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Hypsometric Analysis of Jabal Sanam –Southern Iraq-Using GIS

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Abstract

Hypsometry of Drainage basin (area-elevation analysis) has generally been used to reveal the stages of geomorphic development (old , mature and young) . This study has been conducted to analyze the hypsometric properties of Jabal sanam –southern Iraq . In constructing the hypsometric Integral curve , a Digital Elevation Model (DEM) has been created based on the Triangulated Irregular Network (TIN) . The topographic map has been used as a base map for generating contours to create TIN . The hypsometric Integral Curve results , derived from DEM show that Jabal sanam is in balance state of tectonic activity and erosive processes or in mature stage of geomorphic development.

Key words: Hypsometric analysis , Geomorphological technique , GIS , Jabal sanam , Basrah-Iraq.

1. Introduction

Geomorphological changes or land degradation are affected mainly by weathering processes , stream erosion and sediment transportation by surface runoff . It is important to mention the difficulties of interpretation of such a data due to the complex nature of these hydrological and landform processes acting on watershed system .These data besides tectonic ,climate and lithology of study area are dependable in estimation of geological evolution stages of landform [1].

Hypsometric analysis or as known(area-elevation) analysis is the relation between the area of horizontal cross section of drainage system watershed and corresponding elevation .It has been termed drainage basin relief graph which is considered as an indicator of basin condition [2].

Differences in the shape of hypsometric curve and hypsometric integral value are related to the degree of balance in erosive and tectonic forces [3].

Hypsometric analysis was first time introduced by [4] ,and he used it to express the total slope and the shape of watershed basin.

The hypsometric curve is related to the volume of soil mass in the basin and the amount of erosion that had occurred in the basin against the remaining mass [5].

The topography produced by stream channel erosion and associated processes of weathering ,mass movement and runoff is extremely complex both in the geometry of the forms themselves and in the inter-relations of the process which produces the forms [6] ,moreover ,hypsometric curve is considered non-dimensional distribution

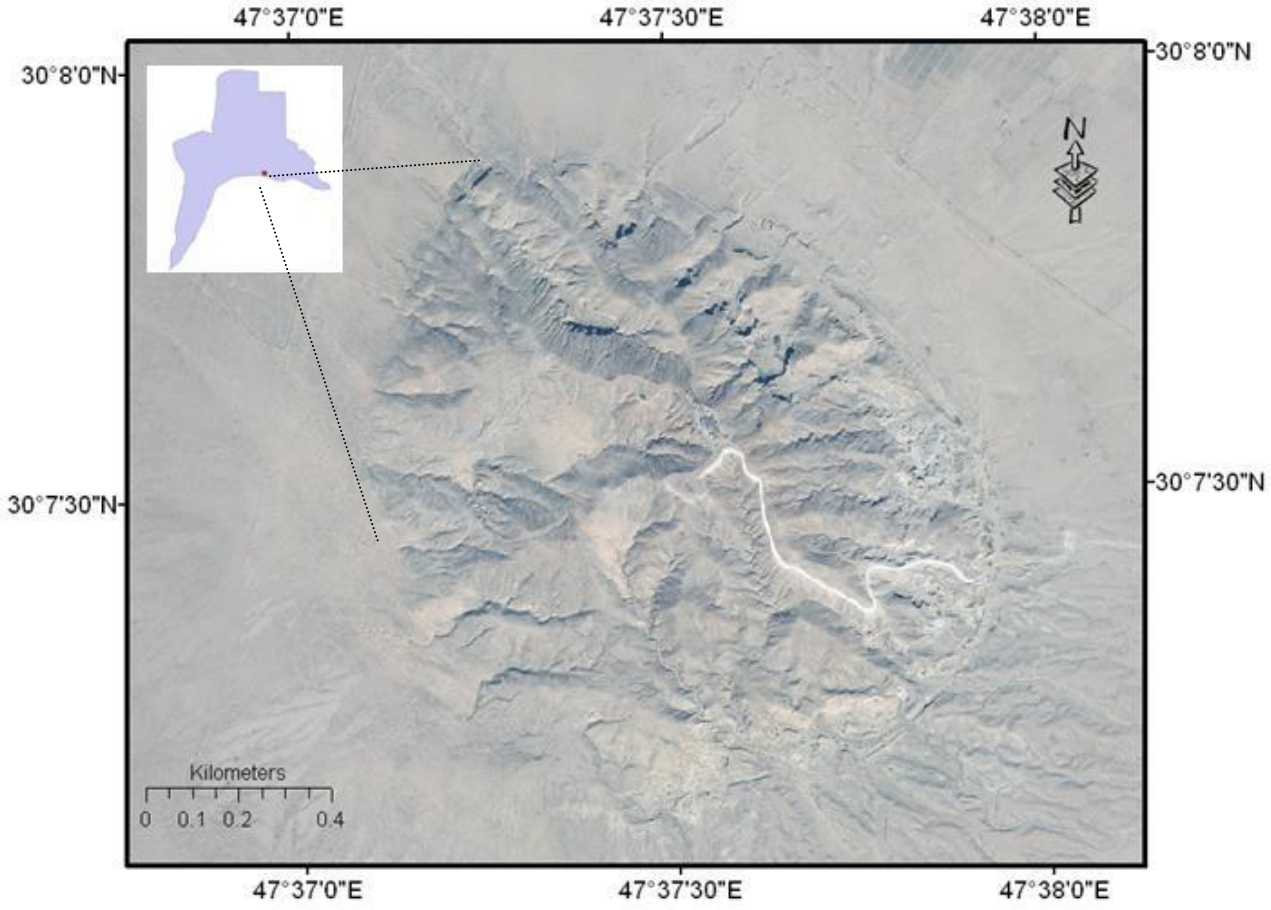
between relative elevation of particular contour line against corresponding relative area [7].

