A COMPARATIVE STUDY BETWEEN MANUAL AND AUTOMATED TECHNIQUE FOR THE MORPHOMETRIC PARAMETERS OF NORTH NINEVEH SUB BASIN/NORTH WEST IRAQ

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ABSTRUCT:

The study performed to show the ability of information technology to build up geographical data containing morphometric parameters: Basin area, basin length, basin circumference, basin shape, basin elongation, relief ratio, drainage texture, stream length, stream order, and bifurcation ratio in addition to hypsometric curve which reflects time scale clarify the erosion stage of the basin, also comparing the results of Arc GIS program with manual calculations of the basin lies northeast of Mosul Lake to the north of Nineveh city, all these variables had been calculated using manual and ARC GIS 9.3 software using digital elevation model(DEM)with ground resolution of 90meters.Stream order maps had been produced by the two methods that showed 6^{th} order basin. The percent of difference between the two methods shows that GIS method is more accurate than the manual. The results reflect the capability of geographical information technology to make accurate and fast calculations for the morphometric parameters.

دراسة مقارنة بين الطريقة اليدوية والتقانة التلقائية للخواص المورفومترية لحوض شمال نينوى الثانوي - شمالي غربي العراق

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الكلمات المفتاحية:الحوض،الخواص المورفومترية،النموذج الرقمي للتضرس ،نينوى،نظم المعلومات الجغرافية

المستخلص:

أجريت الدراسة لإظهار قدرة تقانة المعلومات لبناء قاعدة بيانات تتضمن المتغيرات المورفومترية والمتمثلة بألمساحة الحوضية،طول الحوض،محيط الحوض،شكل الحوض،استطالة الحوض،نسبة التضرس،نسيج التصريف،طول ورتبة الرافد،نسبة التشعب،فضلا عن المعامل الهبسومتري والذي يمثل المقياس الزمني لمرحلة التعرية . تمت عملية المقارنة بين نتائج الطريقة اليدوية مع نتائج تقانة نظم المعلومات الجغرافية التي تمثلت ببرنامج آرك جي أي أس الإصدار 9.3بالإستعانة بالنموذج الرقمي للتضرس (DEM)بدقة تمييز أرضية 90 متر لحوض التصريف الواقع شمال شرق بحيرة الموصل –شمال مدينة نينوى.تم انتاج خرائط وبكلا الطريقتين توضح الرتب النهرية والتي ميزت الحوض على انه من الرتبة السادسة كذلك فإن نسبة الإختلاف بين الطريقتين عكست الدقة العالية لتقانة GIS.كما وأظهرت نتائج الدراسة قدرة تقانة المعلومات الجغرافية على إجراء الحسابات للمتغيرات المورفومترية بدقة عالية وبوقت وجهد اقل من الطرق اليدوية.

INTRODUCTION

Spatial information technology (SIT) i.e. remote sensing (RS), geographical information system (GIS) and global positioning system (GPS) have been proved to be an efficient tool in delineation of drainage pattern and water resources management and its planning. The fastly emerging spatial information technology (SIT), remote sensing, GIS, and GPS have effective tools to overcome most of the problems of land and water resources planning and management on the account of usage of conventional methods of data process(Nageswara ,2010).

Morphometric studies involve evaluation of streams through the measurement of various stream properties. Analysis of various drainage parameters namely ordering of the various streams and measurement of area of basin, perimeter of basin, length of drainage channels, drainage density (D_d), drainage frequency, bifurcation ratio (R_b), texture ratio (T) and circulatory ratio (Rc) (Kumar *et al*., 2000).

CLIMATE

epending on mean monthly data obtained from Makhmoor meteorological station as in table: 1 (Abdulhusien, 2002) using peltier classification the climate classified as semi arid (Figure 1).

Table 1: mean climate parameters for Makhmoor station from 1992 to 2002 (Abdulhusien, 2002)

months	Rainfall/mm	Temperature/C°	Sunshine duration hour /day	Relative humidity %	Evaporation/mm	Wind speed m/s
October	17.8	24.96	8.33	40.22	310.8	3.79
November	46.08	16.60	6.33	61.33	149.18	3.67
December	51.62	11.08	4.79	76.11	86.40	3.72
January	63.61	9.5	4.71	79.50	72.98	3.69
February	41.30	10.5	6.39	71.00	110.06	3.75
March	37.99	14.5	7.31	64.25	188.11	4.75
April	37.11	20.3	8.19	54.67	259.56	4.13
May	18.46	27.3	8.95	37.33	469.56	4.47
June	1.89	32.8	11.63	27.44	563.00	4.34
July	0.40	36.01	11.74	24.67	604.22	4.42
August	0.0	35.85	11.1	26.56	567.29	4.10
September	0.99	31.00	9.78	30.67	426.88	3.67

