Analysis of the slopes of Jambour Anticline in Kirkuk and its Effect on Soil Formation using Remote Sensing (RS) Data and Geographic Information Systems (GIS)

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Abstract
The area slope was studied according to several classifications and the matching, as well as studying the direction of the slope, the study found the direction south-east and south is prevalent in the region, because of the origin of tectonic processes, responsible for the emergence of the Jampour Anticline and the slope receding, it appears that most of the slopes in the region correspond to the directions of the river valleys, these slopes increased the speed of efficacy of riverine operations, resulting in an increase in the movement of surface materials. The shadow of the hills was also analyzed, and medium shade areas came first, followed by many shade areas, as well as studying the degree of curvature, it was found that straight, flat shapes outnumber convex and concave shapes if they reached 42.5%.

The soil of the area was also studied according to Al-Ta’i’s classification, the area soil was cultivated according to its potential for agriculture and grazing, the soil will be good for grazing, animals and forests grow due to water and wind erosion.

Keywords: Slopes, Jambour Anticline, Kirkuk, Soil Formation, Remote Sensing (RS), Geographic Information Systems (GIS)

Introduction
There are slopes formed by the processes of tension, compression and Anticlineing, resulted in most of the Anticlines and some of them were formed by external processes, as erosion and sedimentation, the gradients of the slope were determined, using several classifications, and then knowing the effect of steepness on forming a Anticline.

The research problem arose by asking the following question: Do the slopes affect the formation of the soils of the Jambour Anticline in Kirkuk.

The research hypothesis indicates that there is a relationship between the slopes and the formation of the soils of the Jambour Anticline in Kirkuk governorate,

The research aims to study slopes and their effect on soil formation, as well as to know the relationship between slope and rock formations.

The study area was also defined based on topographic maps, satellite visuals and Digital Elevation Data (DEM).

The area was divided according to the criterion of the Jambour anticline, separates it from the surrounding terrain, it has natural and human boundaries, as for astronomy, it extends between longitudes (10/34/44) (50/21 44 44) to the east and two circles of latitude (202023/35) (11-35) north. Administratively located within Kirkuk governorate (Map 1), bordered on the north by Erbil Governorate, from the east it is bordered by the Governorate of Sulaymaniyah and on the south by the district of Tuz Khurmatu, on the southwest side, it is bordered by Salah al-Din Governorate, as for the...
natural site, it is bordered on the north by the Khassa Sow river, on the east by the Malakhana Valley, on the south by the Daquq River, and on the west by the Karma Valley.

The methodology adopted in the research, it is the analytical method, quantitative mathematical methods, and geographic information systems tools, and the research comes in the following order:
1. Tools and ways. 2. Practical procedures for research. 3. Blocks analysis. 4. Soil analysis 5. Results 6. Recommendations.

Map (1) The location of the study area.
(Topographic Maps 1/25000 based on ArcGis 10.4 software output)

First: Tools and Means:
The data used:
1. DEM data with an accuracy of 14 meters per unit area.
2. Landsat 8 2020 satellite imagery, bath 196 row35.
3. Topographic maps, General Directorate of Iraqi Survey, scale 1 / 100,000.

Slope Sections
Five major stages can be deduced through which the geomorphological cycle of the slopes of the Jambour Anticline slopes varied, during which the geological and climatic conditions varied, and thus the way in which the slopes developed (John wiley & sons, 2002).

The first stage: the stage of the emergence of slopes above sea level in response to tectonic uplift and fault movements.
**The second stage:** the region witnessed wet and rainy periods and formed water valleys that made the cliffs recede and form a convex slope, by the effect of active water erosion that did not allow sediment to build up under the feet of the slopes.

**The third stage:** the stage of fluctuating rainfall amounts, during which the factors and processes of sculpting and sedimentation alternated, and the slopes of valley terraces appeared, this stage was characterized by the retreat of cliffs by the method of replacement, that is, the retreat of the upper part of the cliffs, while the lower part of it advanced as a result of the accumulation of loose materials and the beginning of the formation of the Piedmont surfaces.

**Fourth stage:** during which the amount of rain gradually decreased, and sedimentation factors and processes prevailed during that period, and flood fans were built and deposited, the valleys were unable to carry all the products of weathering, avalanches and rock falls, so the crumbs accumulated over the slopes of the region, and the slopes of the Piedmont were finally formed.

