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Research Article

Morphometric Properties of Bulkana (NaftKhanah) North-East Iraq from Topographic Maps

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Abstract

This paper aims to present a study of the morphometric properties of Bulkana area located at the Iran-Iraq border east of Diyala province of Iraq. The study covered an area of 1072 km^2 composed of sediments formed from modern and quaternary glacial ages. Topographic map used to find morphometric parameters in catchment area of Bulkana was with scale 1:100000. The results showed that this area has a circular basin with circularity 0.87. Drainage density was low according to Strahler classification, and morphometric elongation ratio 0.89 and form factor 0.5. We presented five stream orders, namely 6713 as 1st, 2481 as 2nd, 867 as 3rd, 446 as 4th, and 292 as 5th. Calculated stream density was 1.7, stream frequency was 10.06, bifurcation ratio was 2.7, the relief was 3.6, and hypsometric integral was 2.3. Results also indicated that first order streams are localized in low zone while other order decreases whenever we move to the north and east of the highest zone. This was attributed to the slop which gave raining water a big amount of energy. The direction of stream order was agreeable with the slop of surface and break rock, indicating that catchment area complies with topographic surface.

Keywords*: Morphometric Properties, Stream Order, Topographic Maps, Remote Sensing, Bulkana Area-Iraq.*

1. Introduction

The study area Bulkana (or NaftKhanah) is located north east of Iraq at the Iraqi-Iranian border, its area is about 1072 km^2 and it lies at the north of the Nawdoman mountain chain to the south and south-west Hamrin mountain chain and Lake Hamrin as shown in Fig. 1. The study area generally covers deposits of modern Quaternary ice. To identify the characteristics of the area using the techniques of remote sensing a topographic maps scale 1:100000 was utilized using ArcGis9.3 software. This area has drainage patterns which are important variables in the calculation of the water fed from rain water when filtered through the valley bottoms. Drainage patterns are known as surface arrangement of rivers and streams that regulate themselves depending on the synthetic factors and topography.

2. Theory and Methods of Analysis

Intended patterns of drainage network taken by the course of the river consist mainly of tributaries convergetoturn other tributaries, forming the final network. The valleys in the basin of Bulkana are either dry or humid place where the water formed from rainy seasons flows, as in Jondriver. The styles characterizing the basin are (a) Parallel patterns: they are moderate decline lines, with separating distances depending on the ratio of rocks and Topographic the region. (b) Tree dendritic pattern: it is the most common specie in the region, usually arising over heterogeneous rocks and are irregular in shape (Thronbury, W.D. 1966).The importance of morphometric analysis is due to linking the number of lengths and arranged table with basin area. The modern approach of quantitative analysis of drainage basin morphology was given from inputs described by Horton (Horton, R.E. 1945). Evaluated quantities are Parameters (P), drainage density, bifurcation ratio, stream frequency (F), form factor (Rf), circulatory ratio (Rc), and elongation ratio (Re); using established mathematical equations of morphometric analysis that consists of three properties (Strahler, A.N. 1964), namely morphological, terrain, and morphometric characteristics. Morphological characteristics includethe area of catchment, the borders of the studied area, its length and width, circularity factor, elongation factor, form factor, and integration factor. Morphometric characteristics include stream order, number and frequency; drainage density and bifurcation ratio. Terrain characteristics include relief ratio, hypsometric integral and ruggedness value. Below isdescription of each of these characteristics with the results obtained for Bulkana area from the present study.