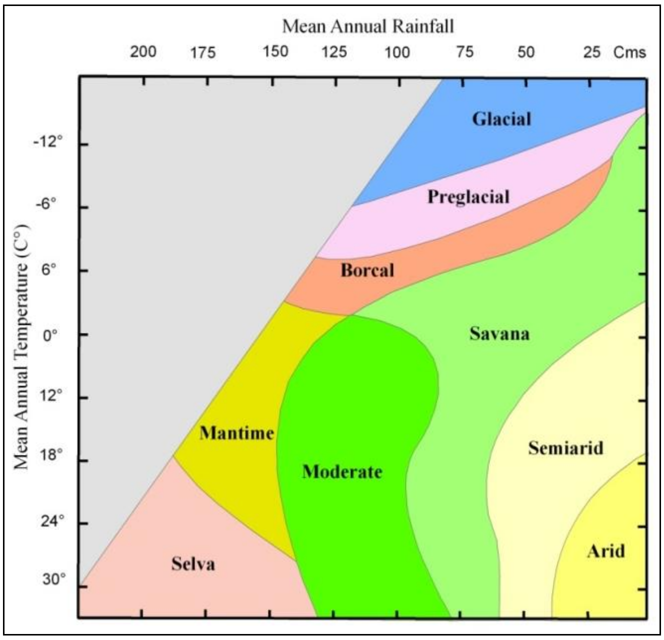


Figure 1: Climatic boundaries of the morphogenetic regions (Peltier, 1950 in Fookes1971).

The study area is located in the North West part of Iraq, between longitudes 42°55'E to 43°05'E, and latitude 36°30'N to 36°40′N(Figure 2).

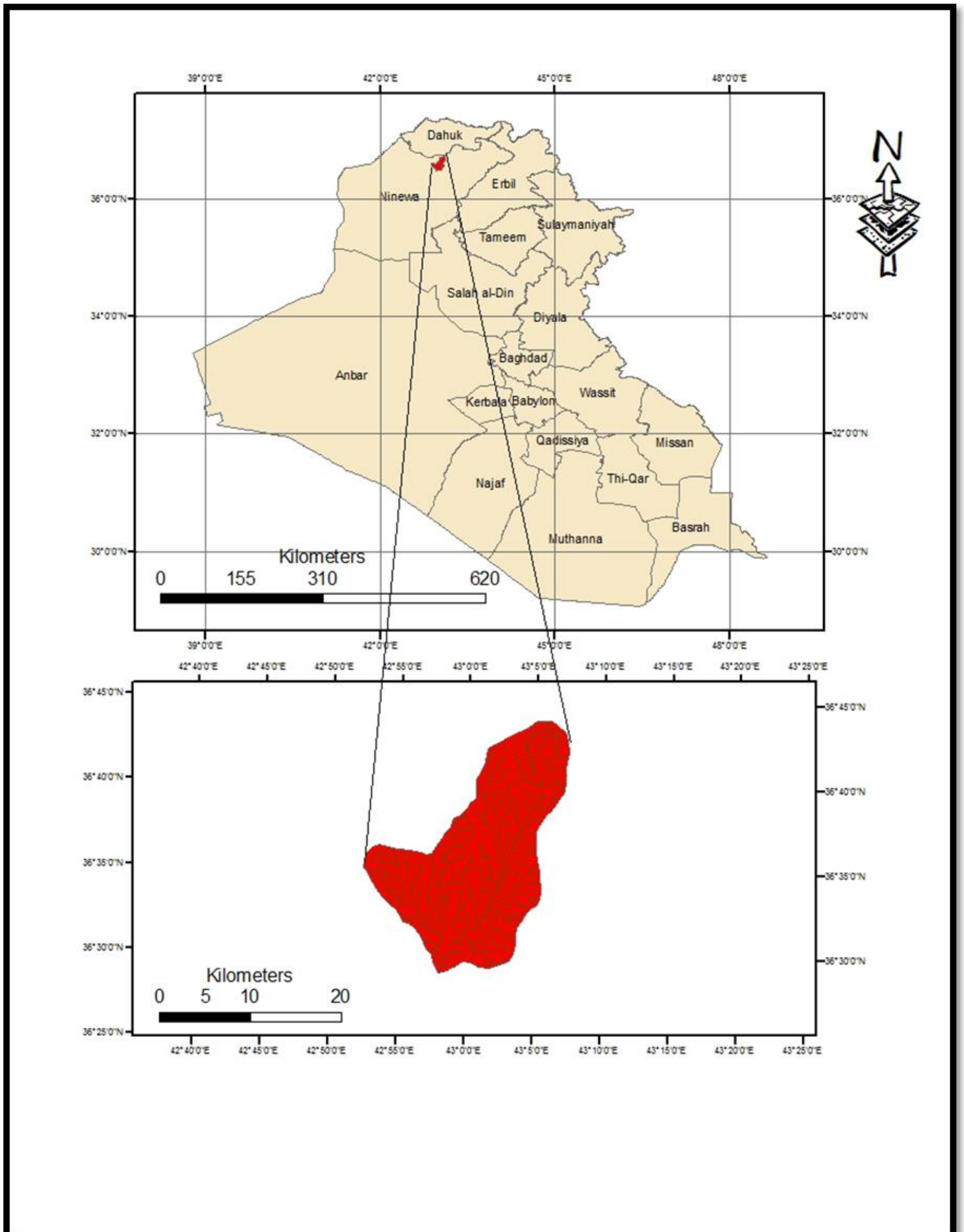


Figure 2: location map of study area.

