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Extraction and Delineation of Pera Magroon Alluvial Fans North East Iraq Using Remote Sensing Techniques and GIS application

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ABSTRACT

Pera Magroon anticline is located within the northeastern of Iraq, covering area estimated by 958 Km^2.
The Landsat ETM^+ false color composite imagery was produced by assigning [741] bands. It is used to distinguish alluvial fans in the southwestern limb of Pera Magroon anticline. Digital elevation models (DEM) were used for describing topographic features related to the alluvial fans, as well as, three dominations model (3D) was created from (DEM) and the Landsat ETM^+ image.

Arc GIS, hydro tool set was used to draw the drainage patterns, the area of study was covered by dendritic and parallel patterns. Contour lines across the fans form segments of ellipses reveal the pattern of tectonic activity at near a mountain front. The slope map depends on ITC system explaining the alluvial fans slope range between almost flat to gently sloping.

Key words: Alluvial Fan, Pera Magroon anticline, Slope map, DEM, GIS.

استخراج وتعيين المراوح الغرينية لطية بيره مكرون شمال شرق العراق باستخدام تقنيات الاستشعار عن بعد وتطبيق نظم المعلومات الجغرافية

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الخلاصة

تقع منطقة الدراسة شمال شرق تغطي مساحة 958كم^2، نتجت الصورة الملونة الكاذبة للاندساتETM^+ بدمج القنوات (741) وذلك لتمييز المراوح الغرينية في الجناح الجنوبي الغربي لطية بيره مكرون، استخدم نموذج الارتفاع الرقمي لوصف المظاهر الطبوغرافية المرتبطة بالمراوح الغرينية، تم عمل نموذج ثلاثي الابعاد بالاعتماد على نموذج الارتفاع الرقمي والصورة الفضائية للاندسات ETM^+، تم رسم المسيلات المائية للمنطقة المدروسة باستخدام برنامج الجي اي اس و اوضحت ان النظام السائد الشجيري والمتوازي ، الخطوط الكنتورية المارة بالمروحتين تأخذ شكل بيضوي وليس دائري دليل على الفعالية التكتونية التي اثرت على المنطقة، اوضحت خريطة الانحدار بالاعتماد على نظام ITC ميول المراوح بين المسطحة الى قليلة الميل.

Introduction

The Pera Magroon anticline is located about 10 km northwest of Sulaimaniyh, with the width is ranged from [2 to 4]km and length about [30] km, and it is a huge asymmetrical doubly plunging anticline, within HFZ of the Zagros Fold Thrust Belt. [1]. Pera Magroon anticline trend is NW-SE in line with the general Zagros Fold trend and this fold is bending.

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Alluvial fans are important landforms, where their morphology and morphometry reflect changes in base level, climate, tectonic and drainage basin characteristics. Along the margins of tectonically active mountain. range like the Zagros mountains.

Alluvial fans are generally supposed to act as useful landforms for recognize the tectonic activity level [2].

Tectonic activity in the form of epeirogenic uplift creates relief, and partially affects long term sediment transfer rates to alluvial fan systems. Uplift also produces the influences of a gradual but continuous long term fall in the base level of erosion, which depending on sediment availability and stream power, may potentially bring about major fan incision [3].

The Google Earth, DEM and Satellite images with the geological and topographical maps were used to identify the present alluvial fans in area of study. Geographic information system techniques were used to calculate the coverage area and geometrical factors of the main large alluvial fans. In this study a method shows evaluating relative active tectonics.

Geographical location

The Pera Magroon anticline is located in Sulaimaniyh governorate, NE of Iraq, between longitude (45˚ 07` 30˚ and 45˚ 20`00˚ E) and between latitude (35˚ 37`00˚ and 35˚ 50`30˚ N), covering area estimated by 958 Km^2, with height ranging from 679 to 2565m, above sea level. The area was located in the northern part of the Zagros mountains, The northeastern part is characterized by the Zagros mountain belt with heights up to [3600]m above sea level (Figure -1).

Tectonic Setting

Buday and Jassim [4], divided Iraq into five tectonic- physiographic zones: three in the Unstable Shelf, and two in the Stable Shelf. These zones are trend NW-SE. Each region has its specific geological, hydrological and climatological conditions, these zones are:

1- Thrust Zone
2- Folded Zone
3- The Mesopotamian plain
4- The Salman Zone
5- The Rutbah-Jezira

The folded zone has been divided into high folded zone and low folded zone (foothill zone).The study is located in the unstable shelf, mainly within the High Folded Zone [5] (Figure - 2).

