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| RESEARCH ARTICLE

Takhar Province Morphometric Analysis for the Watershed Management of Amu River Basin in Afghanistan by using Remote Sensing & GIS

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| ABSTRACT
The drainage characteristics are basic information for watershed management. The morphometric analysis carried the slope contribution and linear, areal, and relief aspects. Takhar province is 390 km distance from Kabul. Located in the North Eastern Region of the country, the capital of Takhar province is Taluqan (Provincial Center). Badakhshan borders Takhar in the North-East, Panjsher in the south, Baghlan in the South-West and Kunduz in the North-West. Takhar is situated at an elevation of 801 meters above sea level and covers a land area of 12328.684 Km^{2,} representing 1.91 percent of the total Afghan territory. The SRTM (90 m) Digital Elevation Model (DEM), in conjunction with SOI toposheets, have been used to delineate the hydrological boundaries of the study area. The finding variation in the elongated shapes of the basins is due to the guiding effect of faulting and thrusting in the basin. The R_c of the basins is fewer than 1. It indicates that the infiltration rate varies throughout the basin. The Bangi, Farkhar, and Warsaj districts have low F_s, which indicates that there is less side flow for a shorter duration and high main flow for a longer duration. High F_s in Khwaja ghar, Taluqan, and Darqad districts with high side flow for a longer duration and low main flow for a shorter duration causing high peak flows in a shorter duration.

| KEYWORDS

GIS, Morphometric, Watershed management, Remote sensing.

| ARTICLE INFORMATION

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1. Introduction

The drainage characteristics are basic information for watershed management. The morphometric analysis carried the slope contribution and linear, areal, and relief aspects. To analyze the morphometric parameter using remote sensing and geographical information systems GIS as powerful tools (Chopra et al., 2005). The measurement and calculation of the basic parameters and shape parameters of drainage using DEM, derived parameters, mathematical equations, and GIS tools (Farhan, 2017). Assessment of geo-environmental aspects, especially watershed management, soil erosion, and floods, for better management that rarely threatens large and small areas of human settlement (Nooka Ratnam et al., 2005).