**The fifth stage:** the drought stage, in which the factors and processes of weathering and rock fall were active, and during which the wildfire slopes were formed in a more mature manner.

**Previous studies:**
1. Ahmad (2009) study: This study included slopes and their applications in Sulaymaniyah Governorate, using geographic information systems and remote sensing, as became clear that there are different types of land slopes.

2. The study of Al-Janabi, (2016): This study deals with the geomorphological evaluation of the slopes of the Hara series, analyzing the slope properties, and matching them with the erosion area, assesses the slopes of the Kara chain, and identifies areas with geomorphological hazards.

3. The study of Al-Halbousi, (2017): a study of the geo-morphological characteristics of a Matin Anticline in Duhok Governorate, in terms of the topographical characteristics, the accuracy, comprehensiveness, and precise compatibility between the degree of slope and the topographic category were shown.

**Second: the practical procedures for research.**
- Plot the longitudinal and cross sections from the dem digital elevation data in a survey authority.

- Derivation of databases (height, slope in degree, direction of slope, shadow maps).

- Geo-return map processors (tectonic, geological, soil).

- Matching the digital elevation data to the topographic map.
- Numbering each cadastral unit with a special code indicating its location on the map.

- Use Extension-Toolbox Arc- Analysis Tools- D Analysis 3.

**Young 1975 classification**
The convex jumbo series was divided according to this classification into four levels out of seven levels according to the angle of the degree of slope for each part, as shown in Table (1) and Map (2).

**Table (1) Earth ridge shapes, slope angles, area and proportions according to (young) classification. (Daoud, 2002)**

| No. | Terrain shape           | Slope angles in degrees | Area (Km²) | Percent (%) |
|-----|-------------------------|-------------------------|------------|-------------|
| 1   | Semi-flat lands         | 0-2⁰                    | 267.8      | 66.3        |
| 2   | Slope simple land       | 2-5⁰                    | 110.4      | 27.3        |
| 3   | Slope land              | 5-10⁰                   | 23.5       | 5.8         |
| 4   | Land of moderate slope  | 10-18⁰                  | 2.3        | 0.6         |
| 5   | Steep terrain           | 18-30⁰                  | -          | -           |
| 6   | Steep terrain, very steep | 30-45⁰              | -          | -           |
| 7   | Shelf lands             | 45⁰+                    | -          | -           |
|     | Total                   |                         | 4.4        | 100         |

**DemeK 1972 classification:**
The area is divided into three levels out of six taxonomic levels, as is the case seen in Table (2) and Map (3) represents a detailed explanation of the topographic map from the DIMC classification.

1. The scope of semi-flat lands. 2- The extent of the plain lands. 3- Scope of undulating lands.
Table (2) Earth forms and slope angles according to Demek classification (Aswad, 1997).

| No. | Terrain shape       | Slope angles in degrees | Area (Km²) | Percent (%) |
|-----|---------------------|-------------------------|------------|-------------|
| 1   | Semi-flat lands     | 0 - 2⁰                 | 267.8      | 66.3        |
| 2   | Plain land          | 2 - 5⁰                 | 110.3      | 27.3        |
| 3   | Undulating land     | 5 - 15⁰                | 25.9       | 6.4         |
| 4   | Low hills           | 15 - 35⁰               | -          | -           |
| 5   | High hills          | 35 - 55⁰               | -          | -           |
| 6   | Very high mountains | 55⁰                    | -          | -           |
|     | Total               |                         | 4.4        | 100         |

Map (3) The gear levels according to the (Demek) classification.
(the work of researchers based on the ArcGis 10.4)

Zink 1989-1988 classification:
The classification came on three classification levels, gradients with slope levels close to the Demek classification, highlight the advantages of the study area, which was characterized by the concentration of its slopes in the few categories, absent at large slope corners. It is seen (Table 3) (Map 4).

Table (3) The shapes of the earth’s surface and the angles of slope according to the classification of (Zink).

| No. | Terrain shape       | Slope angles in degrees | Surface Classification | Area (Km²) | Percent (%) |
|-----|---------------------|-------------------------|------------------------|------------|-------------|
| 1   | Flat-flat land      | 0 - 1.9⁰               | Plains - valleys       | 252.6      | 62.5        |
1. Flat lands zone. 2. Light undulating zone. 3. Undulating lands zone.

