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Morphometric Analysis of Baghlan Province for Amu River Basin in Afghanistan using Remote Sensing and GIS

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ABSTRACT

Baghlan province is located in north of Kabul and surrounded by Bamyan, Kunduz,Parwan, Takhar, and Samangan provinces. It lies on the core route to the north and North-eastern regions of Afghanistan, which in terms of geographical location (coordinates) 29 degrees and 31 minutes north latitude and 58 degrees and 48 minutes east longitude, it is located 230 km from Kabul along the Kabul-Mazar highway; In the past, this province had 12 districts, which has now been raised to 15 districts, but in our current study, it will discuss 12 districts, which are the same 15 districts; 15 districts were canceled because there were no changes in the calculations of morphometric analysis. The different morphometric analysis explains the physical appearance of the watershed, which are suitable for the areas of land development, soil protection, topography rise, and soil erosion (Horton, 1945). This study discloses that DEM and GIS method in calculating morphometric drainage parameters and their effect on hydrological features at the watershed level is suitable than the conservative methods. The complete basin means bifurcation ratio (R_b) is 2.43, which shows that the drainage pattern is partial by geographical structure. Doshi and Khinjan districts have a high elongation ratio (R_e), Ruggedness number (R_n), basin relief (B_h). It shows that peak discharges and erosion are high in these basins. This study is very beneficial for applying rainfall aggregation and watershed management.

Key words : *GIS, Morphometric, Watershed management, Remote sensing,*

Introduction

Studying any watershed basin, its drainage characteristics information is fundamental. A catchment area is a surface that collects the water (rainwater/snow) to a usual outlet (Parvez and Inayathullah, 2019). The morphometric analysis carried the basin's relief, areal and linear aspects, and slope contribution (Parvez and Inayathullah, 2019). The morphometric analysis used techniques of remote sensing, which has emerged as a reliable tool in recent years. Remote sensing can create a concise sight of a large area at one time and is very helpful in examining drainage morphometry (Rudraiah *et al.*, 2008). Lately, several research scholars have used remote sensing information and studied them on the GIS application to understand the catchment's morphometric virtues (Rao *et al.*, 2011). As a result, spatial information technology, remote sensing, and geographical information systems have become practical tools in delineating drainage patterns and water resource management and its development (Nag and Lahiri, 2011).

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Methodology

Study area

Baghlan province with an area of 2,1274.3 square kilometers, and according to the country's estimated population, which was published in the book of the Central Statistics Office in 2018, the population of this province reaches 943,394 people, which includes different ethnic groups. Baghlan province has a good climate, which is hot in summer and cold in autumn and winter. This province was separated from Khan Abad city of Kunduz province in 1957, which was moved to Baghlan city (Fig. 1), and the capital of this province was transferred to Pul-e-Khumri city in 1988. In the administrative structure of the capital of this province, Pul-e-Khumri city has 14 districts, which include: BaghlanJadid, Nahrin, Doshi, Dahana-i-Ghori, Khost, Burka, DehSalah, Khenjan, Taleh and Barfak, Pol Hesar, Banu Andarb, Khoja Hejran (Jelgah), Firing and Guzargah-i-Noor, and the watershed of Baghlan province districts (Fig. 2). Baghlan province borders Kunduz, Takhar, Samangan, Bamyan, and Panjshir provinces. In the north with Ishkamish district of Takhar and Khan Abad and Aliabad districts of Kunduz, in the south with Shibar district of Bamyanand in the east with Warsaj district and part of Namaak Ab and Chal district of Takhar province,in the southeast with Parian district Panjshir province, in the west with Kahmard district of Bamyan and the districts of Roy-e-Du Ab and Khorum Sar Bagh Aibak Samangan, It is bordered by Khulm districts of Mazar-e-Sharif and Hazrat Sultan Samangan in the northwest (Department Economy, 2018)