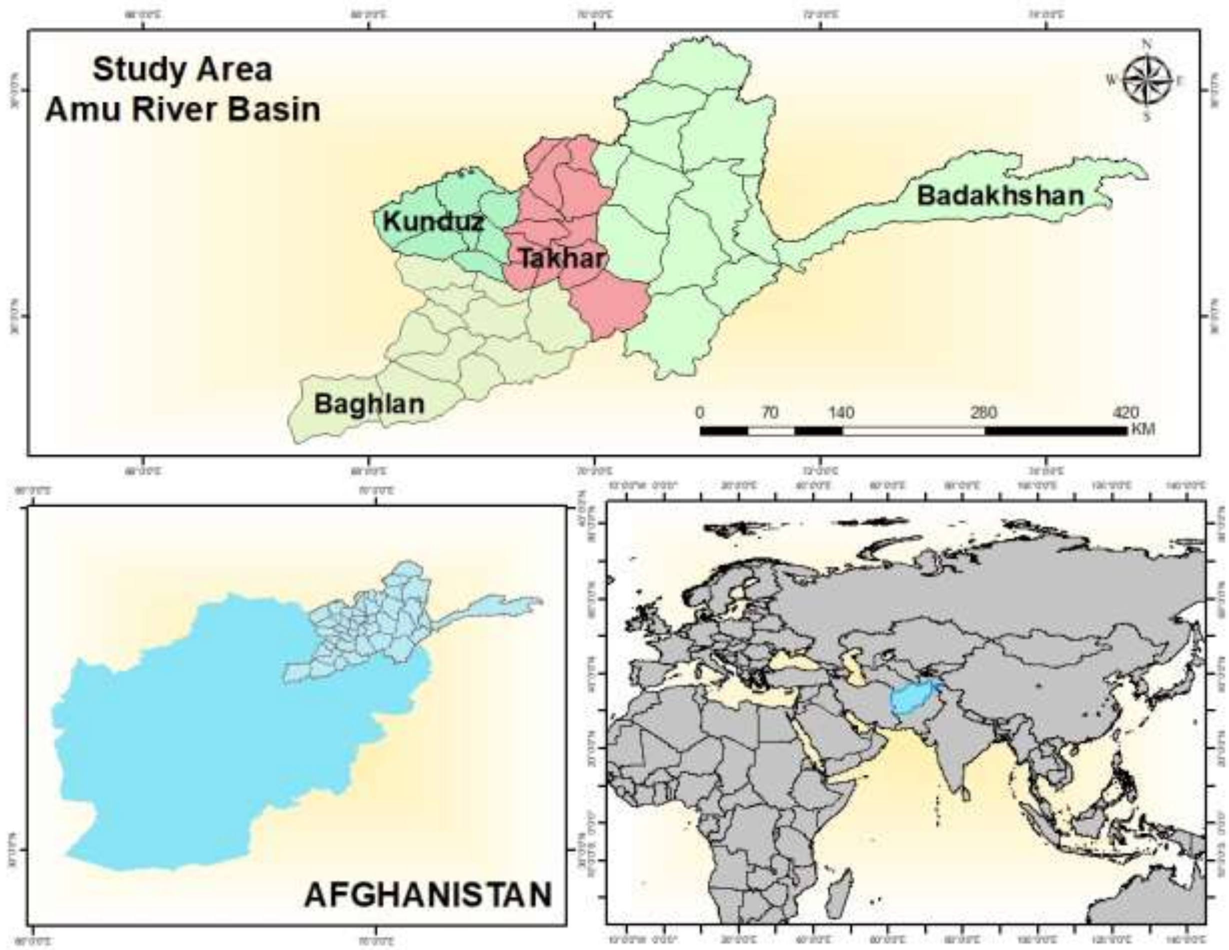
2. Methodology

2.1 Study area

Takhar province is 390 km distance from Kabul. Located in the northeastern region of the country, the capital of Takhar province is Taluqan (Provincial Center). Badakhshan borders Takhar in the North-East, Panjsher in the south, Baghlan in the South-West and Kunduz in the North-West. The province coordinates 36.54 N 69.34 e (CSO, 2015) and is 390 kilometres from Kabul's capital. Takhar is well-positioned between the main trade center in North and Central Afghanistan. Takhar is situated at an elevation of 801 meters above sea level and covers a land area of 12328.684 Km^{2,} representing 1.91 percent of the total Afghan territory Fig 1. Apart from Taluqan, Takhar has 11 districts, namely, Bangi, Chah Ab, Chal, Darqad, Farkhar, Ishkamish, Kalafgan, Khwaja Ghar, Rustaq, Warsaj, Yang-i-Qala.

Takhar is regarded as the most suitable place for agriculture. Wheat and rice are the main field crops. Increasing areas are being cultivated with cotton, potato, and fodder crops (alfalfa, maize, barley, and triticale) and vegetables (watermelon, carrots, onion, tomatoes, okra). Forestry and cottage fruit production can also be found in the province. Households in Takhar are active in subsistence farming by growing grains and small quantities of vegetables and fruits, including cattle (Department Economy, 2020).

Figure 1: The study area location.



