وزارة التعليم العالي والبحث العلمي
جامعة ميسان
كلية التربية الاساسية

مجلة ميسان للدراسات الاكاديمية

العلوم الانسانية والاجتماعية والتطبيقية

ISSN (Paper)- 1994-697X
(Online)- 2706-722X

المجلد 23 العدد 49 السنة 2024

مجلة ميسان
للدراسات الاكاديمية

العلوم الانسانية والاجتماعية والتطبيقية

كلية التربية الاساسية - جامعة ميسان - العراق

ISSN (Paper)-1994-697X
(Online)-2706-722X

مجلد (23) العدد (49) اذار (2024)

www.misan-jas.com

journal.m.academy@uomisan.edu.iq

رقم الايداع في دار الكتب والوثائق بغداد 1326 في 2009

Mapping the Slopes' Geomorphological Classification Using Geomatics Techniques: A Case Study of Zawita, Iraq

Mohammed Abbas Jaber Al-humairi[1], Elaf Amer Majeed Alyasiri[2*]
[1]University of Misan, College of Education, Department of Geography, Iraq; e-mail: mhmed_abbas1984@uomisan.edu.iq
[2]University of Babylon, College of Education for Human Science, Department of Geography, Iraq; e-mail: Ealyasiri@uobabylon.edu.iq.
ORCiD: 0000-0001-8002-4683

ISSN (Paper) 1994-697X

ISSN (Online) 2706-722X

DOI: https://doi.org/10.54633/2333-023-049-009

Abstract:

The aim of this present study is to classify and map the landscape of Zawita, Iraq. Different classification methods of the slope characteristics were considered such as slope degree, slope arching, slope direction, slope direction, hills shade, young classification, Demek classification. Digital Elevation Model was downloaded from USGS (2022) and applied as input data to classify and analyze the slope. The finding out that the area is identified as an elevated area. The elevation of the area is ranged between 520-1500 meters above sea level, which indicate the intensity and effectiveness of the alpine movements. Among analyzing the maps, the area is considered as arisky and sensitive to geomorphological hazards which made the area unstable. Most of the slopes of the study area is ranged from 2-34.9 degrees and this different degree of slopes is a consequent risk of high erosion.

Keywords: Map; Slop; Geological Formation; Elevation; Geomatics

Introduction and Background:

The slope is defined as the inclination of the earth from the horizontal plane; while deviation increase the slope increase (Al-Dulaimi, 2011). Understanding the concept of the slope would help us draw a clear picture of the earth's surface. The geomorphology concept examines the different forms of the earth and how topography and slopes are related to them. In addition, understand its distinctive morphological and spatial characteristics (Salama, 2013). Slopes is one of the geomorphological phenomena that can depend on the informational integration between remote sensing data and geographic information systems in extracting geographic material, which would explain the morphological pattern of the slopes and their geomorphological classification. Therefore, considering geological structures, surface, and elevation are some of the facts that affect the formatting and development of slopes as the following:

1.1. **Geological structures:**

The Geological structures of Iraq are contented two geological periods which are the second geological period and the third geological period see (Table 1) and (Figure.1). The second geological period contented of different type of eras as Gharib in (1983) described it:

Triassic era as appearing in the study area only during second geological period, and it contained Balambo, Akra, and Shiranish formations which cover about (6.05%) of geological formations of the study area.

Table 1. Geological formations Names, Area, and Percentages.

Periods	Ara	Geological formation	Area Km^2	Percentage
Second geological Period	Triassic era	Balambo - Akra	27.42	3.11
		Shiranish	25.87	2.94
Third geological Period	Eocene era	Khurmala-Girks formation	108.68	12.34
		Plasby – Avana formation	195.36	22.18
	Miocene era	Alfateha Formation	117.71	13.36
		Injana Formation	100.68	11.43
	Pliocene era	Muqdadiyah formation	172.13	19.54
		Bai Hassan formation	133.02	15.10
Total			880.86	100

The Balambu formation contained two parts, the upper part which consisted of successive thin layers of organic limestone, and the lower part which consisted of thin layers of blue limestone with overlapping layers of olive-green marl and dark blue shale. The Akra formation contains limestone coral rocks, bituminous dolomites, and organic limestone. Whereas the Shiranish formation entails blue marl, and the lower part of it consists of thin layers of limestone mixed with marl (Znad et al., 2020). These formations appear in the Southeastern and Western parts of the study area.

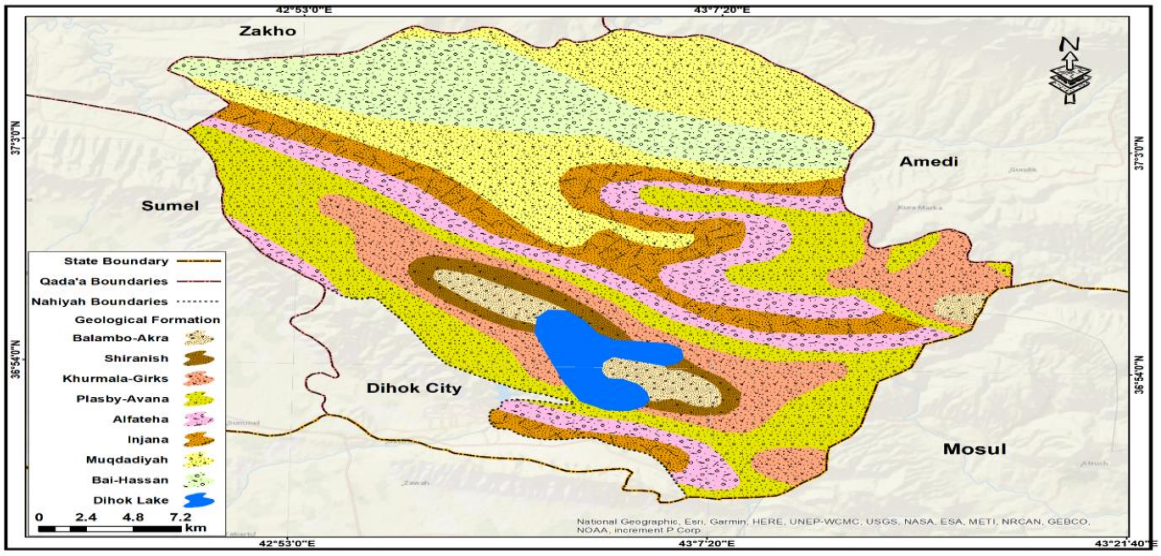

Figure 1. Geological formation of the study area.

