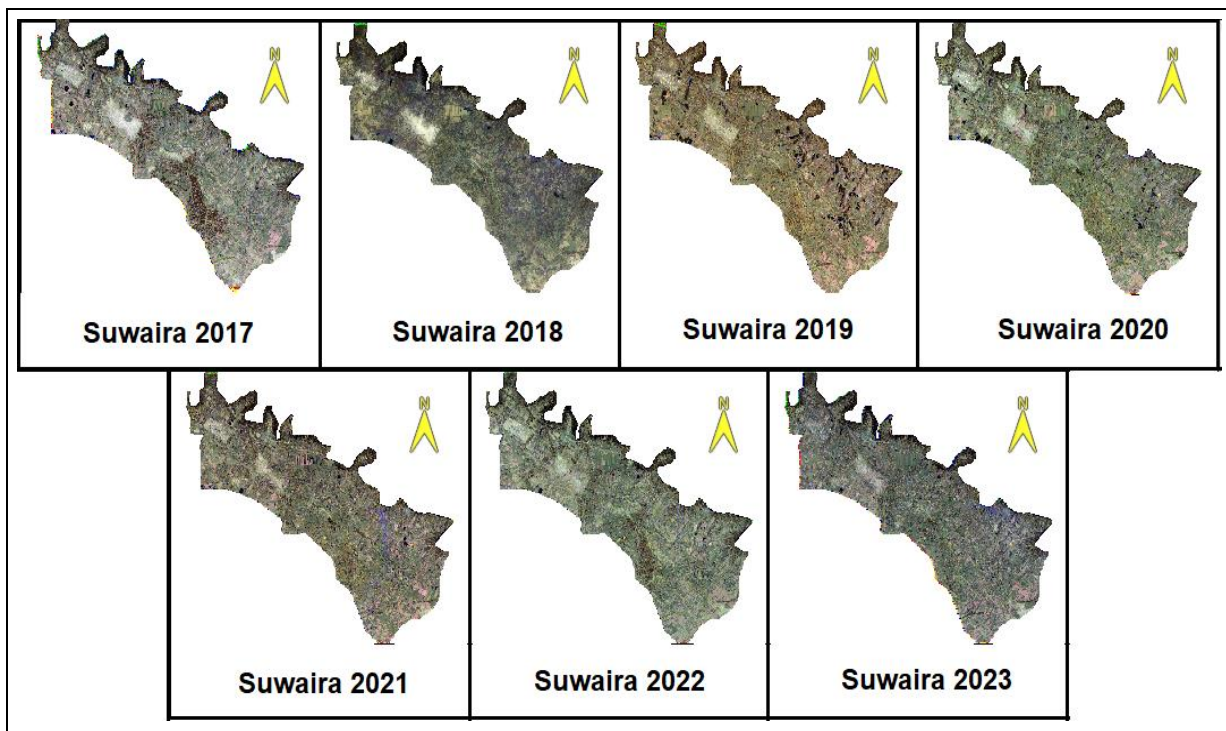


Figure 2: Study area for the adopted years (2017 to 2023) before classification

The classification results of the study area using an SVM classifier are presented in Figure 3, which exhibits the highest accuracy of 99.9468% in 2018, Table 5.