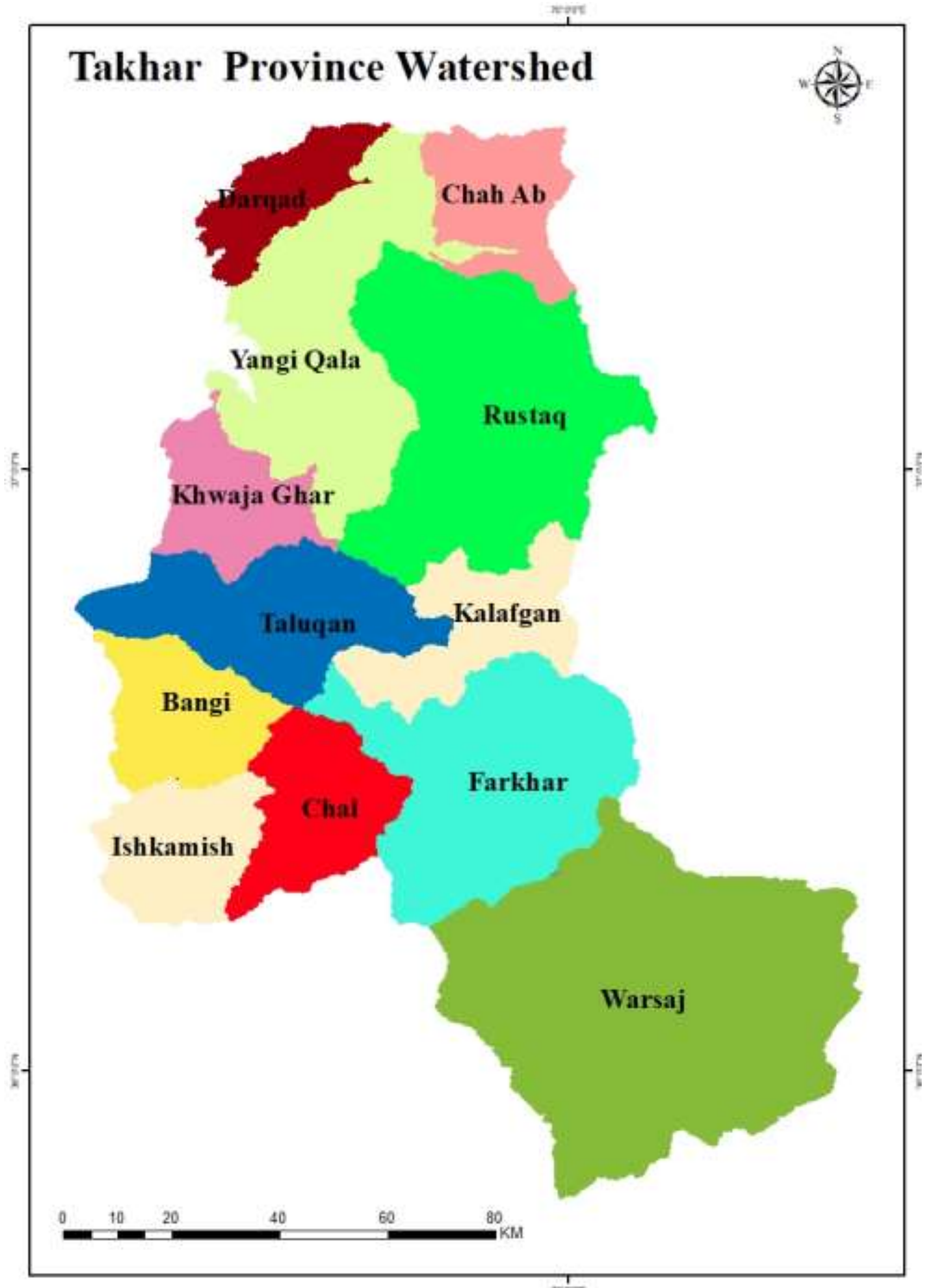


Figure 2: The Takhar province Watershed map.

2.2 Data used

Morphometric analysis of watersheds is carried out based on their hydrological boundaries instead of geographical boundaries. The SRTM (90 m) Digital Elevation Model (DEM), in conjunction with SOI toposheets, have been used to delineate the hydrological boundaries of the study area. In addition, ground truth studies were conducted during field visits to the study area.

2.3 Morphometric analysis

In the present study, the morphometric analysis of the watersheds in the Amu River basin has been analyzed in linear, areal, and relief aspects. The properties of the linear aspects are stream order, stream number, stream length, mean stream length, stream length ratio, and bifurcation ratio. Then, the properties of the relief aspects are basin relief, relief ratio, and ruggedness number, while the areal aspects of the watershed are drainage density, stream frequency, texture ratio, elongation ratio, form factor, circulatory Ratio, Length of overland flow, and constant channel maintenance. Some specific calculations are followed to calculate each parameter, as shown in Table 1.