Data used

Morphometric analysis of watersheds is carried based on their hydrological boundaries instead of geographical boundaries. The SRTM (90 m) DEM digital elevation model combinedthrough SOI toposheets has been used to delineate the hydrological borders of the study area. In addition, ground reality studies have been conducted during the field visits to the study area. The USGS (United States

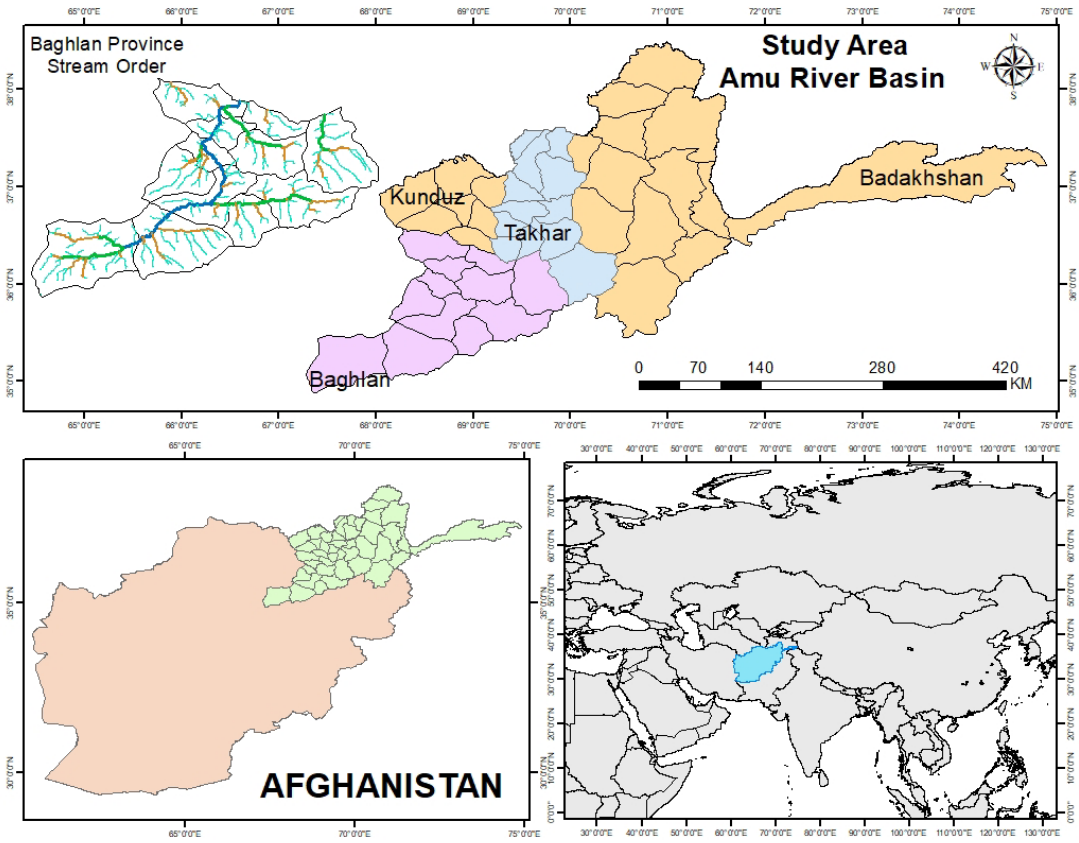

Fig. 1. Location and coverage of the study area.