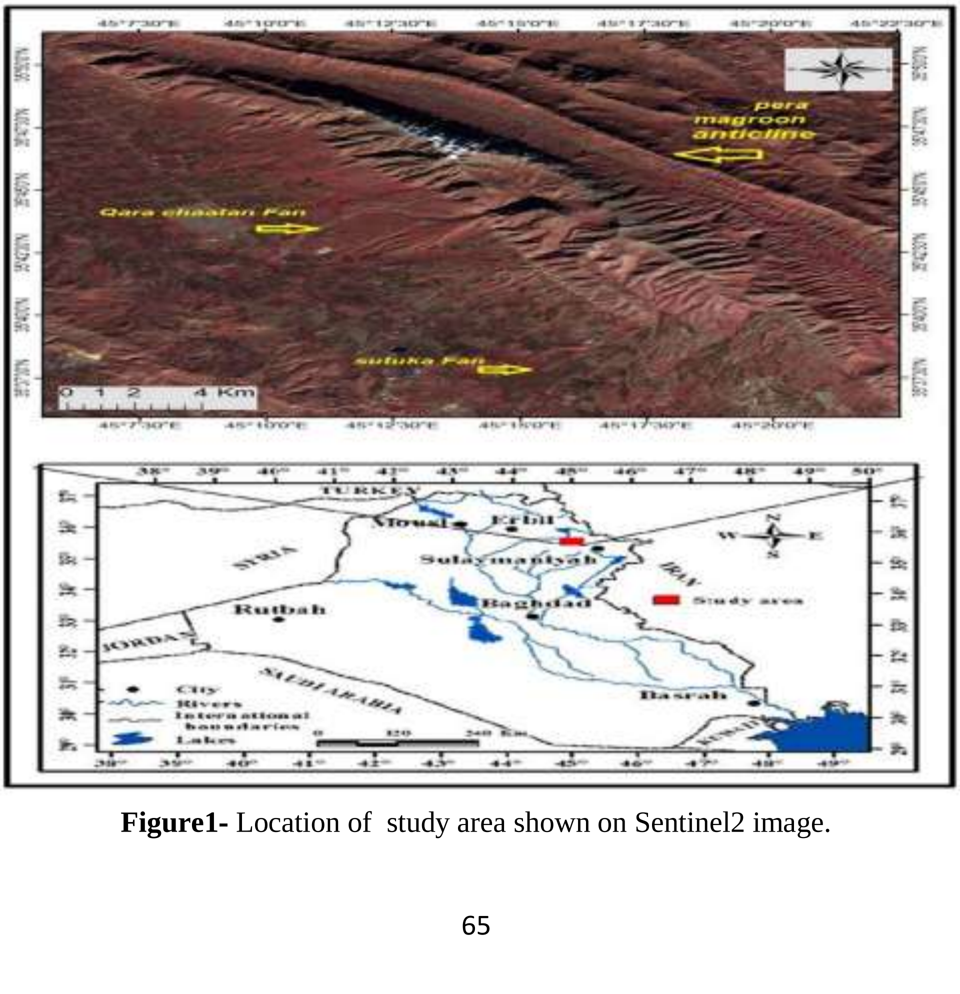

Figure1- Location of study area shown on Sentinel2 image.

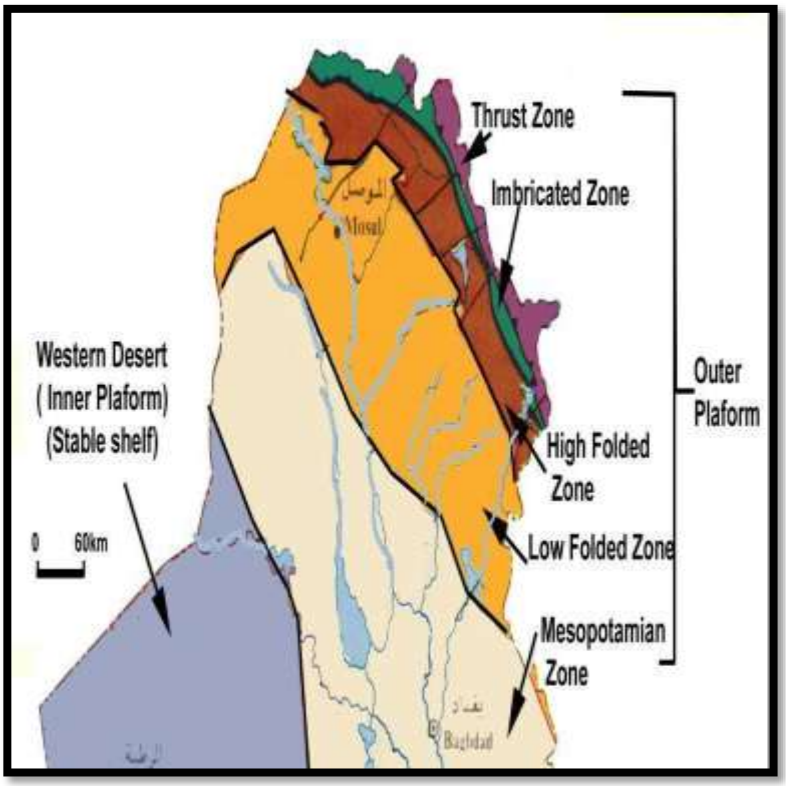

Figure 2- Tectonic map of Iraq [5].

Stratigraphy

The area of study contains many stratigraphic units appeared as outcrop, ranging from Lower Cretaceous to Recent age, these formations are displayed from oldest to youngest as in (Figure -3) :

1. Sargelu Formation. (Middle Jurassic) thickness is about 120 m in Sargelu village. It consists of medium tough to tough, dark grey to black, thickly bedded in the lower (50 m) becomes thinly to medium bedded, in the upper part, fine to medium crystalline limestone and dolomitic limestone, with thin horizon of dark papery shale and bituminous limestone [6].
2. Chia Gara Formation. (Late Jurassic – Early Cretaceous) consists of a alternation of thinly bedded limestone and shale rich with ammonites, the maximum thickness is 232m [6].
3. Balambo Formation. (Early Cretaceous) consists of thinly bedded limestone with intercalations of dark grey marl and or shale, The exposed thickness of this formation in the type section is 762m [6].
4. Sarmord Formation. (Early Cretaceous) The total thickness of the formation is 450m, it consists of alternation of marl and limestone.

1. Qamchuqa Formation. (Early Cretaceous) consists of massive limestone and dolomites. The thickness is variable reaching 1000 m as a maximum [6].
2. Kometan Formation. (Early Cretaceous) consists of thinly and well bedded white limestone which is relatively hard and slightly marly. The formation is a good source for supplying the medium and fine sized particles of the sediments to the alluvial fans [6].
3. Shiranish Formation. (Campanian) consists of thinly well bedded blue marl and marly limestone. The thickness of the formation ranges from [200-220] m.
4. Tanjero Formation. (Maastrichtian) consists of alternation of dark green and yellowish green shale, mud, clay stone and conglomerate [6].

Quaternary Deposits (Pleistocene-Holocene): Quaternary sediments cover a large part of the Pera Magroon anticline and surrounding area, particularly in the south and west parts, and occupy also the low land region like synclines, plains, and slopes. It is seems that it’s the important sediments in the study area. Alluvial fans with fluvial deposits represent most of the quaternary deposits [7].

Data Used

Data from different sources were used in this research:

1. Topographic maps of Pera Magroon anticline at scale 1:25000, 1:100000.
2. Geological map of Pera Magroon anticline at scale 1:250000.
3. Geomorphological maps of Pera Magroon anticline at scale 1:50000.
4. Sentinels2 image, Landsat 8 image, Quick Bird images, with spatial resolution 0.6 m. .
5. Different image processing software used such as, ERDAS Imagine V. 9.1, and Arc GIS V (9.3)-(10.3).