Table 1. Method of Calculating Morphometric parameters of the Drainage basin

	Morphometric Parameters	Methods	References
	Stream order (U)	Hierarchical order	Horton, 1945
	Stream length (L_u)	Length of the stream	Horton, 1945
	Mean stream length (L_{sm})	$L_{sm} = L_u/N_u$ where L_u=Stream length of order' U,' N_u=Total number of stream	Horton, 1945
	Stream length ratio (R_L)	$R_L=L_u/L_{u}-1$; where L_u=Total stream length of order' U,' L_u- 1=Stream length of next lower order.	Horton, 1945
LINEAR	Bifurcation ratio (R_b)	$R_b = N_u/ N_u+1$; where N_u=Total number of stream segment of order; N_u+1=Number of the segment of next higher order	Schumn,1956
	Basin relief (B_h)	The vertical distance of the lowest and highest points of the watershed. Bh = H-h, where H is the Highest point and his lowest point	Schumn, 1956
RELIEF	Relief ratio (R_h)	$R_h=B_h/L_b$; Where, B_h=Basin relief;L_b=Basin length	Schumn, 1956
	Ruggedness number (R_n)	$R_n= B_h \times D_d$ Where, B_h =Basin relief; D_d=Drainage density	Schumn, 1956
	Stream frequency (F_s)	F_s = N/A where N=Total number of streams; A=Area of watershed	Schumn, 1956
	Drainage density (D_d)	D_d = L/A L=Total length of streams A=Area of watershed	Horton, 1945
	Texture ratio (T)	T = N_u/P where N1=Total number of all order streams; P=Perimeter of watershed	Horton, 1945
	Form factor (Rf)	$R_f=A/(L_b)^2$; where, A=Area of the watershed, L_b= square Basin length	Horton, 1945
	Circulatory Ratio (R_c)	$R_c=4\pi A/P^2$; where, A=Area of the watershed, π=3.14, P=Perimeter of watershed	(Miller, 1953)
	Elongation ratio (R_e)	$R_e=2\sqrt{(A/\pi)}/L_b$; where, A=Area of the watershed, π=3.14, L_b=Basin length	Schumn,1956
	Length of overland flow (L_g)	$L_g = 1/2D_d$ where,D_d=Drainage density	Horton, 1945
AREAL	Constant channel maintenance (C)	Lof = $1/D_d$ where, D_d=Drainage density	Horton, 1945

3 Results and Discussions

3.1 Linear Aspects

The linear aspects of morphometric analysis of watersheds are stream order (U), stream length (Lu), Mean stream length (Lsm), stream length ratio (RL), and Bifurcation ratio (Rb).

3.1.1 Stream Order

In Takhar districts, the number of streams in (6) districts has 1st to 5th stream order, in (5) districts have 1st to 4th stream order and only in Ishkamish district have 1st to 6th stream order that the number of 1st stream order in Warsaj district 473, Rustaq district 454 and in Yang-i-Qala district 411, while the number of 5th stream order in Yang-i-Qala district 1, in Chal District number of 5th stream order, is (3) and in Ishkamish district the number of 6th stream order is 4, which shows the high and fewer numbers of stream order. Table 2.

3.1.2 Stream Length

Each district stream length which shown in (Km) with separate stream order is in the table 2, that the total of every district stream length is: Bangi district 501.72 Km, Chah Ab district 541.93 Km, Chal district 427.80 Km, Darqad district 627.42 Km, Farkhar district 844.58 Km, Ishkamish district 521.82 Km, Kalafgan district 608.27 Km, Khawaja Ghar district 753.01 Km, Rustaq district 1242.81 Km, Taluqan district 830.90 Km, Warsaj district 1510.42 Km, Yang-i-Qala district 1127.73 Km, And the total stream length of these districts are 9538.41Km.

3.1.3 Mean Stream Length (Lsm)

The mean stream length (Lsm) elucidates the characteristic size of a drainage basin network's components and its contributing basin surfaces, and it is a dimensional property (Strahler 1957). The formula to calculate mean stream length has been described in Table 2, and the results of the presence of mean stream length of (12) watersheds of the study area of Takhar province are shown in Table 1. The results revealed that the mean stream length exhibits a variation between 0.54-2.46 Km. Further, a general trend is observed, which is that the mean stream length also increases with the increase in stream order.

3.1.4 Stream Length Ratio

The stream length ratio is an essential factor in the drainage composition and geomorphic development of the drainage basin (Hortron, 1945). The results of the stream length ratio for (12) watersheds in the study area are summarised in Table 2, which shows that the observed variations in the stream length ratio are at nearly all watersheds. The change in stream length ratio from one order to another specifies a late youth stage of geomorphic development (Singh & Singh, 2021).

3.1.5 Bifurcation Ratio

Table 2 shows that the bifurcation ratio is not the same from one order to the following order; these irregularities are dependent upon the geological and lithological development (Strahler 1964). At present, the higher values of the bifurcation ratio indicate strong structural control of the drainage pattern. In comparison, the lower values indicate sub-watersheds that are not affected by structural disturbances. Therefore, the mean bifurcation ratio may be defined as the average bifurcation ratio of all orders. In the study area, the low bifurcation ratio is 0.380 in the 3rd stream order of the Kalfghan district watershed. In contrast, the high bifurcation ratio was found at 45 in the 4th stream order of the Yang-i-Qala district watershed.