The third geological period contented of three eras which are the following:

Eocene formations era is founded in the study area within Khurmala-Girks formation and the Plasby – Avana formation which covers about12.3 % of the total area of the region's formations, and the Khurmala Formation consists of dolomite and fine-grained crystalline limestone, and its thickness ranges between (50-150 m) (Al-Sayyab, 1982). Gercuse formation is distinguished by its red-violet color (Al-Omari,1977), and the thickness of this formation ranges between (850-100 m). The formation of Blasby-Avana is (195.36 km2), and the percentage of (22.18%) of the total area of the formations of the region. Blasby formation consists of limestone, dolostone, dolomitic limestone, which is well-applied with a white to yellowish-white and lead color, solid to It is very hard locally and contains flint knots in the upper parts, and the thickness of this formation varies, as it ranges between (100-200 m) (Al-Gadi et al., 2023). Avana Formation consists of limestone and dolomite rocks, and its thickness is about (212 m) (Al-khafaji & Al-

ISSN (Paper)-1994-697X (Online)-2706-722X

Sweiti, 2016). The formations of this era appear in the Eastern, Southern, and western parts of the study area.

Miocene era is contented of two geological formations, Alfateha formation, and the Injana formation, with an area of (117.71, 100.68 km2), which covers about 13.36, 11.43% of the total area. These two formations appear in the region in the form of longitudinal bands extending from east to west. Alfateha formation contends of mudstone, limestone, clay, siltstone, and sandstone, and the layers of mudstone form the basic component of this formation, as it is more than half the thickness of the formation, which is about (300 m) (Beg, 2006). The Injana formation contends of different rock components, most of it is red or gray silt clay rocks or silt clay rocks or sands or red or gray sandstones (Shamuel, 1984).

Pliocene era contented of Muqdadiyah and Bai Hassan formation, with an area of (172.13 and 133.02 km2), which is about 19.54, 15.10% of the total area. The Muqdadiyah formation consists of layers that are thick, lead-colored sand intertwined with mass layers of fine claystone of yellowish to light-brown lead color and brown and leaden alluvial (Buday, 1980). The Bai Hassan formation is content of gray-colored rubble and friable materials of silt and sand (Saad, 2006). This era is founded in the upper part of Northern the expansion starts from the Northeast to the Northwest.

1.1.Structures:

The study area is located, specifically within the Sulaymaniyah-Zakho belt, and this is identified as one of the unstable tectonics within the high folds range in Iraq. There are six convex folds in the study area and most of them extend from east to west with a length of (86.83 km), while there are nine concave folds with a length of (59.73 km). The study area also contains a set of lines, which could be explained through multi-scale satellite visuals, and their total numbers reached (269) lines, and they spread in most of the study area in different directions, and their lengths ranged between (0.06 - 3.39 km) see (Figure 2).

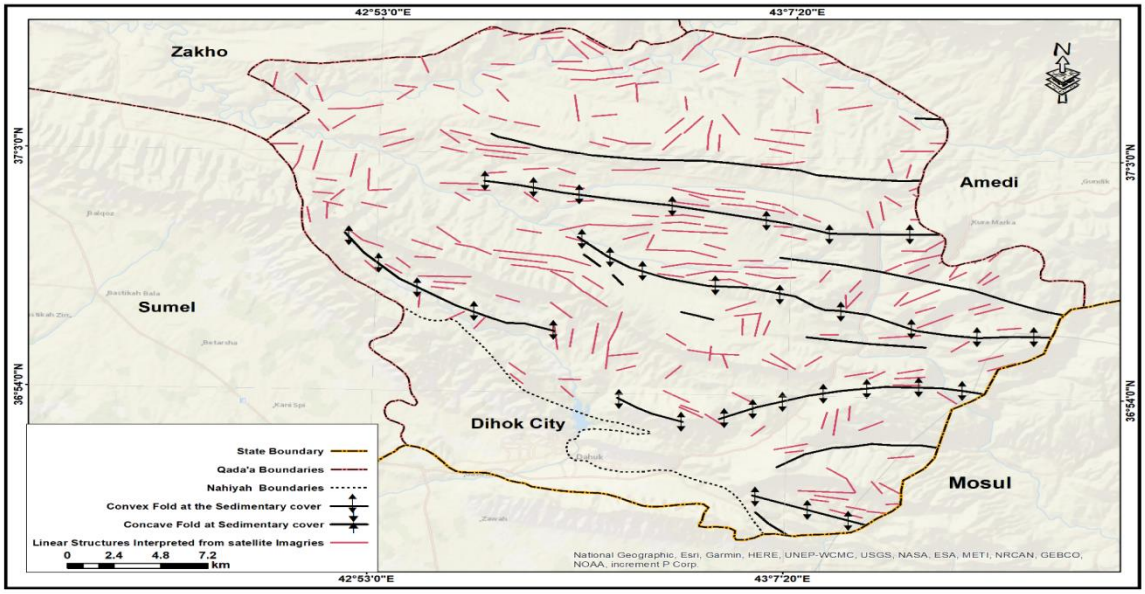

Figure 2. Geological structures of the study area.

1.1.Elevation

The study area is located according to the physiographic division of the surface of Iraq within the range of high-altitude mountains, with its highest altitude (1500 m) above sea level in the eastern and southeastern parts and some dispersed parts of the region. (520 m) above sea level in the northern, northwestern, and some southwestern parts. The height of study area varies between (720 - 1100 m) above sea level, and it is rugged, uneven terrain with some ripples and bends, and thus the area descends from the Southeast towards the Northwest see (Figures 3 and 4).

ISSN (Paper)-1994-697X (Online)-2706-722X

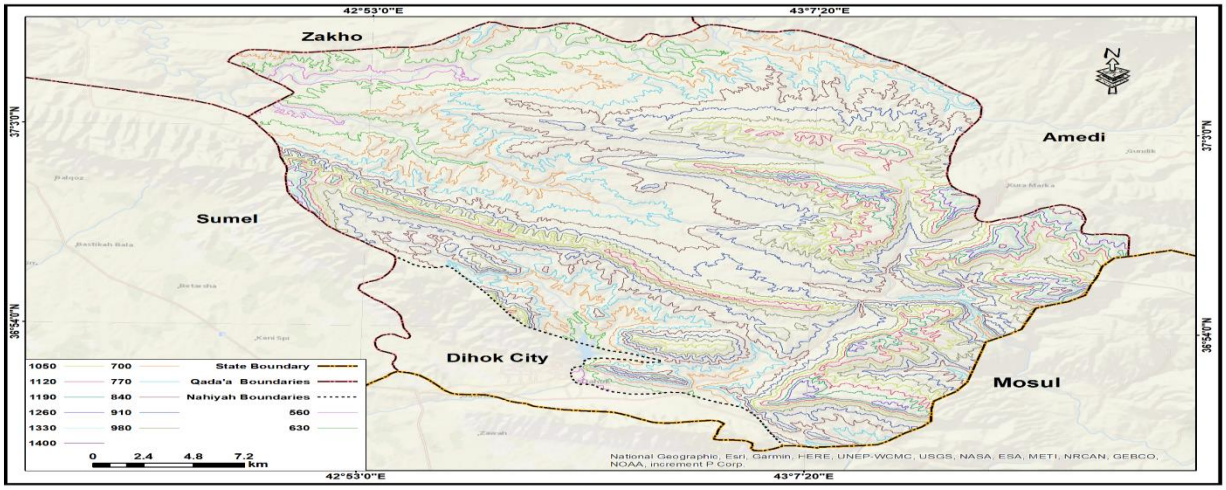

Figure 3. Couture lines map of the study area.