We can use the concept of hypsometric analysis in cases of topographic comparison because of its revelation of three-dimensional information through two dimensional approach [8].

Jabal sanam watershed system under study is sensitive to erosion because of its undulating topography. Employing Geographic Information System(GIS) technique in hypsometric analysis of digitizing contour map helps in improving the accuracy of results and save time. This study was undertaken to estimate the hypsometric integral and to determine the geological stage of development of Jabal sanam .

2. study area

Jabal sanam located in Basrah governorate ,southern Iraq near Iraq-kuwait border ,about 48 km south of city centre and 8km to the west of safwan . It has coordinate of (47 37 10 to 47 38 10)longitude and (30 7 10 to 30 8)latitude (Fig. 1) with elevation ranges between 60 to 150 m above sea level and extends a total area of 1488484 m^2



Figure(1) Ikonos photomap of study area

3. Geology of study area

3-1. lithology

Jabal sanam structure consists of three rock units [9] ,these units are as follows from lower to upper parts Fig.(2):

1. Marl unit: this unit located in the deep valley ,and it consists of green and red marl with banded lamina of gypsum
2. Gypsum unit : It consists of gypsum with different masses of carbonate and marl with zones of hematite along with bedding planes .This unit is separated from marl unit with unconformity surface.
3. Limestone unit : It consists of brecciated limestone ,and separated from gypsum unit with conformity surface.

   Rocks belong to Dibdiba formation (U.Miocene-Pliocene) surrounded jabal sanam area consist of coarse grain of pebble and sand with rounded or semi-angular quartz fragments .A conformity surface is separate Dibdiba formation from limestone unit

3-2. Structural setting:

Jabal sanam considered is as salt plug ,and the cap rock is only exposed above earth surface .The rock core of this structure is about 50 m deep ,and consist of evaporate rocks [10].Cap rock characterized of major normal fault pattern with two main systems of faults :NW-SE and E-W .[9] explained that jabal sanam resulted from salt raising ,however he pointed to the difficulties of the determination the reasons which are responsible for salt raising whether it belongs to secondary folding ,faulting or hydrostatic adjustment