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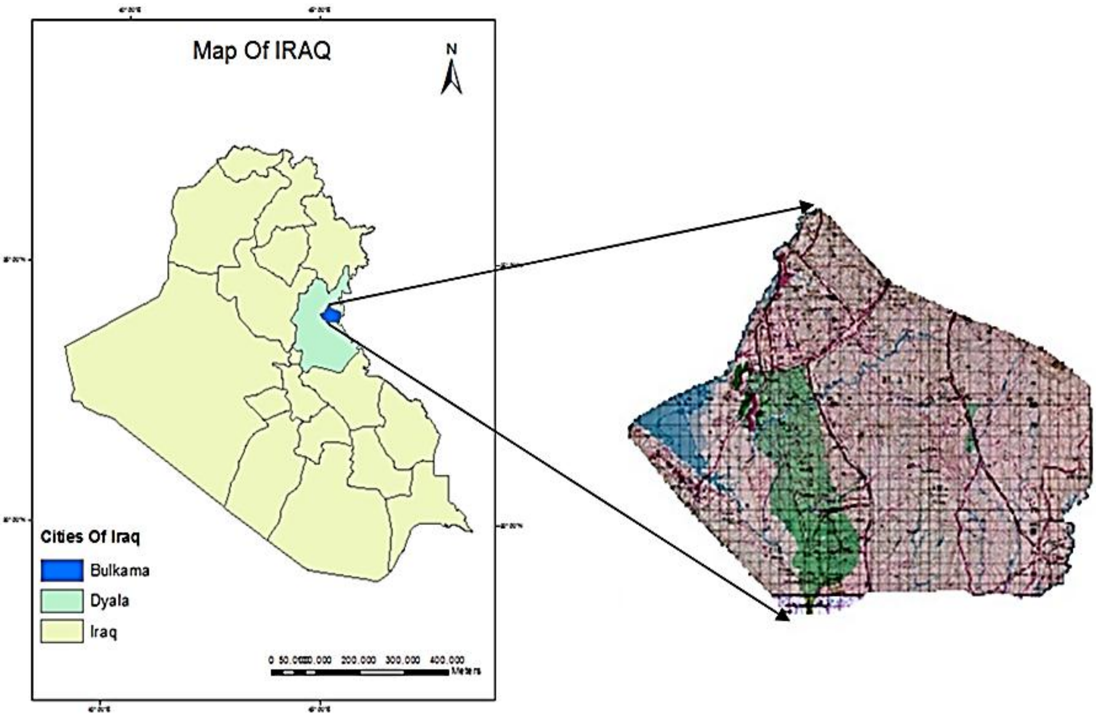

Fig.1 A map of the study area from the Iraqi Diyala province

3. Results and Discussions

3.1. Area of catchment

Area (A) and perimeter (P) of the sub-basin are the important parameters in quantitative morphology. Basin area is the hydrologically important because it directly affects the size of the storm hydrograph and the magnitudes of peak and mean runoff(Singh, V. and Singh, U.C.2011). We calculated study area Bulkana by ArcGis9.3 software for area 1073.7 km^2 from topographic map. Table 1 shows all morphological characteristics of studied area.

Table 1 Topographic map values

Morphological characteristic	Topographic map
Area of Bulkana (A)	1072.7 km^2
Perimeter of basin	124.254 km
Volume of basin	87.3 km3
Long of basin	46.372 km
Lat of basin	38.390 km
Circularity (Rc)	0.87
Elongated ratio(Re)	0.89
Form Factor (Rf)	0.5

3.2. Circularity (Rc)

The circularity ratio is similar measure as elongation ratio. Miller(Gregory, R.J. and Walling, D.E. 1973) defined it as the ratio of the area of the basin to the area of the circle having same circumference as the basin perimeter. The value of circularity ratio varies from 0 (inline) to 1 (circle). Higher the value represents more circularity in the shape of the basin and vice-versa. Usually, the structural control on the drainage development is responsible for the low values of the circularity ratio (Horton, R.E. 1932). Circularity for Bulkana basin was found to be 0.87 from topographic map, this shows that the area Bulkana is close to the circle shape. The circular basin is characterized by dangerous flooding (Saloom, G. 2012).

3.3. Elongated ratio (Re)

Schumm (Schumn, S.A. 1956) defined the elongation ratio (Re) as the ratio of diameter of a circle of the same area as the basin to the maximum basin length. The value of Re varies from 0 (highly elongated shape) to unity (circular shape). Thus the higher the value of elongation ratio the more circular shape of the basin and vice-versa. Values close to 1.0 are typical for regions of very low relief, whereas those of 0.6 to 0.8 are usually associated with high relief and steep ground slope(Strahler, A.N. and Strahler, A.H. 2002). These values can be grouped as in Table 2. From topographic map of Bulkana we found Re as 0.89, which shows that Bulkana basin has high relief, steep ground slopes and far from being rectangular. The circular basin is more efficient in run-off discharge than an elongated basin(Singh, S. and Singh, M.C. 1997).