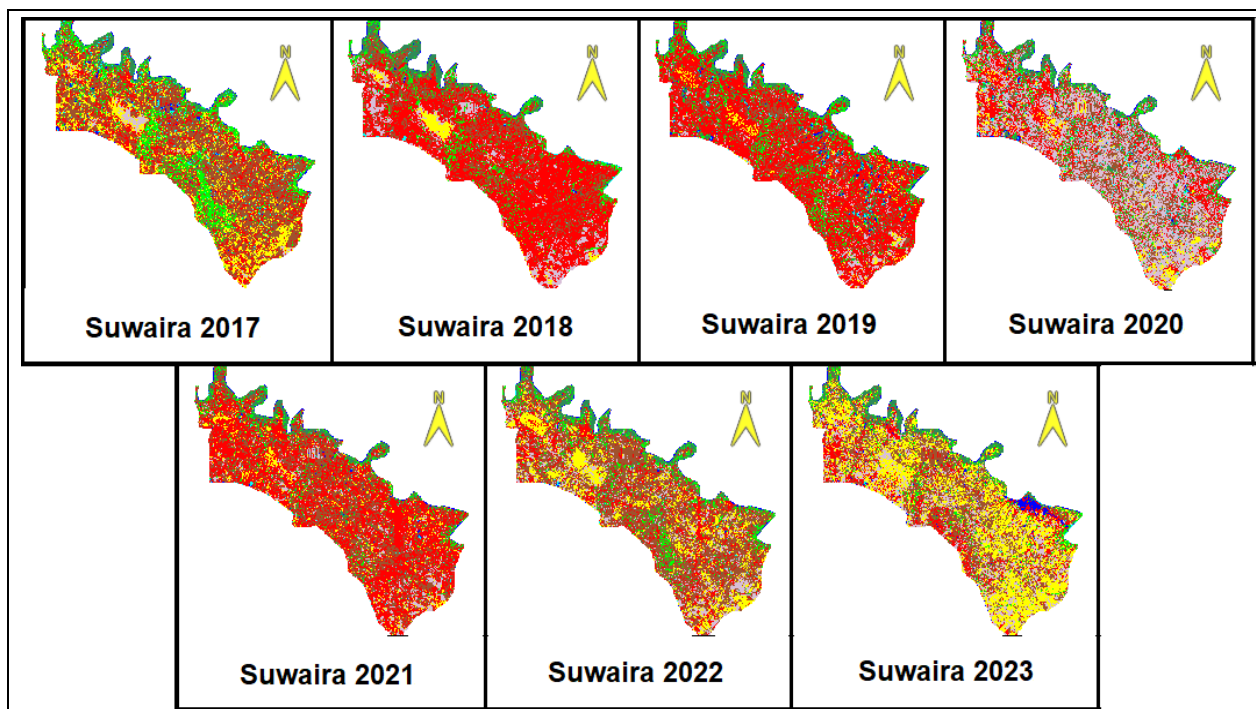


Figure 3: Classification results of the study area during the period (2017-2023)

There is an overlap between urban and sandy soil classes due to the spectral signature of urbanization being similar to the spectral signature of sandy soil, especially in October, when much dust accumulates over buildings, urbanization, and urban areas, giving a spectral signature similar to that of one of the soil types. The interaction between urbanization and soil does not affect the results of this study, as this study focuses on vegetation cover only. The best solution for this interaction in studies focusing on urbanization or soil is to use scenes taken in March. Rain contributes to cleaning buildings, adding a difference between urbanization's spectral signature and soil. The spatial resolution of the satellite (30 m) plays an important role in the inability to separate the overlap between houses with small areas relative to the area of one pixel of 900 m². The areas and percentages of the sub-classes of the classified seven scenes were calculated in Table 3. There was a clear difference in the values of the areas for each class during these periods due to the scarcity of water resources and rain, which decreased vegetation cover area.

Table 3: Sub-classes by percentage and areas.

Class	2017		2018		2019		2020	
	Area (Km ²)	Percent %	Area (Km ²)	Percent %	Area (Km ²)	Percent %	Area (Km ²)	Percent %
Trees	70.95	3.93	84.82	4.70	134.63	7.46	117.41	6.51
Grass	237.78	13.18	143.66	7.97	175.89	9.75	103.99	5.77
Clay soil	701.46	38.89	313.04	17.36	261.21	14.48	322.07	17.86
Salty soil	299.25	16.59	45.18	2.50	47.54	2.64	97.51	5.41
Sandy soil	34.33	1.90	165.11	9.15	101.63	5.64	693.50	38.45
Deepwater	28.96	1.61	13.11	0.73	33.34	1.85	24.39	1.35
Shallow water	42.77	2.37	10.82	0.60	23.47	1.30	35.35	1.96
Buildings	388.03	21.52	1027.78	56.99	1025.81	56.88	409.31	22.69
Total Area	1803.52	100.00	1803.52	100.00	1803.52	100.00	1803.52	100.00

Class	2021		2022		2023	
	Area (Km ²)	Percent %	Area (Km ²)	Percent %	Area (Km ²)	Percent %
Trees	92.23	5.11	88.05	4.88	96.96	5.38
Grass	87.77	4.87	134.00	7.43	95.66	5.30
Clay soil	482.44	26.75	774.80	42.96	453.24	25.13
Salty soil	105.25	5.84	273.25	15.15	570.18	31.62
Sandy soil	111.78	6.20	201.66	11.18	287.11	15.92
Deepwater	21.28	1.18	18.54	1.03	41.23	2.29
Shallow water	9.42	0.52	7.23	0.40	4.64	0.26
Buildings	893.35	49.53	306.00	16.97	254.50	14.11
Total Area	1803.52	100.00%	1803.52	100.00	1803.52	100.00

The areas and percentages of the general (main) classes were calculated for the classified seven images, Table 4. For the same reason, the values of the areas for each class during this period differ.

Table 4: The Main classes' percentage (%) and area

class	2017		2018		2019		2020	
	Area Km ²	Percent %	Area Km ²	Percent %	Area Km ²	Percent %	Area Km ²	Percent %
plant	308.73	17.12	228.48	12.67	310.52	17.22	221.40	12.28
Soil	1035.03	57.39	523.33	29.02	410.38	22.75	1113.08	61.72
Urban	388.03	21.52	1027.78	56.99	1025.81	56.88	409.31	22.69
Water	71.73	3.98	23.94	1.33	56.82	3.15	59.74	3.31
Total Area	1803.52	100.00	1803.52	100.00	1803.52	100.00	1803.52	100.00

class	2021		2022		2023	
	Area Km ²	Percent %	Area Km ²	Percent %	Area Km ²	Percent %
Plant	180.00	9.98	222.05	12.31	192.62	10.68
Soil	699.47	38.78	1249.71	69.29	1310.54	72.67
Urban	893.35	49.53	306.00	16.97	254.50	14.11
Water	30.70	1.70	25.76	1.43	45.86	2.54
Total Area	1803.52	100.00	1803.52	100.00	1803.52	100.00

The overall classification accuracy (OA) and kappa coefficient were calculated for all the scenes in Table 5. There is an apparent increase in the (OA) of 2018 year.