TOPOGRAPHY AND GEOLOGICAL SETTING

The study area lies in the foot hill zone that belongs to unstable shelf from the Nubio-Arabian platform, it comprises as moderate to rugged topography consists of Tertiary and Quaternary deposits. Three rock units' exposures in the study area; anhydrite, gypsum, and salt rock interbedded with limestone and marl which reflects evaporite lagoon environment of Fatha Formation -Middle Miocene. Red or gray color silty marl or claystone with variable thickness belongs to Injana Formation(LateMiocene).Finally Quaternary deposits composed of alluvial fans, river terraces, floodplain deposits, which is usually consist of clay, loam, sand and conglomerate, as well as slope deposits, and polygenetic deposits (Jassim et al. 2006).

METHODOLOGY

Digital elevation model (DEM) for Shuttle Radar Topography Mission (SRTM) image (Figure 3) with ground resolution 90 meters was acquired in the year 2004 to be processed with the aid of Arc GIS 9.3 software to produce digital maps in order to calculate different morphometric parameters and compare this results with the others that perform using manual method to show the importance and superiority of DEM model than traditional methods. Areal, linear, and relief features as well as hypsometric curve had been calculated based on the formula suggested by (Horton, 1945), (Strahler, 1964), (Schumm, 1956), and (Miller, 1953) in order to identify the characteristics of the basin under study, figure 3 illustrate DEM of study area .

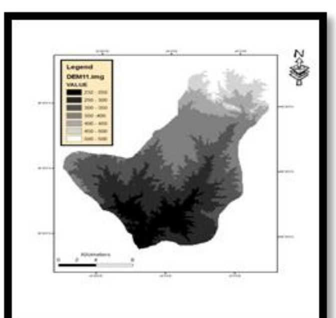


Figure 3: digital elevation model for the study area.

RESULTS AND DISCUSSION

Areal Aspects

Area of the Basin

It is defined as the total area projected upon a horizontal plane contributing to cumulate of all order of basins. The area of the basin under study is computed by both the manual method, it is 398.30 square kilometers and automated method by Arc GIS program; it is about 308.3406 square kilometers. Hydrologically, basin area is important because it directly affects the size of the storm hydrograph and the magnitudes of peak and mean runoff (Nageswara, 2010).

Perimeter (P)

Perimeter is the length of the boundary of the basin which can be drawn from topographical maps. The perimeter of the basin is 82. 9285kilometers calculated by Arc GIS program and83.5308 Kilometers using manual method.

Form Aspects

These parameters relates with the general shape and dimension of the basin when we deals with each parameter.

Elongation Ratio (Re)

Elongation ratio (R_e) defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length (Schumm, 1956), it is equal to (0.65) for the basin under study using manual and automated methods which mean that the basin prone to the elongation shape.

Form Factor (Rf)

It is the dimensionless ratio of basin area to the square of basin length (Horton, 1932) and is calculated by $Rf = A/ (L_b)^{2.}$ The Rf value of 0 indicates a highly elongated shape and the value of 1.0, a circular shape with high peak flows for short duration but for elongated basin with low Rf with a flatter peak flows for longer duration. The flood flows of elongated basins can be easily managed than that of circular. The R_f

value of the basin is 0.33using the tow methods showing its elongated shape and its flood flows can be managed efficiently.

Circularity Ratio (Rc)

It is the ratio of area of river basin to the area of circle having the same perimeter as the basin. R_c for the basin under study calculated by GIS is 0.56 which indicates strongly elongated and highly permeable homogenous geologic materials (Miller, 1953).

Relief Ratio (Rh)

The maximum relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line is termed as "relief ratio" (Schumn, 1956). Relief ratio has direct relationship between the relief and channel gradient. The relief ratio normally increases with decreasing drainage area and size of the watersheds of a given drainage basin (Gottaschalk, 1964). For the basin under study the value of relief ratio is 9.9 and 9.22 calculated by automated (GIS) and manual method respectively. It so important ratio because it reflects the maturity of the river and the amount of transported sediments.

Drainage Texture (T)

Texture ratio (T) is an important factor in the drainage morphometric analysis which is depending on the underlying lithology, infiltration capacity and relief aspect of the terrain. The soft or weak rocks unprotected by vegetation produce a fine texture, whereas massive and resistant rocks cause coarse texture. Sparse vegetation of arid climate causes finer textures than those developed on similar rocks in a humid climate. The texture of a rock is commonly dependent upon vegetation type and climate (Darnkamp and King, 1971) In the Present study the drainage texture of the basin is 11.32 in GIS methods and 14.5 in manual method.

Morphometric Aspects

The method of quantitative analysis for drainage basin characteristics study in this paper is according to (Strahler, 1964).These characteristics are strongly connected with natural factors such as geology, climate, and vegetation cover and any changes occur on them. The value of bifurcation ratio refers that the basic effected with the climate and geological structure.

Stream Order U

The study of stream order lead to understand the amount of water discharge in the basin and reflects erosional and depositional capability of the basins that the highest order reflects gentle slope and high permeability and vice versa(Miller,1953) . Table 2 shows morphometric characteristics of the basin under study, figure 4and 5 shows that the basin is 6^{th} order basin. As it noticed that order one had been ignored (without color) to avoid the dominant of this order because it has the large number of streams among the other orders.

Table2: Morphometric parameters for the Basin under study.