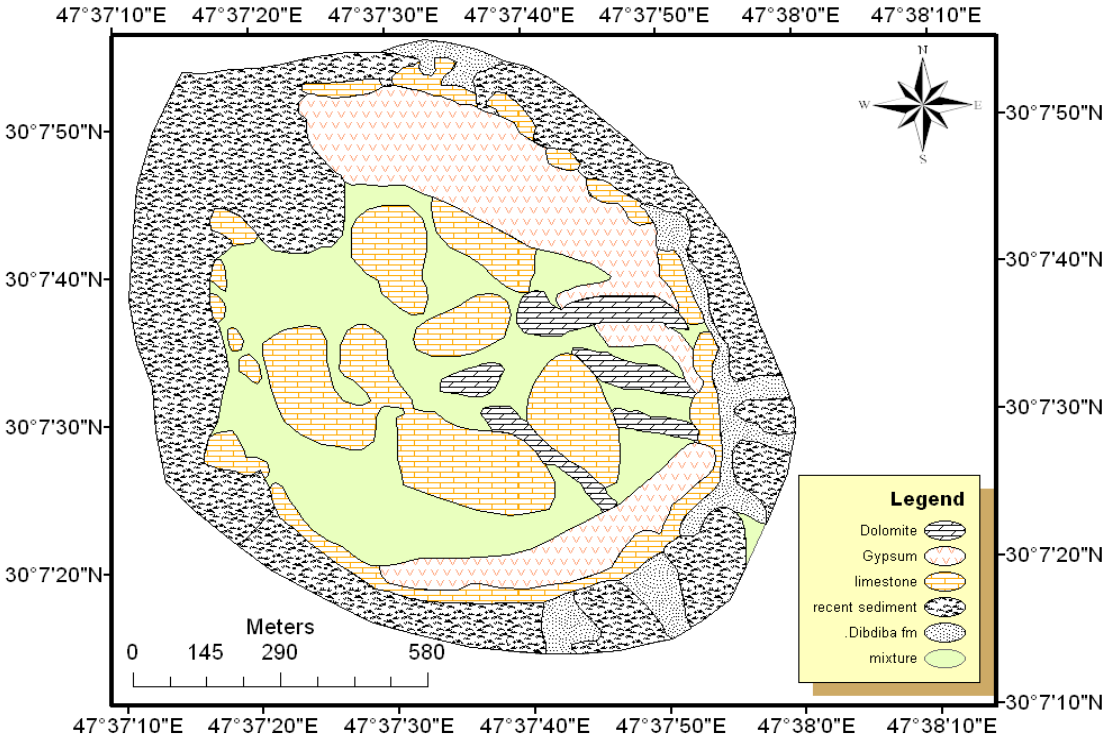
3-3. Geomorphology

Geomorphologic feature of jabal sanam is mainly related to geometric shape of structure and associated fractures (especially faults) ,and also rock type , climate and erosion process .These features include:

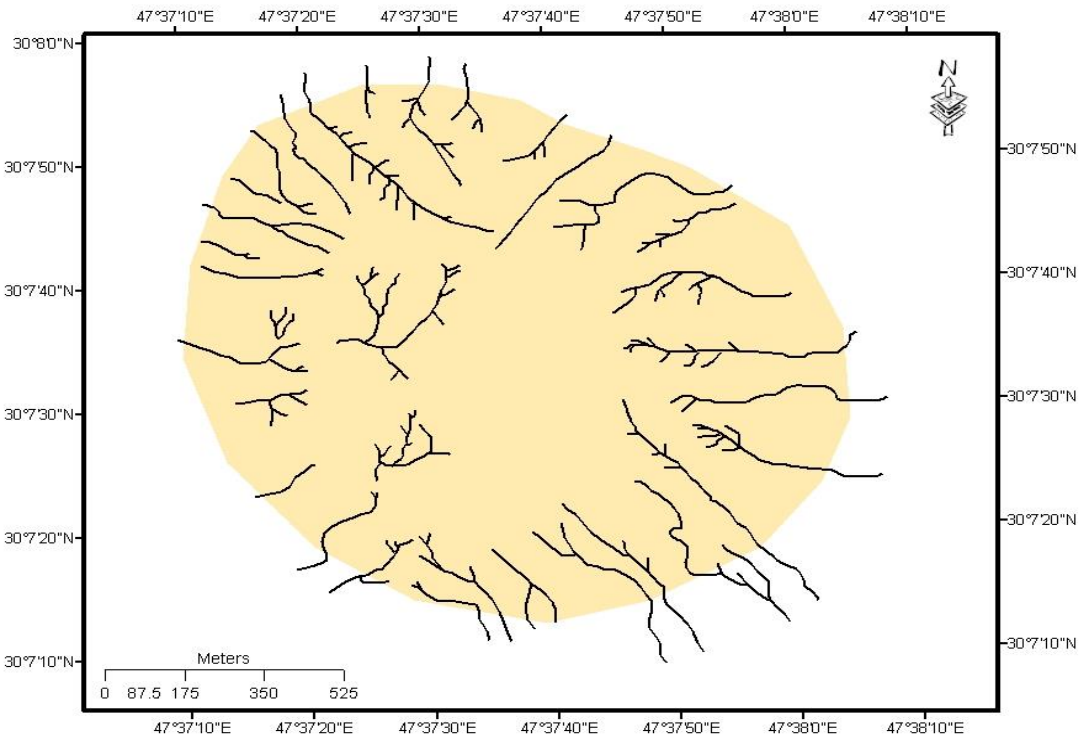
1- Drainage pattern: The dome shape of structure reflected drainage pattern ,thus , radial drainage pattern is associated with cone or dome structure [11] fig.(3).Besides dome shape and direction of faults effects on drainage pattern and rock type . The drainage channel in marl and gypsum units is longer than limestone unit .