Table 5: The classification accuracy.

Satellite Data	Accuracy %	Kappa Coefficient
2017	99.3900	0.9928
2018	99.9468	0.9994
2019	99.4846	0.9937
2020	99.3195	0.9917
2021	99.3215	0.9919
2022	99.3097	0.9918
2023	97.3353	0.9680

As shown in Table 3, there was a change in the areas and percentages of vegetation cover. The highest values were for the years 2017 and 2019. A relationship between years and the percentage of vegetation cover areas is determined to calculate the change in vegetation cover. The decrease in vegetation cover was equal to 1 % per year, Figure 4.

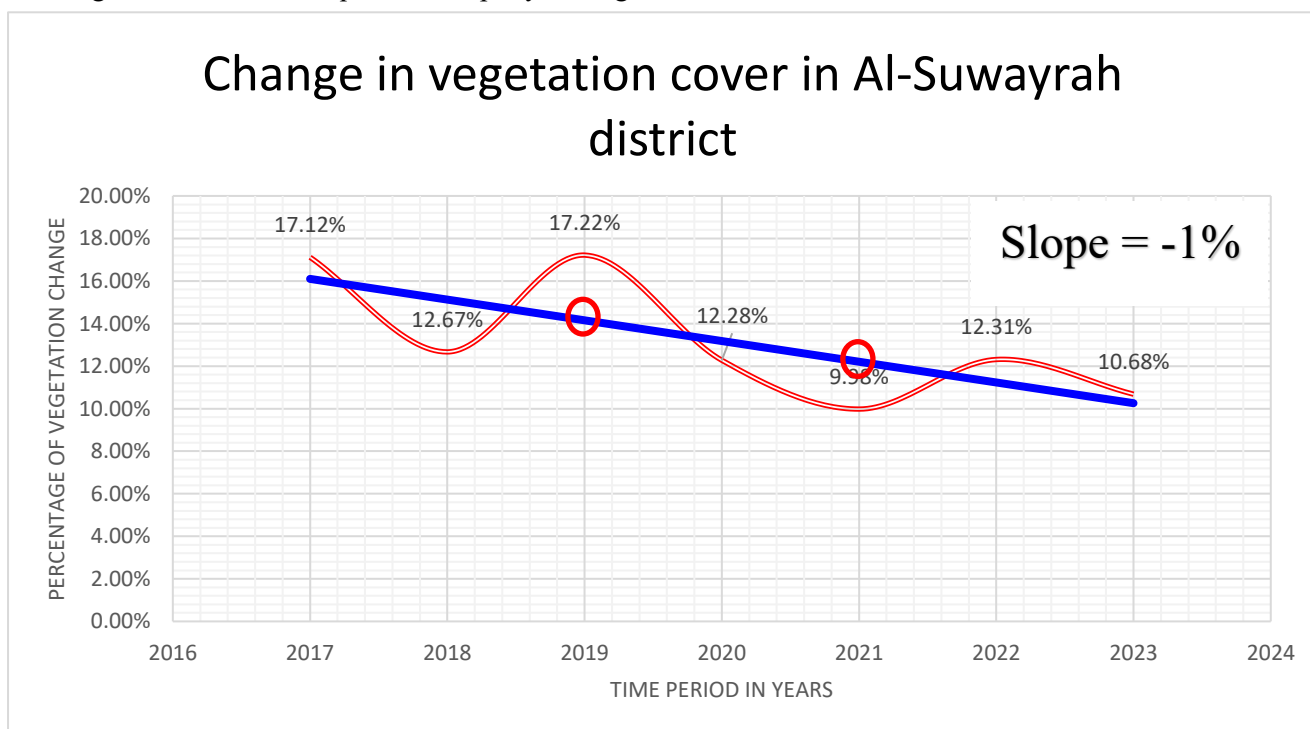


Figure 4: Relationship between time in years and percentage change in vegetation cover for Al-Suwaira region.

4. Conclusion

Depending on the results in Figure 4 and Table 4, there was a change in the percentages of vegetation cover (fluctuations in the percentage curve). The highest values were for the years 2017 and 2019, when Iraq, especially the southern regions, witnessed heavy rainfall for the first time in three decades for these two years, which led to a significant increase in the water level of the Tigris River, which encouraged farmers with relatively highlands to reclaim and cultivate them. The decrease in vegetation cover rate is noted between 2017 and 2018 and 2019 2021. This is due to the decrease in the water level in the Tigris River and the continued decrease in rainfall rate over one year. The rate of decrease in vegetation cover was equivalent to 1% for each year. One of the possible explanations for these fluctuations is the method and methodology followed by farmers in agriculture,

as they leave the lands in the year of cultivation and invest in them in another year in succession, a custom known as "Crop rotation," alternating in cultivating the land to reclaim it.

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