**Direction of slope:**
Table (5) show that the predominant slope is the southeast and south direction, as a result of tectonic processes that created slopes, the southeastern and southern flank is more active with the rest of the other directions, because of along the original axis of the Anticline along the rocky layered racket, leads to a reflection of geomorphological, processes on the appearance of the Anticline structure (Table 4) (Map 5), spread over a wide area with an area of 63.8 km2 out of 15.8% of the total area of the region. The rest of the directions took the direction of the plane, north, northeast, southwest, west, northwest, lesser percentages, but close, as it recorded successively (5.3%, 9.7%, 12.5%, 15, 11.1%, 4.5%, 1.1%).

**Table (4) The location, area, and ratio of the slope direction.**

| No. | Slope direction | Class slope | Area (Km²) | Percent (%) | Color |
|-----|-----------------|-------------|------------|-------------|-------|
| 1   | Flat            | 1-0         | 21.6       | 5.3         | Yellow|
| 2   | North           | 337.5-360   | 39.3       | 9.7         | Red   |
The direction of the slopes.

Hill shad
It is a default luminaire used to measure the amount of solar radiation falling on slopes in the study area (Map 6), during satellite images and visuals and analyzed by Arc Gis software.

Table (5) The distribution of the shadow of the ridges.

| Hill shad            | Area (Km²) | Percent (%) | Color     |
|----------------------|------------|-------------|-----------|
| Areas of little shade| 49.9       | 12.5        | Yellow    |
| Medium shade areas   | 282.5      | 70.5        | Orange    |
| Shade areas          | 67.7       | 16.9        | Brown     |
| Total                |            | 100         |           |

(The work of researchers based on the ArcGis 10.4)
Slope Curvature Analysis

By studying the curvature, it was found that the ratio of flat (straight) shapes exceeds the ratio of convex and concave shapes, reached 42.5% of the area of 172 km² of its area, followed by the ratio of the concave shape (42%) with an area that formed (169.8) km², then convex slopes were formed by (15.5%) and amounted (62.6) km² of the total area of the study area. As shown in Table (6) and Map (7) as follows:

Map (6) The shadow distribution areas of the hills.
(the work of researchers based on the ArcGis 10.4)

Table (6) The type of curvature analysis slope

| The type of curvature slope | Area (Km²) | Percent (%) |
|----------------------------|------------|-------------|
| The flat                   | 172        | 42.5        |
| Concavity                  | 169.8      | 42.0        |
| Convexity                  | 62.6       | 15.5        |

(the work of researchers based on the ArcGis 10.4)
The degree of focus of the gradient curve.

(1) The work of researchers based on the ArcGis 10.4

Degree of congruence between Zink and Demek classification:
Zink and Demek classification was selected, therefore, he found great similarity in terms of the distribution of rocky exposures and the pattern of steeple characteristics, however, Young crossed the boundaries of the congruence area with moderate slope gradient, (Table 7) and (Map 8).

Table (7) The area of congruence between Zink and Demek (*)

| No | Zink's Categories | Demek's Categories | Area (Km²) | Percent (%) |
|----|------------------|--------------------|------------|-------------|
| 1  | 1                | 1                  | 109.8      | 27.2        |
| 2  | 1                | 2                  | 16.2       | 4           |
| 3  | 1                | 3                  | 18.6       | 4.6         |
| 4  | 2                | 1                  | 2.3        | 0.6         |
| 5  | 2                | 2                  | 250.4      | 62.1        |
| 6  | 3                | 3                  | 6.3        | 1.6         |
| Total | 10             | 12                 | 6403       | 100         |

(1) The work of researchers based on the ArcGis 10.4
The degree of congruence between Zink and Young's classification. 
(the work of researchers based on the ArcGis 10.4)

The first category: the degree of congruence between the classification of (Zink and Demek) with a gradient of 1-1 level, which represents the flat plain lands, with slight to semi-simple slopes, it ranks second in terms of its area, which amounted to 109.8 km² out of the total (27.2)% of the total area of the region.

The second category: the categories were represented between 2-1 representing the upper erosive river plains, some of them are located in the feet of the mountain slopes and the accumulation of rockfall from the top of the mountain due to gravity, constituted a small area (16.2 km²) at a rate of 4% of the total area of the study area.