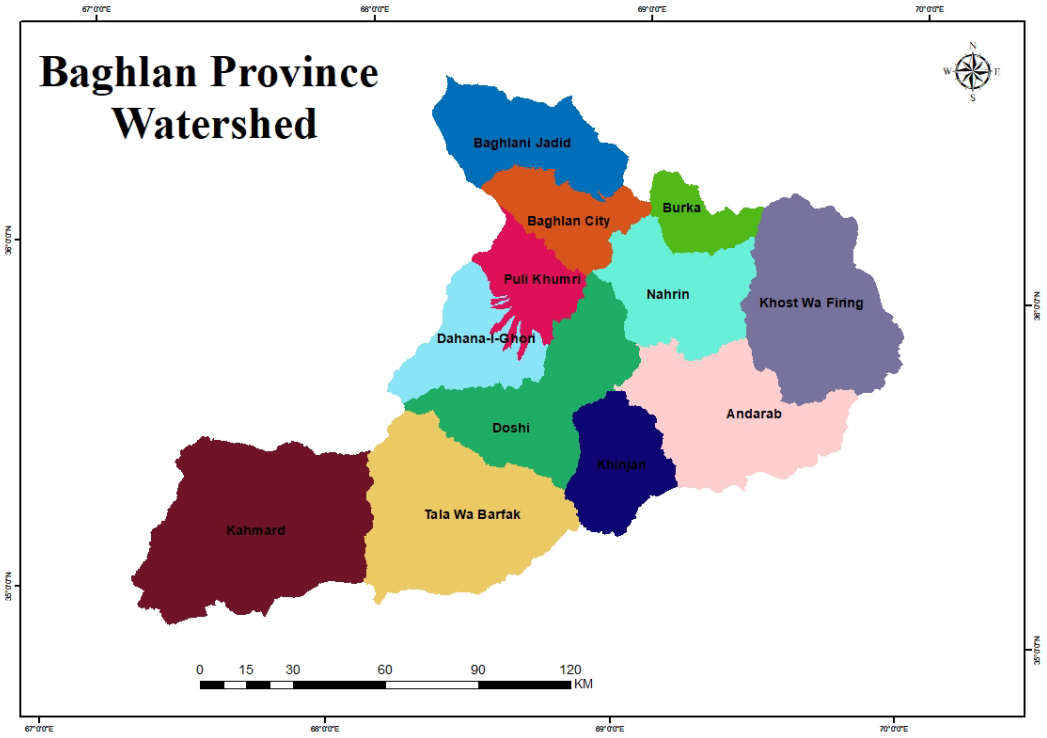

Fig. 2. Watershed of Baghlan province districts.

Geological Survey) has used TNTmips to make a sequence of 32 topographical maps of Afghanistan at a size of 1:250,000, collaborating with the Cartography and Afghan Geological Survey. Head Office (USGS AFG Topo, 2005). Each foursquare by two longitudes and one latitude portion of several quadrangles along the country's boundary. The TNTmips for surface modeling process to turn out topographical contours for the map from SRTM or Shuttle reader topography mission 90-m DEM or digital elevation model data, Fig. 3. (USGS AFG Topo, 2005)

Morphometric analysis

The morphometric analysis of the watersheds in the Amu river basin has been analyzed in relief, areal, and linear aspects. The properties of the relief aspects are basin relief, relief ratio, and ruggedness number. In contrast, 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 (Sreedevi *et al.*, 2012). Then the properties of the linear aspects are stream order, stream number, stream length, mean stream length, stream length ratio, and bifurcation ratio. To calculate each

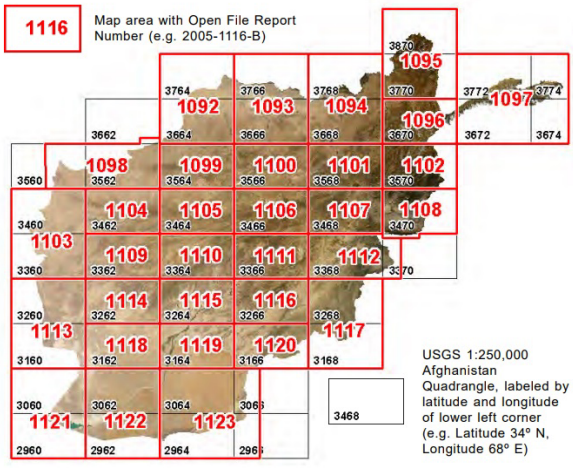

Fig. 3. USGS Afghanistan Geological Map.

parameter, some specific calculations are followed, which are shown in Table 1.