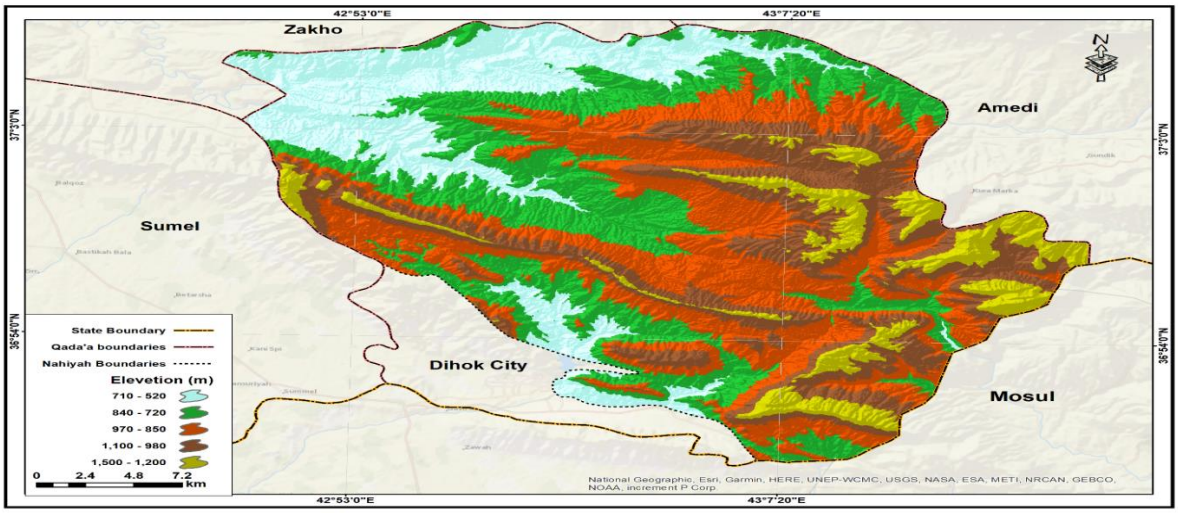

Figure 4. Elevation map of the study area.

After reviewing the background of the study area, now presenting this research study aims to classify and map the slopes of the Zawiya district, as it represents a major obstacle to the development of the region.

Data and Methodology:

2.1. Data:

The current study focuses on the slope and formal main characteristics in the region of Kirkuk governance by applying remote sensing and GIS technique in producing a set of maps showing those characteristics. The study area is located within the Northern part of Iraq with Karkuk Governate see (Figure 5). Map of Dihok Governorate was downloaded from the Republic of Iraq, Ministry of Water Resources (2012) at a scale of 1:500000. DEM data was used to classify and map the slope for Zawita, the DEM was downloaded from (USGS, 2022). Iraq Geological Surveys have been used to inform about the geological formations, and these maps were downloaded on a scale of 1:1000000 (the Republic of Iraq, Ministry of Industry and Minerals, 2012; Republic of Iraq, Ministry of Industry and Minerals, 1996).

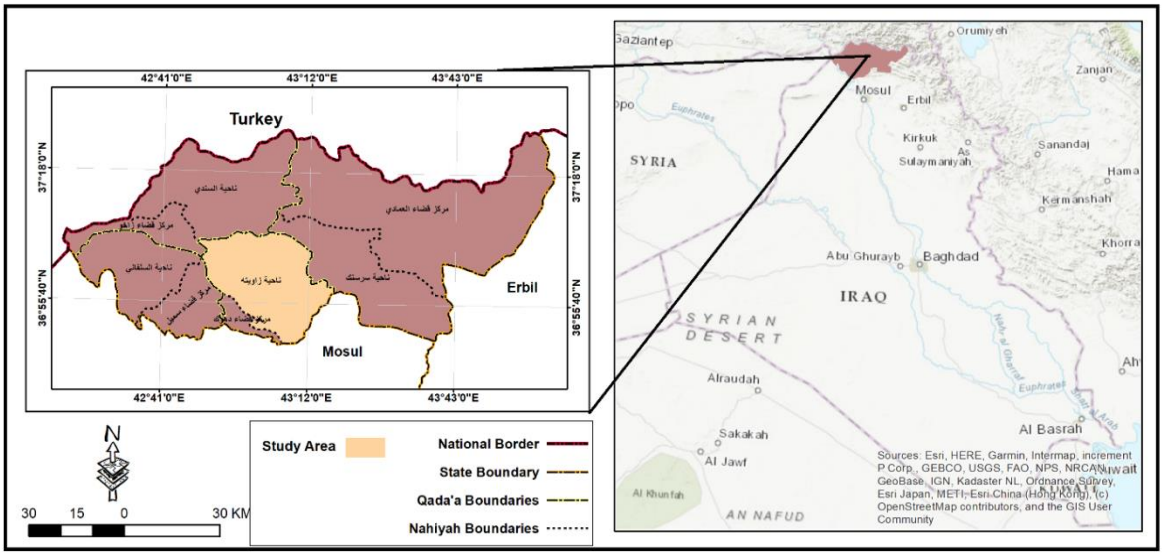

Figure 5. The location of the study area from Iraq

2.2.Methodology

Slope characteristics will be applied to map the landscape of the area and identify the features of the area based on different classification methods which are the following:

2.2.1.Slope Degree

This classification depends on observing the horizontal distance between the contour lines, their extension, their levels, and their convergence.

a)Low slope: this type of slope includes areas with a slight slope in which the contour lines diverge from each other as a result of the amplitude of the horizontal distance between one line and another. These slopes are among the most suitable slopes for various human activities, and often arise from the stability of weathering and erosion residues above the surface of the earth (Abdul-Hussein, 2013).

B)Medium slope: according to this slope the horizontal distances between the contour lines are moderate, and their degrees range between (15 °- 24.9 °) or approximately (27 - 47%). It is more difficult to exploit than simple slope, and of little importance in the field of exploiting it for various human purposes (Al-Khafaji, 2018).

C.)Steep slope: is includes slopes that have degrees of slope ranging between (25°- 45°) or more which is about (47-100%), and the exploitation of these slopes may face many problems as a result of the severity of the gradient as well as the instability of most of its parts (Majid and Hassan, 2013).