3.4. Form factor (R.f)

Form factor is the numerical index commonly used to represent different basin shapes with value between 0.1 to 0.8 (Horton, R.E. 1932). Smaller value of form factor mean more elongated basin. Basin shape may be indexed by simple dimensionless ratios of the basic measurements of area, perimeter and length (Singh, S. 1998). The basins with high form factors as 0.8 have a high peak flows of shorter duration, whereas elongated drainage basin with low form factors have lower peak flow of longer duration. The form factor for catchment area of Bulkana was 0.5. Surface drainage characteristics of many river basins and sub basins in different parts of the globe have been studied using conventional methods (Bagyaraj, M. and Gurugnanam, B. 2011).

Table 2 Elongation ratio (Strahler, A.N. 1964)

Elongation ratio	Basin Shape
<0.7	Elongated
0.7-0.8	Less Elongated
0.8-0.9	Oval
>0.9	Circular

3.5. Stream Systems

Stream systems have been classified according to their relative position within a stream network. Many stream order classification systems have been developed, one of the earliest and most successful methods was developed by Strahler (Strahler A.N. 1952). where the smallest head-water tributaries are called first-order streams. When two first-order streams meet, a second-order stream is created; where two second-order streams meet, a third-order stream is created; and so on as shown in Fig. 2.

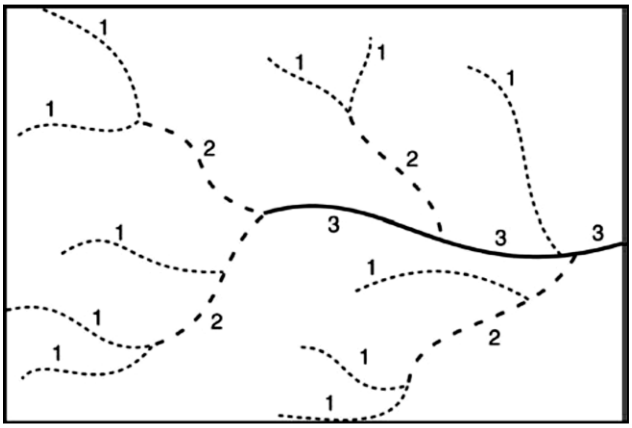

Fig.2 Strahler Stream Order Classification Method (Strahler A.N. 1952).

3.5.1. Stream order

It's an important characteristic of stream systems because it can be related to drainage area and stream size(Ward, A., et al. 2008). Spatial arrangement of streams has given rise to a particular design called the drainage pattern (Singh, S. and Singh, M.C. 1997). Various morphometric parameters such as drainage pattern, stream order, bifurcation ratio, drainage density and other linear aspects were studied earlier using remote sensing techniques and topographical map (Mesa, L.M. 2006). There are many ways used to classify basins relative to its dimensions. This study used the stream order of the drainage basin and have been ranked according to Strahlers stream ordering system. The results of present study in Table 3, give the first order of primary rivers, then two branches rising from the first and third places will from a pool till it covers the size of the network as river as shown in Fig.3.

3.5.2. Stream Number (Nu)

The total number of stream segments presented in this paper are five for each stream number (Nu). In a catchment area for topographic map orders were 6713 as 1^{st} order stream, 2481 as 2^{nd} , 867as3^{rd}, 446 as 4^{th}, and 292as5^{th}. Horton, Schumm and others –see (Matsuda, I. 2004), discussed the relationship between stream order and factors composing a drainage basin. The most important results were, as stream order increases, the number and the mean gradient of streams decrease in an inverse geometric ratio. Also it was found that as stream order increases, the mean length of streams and the mean area of drainage basin increase.