Results and Discussion

Linear Aspects

The linear aspects of morphometric analysis of wa-

Table 1. Formula of Morphometric parameters

Linear Aspects		
Parameters	Methods	References
Stream order (U)	Hierarchical order	(Schumn, 1956)
Stream length (L_u)	Length of the stream	(Horton, 1945)
Mean stream length (L_{sm})	$L_{sm} = L_u/N_u$, Where N_u =total number of stream segment order	(Horton, 1945)
Stream length ratio (R_L)	$R_L = L_u/L_u$-1, Where L_u-1 =stream length of next lower order	(Horton, 1945)
Bifurcation ratio (B_h)	$B_h = N_u/ N_{u+}1$, Where N_u+1 = number of the next higher order	(Schumn, 1956)
Relief Aspects		
Basin relief (B_h)	The highest and lowest point of the watershed, B_h = H-hwhere H = highest point and h = the lowest point	(Schumn, 1956)
Relief ratio (R_h)	$R_h = B_h/ L_b$: where L_b = basin length	(Schumn, 1956)
Ruggedness number (R_n)	$R_n = B_h x D_d$	(Schumn, 1956)
Areal Aspects		
Drainage density (D_d)	D_d = L / A : where L = total length stream A = Area of watershe	(Horton, 1945)
Stream frequency (Fs)	$F_s = N_u/ A$	(Horton, 1945)
Texture ratio (T)	$T = N_u/ P$: where P = Perimeter of watershed	(Horton, 1945)
Form factor (F_f)	$F_f = A / (L_b)^2$: where L_b = square basin length	(Horton, 1945)
Circulatory ratio (Rc)	$R_c = 4\pi A / P^2$: where π = 3.14	(Miller, 1953)
Elongation ratio (Re)	$R_e = 2\sqrt{(A/\pi)} / Lb$	(Schumn, 1956)
Length of overland flow (Lg)	Lg = 1 /2Dd	(Horton, 1945)
Constant channel maintenance (C)	Lof = 1 / Dd	(Horton, 1945)

tersheds are Bifurcation ratio (Rb), stream length ratio (RL), Mean stream length (Lsm), stream length (Lu), stream order (U).

Stream Order (U)

With the joint of two different orders, however, the result will not increase in order. For example, the joint of a second-order and first-order link will not form a third-order but will remain the order of the highest ordered (Strahler method, 1991). In Baghlan province, the number of streams in Andarab, Kahmard, Nahrin, and Tala Wa Barfak districts from 1st to 6th stream, only Danhi -e-Ghori has 1 to 4 stream order, and in remaining (7) districts are having 1st to 5th stream order, that the number of 1st stream order in Kahmard 836, Tala Wa Barfak 563 and Baghlan Jadid district 519, while the number 5th stream order in Burka district 2, in Pul-i-Khurmri District number of 5th stream order, is 10, and in Khinjan district number of 5th stream order is 12 which shows the high and less numbers of stream order (Table 2).

Stream Length (LU)

One of the vital hydrological characteristics of the basin, as it makes known surface runoff features, is stream length (Walkar and Nilawar, 2014). Each district stream length which is shown in km with separate stream order, is in Table 2 that the total of every district stream length is: Andarab district 1398.62 km, Baghlan Jadid district 1536.84 km, Baghlan City district 756.98 km, Burka district 601.58 km, Dahan-i-Ghori district 1026.40 km, Doshi district 1287.75 km, Kahmard district 2374.88 km, Khinjan district 726.95 km, Khost Wa Firing district 1504.80 km, Nahrin district 1102.21 km, Pul-i-Khumri district 598.54 km and Tala Wa Barfak 1661.88 km. And the total stream length of these districts is 14580.49 km.

Mean Stream Length (Lsm)

The elucidates of mean stream length (Lsm) in characteristic size of components for a drainage basin network and its contributing basin surfaces and is a dimensional property (Strahler, 1957). The formula to calculate mean stream length has been described in Table 1; the results of the presence of mean stream length of 12 watersheds of the study area of Baghlan province are shown in Table. 2. The results revealed that the mean stream length exhibits a variation between 0.356-2.021km.