Basin characteristics		GIS method	Manual method	Deference percent	References
Basin area(A) in (Km^2)		308.3406	298.3068	3.2%	Horton (1945)
Basin Length (L_b) in(Km)		30.12	29.7	1.3%	Horton (1945)
Basin perimeter (P) in(Km)		82.9285	83.5308	0.7%	Horton (1945)
Form factor $R_{f=}A/ L_b^2$		0.33	0.33	0.0%	Horton (1945)
Elongation ratio $R_e=2\sqrt{A}/L_b$		0.65	0.65	0.0%	Schumm (1956)
Circularity ratio $R_{c=}2\Pi A/p^2$		0.56	0.536	4.3	Strahler 1964
Drainage Texture T=Nu/P		11.32	14.55	28.5%	Horton (1945)
Relief ratio Rh= H / L_b		9.9	9.22	6.8%	Schumm (1956)
Drainage Density (Dd)		2.56	2.64	3.1%	Horton (1945)
Number of streams(Nu)	1st order	940	966	2.7%	Strahler (1964)
	2nd order	168	192	14.2%	
	3rd order	37	43	16.2%	
	4th order	9	12	33.3%	
	5th order	2	2	0.0%	
	6th order	1	1	0.0%	
	summation	1157	1207		
total length of Streams (Lu)	1st order	409.16302	426.6	4.2%	Horton (1945)
	2nd order	199.60657	192.9	3.3%	
	3rd order	98.06472	86.4	11.8%	
	4th order	47.06719	44.28	5.9%	
	5th order	25.12623	24.58	2.1%	
	6th order	13.00401	13.50	3.8%	
	summation	792.03174	1695.53		
Mean stream length(Lu/ Nu)		0.68	1.4		Strahler 1964
Stream Frequency (Fs)=∑ Lu/A		3.752	4.07	8.4%	Horton (1945)
Bifurcation Ratio	1st order/ 2nd order	5.5	5.03	5.8%	Horton (1932)
	2nd order/ 3rd order	4.5	4.40	2.2%	
	3rd order/ 4th order	4.1	3.58	2.16%	
	4th order/ 5th order	4.5	6.0	33.3%	
	5th order/ 6th order	2	2.0	0.0%	
Mean Bifurcation Ratio R_b		4.12	4.20	15.8%	Strahler (1952)