2- Mass movement processes: It is also termed mass wasting which means movement of rocks by gravity [12] ,and it is classified according to the type of materials and nature of movement in to rock sliding , rock fall ,rock toppling and debris flow.

3- Caves : It occurred in valleys sides within limestone and gypsum units .These caves resulted from dissolving process after rain storm which infiltrates through fractures. Moreover, field observation reported by [13] support this idea in more cases or sites by existing fractures above the caves



Figure(2):Geologic map of Jabal sanam modified after [9]

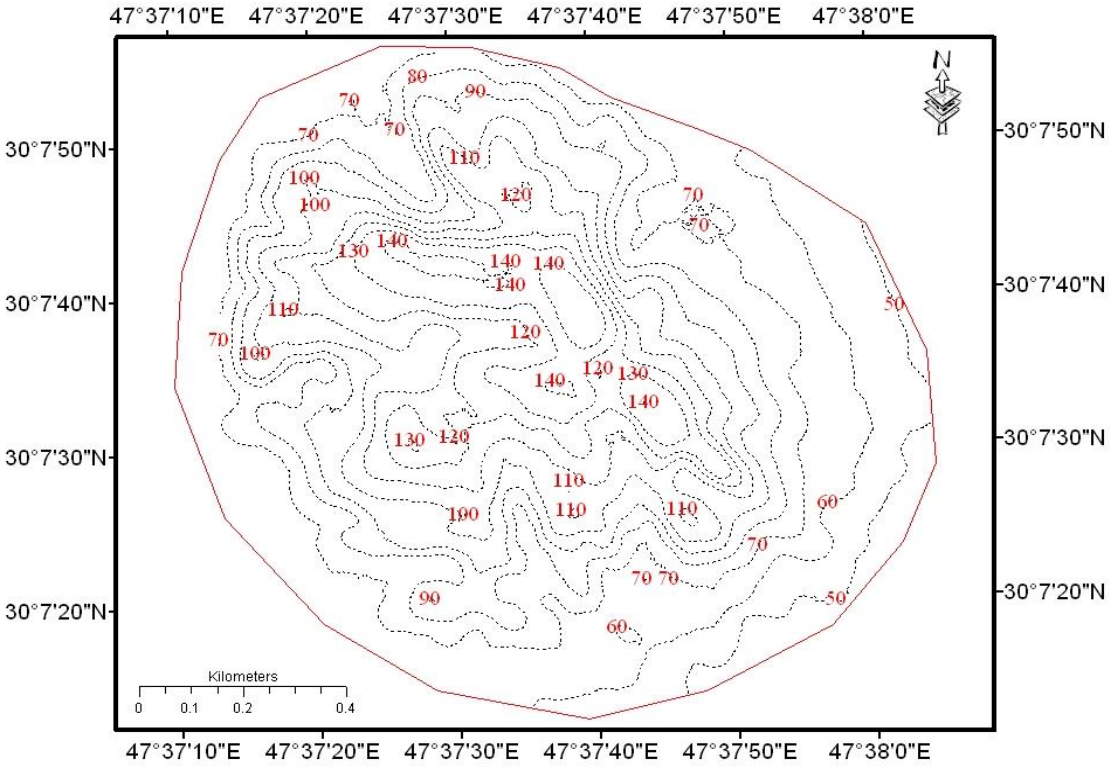


Figure(3)Drainage pattern map of jabal sanam modified after [9]