Table 2: Value of Linear aspects in Takhar province districts.

Takhar Province					
1. Bangi District					
stream order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	144	286.199	1.987		2.215
2	65	148.768	2.288	0.519	1.710
3	38	46.533	1.224	0.312	1.461
4	26	20.225	0.777	0.434	
2. Chah Ab District					
stream Order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	185	294.843	1.593		2.055
2	90	159.126	1.768	0.539	1.8
3	50	63.429	1.268	0.398	2.777
4	18	24.533	1.362	0.386	
3. Chal District					
stream order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio

1	174	226.896	1.304		2.383
2	73	96.53	1.322	0.425	1.403
3	52	73.042	1.404	0.756	1.733
4	30	29.678	0.989	0.406	10
5	3	1.644	0.548	0.055	
4. Darqad District					
stream order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	346	323.58	0.935		2.337
2	148	159.33	1.076	0.492	1.973
3	75	91.29	1.217	0.572	1.229
4	61	53.21	0.872	0.582	
5. Farkhar District					
stream order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	328	444.57	1.355		2.309
2	142	205.67	1.448	0.462	2.088
3	68	84.44	1.241	0.410	0.819
4	83	101.24	1.219	1.198	9.222
5	9	8.63	0.959	0.085	
6. Ishkamish District					
stream order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	193	283.96	1.471		2.144
2	90	137.42	1.526	0.483	2.307
3	39	53.03	1.359	0.385	2.294
4	17	28.88	1.6997	0.544	1.133
5	15	13.51	0.90	0.467	3.75
6	4	5.003	1.250	0.370	
7. Kalfgan District					
stream order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	258	348.87	1.352		2.324
2	111	150.56	1.356	0.431	4.111
3	27	46.65	1.727	0.309	0.380
4	71	62.18	0.875	1.332	
8. Khwaja Ghar District					
stream order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	372	420.42	1.130		2.22
2	167	199.07	1.192	0.473	1.77
3	94	99.47	1.058	0.499	2
4	47	34.04	0.724	0.342	
9. Rustaq District					
stream order	No of stream	stream Length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	454	635.78	1.40		2.10
2	216	317.86	1.47	0.49	1.846

3	117	185.84	1.588	0.58	1.82
4	64	80.30	1.25	0.43	2.46
5	26	23.01	0.88	0.28	
10. Taluqan District					
stream order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	237	456.37	1.92		1.99
2	119	198.48	1.66	0.434	2.05
3	58	101.66	1.75	0.512	2.52
4	23	49.17	2.13	0.48	1
5	23	25.19	1.095	0.512	
11. Warsaj District					
stream order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	473	838.20	1.772		2.241
2	211	355.15	1.683	0.423	1.688
3	125	171.98	1.375	0.484	1.689
4	74	86.92	1.174	0.505	1.541
5	48	58.15	1.211	0.669	
12. Yangi Qala District					
stream order	No of stream	stream length (KM)	Mean stream length	stream length ratio	Bifurcation ratio
1	411	595.49	1.44		2.024
2	203	310.02	1.52	0.520	1.691
3	120	163.94	1.366	0.528	2.666
4	45	55.79	1.239	0.340	45
5	1	2.46	2.46	0.044	

3.2 Relief Aspects

Linear and areal features are two-dimensional aspects of the basin. The relief introduces the concept of the third dimension of the basin. Basin relief is one of the essential factors in predicting the extent of denudation in a basin. Higher relief with steeper slopes offers potentially more energy than more subdued basins. Relief parameters of the watersheds play significant roles in drainage development, surface and sub-surface runoff, water infiltration, and landscape development in the basin area (Vijith & Satheesh, 2006). The maximum and minimum elevation of the whole study area (Takhar) are 395 and 5765 m, respectively. The relief aspects are relief ratio, relative relief, and ruggedness number. Each parameter in the relief aspects has been studied in the present study, and its result is discussed below.

3.2.1 Basin Relief

The maximum vertical distance between the highest and lowest elevation in a basin is called basin relief (Horton, 1945; Strahler, 1964).