The third category: the categories represented the regression grades between 1-3, there are low hilly lands with an area amounting to 18.6 km², and by a percentage of 4.6% of the total area of the study area, represent the central river terraces that concentrate on the sides of the main basins streams of two basins 2-3.

The fourth category: The grades of gradations range between 1-2, which found a very small area with an area of 2.3 and 0.6%.

The fifth category: It represents the steeper categories between 2-2, occupies the largest part with an area of 250.4 km² and occupies a rate of 62.1% of the total area of the study area, which represent the areas of agricultural agriculture (wheat and barley) and some natural plants that appear in the rainy season directly.
The sixth category: regressive categories focused between 3-3, it has a small area of 6.3 km² and occupies a rate of 1.6% of the total area of the study area, which represents the areas of valleys.

Rock formations:
Geological formations can be observed in the study area from the oldest to the newest age. Table (8) and Map (9) notes as follows:

1. Al-Fatha Formation (Middle Miocene):
It extends on one end of the north-eastern edge, and the other is exposed at the end of the southwestern edge, occupies an area of 10.8 km², representing a ratio of 2.6% of the area of the study area.

2. Injana formation:
That the study area contains layers of sandy rocks of 1-4 m thickness, the thickness of the clay layers ranges between 2-4 m, clay layers have poor resistance to erosion, compared to sandy rocks with high resistance, as this formation was exposed in the form of a broad tongue that extends in a southwestern direction, comes in fourth place and occupies an area of 42.0 km², while its percentage occupies 10.6% of the studied area.

3. Mukdadiya formation (Pliocene):
It is concentrated in the vicinity of the study area and is the boundary between the Bai Hasan Formation and the Injana Formation, constitutes 102.6 km², while it constitutes 25.4% of its percentage within the area of the study area.

4. Bai Hassan formation (Late Pliocene):
It is located in the center of the study area in the form of a broad condition extending from north to south, its area is 84.3 km², while the percentage constitutes 11.9% of the total area of the study area.

5. sediments of surface runoff:
Its sediments come from the Silokan Valley, which branches into two valleys, namely Malakhana and Shewa, located on the east side, made of mud, sand and silt, spreads in the form of a long and wide tongue that occupied an area of 15.5 km² out of 3.8% of the total area of the study area.

6. Flood plains deposits:
They are sediments coming from the convex range of Jambour Anticline Heights, This dominates the straight slope and the formation of alluvial fans, created a land for it to collect sediments consisting of mud, sand, silt and coverings of gypsum during flood seasons, so that these sediments gather on top of each other, made it fertile and arable land, the seasonal winter crops, which are wheat and barley, its cultivated area reached 184.2 km² out of 45.6% of the total area of the study area.
| Time       | The era    | Formation       | Area (Km²) | Percent (%) | the description                                                                 | Sedimentation environment |
|-----------|-----------|-----------------|------------|-------------|--------------------------------------------------------------------------------|------------------------------|
| Quadruple | Holocene  | Floodplain sediments | 184.2      | 45.6        | It consists of silty sand clay and gypsum coverings                            | Continental                  |
|           | Pleistocene | Runoff       | 15.5       | 3.8         | Silts and clay materials with sand, clay and gypsum                            | Continental                  |
| Triple    | Pliocene  | Bai Hassan     | 84.3       | 11.9        | A succession of layers of agglomerates, sandstone, mudstone                    | River                        |
|           | Myosin,  | Mukdadiya      | 102.6      | 25.4        | Alternating courses of gravel, sandstone and alluvial stone, with horizons of sandstone containing gravel | River                        |
|           | Pliocene  | Injana         | 42.0       | 10.6        | Sandstone succession, alluvial stone, mudstone, child stone                    | River                        |
|           | Middle myosin | Al-Fatha     | 10.8       | 2.7         | Top part: red clay stone with fine sandstone as well as evaporative rocks Lower part: alternation of marl and limestone | Shallow sea                  |
| Total     |           |                 | 404.3      | 100         |                                                                                 |                              |

(General Directorate of Geological Survey and Mineral Investigation)

Relationship between gradient and rock formations:

1. Runoff sediments:
They are the deposits that come from outside the study area, located on the east side and is bordered by Malakhana and Shiro Valley, during the sediments of the crumbs seep into the area, so that the percentage of congruence between the Sahel regions was 11.923 km², while the extent of the upper river erosion plains reached 3,424 km², as for the range of low hills 0.008 km², therefore, its total percentage reached 15.4%.