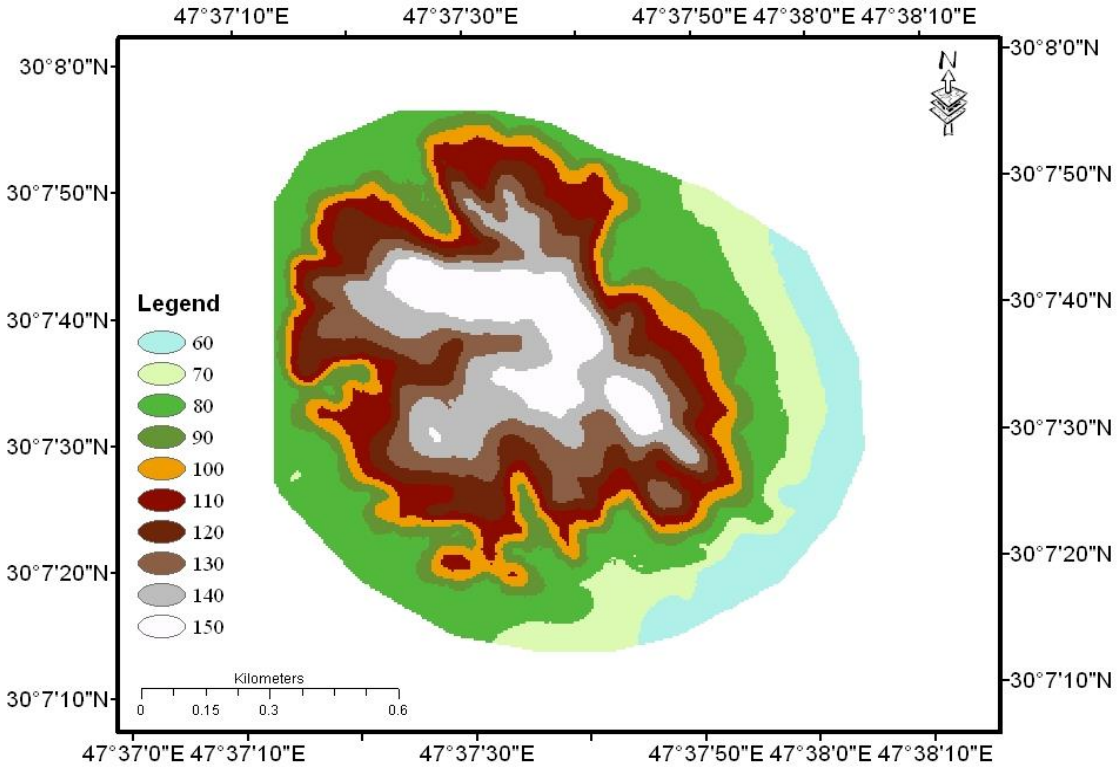
4. Methodology :

4-1. Preparing Digital Maps :

The topographic information of the study area was georeferenced and digitized using the maps of [9] by applying ArcGis9.3 tools . The contour lines were digitized to generate the line feature class of digital contour map fig.(4) which was further processed using the spatial analyst module to generate the digital elevation model (DEM) representing the watershed terrain topography fig.(5). The digital drainage system map is generated using method of [7] fig(3) ,which considered one of the most effective method in representing drainage systems [14].