Basin Relief = H-h

Where,

H = Maximum height (elevation) of the basin.
h = Minimum height (elevation) of the basin.

The basin relief for different sub-watersheds has been summarized in Table 3. The Warsaj district and the Darqad district watershed observed the highest and lowest basin relief of 4234 m & 217 m, respectively.

Table 3: Value of elevation and basin relief in Takhar province districts.

Takhar Province				
No	Name of District	Maximum elevation (m)	Minimum elevation (m)	Basin Relief (Bh) (m)
1	Bangi	1976	549	1427
2	Chah Ab	2518	531	1987
3	Chal	4228	906	3322
4	Darqad	616	399	217
5	Farkhar	5090	873	4217
6	Ishkamish	4079	1088	2991
7	Kalafgan	3815	640	3175
8	Khwaja Ghar	1889	395	1494
9	Rustaq	2810	543	2267
10	Taluqan	2126	573	1553
11	Warsaj	5765	1531	4234
12	Yangi Qala	1460	404	1056

3.2.2 Relief Ratio (Rh)

In the present study, the relief ratio has been calculated for each watershed; the relief ratio for 12 sub-watersheds has been given in Table 4, where Ishkamish district and Darqad observed the highest and lowest relief ratio of 0.115 m & 0.012 m, respectively, which indicate that the basins possess low relief.

Table 4: Relief ratio of sub-watershed in Takhar province districts.

Takhar Province		
No	Name of District	Relief Ratio Rh (m)
1	Bangi	0.050
2	Chah Ab	0.088
3	Chal	0.104
4	Darqad	0.012
5	Farkhar	0.090
6	Ishkamish	0.115
7	Kalafgan	0.097
8	Khwaja Ghar	0.043
9	Rustaq	0.044
10	Taluqan	0.037
11	Warsaj	0.068
12	Yangi Qala	0.065

3.2.3 Ruggedness Number

The computed values of ruggedness number for different sub-watersheds have been given in Table 5, where the Kalafgan district observed a higher value (2.64557 m) compared to the rest of the sub-watersheds of the study area. The higher the ruggedness value, the higher the terrain's structural complexity is in association with drainage density and relief and the more susceptible it is to soil erosion.

Table 5: Value of ruggedness number of Takhar province districts.

Takhar Province		
No	Name of District	Ruggedness Number Rn (m)
1	Bangi	1.21238
2	Chah Ab	1.61886
3	Chal	2.42214
4	Darqad	0.29861
5	Farkhar	2.44699
6	Ishkamish	2.44304
7	Kalafgan	2.64557
8	Khwaja Ghar	1.49870
9	Rustaq	1.74701
10	Taluqan	1.55982
11	Warsaj	2.23673
12	Yangi Qala	1.02843

3.3 Areal Aspects

Basin area, basin length, and basin perimeter are the three main parameters for quantitative morphometry of a basin. To explain the basin in more detail, these three factors can be used to compute some other important parameters, including Drainage density (Dd), Stream frequency (Fs), Texture ratio, Form factor, Circulatory ratio (Rc), Elongation ratio, Length of overland flow and constant channel maintenance. All these factors are explained in detail below:

3.3.1 Basin area

The basin area is an essential parameter for calculating the basin geometry. The basin area (A) is defined as an area that is drained by a stream network so that all streams flow within the basin boundary discharge through a common outlet. The area of the different sub-watershed basins of the study area has been computed using ArcGIS 10.4.1 software; the results have been summarized in Table 6. The total area of the whole basin (Takhar) was calculated as 12328.684 Km^2. The Darqad and Warsaj are the smallest (455.94 Km^2) and biggest (2859.13 Km^2) basin areas among the different sub-watersheds, respectively.

3.3.2 Basin Perimeter (P)

The basin perimeter is the outer boundary of the basin that surrounds its area. The perimeter of the individual sub-watersheds of the study area has been computed using ArcGIS 10.4.1. the basin perimeter is a linear measure of the basin size and is mainly dependent on the basin's topography. Among all the sub-watersheds, the Ishkamish observed the smallest perimeter (100.996 Km), and Warsaj showed the largest perimeter (231.338 Km), as shown in Table 6.