Table 3 Preparation and represents the average total orders to area Bulkana (NaftKhana) from topographic map.

Topographic map orders	Number of streams each order	Total lengths for each order unity km
1	6713	1201.5
2	2481	418.76
3	867	147.97
4	446	75.31
5	292	51.28
Sum	10799	1894.84

3.5.3. Stream Frequency (F)

Stream frequency (Fs) is the total number of stream order of all orders per unit area(Parveen, R. et al. 2012). Morphometric parameters of the present study were calculated using Table 4. Calculated value of stream frequency for catchment area Bulkana was 10.06 river/km^2, the increase in rivers primary streams and non-branching of large ponds where there are large rivers lead to increased frequency of river due to the basins large area containing the rivers non-branching and elementary more streams of small basins and contains the largest rivers and this affects the river in increasing frequency this value for Bulkana basin evidence it has large docks –see Tables 5 and 6.

3.6. Drainage Density (Dd)

It's defined as a ratio of total length of all streams to the total area of the basin. Dd of any basin reveals the terrain configuration that is properties of rock of the area (Magesh, N.S. et al. 2013). It is an important indicator of the landform element and provides a numerical measurement of landscape dissection and runoff potential (Pisal, P.A. et al. 2013).When the value of the stream density low the basin is highly permeable sub soil and

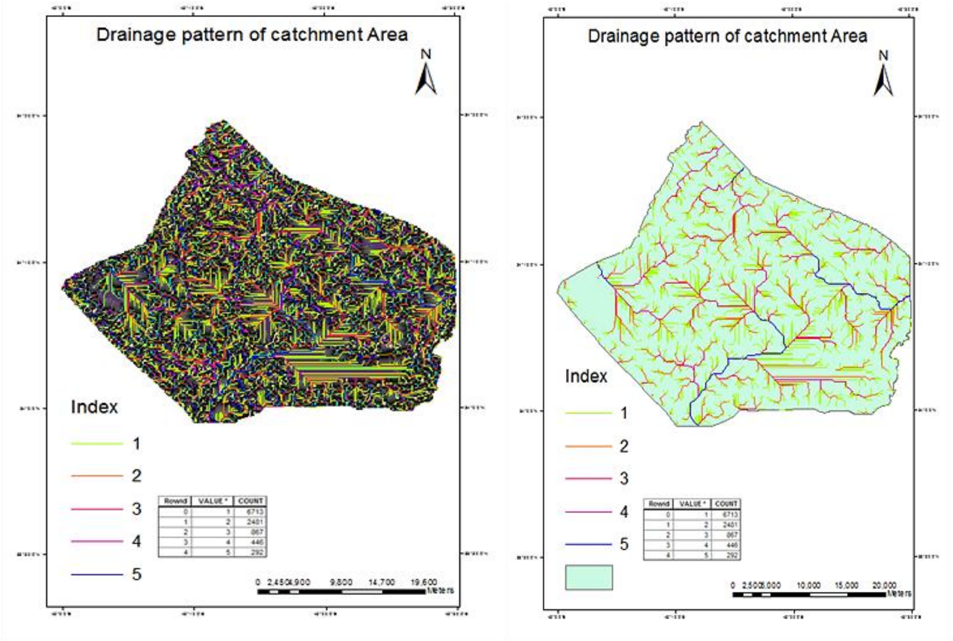

Fig.3 All stream order from topographic map

Table 4 Morphometric parameters and their mathematical expressions (Parveen, R. et al. 2012)

Morphometric parameter	Formula	Description
Stream frequency (Fu)	Fu = N/A	Fu was computed as the ratio between the total number of streams and area of the basin
Drainage density (Dd)	Dd = L/A	Dd was measured as the length of stream channel per unit area of drainage basin
Form factor (Rf)	$Rf = A/(Lb)^2$	Rf was computed as the ratio between the basin area and square of the basin length
Elongation ratio (Re)	$Re = (2/Lb)\times A/\sqrt{A}/P\pi$	Re was computed as the ratio between the diameter of the circle having the same area as that of basin) and the maximum length of the basin
Bifurcation ratio (Rb)	Rb = Nu/(Nu + 1)	Rb was computed as the ratio between the number of streams of any given order to the number of streams in the next higher order
Basin relief (Bh)	Bh = hmax – hmax	Bh was defined as the maximum vertical distance between the lowest and the highest points of a sub basin

sparse vegetation cover. High Dd results from weak and impermeable subsurface material and sparse vegetation and mountainous relief (Singh, V. and Singh, U.C.2011). The area Bulkana characterized according to the value to the obtained it's an area with a low density both in topographic map 1.7 km/km^2.