Where

Lu = Total stream length of all orders

Nu = Total no. of streams of all orders

Π = 3.14

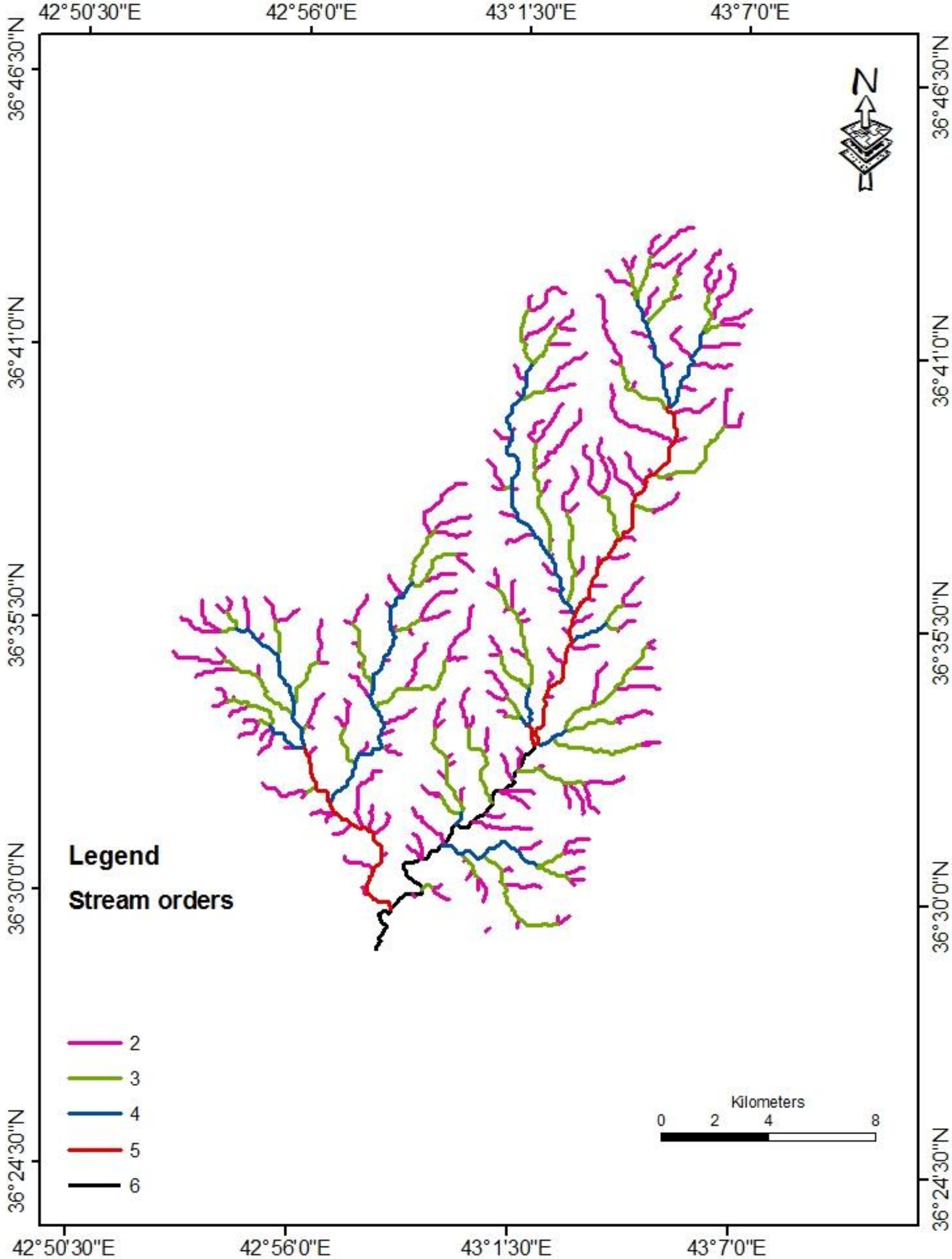


Figure 4: stream order map for the study area using GIS method.

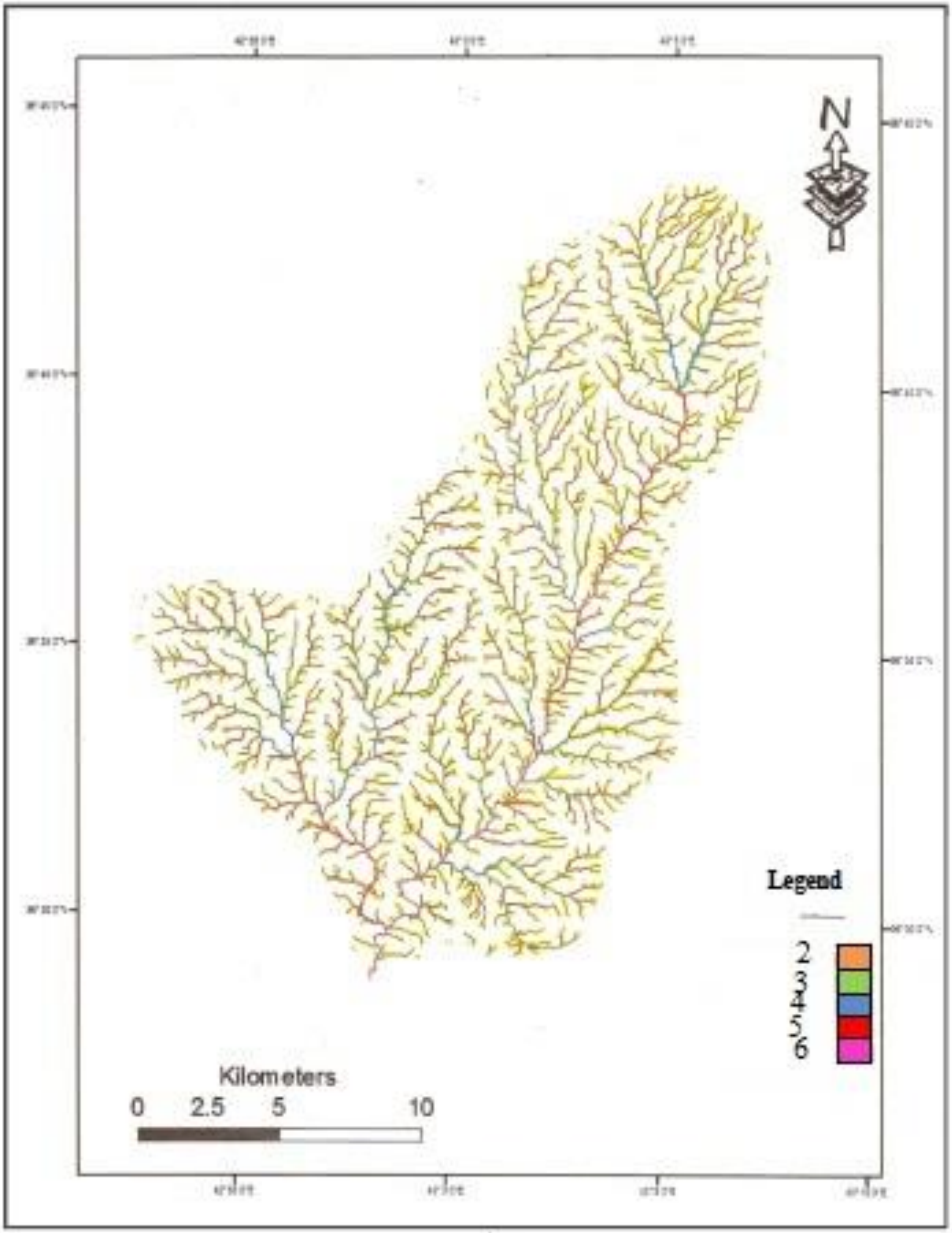
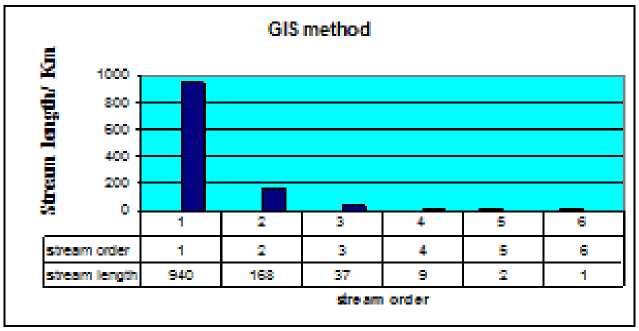


Figure 5: stream order map for the study area using manual method.