2. Floodplain Deposits:
It is divided into three areas, including the flat plain, so that its identical area reached 173.288 km², while the range of the upper erosion plains or the range of the feet of the mountains was found in which a corresponding ratio of 10.752 km², as for low hills, it formed 0.045 km², so that the total number of matches reached 184.11%, this indicates that floodplain sediments occupy the largest area, therefore, the activity of cover
erosion and liquefaction erosion increases, the formation of the fans flowing from the heights of the convex chain of Jambour Anticline located in the middle of the study area.

Map (9) The rock exposures of the study area.
(Ministry of Industry and Minerals)

3. Bai Hassan formation:
The fall of the rock masses from the heights of Jambour and the gathering of pebbles and boulders of different sizes, as a result of its response to geomorphological processes due to the action of the Earth's gravity in sloping lands and valleys, formed a match ratio of 24.963 km², while hills' feet constituted 22,886 km², while low hills amounted 0.333 km² of the total percentage of 48.2% of the area of the study area.

4. Mukdadiya formation:
The area of the flat lands and their valleys constituted 21,468 km², while the range of the feet of the mountains reached 77.028 km², undulating hills amounted to 3,977 km² out of a total of 103.5% of the total area of the study area.

5. Injana formation:
In this formation, the area of the plain and the valley reached 12,386 km², of which the area of the upper river erosion plains or the feet of the hills, formed 29,372 km², the area of low hills (0.686) km² of the total area of Anjana formation constituted 42.4% of the total area of the studied area.
6. Al-Fatha formation:
This formation receives a very small percentage of matching formation with degree gradient, formed a proportion matching the area of flat land (5.439) km$^2$, including the Tahati plain, which borders a flat plain 5,012 km$^2$, located on the northeastern outskirts, while low hills located at the exits of the end of the southwestern wing of Anticline with an area of 0.227 km$^2$ of the total 10.7% of the total area of the study area.

Table (9) The relationship between the degree of slope and rock formations.

| No. | Rock formations          | The angle of slope is in degrees | Area Identical (Km$^2$) | Total |
|-----|--------------------------|---------------------------------|-------------------------|-------|
| 1   | Bai Hassan               | 1.9-0                           | 24.963                  | 48.2  |
|     | 7.9-1.9                  | 22.886                          |                         |       |
|     | 15-7.9                   | 0.333                           |                         |       |
| 2   | Al-Fatha                 | 1.9-0                           | 5.439                   | 10.7  |
|     | 7.9-1.9                  | 5.012                           |                         |       |
|     | 15-7.9                   | 0.227                           |                         |       |
| 3   | Injana                   | 1.9-0                           | 12.386                  | 42.4  |
|     | 7.9-1.9                  | 29.372                          |                         |       |
|     | 15-7.9                   | 0.686                           |                         |       |
| 4   | Runoff sediments         | 1.9-0                           | 11.923                  | 15.4  |
|     | 7.9-1.9                  | 3.424                           |                         |       |
|     | 15-7.9                   | 0.008                           |                         |       |
| 5   | Mukdadiya                | 1.9-0                           | 21.468                  | 103.5 |
|     | 7.9-1.9                  | 77.028                          |                         |       |
|     | 15-7.9                   | 3.977                           |                         |       |
| 6   | Floodplain sediments     | 1.9-0                           | 173.288                 | 184.1 |
|     | 7.9-1.9                  | 10.752                          |                         |       |
|     | 15-7.9                   | 0.045                           |                         |       |

(The researchers’ work, depending on the regression maps and using Arc Gis 10.4)

Third: Analysis of private sectors of the transverse side slopes of the study area:
The determination of the morphological characteristics of the slopes and the level of erosion of their sections on both sides are the eastern wing shown in figure (1) and the western wing shown in figure (2), 13 cross sections of the two wings, (map 9), were selected, of which there were 28 wings, for the purpose of detailed side coverage, to see the degree of development of the slopes and the level of their height and length, and to know its tectonic and morphological activity, there was a great discrepancy between the east and west of the Anticline, in addition to a clear activity in the foothills of the southern wings of the Anticline, its high level and its low level in the foothills of the northern wings of the Anticline. The formation of a prominent mountain basin in the core of the Anticline and the runoff of seasonal slopes along its slopes and the level of their retreat in parallel, as a result of differential erosion. The analysis of the terrain sections of the Jambour slopes came according to their sequence of 1-13 wings, which were as follows:
Map (9) the transverse lateral special sectors of the Jambour slopes

Figure (1) the eastern wing of the slopes of the Jumbur Anticline. (Digital elevation model (DEM) and using Global Mapper 11 software)
1. **Sector No. 1**: This section is located at the outskirts of the north-eastern wing of the Anticline and swallows its length from the top of the summit to the bottom of the slope of 410 meters above level sea.