Figure(4)Digital contour map using ArcGis9.3

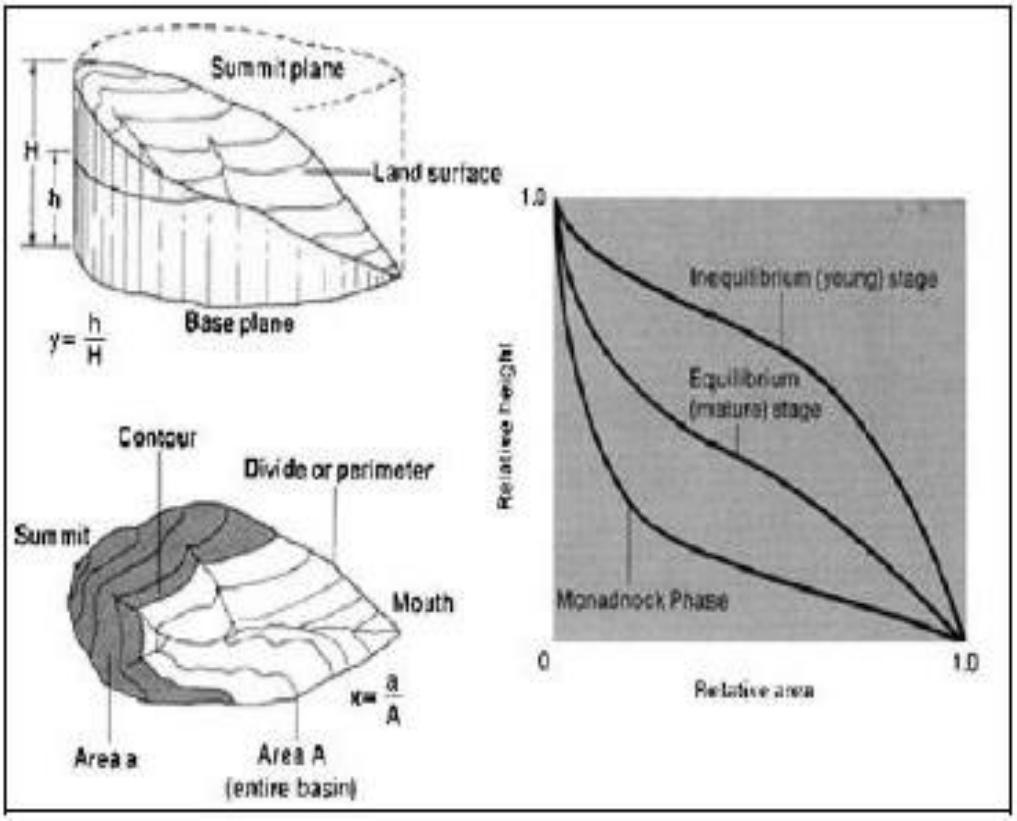


Figure(5)DEM of study area using ArcGis9.3

The attribute tables of the georeferenced feature classes representing the contours and their enclosed area were created .The data of elevation and length of contours and their respective area were used to plot the hypsometric curve whose hypsometric integrals were estimated.

4-2. plotting the hypsometric curve(HC):

Hypsometric curve is obtained by plotting the relative area (a/A) along the abscissa and relative elevation (h/H) along the ordinate . Referring to fig.(6) , the relative area is obtained as a ratio of the area above a particular contour (a) to the total area of watershed basin (A). Similarly , the relative elevation is calculated as a ratio of the height of a given contour (h) to the maximum basin elevation (H) [2] and [15] .On the basis of this information the area and elevation of this study were calculated in table(1) using these data to plot a hypsometric curve fig.(7)



Figure(6) The concept of hypsometric analysis and hypsometric curve after [2]

Table(1)Hypsometric data

Elevation(m)	Area(m^2)
60	1448618
70	1320378
80	1198036
90	886892
100	756820
110	642456
120	500213
130	360997
140	223394
150	96090