Stream Length (Lu)

The importance of stream length calculation is to conclude the mean of stream length by divided the summation of stream length for certain order over the number of streams for this order. The higher value of mean stream length reflects a plain area, so relatively smaller lengths are characteristics of areas with larger slopes and finer textures. The mean stream length extracted by GIS method is 0.68And 1.4 by manual method. Figure 6 shows the relation between stream order and stream length, it is clear that the maximum frequency is in the first stream orders and when the streams order increases the frequency will be decrease.



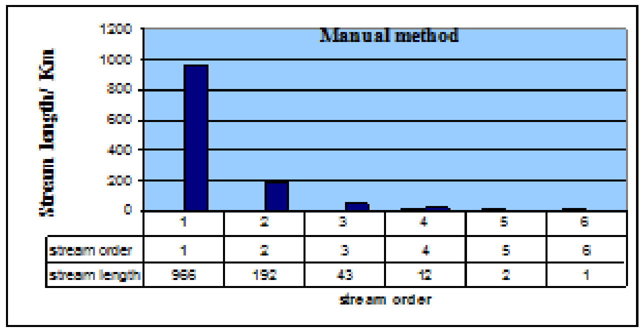


Figure 6: Histogram showing the relation between stream order and stream length-on the left data extracted by GIS method and on the right by manual method.

Drainage Density (D)

It is the ratio of total channel segment lengths cumulated for all orders within a basin to the basin area. It reflects a balance between erosive forces and the resistance of the ground surface, and is therefore related closely to climate, lithology, and vegetation. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief (Huggett, 2007). For the basin under study the value of drainage density is 2.56 and 2.64 for GIS and manual methods consequently that mean for 2.56-2.64kilometers of stream length takes an area of 1 kilometer.

Stream Frequency (Fs)

It is the total number of stream segments of all orders per unit area (Horton, 1932). The stream frequency value of the basin is 3.75calculated by GIS method and
4.07 By manual method. It is observed that the drainage density value of the basin exhibits proportional correlation with the stream frequency.

Bifurcation Ratio (R_{b})

The term bifurcation ratio (Rb) is used to express the ratio of the number of streams of any given order to the number of streams in next higher order (Schumn, 1956).It range between 3.0 and 5.0 for basins in which the geologic structures do not distort the drainage pattern (Strahler, 1964).The basin under study has a value of Bifurcation ratio of 4.12 and 4.20 calculated by GIS and manual method respectively which reflects the homogeneity and climatic and structural similarity.

Hypsometric Analyses

Hypsometric Curve essentially describes the distribution of area with elevation; it is the relative proportion of a region's area that lies at or above a given height relative to the total elevation range in the area under consideration (Luo, et al., 2003). Mathematically it is calculated by dividing the relative height over the relative area. First, the relative area must be calculated for each relative height (figure 7 and 8). For the basin under study the hypsometric factor is 0.9638this value derived from the percent between the relative area produced by GIS method to the relative elevation as in table-3 it is more accurate than the value that derived from manual method because in the manual method there were multiple missed area does not taken in consideration when calculate the area of hypsometric zones. The shape of hypsometric curve reflects the youth stage in the river cycle as it shown in figure9.

Table3: hypsometric analysis of the study area.

Sub areas	Total elevation(H) for the two methods	Local elevation(h)for the two methods	Relative elevation=h/H For the two methods	Local area(a) by GIS method	Local area(a) by manual method	Total area(A) by GIS method	Total area(A) by manual method	Relative area=a/A by GIS method	Relative area=a/A by manual method
1	18	18	1	1.3365	51.3	1.3365	51.3	1	1
2	68	50	0.735	69.2388	111.24	70.5753	162.54	0.9810	0.6851
3	118	50	0.423	138.817	162	209.3931	324.54	0.6629	0.4994
4	168	50	0.297	47.5875	118.8	256.9806	443.34	0.1851	0.2680
5	218	50	0.229	31.266	42.66	288.2466	486	0.1084	0.0877
6	268	50	0.186	20.088	42.12	308.3346	528.12	0.0651	0.0797
7	274	50	0.021	0.0648	24.3	308.3994	552.42	0.0002	0.0439
			∑= 2.8941					∑= 3.0027	∑=2.6638

Where:
h= the difference between highest and lowest elevation in a certain sub area.
H= the difference between the highest elevation of certain sub area and lowest elevation of the basin.
a= the area of certain part from the total basin area.
A=the total area of the basin.
Hypsometric Ratio (GIS) method=Relative height/Relative area
=2.8941/3.0027=0.963
Hypsometric Ratio (manual method)
=Relative heights/Relative area
=2.8941/2.6638=1.07