2. **Sector No. 2**: This section is located in the north of the perimeter of the eastern flank of the Anticline and swallows 541 meters in length from the top of the summit to the bottom, and it is clear from Figure (3) that the slope of the summit started from 335 m above sea level.

3. **Sector No. 3**: This section is located on the perimeter of the eastern wing and its length from the top of the summit to the bottom of the Anticline is 650 meters, and it can be seen from Figure (3) that the slope of the summit reaches more than 340 meters above sea level.

4. **Sector No. 4**: This section is located on the perimeter of the eastern flank of the Anticline. Its length from the top of the summit to the bottom of the slope is 709 m and its height reaches 340 m above sea level.

5. **Sector No. 5**: This section is located in the middle of the eastern wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 933 meters and its height reaches 345 meters above sea level.

6. **Sector No. 6**: This section is located in the middle of the eastern wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 1097 km, and its height reaches 355 m above sea level.

7. **Sector No. 7**: It is located at the core of the eastern wing of the Anticline. Its length from the top of the summit to the bottom is 1044 km, and its height reaches 355 m above sea level.

8. **Sector No. 8**: This section is located at the core of the eastern wing of the Anticline and is 799 m in length and reaches 357 m above sea level.

9. **Sector No. 9**: It is located in the middle of the eastern wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 1767 km and the level of height is 355 m above sea level.

10. **Sector No. 10**: It is located in the middle of the eastern wing and is 1243 km long and 365 m above sea level.

11. **Sector No. 11**: It is located in the perimeter of the eastern wing of the Anticline and is 1711 km long and is the longest section of the slopes at the level of the eastern wing, and the height of the cliff top reaches 370 m above sea level.

12. **Sector No. 12**: It is located in the vicinity of the eastern wing and is 1657 km in length and 370 m above sea level.
13. **Sector No. 13**: which is the last section that ends in the south of the eastern wing of the Anticline and is 1720 km long and 345 m above sea level.

Figure (2) the slopes of the east wing figures.
*(Digital elevation model (DEM) and using Global Mapper 11 software)*
Figure (3) West Wing Model of the Jumbo Anticline Slopes.
(Digital elevation model (DEM) and using Global Mapper 11 software)

1. **Sector No. 1:** This section is located on the northern outskirts of the western wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 733 meters and a level of 315.0 meters above sea level.

2. **Sector No. 2:** This section is located in the north of the perimeter of the western wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 724 meters, and its height reaches 335 meters above sea level.

3. **Sector No. 3:** It is located in the perimeter of the western wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 995 m and its height is 345 m above sea level.

4. **Sector No. 4:** It is located on the perimeter of the western wing of the Anticline, its length from the top of the summit to the bottom reaches 1212 km and its height reaches 350 m above sea level.

5. **Sector No. 5:** It is located in the center of the western wing of the Anticline and is 1047 m in length and 350 m above sea level.

6. **Sector No. 6:** It is located in the center of the western wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 1079 km and its height is 360 m above sea level.

7. **Sector No. 7:** It is located in the core of the western wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 1043 km and its height is 360 m above sea level.
8. **Sector No. 8**: It is located in the core of the western wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 1236 km and its height is 360 m above sea level.

9-10 **Sector No. 9-10**: They are located in the core of the western wing of the Anticline. Their length from the top of the summit to the bottom of the slope is 1598 km and its height is 360 m above sea level.

11. **Sector No. 11**: It is located in the perimeter of the western wing. Its length from the top to the bottom is 1598 km and its height reaches 360 m above sea level.

12. **Sector No. 12**: It is located in the perimeter of the western wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 1675 km and its height is 360 m above sea level.