Aim of study

This study aims to discuss the origin of deposition of the Qara Chattan and Sutuka alluvial fans, which are developed in the Pera Magroon anticline. This aim was completed by using different geological data, with interpretation of satellite images and digital elevation model (DEM) using Arc GIS technique.

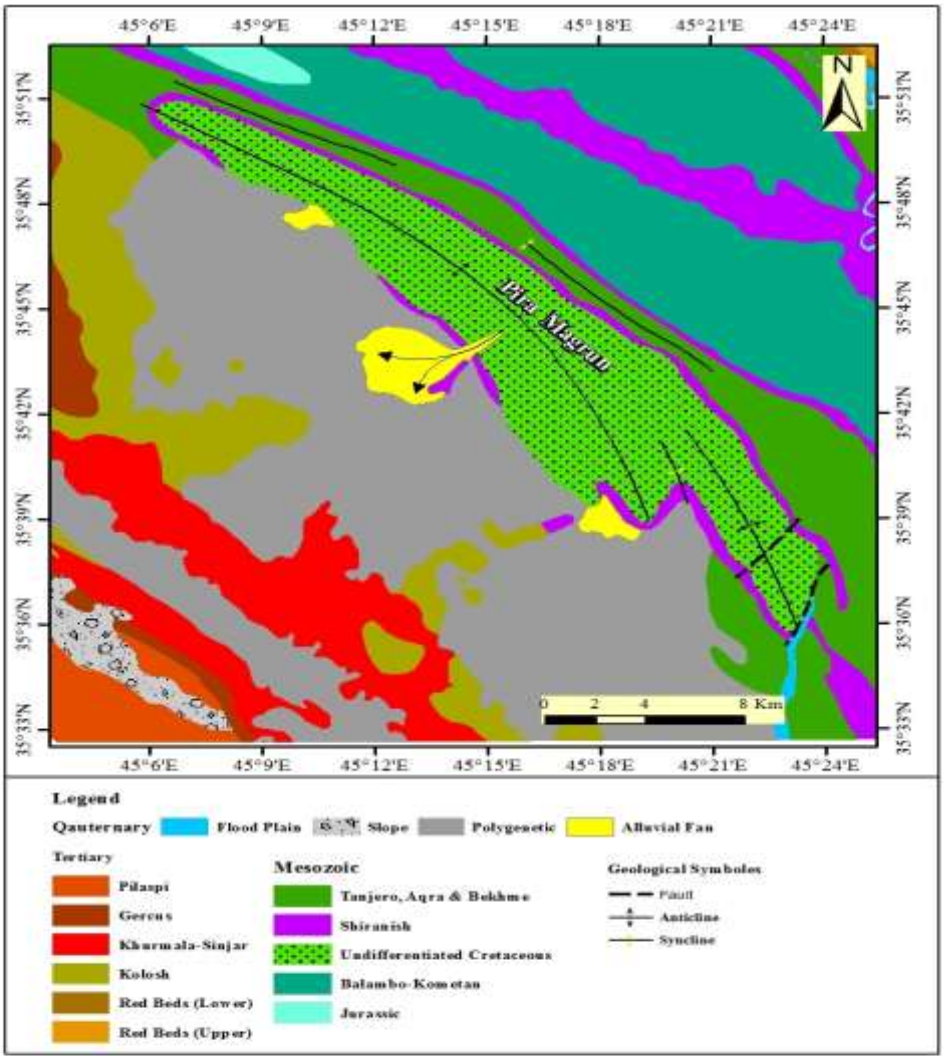

Figure 3- Geological map include study area [7].

Results and Discusion

The Use of Remote sensing Data:

Satellite images and DEM were used to determine Pera Magroon fold and alluvial fans shapes and size, also to mark diversions and locations of the stream network.

Color composites were created by combining Landsat ETM$^+$ bands "742" RGB. as combination of three bands can be used as input to the RGB channels. The option should be made based on the application of the image data. 742 combination was used to reduce image for better visual interpretation, useful for cultural feature identification and for geological mapping, the alluvial fans appears dark rose to blue color because of relative absorption in 7 and 4 bands (Figure -4).