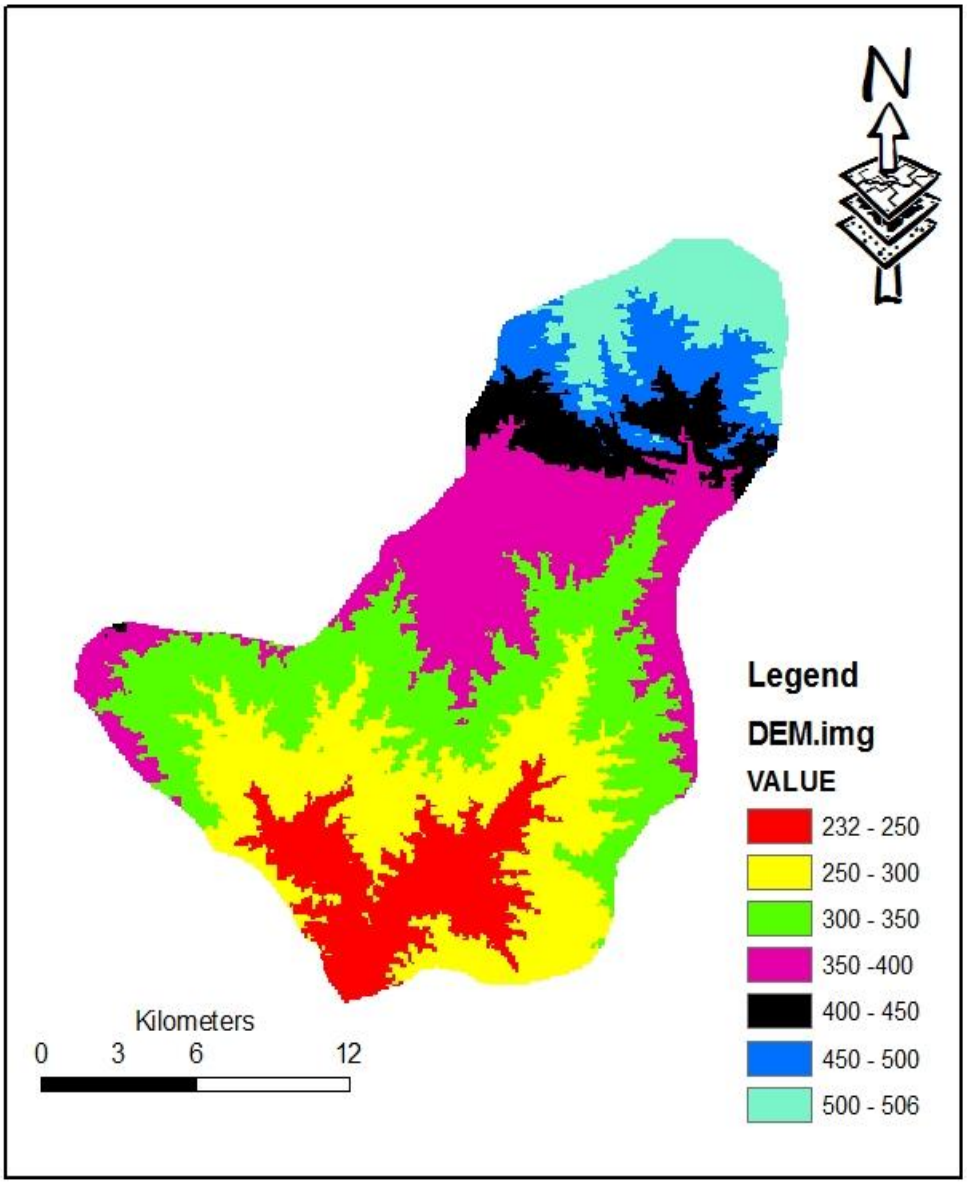


Figure 7: sub division area of basin under study using GIS method.