13. **Sector No. 13**: It is the last wing in the south of the edges of the western wing of the Anticline. Its length from the top of the summit to the bottom of the slope is 1682 km and its height is 350 m above sea level.
Analysis of the public sectors of the study area:-
It is intended to analyze the cross section and longitudinal sector in general for the study area, six topographic sectors were elected, which starts from west to east in the form of a cross section. The sectors included as follows 1-2-3-4, while a longitudinal section was measured that included (5-6) in the middle of the Jambour Anticline up to the north and a second point from the middle to the south side.
In order to know the evolution of the slopes, and they will be analyzed in general later, and to know the causes and consequences, see the map (10), emphasized the division of sectors in general and the study area was divided into four sectors, in addition to dividing the Anticline from the middle and making it into two sectors, this is to highlight the continuity of evolution of the slope models in general, in order to know the erosion and the effect of geomorphological, climatic and tectonic processes and linear phenomena. The West Wing sector will be explained in detail as follows:

1. Sector No. 1: length from the west with a distance of 2.5 km to the east, with a distance of 16.25 km, the sector has slopes with different configurations, vulnerable to water erosion, with a rate of (55%) eroded and altered slope features, turned into structural plateaus with a distance of 6.5 km and a height of 5000 m above sea level.

2. Sector No. 2: length is measured from the west side, with a distance starting at 2.5 km to the east, reaching 14.28 km, so that the slope is distinguished by its different rock formations.

3. Sector No. 3: The length of the public sector starts from the west to the east with a distance of 14.35 km, characterized by the presence of the Anjana and Muqdadiyah formations, and their rocks are different due to their exposure to tectonic lifting processes, height gradually forms steep rocky edges, and the highest mountain peak reaches more than 350 meters above sea level and a distance of 6.0 km.
4. Sector No. 4: The length of the public sector from west to east, with a distance of 14.73 km, characterized by the presence of all rock formations, except for sediments, runoff is observed at the start of a slope, initially, the formation of the hole (evaporate rocks) is exposed and salts are deposited on its surface, its formations are exposed at the bottom of the solid rocks that are resistant to weathering, the rule of terrestrial forms of structural origin, such as the phenomenon of pigs (hook-back), it ends at a distance of 7.5 km, and then the rise of the slope to the highest peak is seen in the form of very rocky ridges, and it stands out like rocky cliffs, steep, height reached more than 350 meters above sea level, especially the Muqdadiyah formation is resistant to water erosion due to the hardness of its rocks, gradually descends at the feet of the slopes, forming depressions, due to the speed of its erosion, it is crossed by a dry river valley (seasonal). The spread of vegetation along the sides of the riverbed, basin No. 3 of moderate tectonic activity, likewise, Basin No. 11 is subject to the same activity, while Basin No. 12 has a very low tectonic activity (geologically stable).

5. Sector No. 5: The length of the fifth sector begins at the middle of the Anticline, denoted by the letter (A), and at a distance of 2.5 km to the north with a symbol (B), and ends with a distance of 13.90 km. The slopes of the Anticline are characterized by the stiffness of the rocky layers and the presence of oil and gas reservoirs in the domes of the Jumbhur series (Figure 5), the slope decreases to a distance of 7.5 km,
the line of change in slope emerges (the slope elbow) and it is located at an altitude of 270 m above sea level.

6. **Sector No. 6:** The length of the sixth sector begins with a symbol (A) from the middle of the Anticline at a distance of 2.5 km to the south side with a distance of 12.08 km and is denoted by the letter (B), reached a height of more than 350 meters above sea level.

**Soil:**
The class of soils in the region were determined by relying on millions of maps, which classified the types of soils in Iraq and made a comparison to them, the most important of these classifications:

* Classification of Hasan Fulayh Al-Taie: The expert of the Iraqi Ministry of Agriculture and Irrigation, Dr. Falih Hasan Al-Taie, classified the region's soils according to their ability to cultivate and graze. (Table 10), (map 11), into the following classes:

1. **Class 32 / d:** This class is found in the north-eastern half of the study area, area occupies 1,111 km², out of 27.5% of the study area, therefore, the soil quality is medium to good for cultivation.

2. **Class 34 / gd:** This class occupies the southeastern part of the study area, area is 65.8 km² out of 16.3% of its area, the soil is of limited or medium capacity for cultivation due to the presence of high levels of gypsum and low rainfall.