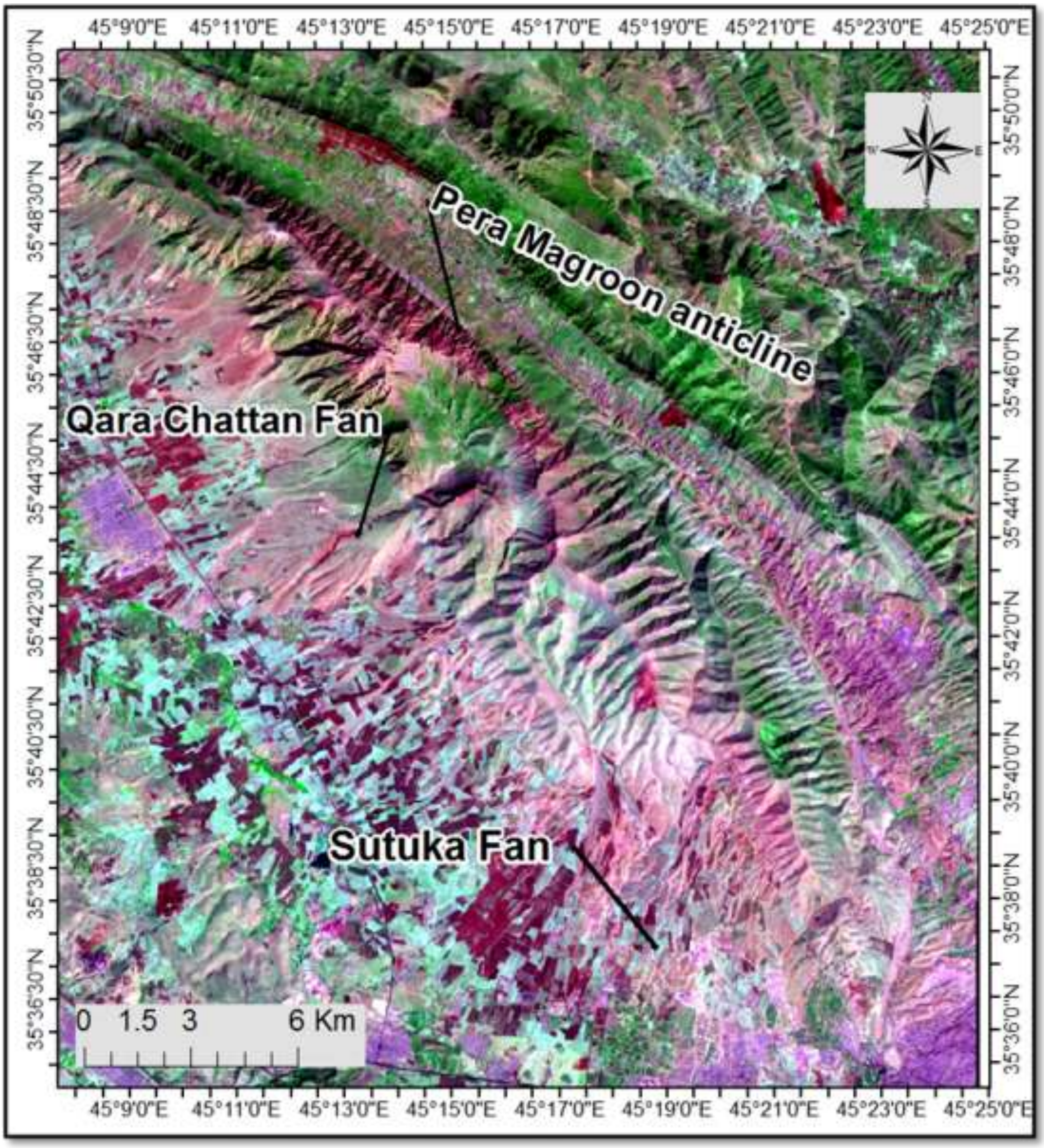

Figure 4- Landsat ETM+ Image (742) RGB showing the alluvial fan

The GIS and DEM applications

General topographic map

The topographic surface of the High Fold Zone generally rises in elevation towards north and northeast. The lowest areas range in height from [215 – 230]m to the highest elevated areas, which range from [2000 – 2500]m with some especially high peaks of the mountains that reach (2763) m as in Pera Magroon mountain [8].

According to the DEM the height in the study area is ranging from [679 to 2598]m, above sea level.

Geomorphologic, structural and lithology processes are the main factors that effect on the development of the surface features and the topography. Within the study area, the main topographic features are elongated and elevated mountainous chains reflecting the anticlinal structure, which are separated by synclinal troughs forming flat plains with local slight undulations [9].

Digital Elevation Models was used to extract geomorphic characteristics of the river network, such as: mean elevation, basin slope, length, and river network. The morphology characteristics helped to understand the relationship between geological structures and geomorphic energy controlling the river long profiles (Figure -5).

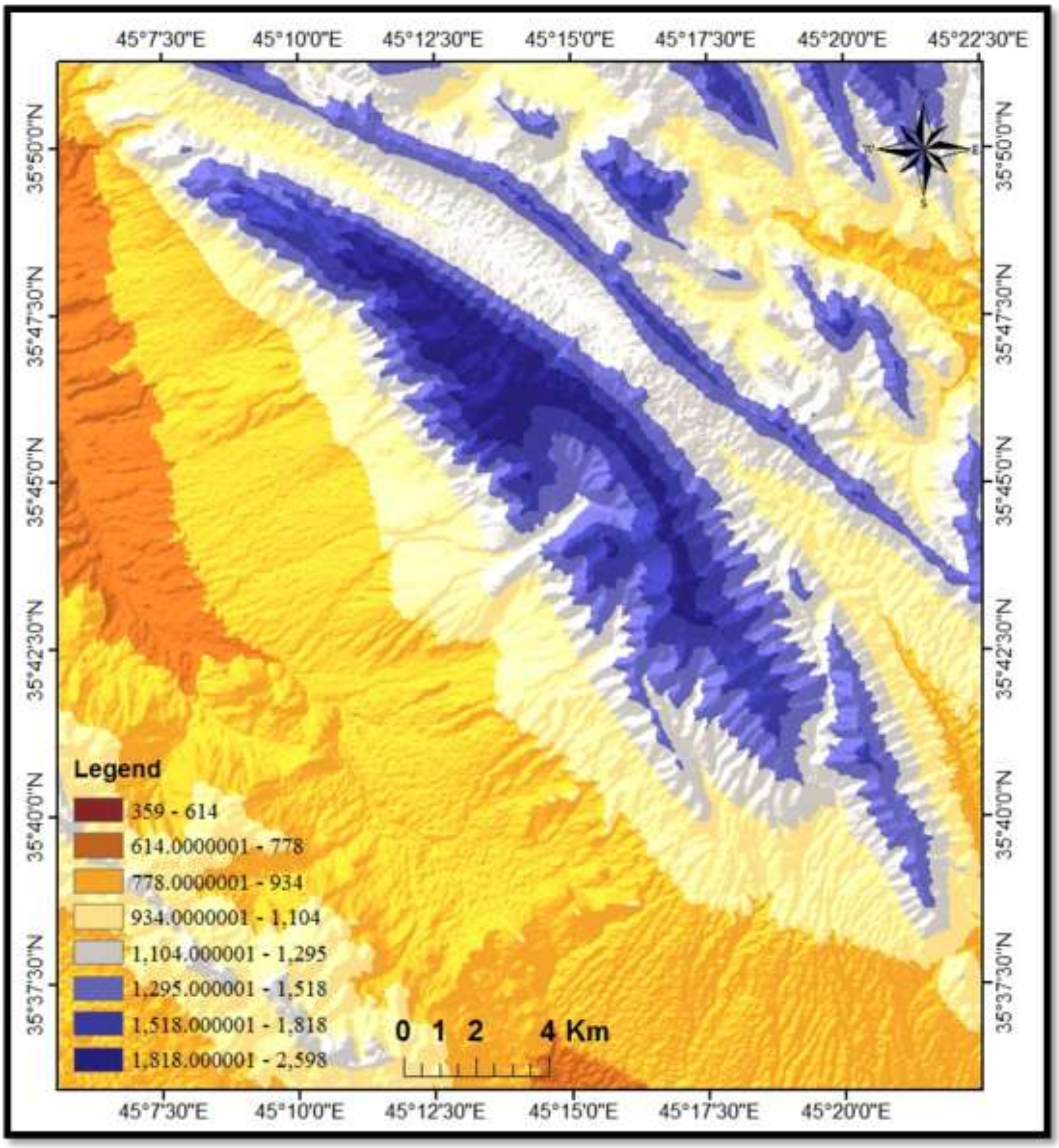

Figure 5- Elevation map of the study area based on Hillshade, (extracted from DEM, 30 m).