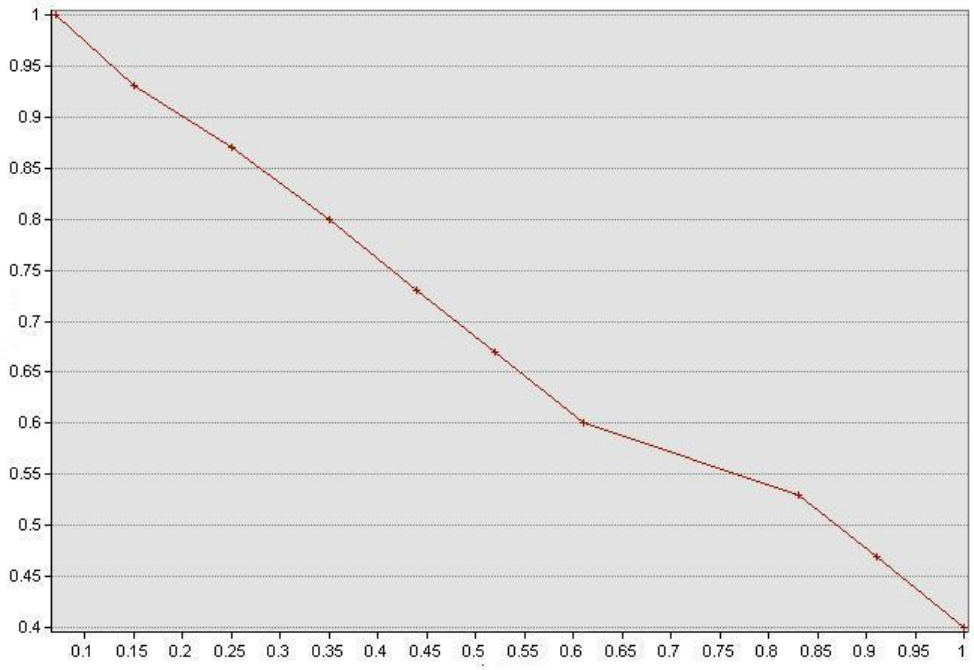


Figure (7) Hypsometric curve of study area

4-3. Estimation of hypsometric integrals(HI):

In order to estimate the hypsometric integrals , the elevation – relief ratio method proposed by [16] was used . The relationship is expressed as :

$$E \approx Hsi = \frac{Elev.\ mean - Elev.\ min}{Elev\ .\max - Elev.\ min} \quad \text{.....(1)}$$

where , E is the elevation –relief ratio equivalent to the hypsometric integrals Hsi , Elev.mean is the weighted mean elevation of the watershed estimated from contour lines , Elev.min and Elev.max are the minimum and maximum elevations . The hypsometric integrals are classified into five stages table(2) .As for this study , the hypsometric integrals value is 46% which represents mature stage of geologic and geomorphologic stages .

Table(2) Stages of hypsometric integrals [17]

%of hypsometric integrals	Stages
30	Old
30-59	Mature
60-79	Youth
80-99	Middle
100	Initial

5. Result and discussion

Referring to fig.(6 and 7) , Jabal sanam is in balance state of erosive and tectonic processes or in mature state of common geomorphological processes . This can be explained due to the incision of channel beds , down slope movement of top soil and rock materials , washout of the soil mass and cutting of channel sides .

The hypsometric integral value can be considered as an indirect estimator of the erosion from the watershed system . It was observed by applying formula (1) , the H_{si} value was 46% ,and this mean that Jabal sanam is in mature stage and it moved towards deteriorating or old stage . The H_{si} value reflects slow in erosive processes and moved towards balance state with tectonic activity

6. conclusion

Hypsometric analysis of watershed expresses the denudational processes and the rate of morphological changes . Therefore , it is useful to estimate the erosion status of watershed and prioritize them for undertaken soil and water conservation measures . The result of hypsometric curve and hypsometric integrals shows that study area is in mature stage moving towards old stage of erosive system . This means that there is a state of balance between erosive and tectonic activity . According to this conclusion , the area needs system of rain harvesting more than soil conservation . The study revealed the importance of using the software that deals with spatial information like ArcGis package . This software revealed high performance in preparation of different digital maps , and eventually the calculation of hypsometric curve

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التحليل الهايبسومتري لجبل سنام– جنوبي العراق– باستخدام نظم المعلومات الجغرافية

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المستخلص

تم استخدام مصطلح الهايبسومتري او تحليل (الارتفاع–مساحة) في هذا البحث لاظهار اي من مراحل التطور الجيومورفي (الشباب او النضج او الشيخوخة) تمر به منطقة الدراسة. في هذه الدراسة تم اجراء تحليل الخصائص الهايبسومترية لجبل سنام والذي يقع في محـافظـة البصرة جنوبي العراق . تم تخليق نمـوذج الارتفاع الرقمي اعتمادا على مفهوم شبكة التثليث غير المنتظم . استخدمت الخارطة الطوبوغرافية التي غطت منطقة الدراسة كخـارطة اساس لرسم خطوط الكنتور الرقمية والتي استخدمت فيما بعد في اعداد ملف الارتفاعـات الرقمية . اظهرت نتائج التحليل الهايبسومتري والمشتقة من ملف الارتفاعات الرقمية ان جبل سنام يمر بحالة من التوازن بين القوى التكتونية والتي تساهم في بناءه وبين القوى التعروية التي تحاول ان تقلل من حجمه وبعبارة اخرى فان جبل سنام يقع ضمن مرحلة النضج من مراحل التطور الجيومورفي.

الكلمات المفتاحية: التحليل الهايبسومتري , التقنيات الجيومورفولوجية , نظم المعلومات الجغرافية , جبل سنام , البصرة–العراق .