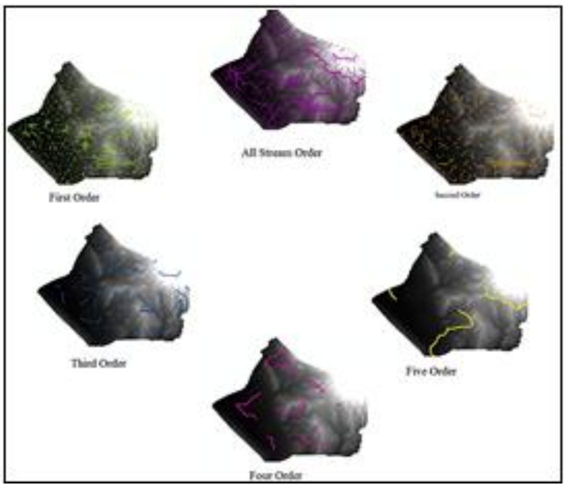

Fig.4 Stream orders from topographic map

3.7. Bifurcation Ratio (Rb)

Rb is related to the branching pattern of a drainage network and defined as the ratio of the streams number of any given order to the streams number in the next higher order in a drainage basin (Pisal, P.A. et al. 2013). Rb range between 3.0 to 5.0 for basins which the geologic structures do not distort drainage pattern. Strahler demonstrated that Rb shows a small range of variation for different regions or for different environment dominates (Nageswara R.K. et al. 2010). Rb is normally not more than five or less than three (Koshak, N., and Dawod, G. 2011). Rb importance

Table 5 Strehler rating for stream density

Longitudinal drainage density	Border
Low	3-4
Medium	12-4
High	13>

in drainage basin analysis as it isthe foremost parameter to link the hydrological regime of a watershed under topologicaland climatic conditions then Rb in catchment area 2.7 topographic map is low. Higher Rb suggests that the area is tectonically active (Zavoianu, I., 1985).

Table 6 Morphometric characteristics from topographic map

All Stream order	Stream Frequency	Stream Density	Bifurcation Ratio
1894.8 km	10.06 river/Km^2	1.76 km/km^2	2.7

3.8. Relief (Rr)

It's a ratio index of the basin relief divided by the basin length (Gallagher, A.S. 1999). Rr defines the difference in elevation between the highest and lowest points in the basin, and controls the stream gradient thus influences flood patterns and amount of transported sediment. It plays an important role in drainage development, surface and sub surface water flow, permeability, landforms development and erosion properties of the terrain (Bagyaraj, M. and Gurugnanam, B. 2011). The terrain characteristics of great importance as it shows us the erosion factor activity and its strength and its impact on other properties, Bulkana Relief Ratio from topographic map 3.6. From Fig.5 it is shown that the lower zone in Hamrin lake as profile [CD] where we see that the surface slop down from north and east to the west and south also we see in profile [AB] the Jond river clearly that the surface height relief in north and west and go down until to become flat in Hamrin lake like sink as profile [EF].