2.2.1.Slope Arching:

The arching of the slopes is defined as the rate of change in the slope angles with the ground distance and the direction of the bottom of the slope, and it is expressed in degrees (Mahmoud, 2007). The values of arching range between (0 - 1) and the closer the result is to zero, this indicates the flatness of the surface and its straight extension. The impact of the various erosion factors and their role that contributed to determining the shapes of these slopes and then the general geomorphological shape of the area, and the process of spreading a certain type of slope shows advanced or initial stages of the erosive cycle. The concave elements will appear indicating that the area is going through advanced stages of the erosive cycle. When the convex slopes increase, they indicate that the region is still at the beginning of its downward cycle (Khairallah, 2017). The amount of curvature in the area is calculated for each cell of the cell shape, and the digital signature of the grid cells indicates

concavity if it is negative, while if it is positive it indicates convexity, while if it is zero or close to zero it indicates that the area is flat (JarJis, 2010).

2.2.1.Slope Direction:

The direction of the slope means the face of the elevated area or the face of the slope, and it can be determined by the main directions (north - south - east - west), and other secondary directions according to the directions of the slope (Al-Ajili, 2014). The direction of the slope can be calculated from one cell to another through the DEM or from one point to another in the triangular network (TIN), and the output network carries new values that express the direction of the earth's surface to the north direction. If the value of the cell in the output map is equivalent to 90 degrees, this means that the direction of the highest slope of the earth's surface is to the east. In other words, the line of travel down the slope will be in the east direction. If the surface of the earth is horizontal and not sloping, it will not have a slope direction. In this case, the values of the cells in the map grid will take the value (-1) (Fodda, NA). Slope direction maps are important in geographical and geomorphological studies, as many human manifestations and activities depend on them. Knowing the southern direction of the slope helps reduce the risk of avalanches, as well as predicting the direction of movement of surface materials, and the slope direction provides information on the direction of torrential rains in the region, which also contributes to changing the direction of the slope in some way, especially the secondary trends (Al-Ajili, 2014).

Hills Chade:

The shade of the hills gives a virtual illumination of the surface, and this is done by specifying the values or the amount of illumination for each cell of the grid. The process of analyzing the shadows is carried out by shining a light or any light source on each cell in the grid and calculating the effect of that illumination on the neighboring cells, which is meant by illumination. It is sunlight, and the illumination angles of sunlight start from 0-180 degrees from the moments of sunrise to sunset, and the measurement of the shadow characteristic is clockwise (kiefer & Lillisand, 2008). The hills' shadow characteristic can be used to theoretically determine the severity of the degree of slope, as dark areas with large shadows can be areas of a steep slope, while areas with little shade are areas with simple or slight slopes.

2.2.1.Young Classification

According to Young's classification, the study area will be classified into seven classes of slope based on the ratio of the area slope which is (flat land, simple sloping lands, low slope lands, Medium sloped ands, Steep lands, Very steep lands, and cliff lands).

2.2.1.Demek Classification

This classification is characterized by being sequential, and it contains six classification levels, as it is characterized by a high degree of generalization at the end. It is suitable to represent regions with large slopes. Within this classification, there are six classification levels which are (Semi-flat land, Plainland, undulating land, Low Hills, High Hills, and Very high mountains).

2.2.1.Other classifications:

There are other classification methods used to describe slopes according to regression degrees, including which are Zink classification consisting of five classification levels ranging between (0˚-66.5˚, which are (Flat, Low undulating, Undulating, Partially divided, and Very divided). Zuidam classification is consist of seven slope levels, the classification starts from zero and ends at the slope of degree 54.46˚which are (Flat land, Low slope land, slanted land, medium slanted land, and steep land, very steep land, and cliff land).

3.Results and Discussion :

Different slope classification methods were applied to explain and map the geological formations of the study area. Most of these classifications are characterized as a hierarchical sequence that contains several classification levels. These classifications can be used to identify types of terrain and landforms at the ground level.

ISSN (Paper)-1994-697X (Online)-2706-722X

3.1. Slope Degree:

Slope degree applied is based on the classification that depended on observing the horizontal distance between the contour lines, their extension, their levels, and their convergence. As seen in figure 6 the study area is classified based on slope degree into three classes:

low slope covered about 72.06% of the total area of the study area.

Medium slope covered about 20.57% of the total area.

Steep slope covered about 7.37% of the total area.

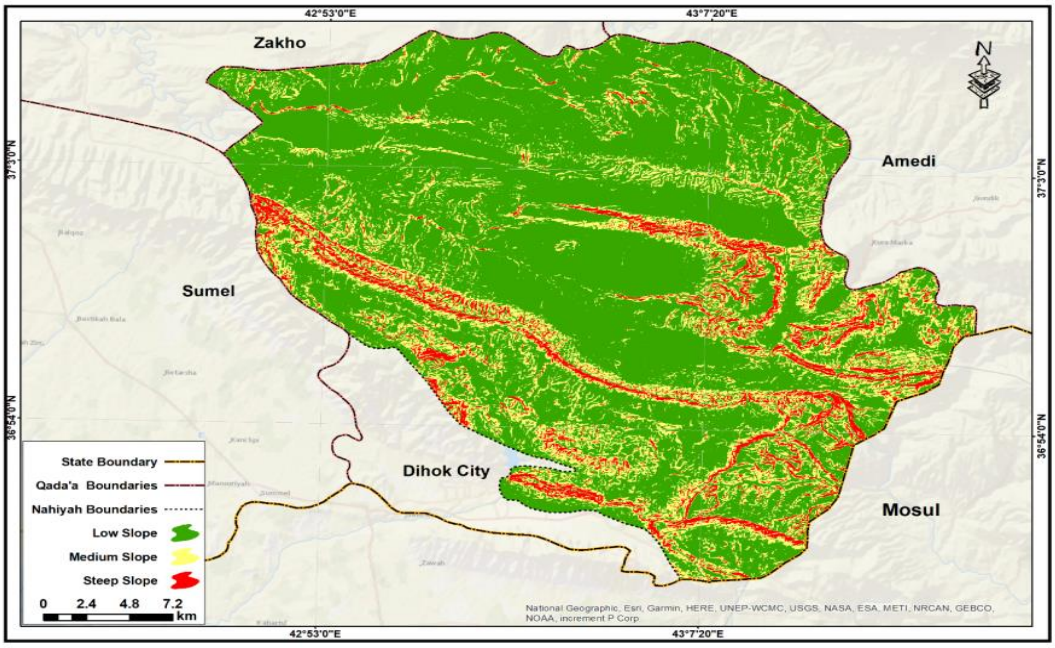

Figure 6. Slope classification based on slope degree of the study area.

3.1.Slope Curvature :

As seen in (Table 2) and (Figure 7) and (Figure 15) the concave elements' curvature degree is negative and has the highest percentage in the study area, with an area of about 46.87%. The convex elements have a positive curvature with an area of about 45.41%. while the straight area reached covered bout 7.71%.