Drainage networks

Drainage networks are major elements of watershed assessment as they reflect it geologic, topographic, hydrogeologic and tectonic characteristics. Drainage networks are one of the major elements characterizing topology and geometry of basins [10].

They have been described as the aggregate of all terrain surfaces adapted to hydrological flow and accumulation. The flow direction calculates the flow for each cell to its steepest down-slope neighbor in the ranked elevation matrix, the cells of the DEM are ranked from the highest to the lowest elevations. The flow accumulation matrix calculates the value of flow from one cell to another, accumulating values from uphill cells into each cell. Thresholds are defined giving the minimum number of cells required to form the connected drainage network. In addition to the applied algorithms, the extraction of drainage network is highly dependent on the accuracy and precision of the DEM used [10]. Drainage patterns contain useful information about the present and past tectonic regime [11].

Drainage network in the area of study represents part of the major drainage basin of Sharazoor-Pera Magroon basin, specifically it represents parts of Tanjero basin which drained into Sharazoor - Peramagroon basin [12] [13].

The drainage basin of the area of present study was analyzed to estimate its neo-tectonic development, Depending on the DEM, the drainage network of the area under search was extracted by using GIS technology, mostly the area of study was covered by dendritic and parallel patterns as shown in the (Figure -6). Parallel pattern occurs within mountain area in the study area and it indicates that the topographical features are folded, dipping and highly jointed.

Geometry of alluvial Fans:

Alluvial fans are fan-shaped deposits that accumulate along steep mountain fronts. When mountain streams emerge into relatively flat low land their gradient drops and they deposit a large portion of their sediment load. Although alluvial fans are more prevalent in arid climates, they are occasionally found in humid regions [14]. Alluvial fans are well developed in Pera Magroon anticline due to the high relief and the existence of mountains, which are drained by many valleys. In the area of the study, all alluvial fans occur at mountain fronts like the fans exist on the foot of Pera Magoon anticline. According to their dimensions, these are multi stage fans of Medium type, with medium areal coverage, and their lengths range between (3 – 10) Km, developed from one single stream or valley, usually flowing out of a mountain, after deep erosional cutting, forming locally cirques, such as Zewi Alluvial Fan (Figure -7) at Zewi Cirque in Pera Magroon Mountain, west of Sulaimaniyah. The age of these fans is most probably Pleistocene-Holocene [8] .

1. **QaraChatan Alluvial Fan** is located in the south Qara Chatan village, southwestern limb of Pera Magroon anticline, it can be described by length near to 7 Km, width reaches 3.5 Km, with thickness close to 20 m. The sediments of the fan are consist of clay, sand, silt and rock boulders of limestone and sandstone range between (1 – 2) m in size .
2. **Sutuka Alluvial Fan** is located within the southwestern limb of Pera Magroon anticline, near the southeastern plunge. Sutuka fan deposits where several alluvial fans exist beside each other coalescing in a tectonically active area and made bajada. The maximum width of this alluvial fan is about 6 Km and the length is about 9.5 Km.

The sediments consist mainly of soil and limestone boulders of Kometan and Qamchuqa formations, the average diameter of these boulders reaches to 1m, poorly cemented by calcareous materials, the thickness of this fan reaches up to 10 m (Figure -8).