3.9. Hypsometric integral (Hi)

It indicates the stages of cycle of erosion and is expressed as percentage, and it's an indicator of the remnant of the present volume of material as compared to the original volume of the watershed. Differences in the shape of the curve and the integral value are related to the degree of disequilibria in the balance of erosive and tectonic forces. Convex-up curves with high integrals are typical for youth, s-shaped curves crossing the center of the diagram characterize mature or equilibrium stage, and concave up with low integrals typify old geomorphic stage of landscapes(Tejpal, 2013). We can get values of Hi by calculating the area divided by the difference between the highest point and the lowest point and the value squeezed between 0-100. The lower Hi values indicate an increase height in terrain and lack of water area of the region or basin, therefore, the maximum elevation from topographic map was 550 m and minimum elevation 93 m, while DEM maximum elevation 623 m and minimum 99 m. These values indicate that the area Bulkana characterized by high values of terrain. When the value of hypsometric from topographic maps 2.34km^2/m. From Fig.9 we see that the first order is localized in low zone while other order decrease whenever we move to the north and east of the highest zone, because the slop gave the raining water a big amount of energy to go down. The direction of stream order was agreeable with the slop of surface and break rock and this indicated that the catchment area is agreeable with topographic surface.

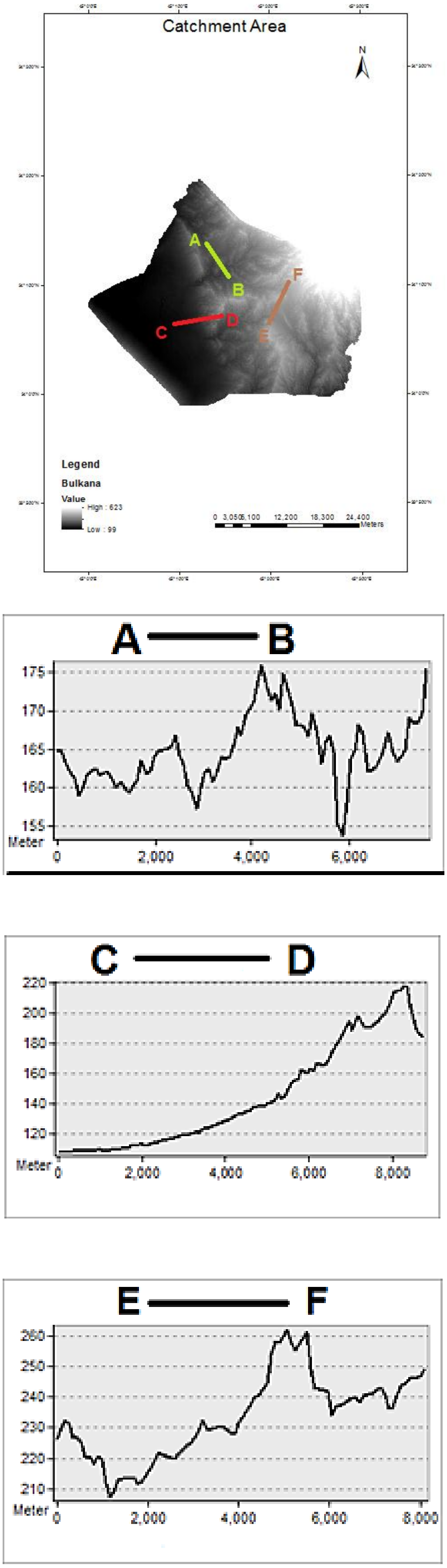

Fig.5 Relief and slop of catchment area

Fig.6 Drainage pattern in Bulkana

Fig.7 Lower point Lake Hamrin

4. Conclusions

Bulkana area north east Iraq was studied, based on its morphometric properties. The elevation error between digital elevation model and topographic maps was calculated then the distortion or shifting between topographic maps and high resolution image like QuickBird satellite was found. After that, the difference between GPS navigation and topographic maps on elevation was also found from DEM and the slop of study area from north, east to ward of west and Drainage density was also found. From morphometric results, it is concluded that Bulkana area has a basin with a shape closer to circular because Rc was found as 0.87. The drainage density was low according to Strahler classification, because Re was 0.89 and R.f was 0.5. In Bulkana there are five stream orders, namely 6713 as 1st, 2481 as 2nd, 867 as 3rd, 446 as 4th, and 292 as 5th. This indicated that first order streams is localized in low zone while other order decrease whenever we move to the north and east of the highest zone. This was attributed to theslop which gave the raining water a big amount of energy, and to calculated values of the streams where Dd was 1.7, F was 10.06, Rb was 2.7, Relief was 3.6, and hypsometric integral was 2.3.The direction of stream order was agreeable with the slop of surface and break rock, indicating that the catchment area complies with topographic surface. From the topographic study of Bulkana it is concluded that the present results are very accurate and can be used in place of the older maps of this area. This is because the present error limits on field wok were ranging from 2% to 10.3%, with maximum elevation error 2.970% for point no. 46. Error between field work and topographic map maximum was 4.4%.