Stream Length Ratio (RL)

The given order ratio of the mean stream length to

the next lower stream order is the stream length ratio; the mean stream length has a significant relationship with the discharges and surface flow (Walkar and Nilawar, 2014). Thus, stream length ratio is an essential factor in the drainage structure and geomorphic development of the drainage basin (Horton, 1945). The results of stream length ratio for 12 watersheds in the area have been summarised in Table 2, which depicts that stream length ratio observed variations at nearly all watersheds (Sahu *et al.*, 2016).

Bifurcation Ratio (RB)

The ratio of the segments in a given order to the segments number of the next higher-order is bifurcation ratio(Horton, 1945), considered an index of relief and discussion. The bifurcation ratio shows only a tiny difference for different regions in the different environments except where robustgeographical control dominates (Strahler, 1957). Table 2 demonstrated that the bifurcation ratio is not the same at all orders; these anomalies depend upon the drainage basin's geographical and lithological development (Strahler, 1957). In the present study, solid structural control on the drainage basin shows the higher bifurcation ratio values.

In comparison, the lower values are indicated of sub-watersheds that are not affected by the structural disorder. The average bifurcation ratio of all orders is called mean bifurcation. In the study area, the low bifurcation ratio is 0.904 in the 3rd stream order of the Khinjan district watershed. In contrast, the high bifurcation ratio found 20 in the 4th stream order of the Burka district watershed.

Relief Aspects

Linear and areal features are two-dimensional aspects of the basin. The relief introduces the concept of the third dimension for the basin. Basin relief is one of the essential factors in predicting the extent of denudation in a basin. Steeper slopes with higher relief show that the basin potentially has more energy than a more subdued basin. Relief parameters of the watersheds play significant roles in drainage development, sub-surface and surface runoff, water infiltration, and landscape development in the basin area (Vijith and Satheesh, 2006). The minimum and maximum elevation of the whole study area (Baghlan) is 436 and 5419 m, Fig. 4, respectively. The relief aspects of a watershed are ruggedness number, relative relief, and relief ratio.

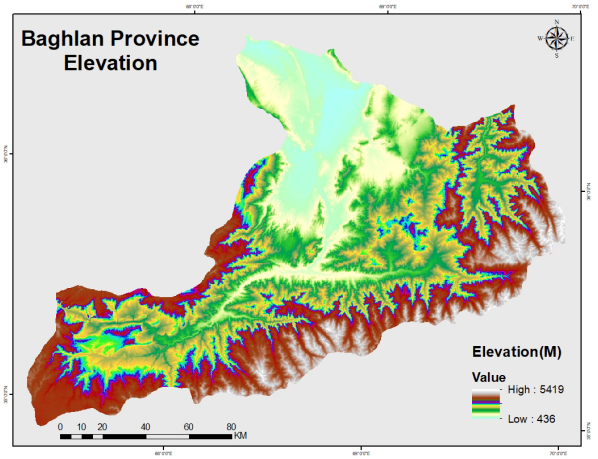

Fig. 4. Baghlan province elevation.

Basin Relief (B_h)

The distance between the highest and lowest elevation in a basin is called basin relief (Horton, 1945). The basin relief for different sub-watersheds has been summarized in Table 3. The Khost Wa Firing district and the Baghlan Jadid district watershed observed the highest and lowest basin relief of 4099 m and 1476 m, respectively.

Relief ratio (RH)

The relief ratio provides the overall steepness of the sub-watershed basin. The suggested scheme's close correlation between hydrologic features and relief ratio found that loss of sediments per unit area is closely associated with relief ratios (S.F.R and Moharir, 2013). 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 3, where Burka district and Baghlan Jadid observed the highest and lowest relief ratio of 0.094 and 0.037, respectively, which indicate that the basins possess low relief.