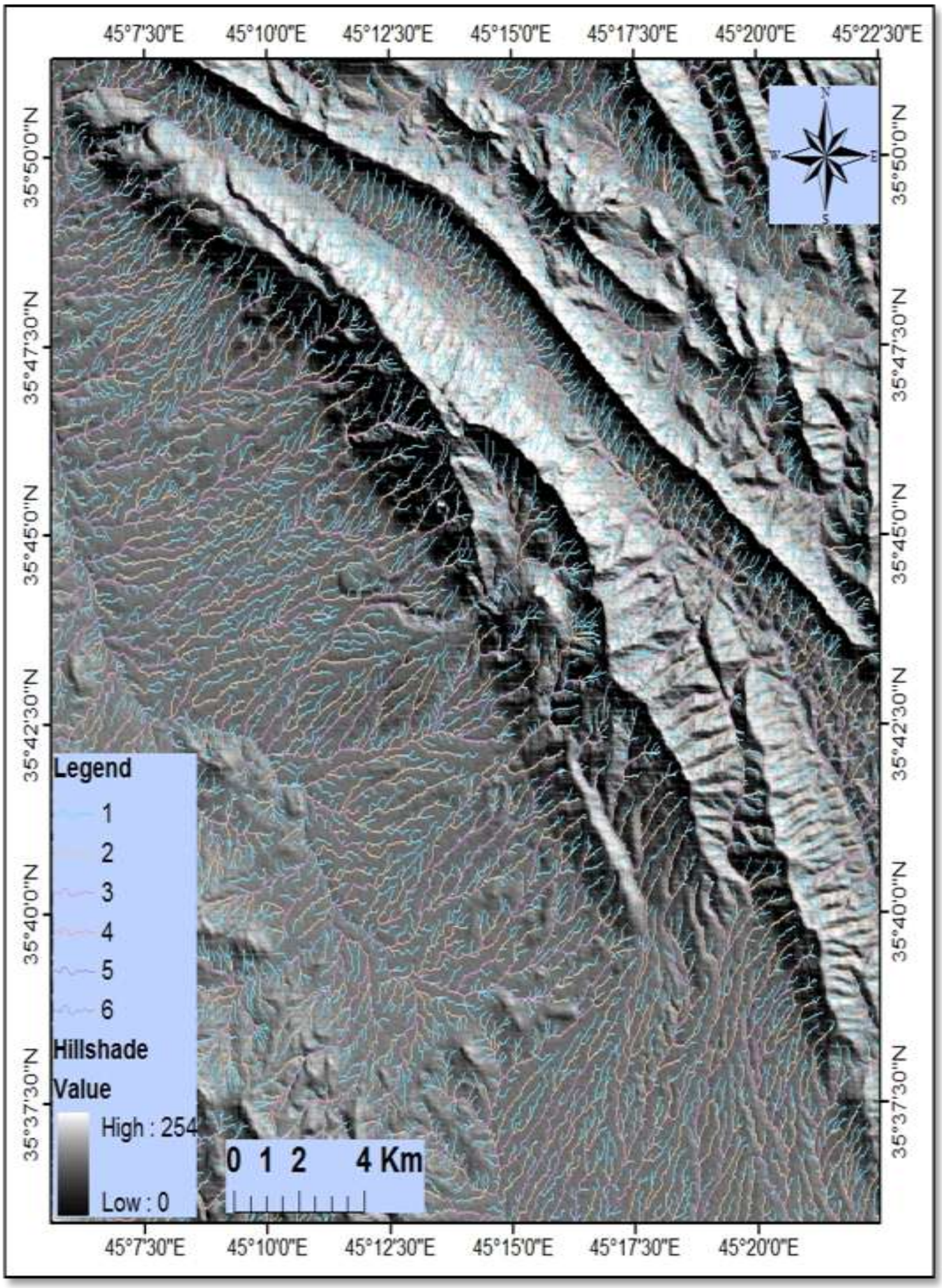

Figure 6- Drainge network in study area based on hillshade.

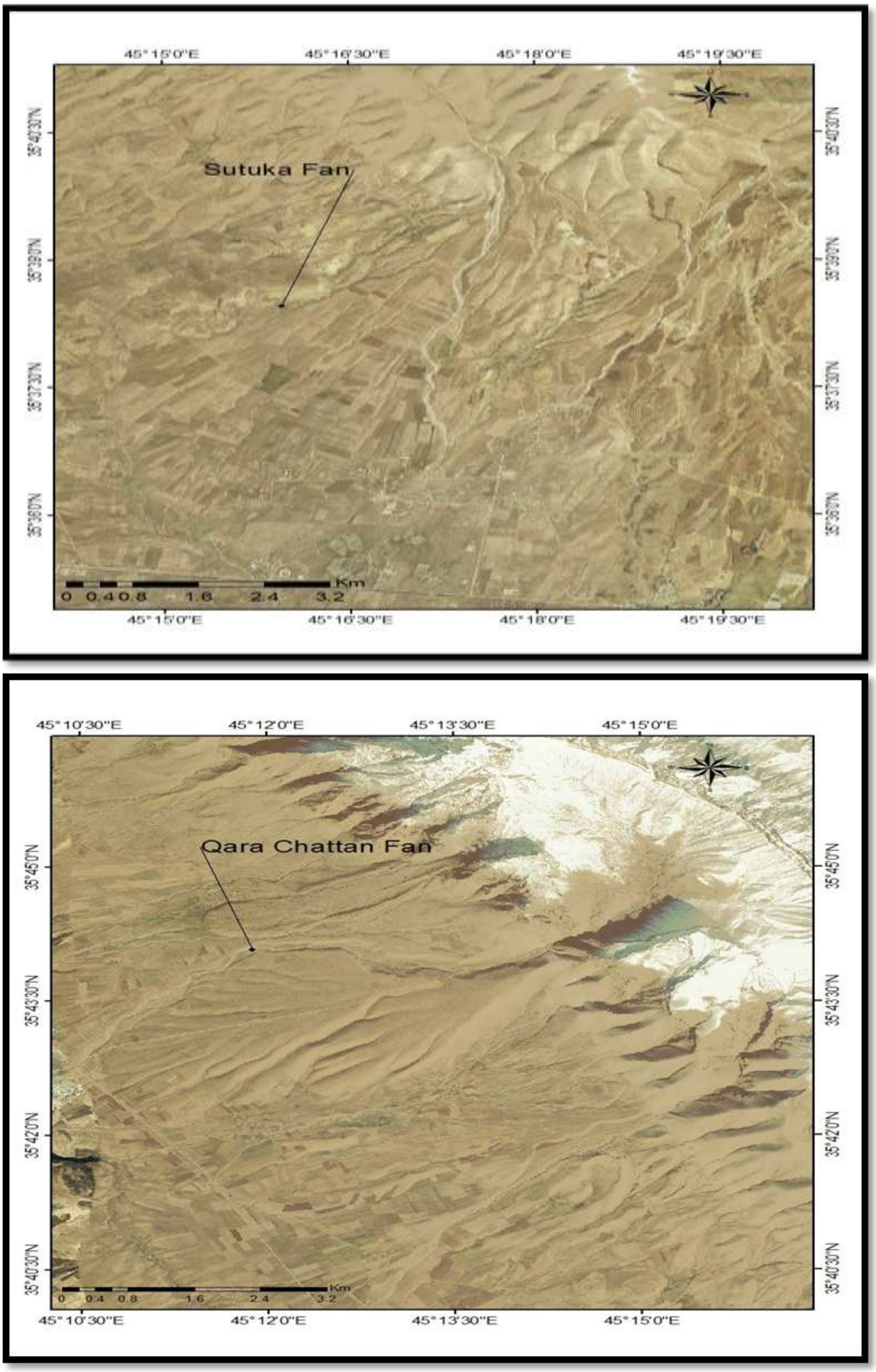

Figure 7- Quick Bird image of Qara chattan and Sutuka fans with spatial resolation 0.6m.

Figure 8- Pera magroon fan , the road to Zewi Gorge.

Three dominations model (3D):

False color composite image of bands [741] draped over the digital elevation and then 3-D view image of Pera Magroon anticline was created (Figure -9). The 3-D image displays the structural zone of all the anticline besides, enhancing the main geological characteristics, furthermore, alluvial fan features are clearly visible with their extensions.