3.3.3 Basin Length

Different researchers define basin length in different ways. However, basin length is defined as the longest length of the basin from the catchment to the point of confluence (Grogory and Walling, 1973). At the same time, in the Schumm (1956) method, basin lengths of different sub-watersheds were calculated, which have been summarized in Table 6. The results revealed that Yang-i-Qala Has the shortest (22.41 km) and Warsaj has the longest (84.04 km) basin lengths. The basin length provides useful information regarding the basin's shape and size.

Table 6: Areal Aspects of sub-watershed in Takhar province districts.

Takhar Province				
No	Name of District	Basin Area km^2	Basin Perimeter (km)	Basin Length (km)
1	Bangi	590.54	105.505	38.88
2	Chah Ab	665.17	123.472	28.6
3	Chal	586.73	105.953	40.47
4	Darqad	455.94	116.150	48.68
5	Farkhar	1455.49	175.115	56.11
6	Ishkamish	637.094	100.996	35.44
7	Kalafgan	729.99	152.294	39.2
8	Khwaja Ghar	750.65	133.558	43.56
9	Rustaq	1612.73	186.703	64.95
10	Taluqan	827.26	136.234	56.74
11	Warsaj	2859.13	231.338	84.04
12	Yangi Qala	1157.96	192.660	22.41

3.3.4 Drainage Density (Dd)

Drainage density shows variation with climate and vegetation, relief, soil and rock properties, and landscape evolution processes (Chorley & Morgan, 1962); (Kelson & wells, 1989); (Moglen et al., 1998). High drainage density is found in weak and impermeable subsurface materials, less vegetation, and high relief. In contrast, low drainage density is preferred in highly permeable subsoil materials under dense vegetation cover having low relief (Prasad et al., 2008). The Spatial Analyst Tool in ArcGIS-10.4.1 was used; the results are shown in Table 8. Warsaj district observed the lowest Dd of 0.528 Km/Km^{2,} and Darqad district showed the highest Dd of 1.376 Km/Km^{2,} which suggests that the drainage density is very coarse and the region is highly permeable.

3.3.5 Stream Frequency

Stream Frequency provides an idea about the characteristics of the underlying lithological features in an area and the drainage density. (Horton, 1945) stream frequency as the total number of stream segments of all orders per unit area of the basin (Table 4.1). The area with impermeable subsoil and steep gradients has high stream frequency with rapid surface runoff and less infiltration time. In the present study, the stream frequency is low in the range of 0.325 to 1.381 in the Warsaj district and Darqad district, as shown in Table 8. The low stream frequencies in the study areas are characteristic of areas having low relief and high infiltration capacity of the underlying bedrock.

3.3.6 Texture Ratio (T)

The texture ratio depends on the terrain's underlying bedrock, infiltration capacity, and relief aspects. The present study's texture ratio is highest for the Darqad district (5.424) and lowest for the Bangi district (2.587), as shown in Table 8, indicating high runoff and low infiltration capacity.

3.3.7 Form Factor

Horton (1932) made a quantitative expression for the outline form of drainage basin by introducing form factor (Rf), the ratio of basin area to the square of basin length. With the smaller form factor values, the basin will be more elongated. The form factor value varies from 0 (highly elongated basin) to 1 (perfectly circular basin). The calculated values of the form factor for 12 sub-watersheds of the study area have been summarized in Table 8. The results revealed that the form factor value ranges from 0.192 (Darqad district) to 2.305 (Yang-i-Qala district), indicating that the shape of the basins is highly elongated to slightly elongated.

3.3.8 Circulatory Ratio (Rc)

The circulatory ratio is influenced by several factors, such as underlying lithology, slope, relief of the basin gradient, and stream discharge (Schumm, 1956; Strahler, 1964). Low, medium and high values of circulatory ratio reveal the youth, mature and old stages of tributaries in a basin, respectively. Table 8 summarizes the circulatory ratio of different sub-watersheds of the study area. The circulatory ratio ranges from 0.391 (Yang-i-Qala) to 0.784 (Ishkamish), indicating youth stage topography and elongated basins.

3.3.9 Elongation Ratio (Re)

Table 6 shows the basin shape with the elongation ratio. Usually, values between 0.6-0.8 are commonly associated with high relief and steep basins. However, sub-watersheds of the study area observed an elongation ratio ranging between 0.777 (Darqad district) to 2.690 (Yang-i-Qala district), as shown in Table 8, revealing that they are more elongated.