3. **Class 6 / e:** This class occupies the middle part that overlaps the middle of the range of soils of Class 63, ed, area occupies 2,67 km² out of 16.6% of the total area of the region. They are good grazing and forest soils and their factors are simple determinants due to water and wind erosion.

4. **Class 63 / ed:** This class occupies large parts that take up half of the study area Which extends from the middle of the north to the south and reaches the west side. Its area is about 160.3 km², and it is 39.6% of its total area. The soil is of medium quality with limited viability and simple for cultivation, but is good for animal grazing and forest growth due to water and wind erosion (map 11).

| Soil Class | Hasan Falih Al-Taie classification | Area (Km2) | Percent (%) |
|------------|-----------------------------------|------------|-------------|
| 32/d       | Soil quality is of medium to good cultivation | 111.1      | 27.5        |
| 34/gd      | The soil has limited or medium capacity for cultivation due to the presence of high levels of gypsum and low rainfall | 65.8       | 6.3         |
| 6/e        | They are good grazing and forest soils and their limiting factors are simple due to water and aerobic erosion | 67.2       | 16.6        |
The soil is good for grazing, animals and forests grow due to both water and wind erosion.

| 63/ed  | The soil is good for grazing, animals and forests grow due to both water and wind erosion | 160.3 | 39.6 |
|--------|----------------------------------------------------------------------------------------|-------|------|
| Total  |                                                                                        | 404.4 | 100  |

(The researchers' work, based on the classification of Hasan Fulaij Al-Tai and the use of ArcGis 10.4)

**Map (11)** The classes of soils according to Hasan Flih Al-Ta'i's classification.
(The researchers' work, depending on the Al Tai soil classification map, and the outputs of ArcGis 10.4 software)

**Fourth: Results**

When applying the regression classifications to the study area for each of the (Zink and Demek) classification, they apply in terms of the regression, however, they differ in terms of the topographical nature as the classes were compared and merged with each other in order to find an optimal classification for them. Accordingly, the results showed the combined classification of six classes between ZINK and DEMIC. The first category was found to be a flat area of the plain. The second with 27.2% of the area of the study area, a for the second category, they represent the upper erosion of river plains and the feet of the mountains occupied 4%, the third category represented hilly land area, which constituted 4.6% of the total study area, the fourth category included the lowest river terraces by 0.6%. The fifth category was devoted to hemodialysis, which occupies the largest part with a percentage 62.1% of the total area of the study
area. The sixth category represents valley depressions at a rate of 1.6% of the total area of the study area.

- Analysis of the shadow of the hills came in the first place, characterized by being medium shade and sunny areas, the highest percentage of sloping land area was 70.5%, as for the many shady areas, it ranked second, as it represented 16.9% of the area of the study area, it was followed by the third place in low shade areas, which amounted to 12.5%, these variations in shade affected the course of morphological processes within the study area towards the regions, they have large shade, which are wetter than sunny and continuous areas.

- Slope direction determined from the DEM data, included nine directions, but the most prevalent trend was the south, east and south, recorded an area of 18.5 and 21.5%, respectively, the origin of the tectonic processes responsible for the creation of the jumbo Anticline and the regression of the backward slopes, appears that most of the slopes in the area coincide with the directions of river valleys, these slopes led to an increase in the speed of the efficacy of riverine processes, which resulted in an increase in the movement of surface materials, analyzing the degree of curvature, it was found that the ratio of flat (straight) shapes exceeds the ratio of convex and concave shapes, as it reached 42.5% of the area of 172 km² of its area, followed by the ratio of the concave shape (42%) with an area that formed (169.8) km², then convex slopes were formed by (15.5%) and amounted (62.6) km² of the total area of the study area.

**Recommendations**

Attention to protecting the slopes by replanting the slopes and afforestation, as well as making use of them in providing herbs for the natural pastures. Establishing mineral water bottling laboratories for the spread of spring and spring water. Paying attention to the geomorphological aspects in the study area as it is a tourist attraction in the spring and summer seasons, due to the presence of the Shirin Dam, mountain paths and basins, and forests, and preparing the roads leading. Merging villages and turning them into urban areas and building health centers, educational schools, institutes and local police stations. Establishing climatic stations and their important role in order to reduce the risks faced by the Jambour fields and agriculture. To produce geo-maps for the purpose of planning and optimal use of human population, urban and engineering planning.

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