Table 2. Arching slope elements

Type of curvature	Type of Arch	Degree of Arch	Area Km^2	Percentage
Concave	Negative	Less than Zero	425.99	46.87
Straight	Even	Zero	70.11	7.71
Convex	Positive	More than Zero	412.71	45.41
Total			908.81	%100

ISSN (Paper)-1994-697X (Online)-2706-722X

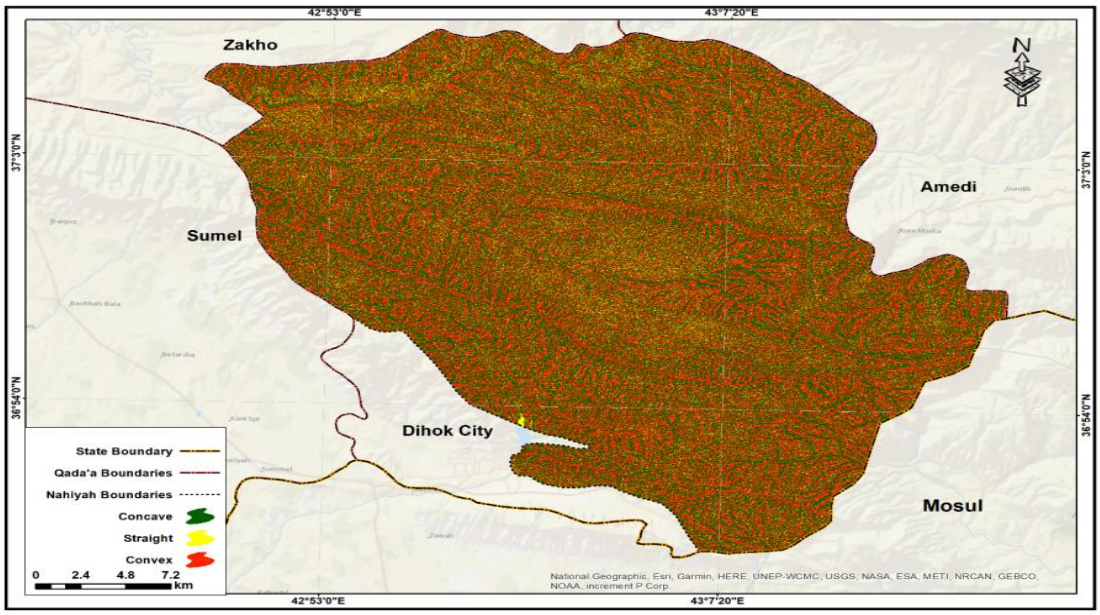

Figure 7. Arching slope of the study area

3.1. Slope Direction

The slope direction in the study area is presented by eight levels seen in Table.8 and figure 16. The lands are sloping to the south direction recorded the largest in terms of 15.69% of the area, while the lands sloping to the eastern direction represented the least interarm of 9.50% of the area. The slope direction area present by 14.63% North, 10.32% Southwest, 12.18% Northeast, 11.65% West, 11.42% Northwest, and 10.32% Southeast see Table 3. As well as flat surface is about 0.09% of the total area. The direction of the slopes is in all directions. The areas contained of foothills, aggregate plains, and river valleys, and can lead to an increase in the speed of the activities of the river erosion processes, which results in activity in the morphodynamical processes see (Figure 8).

Table 3. Slope direction elements.

Slope Direction	Area Km^2	Percentage
Flat	0.85	0.09
North	132.92	14.63
Northeastern	110.69	12.18
East	86.33	9.50
Southeastern	93.79	10.32
south	142.61	15.69
Southwestern	131.98	14.52
West	105.84	11.65
Northwestern	103.8	11.42
Total	908.81	%100

ISSN (Paper)-1994-697X (Online)-2706-722X

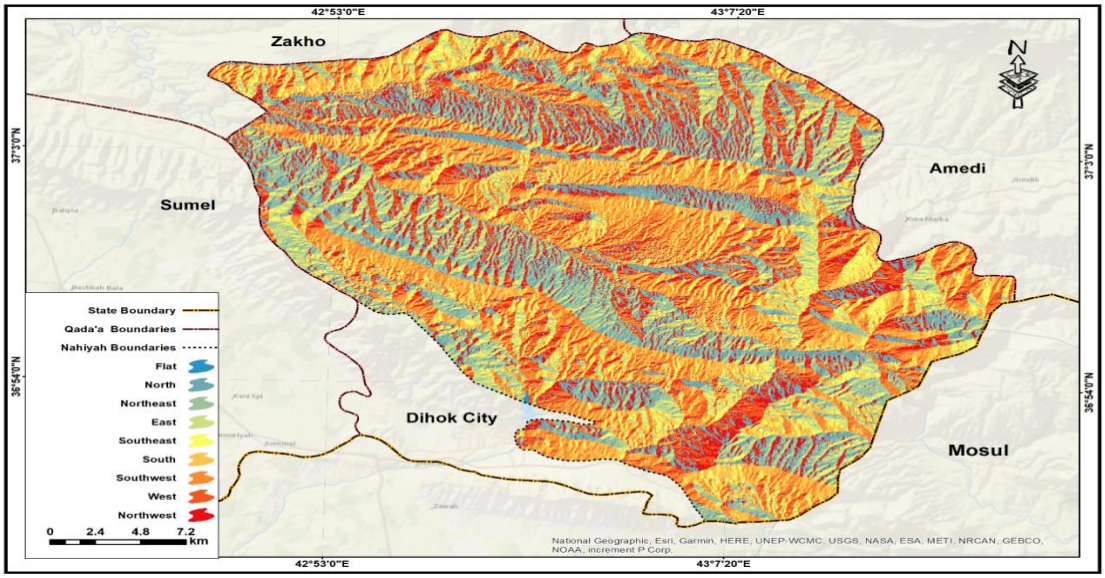

Figure 8. Slope direction of the study area

3.2.The Shadow of the Hills

There are different shaded areas in the study area seen in (Figure. 9) and (Table. 4) that ranging from very shaded areas to medium shade areas and then to low shade areas. The highly shaded areas recorded a small spatial space about 3.40% of the total area of the area, which is the most humid area in the study area. Medium shade areas occupied a spatial space of about 62.87% of the total study area. The low shade area recorded about 33.73% of the study area.