Table 7 Terrain characteristics in Bulkana.

Source	Relief ratio	Hypsometric integral
Topographic map	3.6	2.3

Table 8 Classification of catchment area according height

Zone	Height in meter		Relative area%
	from	to	
A	99	111	14.5
B	111	120	6.89
C	120	133	6.83
D	133	152	8.1
E	152	179	17.45
F	179	271	21.5
G	271.2	271.8	16.74
H	271.8	350	6
I	350	462	1.75
J	462	623	0.24

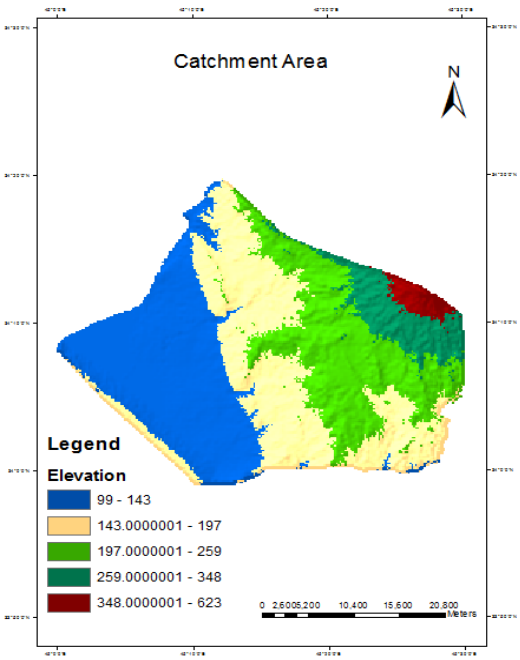

Fig.8 Elevation of catchment area

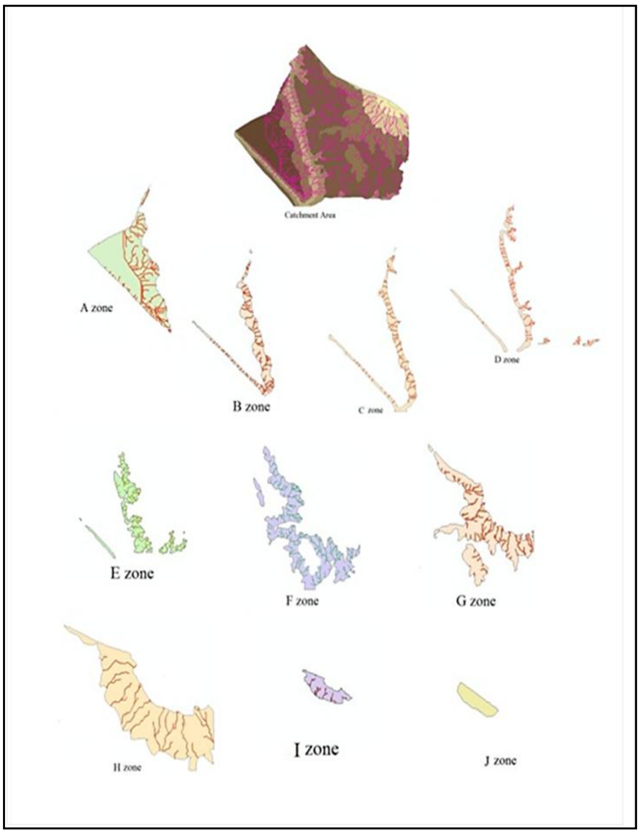

Fig.9 The basin's zones according to their heights

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