Table 7: Elongation ratio and basin shape (Krishnamurthy et al., 1996)

Elongation ratio	Basin shape
< 0.5	More elongated
0.5-0.7	Elongated
0.7-0.8	Less elongated
0.8-0.9	Oval
>0.9	Circular

3.3.10 Length of Overland Flow

A lower value of overland flow indicates that the streams are short, integrated, and controlled, having a short spacing between them and resulting in a high rate of erodibility. Whereas higher values of length of overland flow indicate wider steam spacing, flow over longer lengths before draining into the mainstream results in less erodibility (Patton & Baker, 1976). The present study results (Table 8) revealed that the length of overland flow at the sub-watershed level ranges between 0.264 and 0.688 in Warsaj district and Darqad district, respectively. Nearly all the sub-basins in the study area (Takhar) are less susceptible to erosion.

3.3.11 Constant Channel Maintenance

The constant of channel maintenance (C) is the inverse of drainage density and is given as square kilometer per kilometer (Km^2/Km) (Schumm, 1956). Mostly, the higher the values of constant channel maintenance, the greater the rock permeability of the region. The calculated values of constant channel maintenance for different sub-watersheds of the study area are given in Table 8. The Baghlan City district observed the smallest values of constant channel maintenance as 0.726 Km^2/Km and the Darqad district as highest value as 1.892 Km^2 /Km, indicating that these sub-watersheds are under high structural disturbance, having less permeability, high steep slopes with high runoff conditions.

Table 8: Areal aspects of Morphometric Analysis.

Takhar Province									
No	Name of District	Dd Km^2/Km	Fs	T	Rf	Rc	Re	Lg	C
1	Bangi	0.849	0.462	2.587	0.390	0.666	1.107	0.424	1.177
2	Chah Ab	0.814	0.515	2.777	0.813	0.548	1.597	0.407	1.227
3	Chal	0.729	0.565	3.133	0.358	0.656	1.060	0.364	1.371
4	Darqad	1.376	1.381	5.424	0.192	0.424	0.777	0.688	0.726
5	Farkhar	0.580	0.432	3.597	0.462	0.596	1.204	0.290	1.723
6	Ishkamish	0.819	0.561	3.544	0.507	0.784	1.262	0.409	1.220
7	Kalafgan	0.833	0.639	3.066	0.475	0.395	1.221	0.416	1.200
8	Khwaja Ghar	1.003	0.905	5.091	0.395	0.528	1.114	0.501	0.996
9	Rustaq	0.770	0.543	4.697	0.382	0.581	1.095	0.385	1.297
10	Taluqan	1.004	0.556	3.376	0.256	0.559	0.898	0.502	0.995
11	Warsaj	0.528	0.325	4.024	0.404	0.671	1.127	0.264	1.892
12	Yangi Qala	0.973	0.673	4.048	2.305	0.391	2.690	0.486	1.026

4. Conclusion

The present study shows that the SRTM DEM and GIS-based methods in the calculation of drainage morphometric parameters and their influence on hydrological physical characteristics at the watershed level are more appropriate than the conventional methods. The GIS-based approach facilitates the evaluation of different morphometric parameters and explores the relationship between hydrological characteristics and drainage morphometry. The variation of the elongated shapes of the basins is due to the guiding effect of faulting and thrusting in the basin. The R_c of the basins is fewer than 1. It indicates that the infiltration rate varies throughout the basin. The Bangi, Farkhar, and Warsaj districts have low F_s, which indicates that there is less side flow for a shorter duration and high main flow for a longer duration. High F_s in Khwaja ghar, Taluqan, and Darqad districts with high side flow for a longer duration and low main flow for a shorter duration causing high peak flows in a shorter duration. Farkhar and Warsaj districts have the highest C values; they represent very little structural disturbance and less runoff condition. Chal, Farkhar, and Warsaj districts have high B_h values, which indicates that the gravity of water flow, low infiltration, and high runoff conditions prevail in the basin. Chal, Ishkamish, Farkhar, Kalafghan, and Warsaj districts having high R_n values indicate that it is highly susceptible to erosion and, therefore, susceptible to an increased peak discharge. Chah Ab, Yangi Qala, and Ishkamish have high R_e and F_s. Darqad, Khwaja Ghar, and Yangi Qala have high B_h and R_n. It shows that the erosion and peak discharges are high in these basins. Therefore, the building of the check dams and earth dams will support decreased peak discharge on the main channel.

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