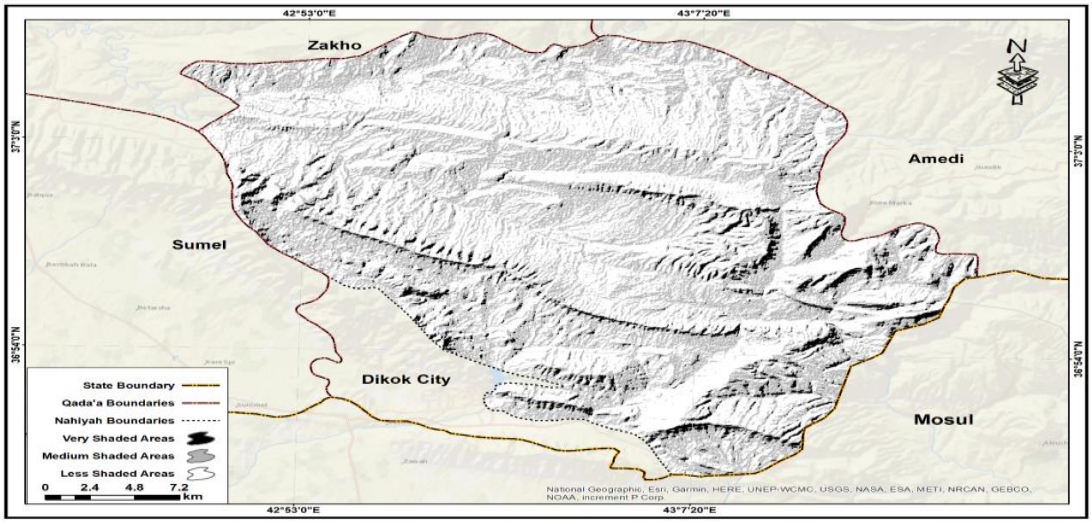

Figure 9. Shade classification of the study area

Table 4. Shade classification and the area of the variety and their percentages.

Type of Shade	Area Km^2	Percentage
Very Shaded Areas	30.92	3.40
Medium Shaded Areas	571.33	62.87
Less Shaded Areas	306.56	33.73
Total	908.81	%100

ISSN (Paper)-1994-697X (Online)-2706-722X

3.2.Young Classification:

According to Young's classification, the study area has been classified into seven classes of slope based on a ratio of the area slope see (Figure 10).

Flat land distributed on a small part of the study area in the north and north-west which cover about 3.93% of the study area. The degree of the slope angle in this level is ranged between 0 ˚ - 1.9 ˚ as seen in Table 5.

a)Simple slope land covers about 16.14 of the total study areas. The slope angle ranges between 2˚-4.9˚ and is spread nearby around the flat lands. It is concentrated in the western and central parts of the study area.

B)Low slope lands cover about 29.88% of the total area. The angle of land slope is ranged between 5˚-9.9˚and they are found in most parts of the study area.

c)Medium sloped lands covered about 30.54% of the study area. The angle of the slope ranged between 10˚-17.9˚ is the most prevalent in the study area and covers about.

D)Steep lands is covered about 16.42% of the total area. The angle of the slope ranged between 18˚-29.9˚, and they are considered lands with steep slopes and spread within all high areas in the region.

E)Very steep lands are covered 3% of the total area. The angle of the slope range between 30˚-45˚ and this land is distributed at the tops of the region's heights, and they are in. The areas are connected and in other intermittent areas similar to the highest elevations in the study area.

F)Cliff land is land that has an angle of slope greater than 45˚. This type of land is occupied a very small space of about 0.08%. Mountains, especially in the area of Darloch, Kherbat Otima, Ostakorky, and Glyuki.

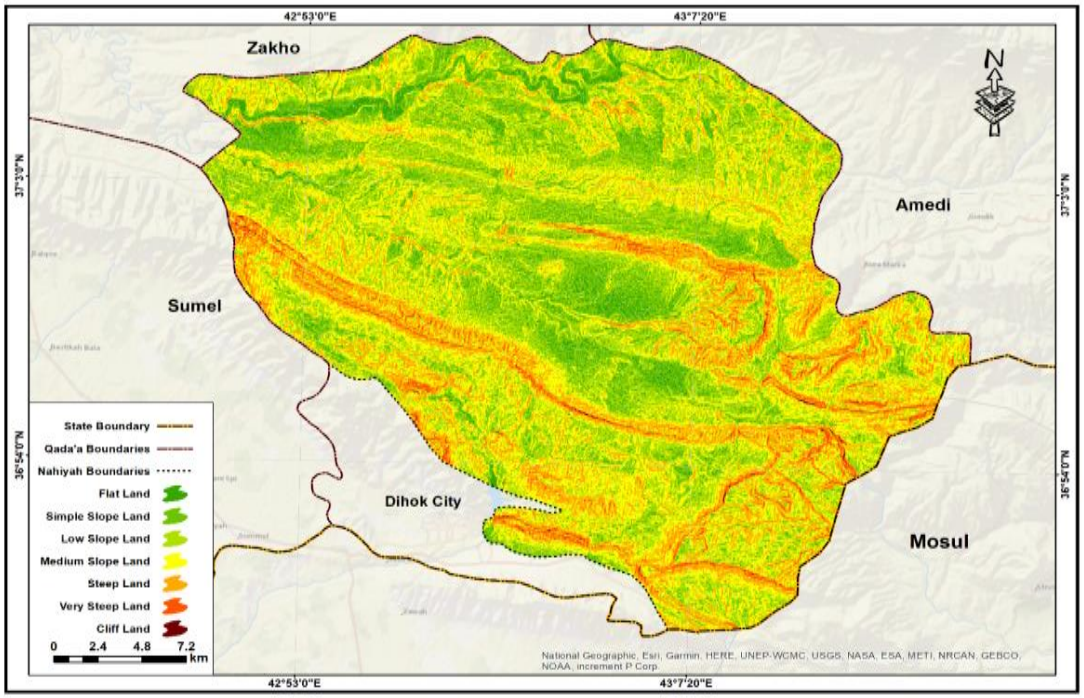

Figure 10. Young classification for slope of the study area

www.misan-jas.com
ISSN (Paper)-1994-697X (Online)-2706-722X

Table 5. Young Classification shapes, slope angles, areas and percentages.

Terrain Shape	Slope Angle	Area Km^2	Percentage
Semi-Flat Land	˚ 1.9 -˚ 0	35.74	3.93
Plain Land	˚ 4.9 -˚ 2	146.7	16.14
Undulating Land	˚ 14.9 -˚ 5	465.63	51.24
Low Hills	˚ 34.9 -˚ 15	251.04	27.62
High Hills	˚ 54.9-˚ 35	9.63	1.06
Very High Mountains	+˚ 55	0.07	0.01
Total		908.81	%100

Demek Classification:

Semi-flat land where the degree of slope ranges between (0˚-1.9˚), and covered about 3.93% see (Table 6) and (Figure 1). This area represents the most stable area for the movement of materials, and it is th1e most suitable area for various human activities.

Table 6. Demek classification, shapes, slope angles, areas and percentage.