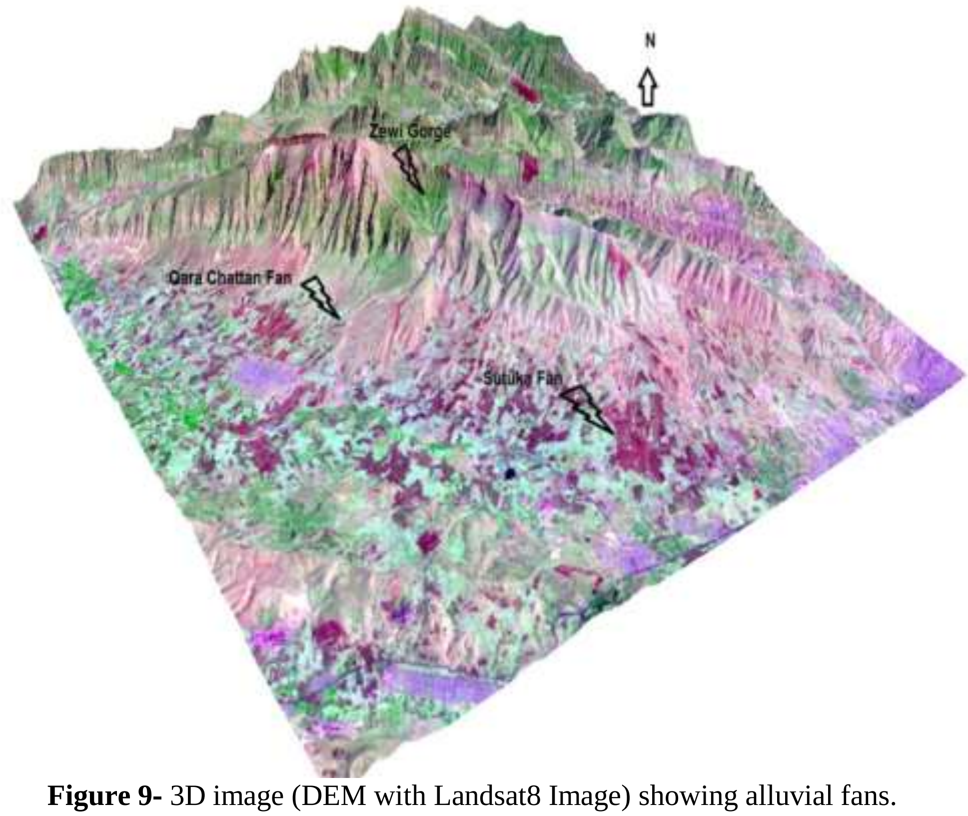

Figure 9- 3D image (DEM with Landsat8 Image) showing alluvial fans.

Contour Line

The fan contours may be useful in identifying the position of a fan apex, relic mountain fronts., and calculating of tectonic tilte [11].

The overall shape of an alluvial fan can also reveal the pattern of tectonic activity at near a mountain front. Because alluvial fans are roughly conical in shape, topographic contours across simple fan are approximately circular (the intersection of a cone with a horizontal plane is a circle). Where alluvial fans are not simple, and have submit tectonic tilt, contour lines across the fans form segments of ellipses, not circles [the intersection of a tilted cone and a horizontal plane is an ellipse]. The highest peak is in Pera Magroon mountain., reach [2600] m, contour lines across the Qara Chattan and Sutuka fans forms segments of ellipses, not circles (Figure -10).

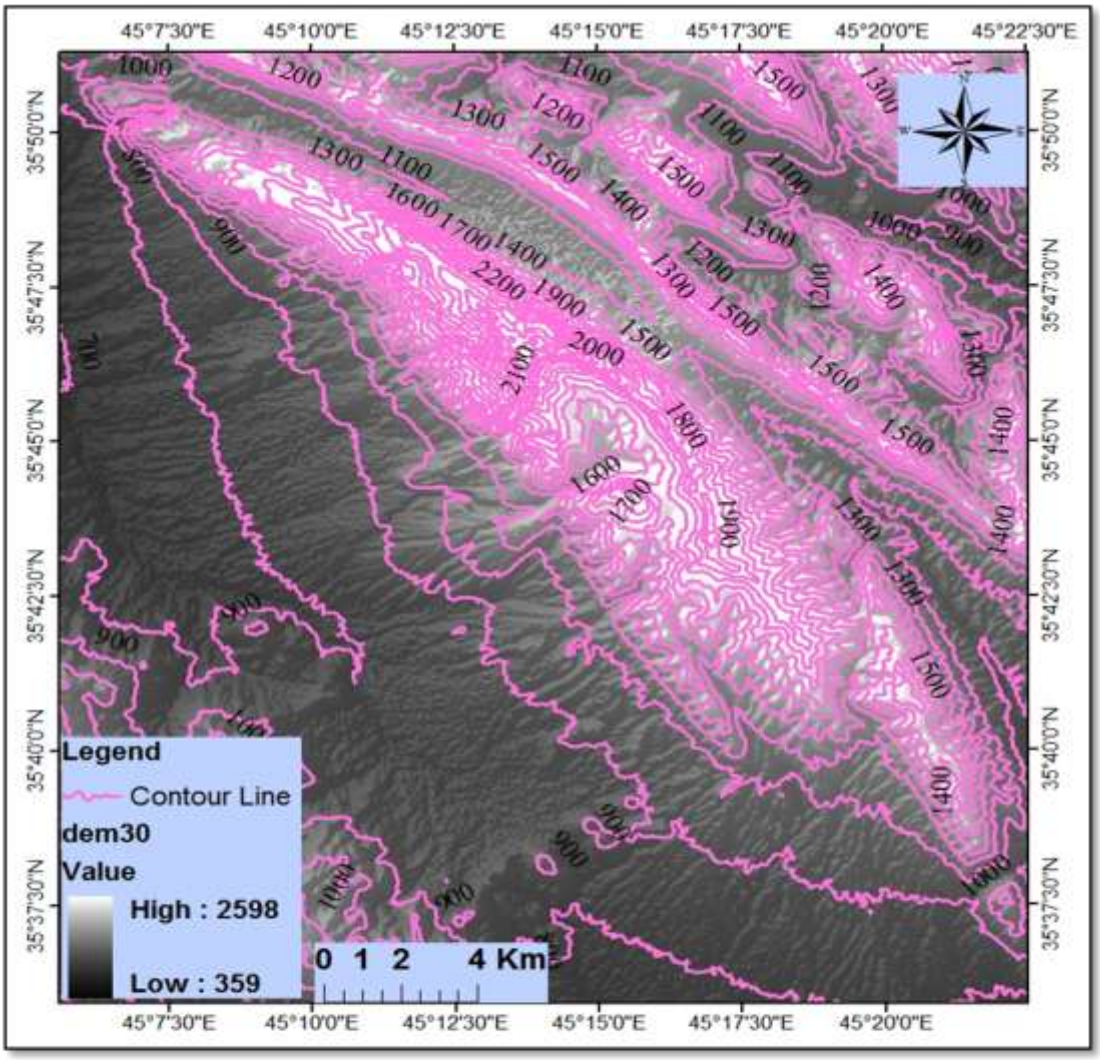

Figure 10- Countour map of study area based on DEM.