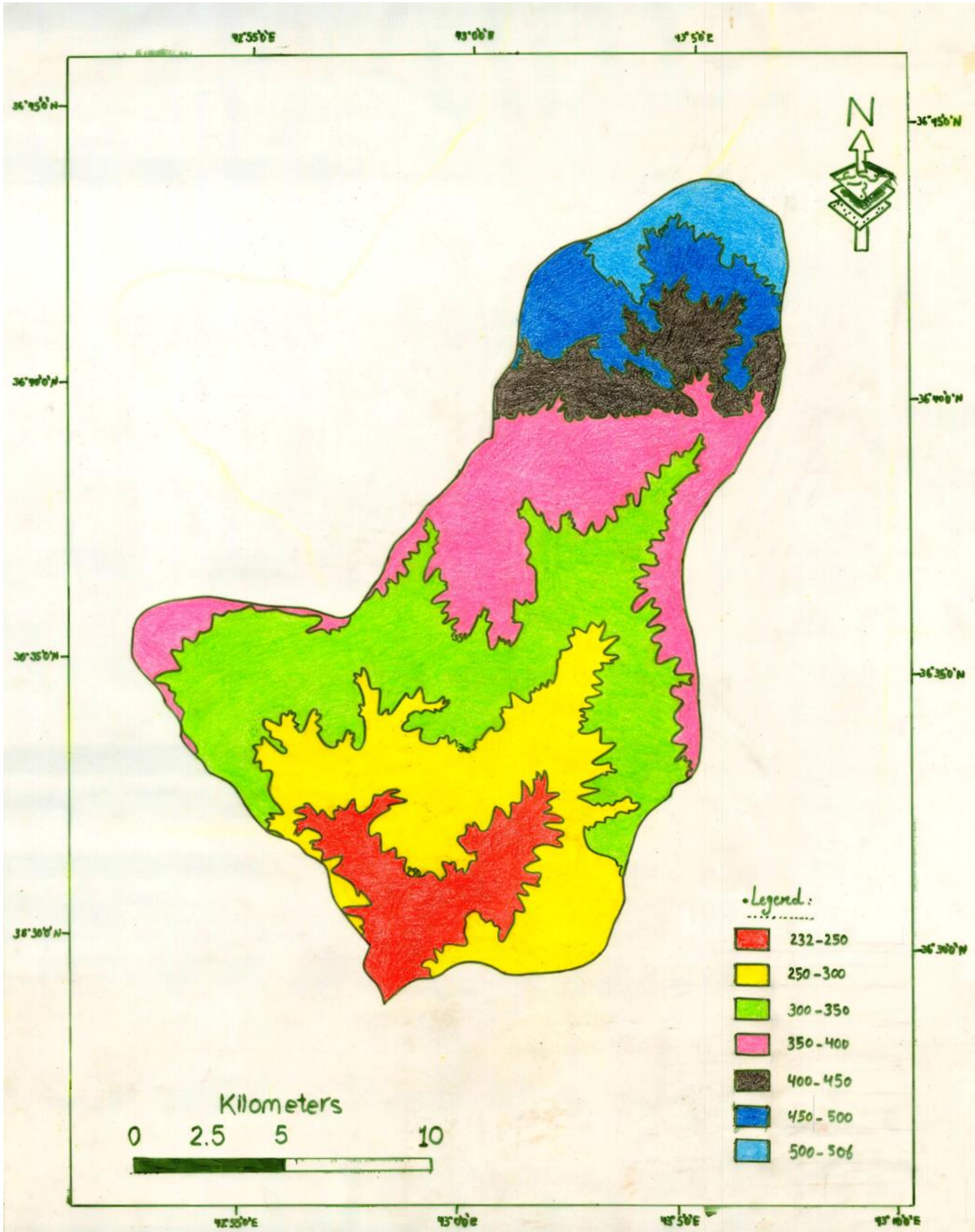


Figure 8: sub division area of basin under study using manual method.

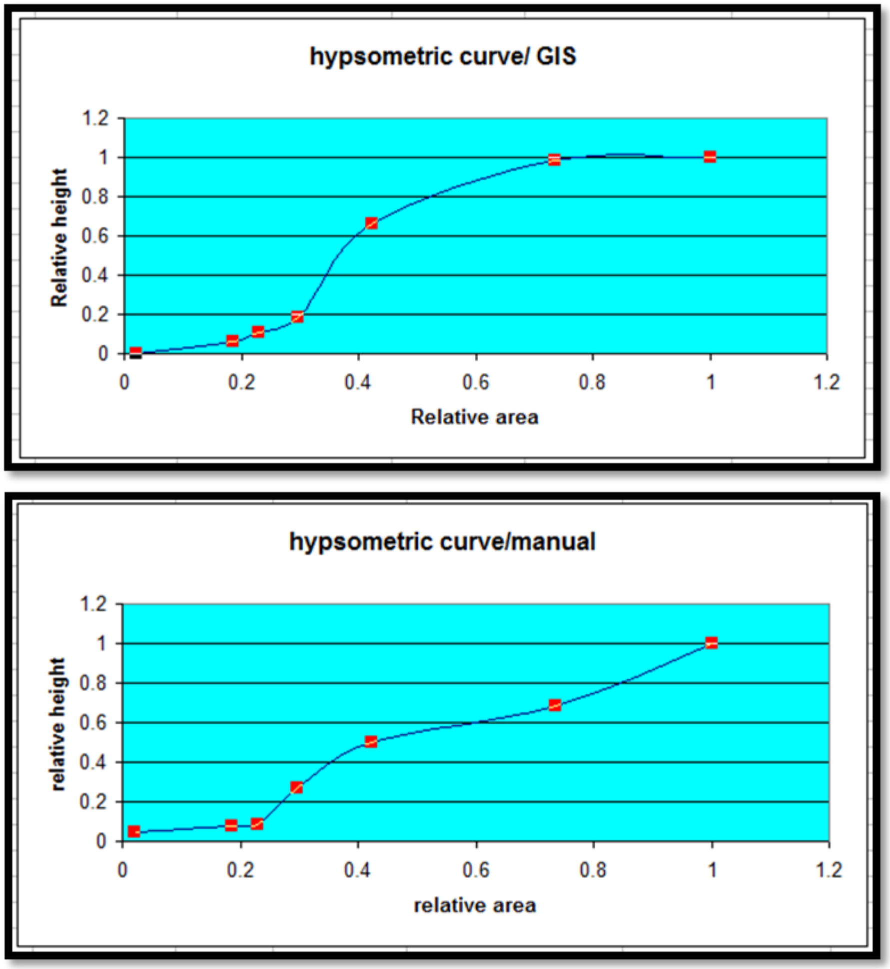


Figure 9: hypsometric curves (manual method on the left and automated (GIS) on the right).

CONCLUSION

The morphometric analysis carried out in this study shows that the basin is 6th order having low relief of the terrain and is oval tending towards elongated shape. There was a difference between the two methods especially in calculation of area, length, and perimeter of the basin, stream length and hypsometric curve. This difference comes from the lack of accuracy in using manual method. The present study demonstrates that remote sensing techniques and GIS play a vital role for the preparation of updated drainage map in a timely and cost-effective manner and morphometric analysis.

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