Terrain Shape	Slope Angle	Area Km^2	Percentage
Flat Land	˚ 1.9 -˚ 0	35.74	3.93
Simple Slope Land	˚ 4.9 -˚ 2	146.70	16.14
Low Slope Land	˚ 9.9 -˚ 5	271.53	29.88
Medium Slope Land	˚ 17.9 -˚ 10	277.56	30.54
Steep Land	˚ 29.9-˚ 18	149.27	16.42
Very Steep Land	˚ 45 -˚ 30	27.24	3.00
Cliff Land	+˚ 45	0.77	0.08
Total		908.81	%100

Figure 11. Demek classification for slope of the study area

a)Plainland where the slope land angles ranged between 2˚- 4.9˚ which covered about 16.14% of the total area of the study area. It is considered one of the most suitable areas for agriculture, and it is currently used for the cultivation of wheat and barley, as well as various types of fruits and trees.

b)Undulating land is the land where slope angles are ranged between 5˚-14.9˚ and it covers more than half the area of the region about 51.24% of the study area.

c)Low hills land is the slope angles of this area range between (15˚-34.9˚) and occupies the second largest area in the region, amounting to about 27.62% of the total area of the total study area. This area is characterized by the activity of erosion processes and the movement of the materials on the earth's surface; therefore, it cannot be suitable for various human uses. It is concentrated in the eastern, southern, and western parts and some scattered areas in the northern parts of the study area.

d)High hills land is the land where sloping angles are confined between 35˚-54.9˚ and cover about 1.06% of the total area of the region. This level of slops is concentrated at the tops of the high

ISSN (Paper)-1994-697X (Online)-2706-722X

mountains in the region. These lands are filled with the activity of intense rain erosion and the movement of surface materials.

e)Very high mountains represent areas which is slope angles are greater than 55˚, and their area is about 0.01% of the total area of the study area. It is one of the most dangerous parts of the study area located eastern part. These areas are characterized by very steep slopes, which are on rocky walls devoid of vegetation and soil as a result of being exposed to severe and continuous erosion processes and are also characterized by a large movement of surface materials, therefore, these areas are completely unsuitable for various human activities. This classification is characterized by being consecutive and classified by six levels ranged between–semi-flat regions to mountainous regions very high.

3.2.Zink Classification:

Zink classification consists of five classification levels seen in Figure 12 and Table 7. The classification starts at an angle of zero and ends at the angle of thirtieth and more. As for the angles of the slope in the study area, it ranged between (0˚- 66.5˚), and thus more than half of the slope of angles of the study area is represented by the last level of the classification mentioned in overhead. Thus, most of the results are very generalized, so it was limited to mapping, and organizing a table showing the levels and shape of the sprocket, surface classification, area, and percentages for each slope angel category only.

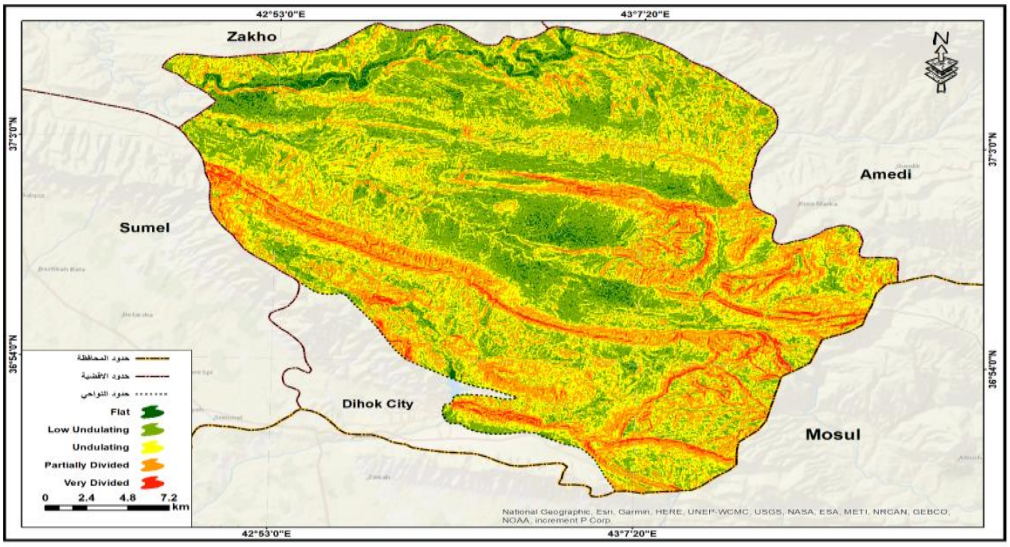

Figure 12. Zink classification for Slope of the study area

Table 7. Zink Classification, shapes, slope angles, areas and percentages

Terrain shape	Slope angle	Surface classification	Area KM^2	percentage
Flat	˚ 1.9 -˚ 0	plain and valley	35.74	3.93
Low Undulating	˚ 7.9 -˚ 2	River plains, foothills, mountain feet	319.65	35.17
Undulating	˚ 15.9 -˚ 8	Low Hills	325.46	35.81
Partially Divided	˚ 29.9 -˚ 16	High Hills	200.03	22.01
Very Divided	+˚ 30	Mountains	27.93	3.07
Total			908.81	%100

ISSN (Paper)-1994-697X (Online)-2706-722X

3.2.Zuidam Classification:

Zuidam classification is contain seven slope levels starting from zero and ends at the slope of degree 54.46˚ seen in Table 8 and Figure 13. This model leads to generalization. The difference between the fourth category and the fifth category is about 16.95˚degree of a slope, and between the fifth and sixth is about 25.66˚, and this is a very big difference, which leads to showing inaccurate results characterized by a very high generalization. In addition to that, this classification is not connected to its slope degrees.

Table 8. Zuidam classification, shapes, slope angles, areas and percentages.

Terrain Shape	Slope Angle	Area Km^2	Percentage
Flat Land	˚ 1.14 -˚ 0	16.43	1.81
Low Slope Land	˚ 4.0 -˚ 1.72	107.09	11.78
Slanted Land	˚ 7.41 -˚ 4.57	190.36	20.95
Medium Slanted Land	˚ 11.30 -˚ 7.97	180.15	19.82
Steep Land	˚ 28.8 -˚ 11.85	378.28	41.62
Very Steep Land	˚ 54.46 -˚ 29.2	36.42	4.01
Cliff Land	+˚ 54.46	0.08	0.01
Total		908.81	%100