Slopes map

The slope is one of the most important topographic attribute used in geomorphologic evaluation and of variable relief**.**

The term slope has two meanings. First, refers to the inclined surface itself. Second, slopes refer to the angle of inclination of the ground surface, expressed in degrees or as a percentage slopes. To avoid mis - understanding, the term hill slope usually applies to the inclined surface and the term slope gradient, slope angle or simply slope to its inclination. [15].

In addition, the slope has an important role in any area; this importance is determined through its effect on the forms of drainage patterns and its impact on the operations of removing, transporting and depositing of soils, as well as its impact on growing vegetations, Aswad [16], shows that slope can be measured directly from topographic map through three main methods depending on horizontal distances and finding the vertical intervals. To change slope degree to percentage slope or conversely percentage to slope degree, a special table is used [17] [13].

The slopes are expressed in degrees and classified into 6 classes (Figure -11). ITC system is used to classify slope, the percentage slope is used and then the slope percentage alteration to describe the surface area with respect to slope as shown in the (Table -1), also it is important to mention that there are specific chart to convert slope from percentage to degree.

Table 1- shows description of slope on the study area [17] [13].

Slope %	Descriotion
0-2	Flat- Almost Flat
3-7	Gently Sloping
8-13	Sloping
14-20	Moderatly Steep
21-55	Steep
56-140	Very Steep
>140	Extremely Steep

The zonation of these classes is taking into consideration the resolution of the available DEM (30m) data and the scale of the final map. The slope analysis of the study area shows that gentle slopes are common depending on ITC system represents the flood plains and flat plains of the main rivers, foothills slopes and the upper parts of the pediment plains, with active slopes located in the cores of the high anticlines, such as, Pera Magroon anticline, where erosional cliffs, steep structural slopes and structural scarps are well developed. Moreover, these slopes occur along gorges and the deeply cut valleys.

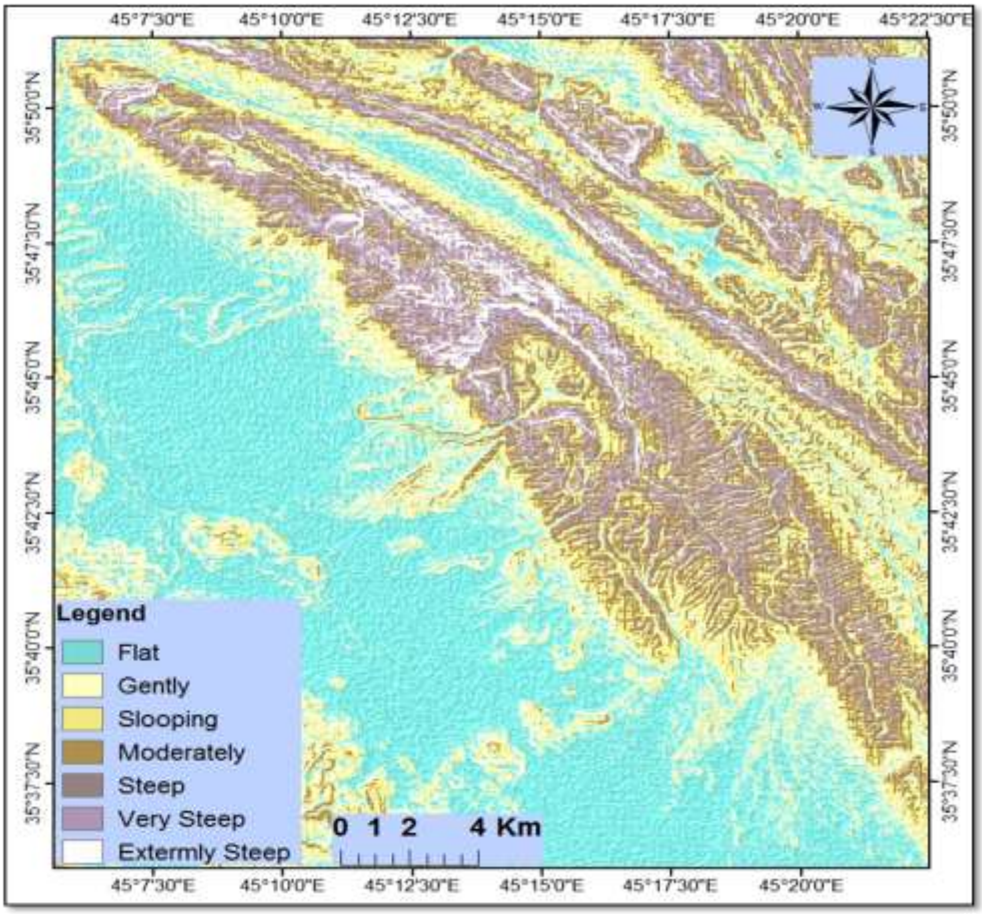

Figure 11-Slope Map of the Pera Magroon anticline based on hillshade (Compiled from DEM, 30 m).

Conclusions

1. This research has introduced methodology for the extraction alluvial fans features from Landsat ETM+ and Digital elevation models (DEM).
2. False color compositions were used to spectrally enhance the alluvial fans features. They allowed the identification of the accurate places at Pera Magroon anticline from the same DEM.
3. According to the analysis of the drainage network, the dendritic and parallel patterns are the most common type within study area.
4. The study created topographic contour lines on the alluvial fan to clarification alluvial fan borders.
5. The slope map appears that Qara Chattan fan has gently sloping depended on ITC system, while Satuka fan has flat to gently sloping.

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