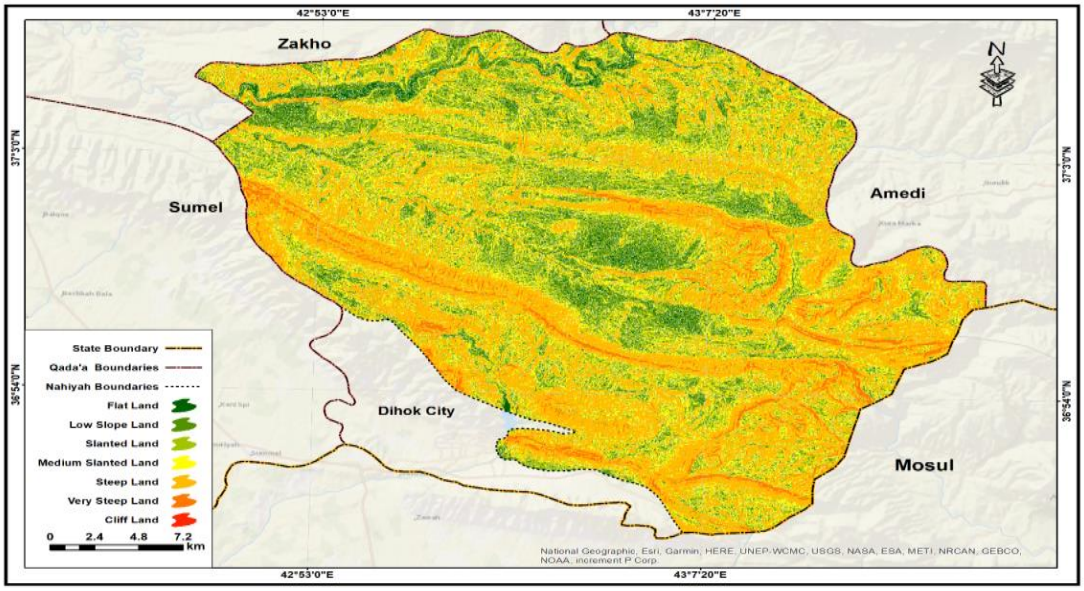

Figure 13. Zuidam classification for slope of the study area

4.Conclusion:

In conclusion, the research study classified slope characteristics by using DEM data and geospatial techniques. Different methods of slope classification were applied for mapping the slope which are slope degree, slope arching, slope direction, slope direction, hills shade, young classification, Demek classification, Zink classification, and Zuidam classification. The results of the research study found the area is identified as an elevated surface ranging between 520-1500 meters above sea level, which contributes to the intensity and effectiveness that is affected by the alpine movements. The study area has a different shape of formation of convex and concave folds which

ISSN (Paper)-1994-697X (Online)-2706-722X

left an impact on the severity of geomorphological processes. The area is considered risky and sensitive to geomorphological hazards which made the area dangerous and unstable. Most of the slopes of the study area range from 2-34.9 degrees which can be marked as risk, especially in the areas with high erosion.

Conflict of Interest:

The authors of this publication declare there is no conflict of interest.

Funding Agency:

This research received no specific grant from any funding agency in the public, commercial, or not- for-profit sectors.

References:

Abdul-Hussein, H. K., (2013). The slopes of the Bradost mountain range (a geomorphological study), a master's thesis, College of Education, Al-Mustansiriya University.

Al-Ajili, A. S. A., (2014). The slopes of the Brannan mountain range, a geomorphological study," Journal of Education / Wasit, No. 15.

Al-Din, R. A. S., (1988). Drawing standards and their practical applications, Libya, Arab Book House.

Al-Dulaimi, K. H. (2011). Terrain, an applied scientific geomorphological study, 1st edition, Amman, Dar Safa for Publishing and Distribution.

Al-Gadi, N. A., Al-Saffawi, A. Y., Béjaoui, M., & Mahmoudi, E. (2023). Investigation of the potential risks to the human health risk of fluoride and nitrate via water consumption for some areas in Nineveh Governorate, Iraq. *Acta Geophysica*, 1-15.

Al-khafaji, A. K., & Al-Sweiti, F. H. (2016). Using Digital Elevation Model (DEM) and it's applications in morphometric analysis for the upper part of Tigris River basin northern west of Iraq. *Diayal journal for pure science, Iraq*, *9*(1).

Al-Khafaji, S. N., (2018). Geomorphology, Forms of the Earth's Surface, first edition, Amman, Methodological House for Publishing and Distribution.

Al-Omari, F. S, and Sadiq. A., (1977) Geology of Northern Iraq, Dar Al-Kutub Institution for Printing and Publishing, Mosul.

Al-Sayyab, A. et al., (1982). Geology of Iraq, Ministry of Higher Education and Scientific Research, University of Mosul, Directorate of Dar Al-Kutub for Printing and Publishing.

Beg, A. M. S., (2006) Stability study of the rocky slopes of the Fatah and Injanah formations surrounding Wadi Mirawa - Shaqlawa District - Erbil Governorate, Master's thesis, University of Baghdad, College of Science.

Buday. (1980) The Regional geology of Iraq Vo(1) , Strategraphy And Poleo Geagraphy , Baghdad.

Fodda, I. H., (N.A). Spatial Analysis of Areas Threatened by Floods in the North of Riyadh Using Remote Sensing Techniques and Geographic Information Systems, King Saud University, Riyadh.

Gharib, A. H. (1983). Geomorphology of the mountainous region of Permakron in the Iraqi Republic, Master's thesis, unpublished, Faculty of Arts, Alexandria University.

Jarjis, A. K., (2017). The effect of the terrain curvature factor on the spatial distribution of natural vegetation in the Atrush area using geographic information systems", Education and Science Journal, Volume 17, Number 4.

Khairallah, H. I., (2017). Extraction of geomorphological information using automated processing of SRTM satellite image data - Wadi Kufra, a case study", Sirte University Research Journal, issue ninth.

Lillisand, T.M. and kiefer, R.W, (2008) Remote sensing and Image Interpretation, John wiley and sons Inc, 6th Ed, Canada.

Majeed, B. M, Hassan. A. A., (2013). The Forms of the Slopes in Mount Acre, a Study in Applied Geomorphology", Journal of Research of the College of Basic Education, Vol. 12, No. 3.

Republic of Iraq, Ministry of Industry and Minerals, General Company for Geological Survey and **Mining. (2012). Geological** map of Iraq, at a scale of 1: 1,000,000.

Republic of Iraq, Ministry of Industry and Minerals, General Company for Geological Survey and **Mining, (1996).** Structural map of Iraq, at a scale of 1: 1,000,000.

Republic of Iraq, Ministry of Water Resources, General Directorate of Survey, (2012). Map Production Department, Digital Unit, M.P.D, Baghdad, Dohuk Governorate Map, at a scale of 1:500000.

Saad Z. J., and Jeremy C. C., (2006) Geology of Iraq , printed in the Gzech Republic , first edition.

Salama, H. R. (2013). The Origins of Geomorphology, 4th Edition, Amman, Dar Al Masirah for Publishing and Distribution.

Shamuel, b. I., (1984). Report on the photogeology of apart of the folded zone, northern Iraq, D.G of geological survey and mineral investigation.

USGS. (n.d.). Home. Retrieved May 05, 2022, from https://earthexplorer.usgs.gov/.

Znad, R. K., Mostafa, S. E., & Al-Sumaidaie, M. A. (2020). Effect of tectonic setting on distribution of pelagic sediment unit (shiranish formation) in Zagros foreland basin, Iraqi segment. The Iraqi Geological Journal, 105-119.