Ruggedness number (RN)

Ruggedness Number is defined as the drainage density and total relief of the basin where both terms are in the same units (Schumn, 1956). The different calculated values of ruggedness number for sub-watersheds have been given in Table 3, where the Dahana-i-Ghori district observed a higher value (2.58233) compared to the rest of the sub-watersheds of the study area. The higher the value of ruggedness number, the higher is the structural complexity of the terrain in association with relief, drainage

Table 2. Linear aspects of Baghlan province.

Baghlan Province

1. Andarab District

Stream order	Stream length (km)	Mean stream length	Stream length ratio	Bifurcation ratio
1	767.420	1.686		2.263
2	333.165	1.657	0.434	1.827
3	159.057	1.445	0.477	1.549
4	87.540	1.232	0.550	2.151
5	28.145	0.852	0.321	1.375
6	23.348	0.972	0.829	

2.Baghlan Jadid District

Stream order	Stream length (km)	Mean stream length	Stream length ratio	Bifurcation ratio
1	797.662	1.536		2.011
2	445.938	1.728	0.559	2.015
3	176.727	1.380	0.396	2.031
4	68.383	1.085	0.386	1.26
5	48.127	0.962	0.703	

3.Baghlan City

Stream order	Stream length (km)	Mean stream length	Stream length ratio	Bifurcation ratio
1	387.061	1.412		1.957
2	217.504	1.553	0.561	1.842
3	110.625	1.455	0.508	4.470
4	26.244	1.543	0.237	1
5	15.546	0.914	0.592	

4.Burka District

Stream order	Stream length (km)	Mean stream length	Stream length ratio	Bifurcation ratio
1	363.456	1.844		2.118
2	147.029	1.580	0.404	2.325
3	41.303	1.032	0.280	1
4	49.078	1.226	1.188	20
5	0.712	0.356	0.0145	

5.Dahana-i-Ghori District

Stream order	Stream length (km)	Mean stream length	Stream length ratio	Bifurcation ratio
1	548.727	1.693		2.063
2	293.875	1.871	0.535	2.343
3	103.167	1.539	0.351	1.313
4	83.631	1.639	0.810	

6.Doshi District

Stream order	Stream length (km)	Mean stream length	Stream length ratio	Bifurcation ratio
1	705.808	1.455		2.165
2	313.377	1.399	0.443	1.763
3	168.091	1.323	0.536	2.351
4	58.171	1.077	0.346	1.421
5	42.306	1.113	0.727	

7. Kahmard District

Stream order	Stream length (km)	Mean stream length	Stream length ratio	Bifurcation ratio
1	1294.104	1.547		2.235
2	552.313	1.476	0.426	1.647
3	325.479	1.433	0.589	2.414
4	104.052	1.106	0.319	1.220
5	82.509	1.071	0.792	5.923
6	16.426	1.263	0.199	

8. Khinjan District

Stream order	stream length (km)	Mean stream length	stream length ratio	Bifurcation ratio
1	391.636	1.483		2.467
2	174.758	1.633	0.446	1.877
3	84.076	1.475	0.481	0.904
4	69.512	1.103	0.826	5.25
5	6.972	0.581	0.100	

9. Khostwa firing District

Stream order	stream length (km)	Mean stream length	stream length ratio	Bifurcation ratio
1	822.050	1.621		2.425
2	311.132	1.488	0.378	1.194
3	234.186	1.338	0.752	2.464
4	96.200	1.354	0.410	1.918
5	41.223	1.114	0.428	

10.Nahrin District

Stream order	stream length (km)	Mean stream length	stream length ratio	Bifurcation ratio
1	559.301	1.532		1.921
2	316.407	1.665	0.565	2.533
3	123.028	1.640	0.388	2.272
4	48.244	1.461	0.392	1.137
5	36.164	1.247	0.749	1.526
6	19.069	1.003	0.527	

11.Pul-i-Khumri District

Stream order	stream length (km)	Mean stream length	stream length ratio	Bifurcation ratio
1	343.644	2.021		1.847
2	153.607	1.669	0.446	2.3
3	55.925	1.398	0.364	2.222
4	36.098	2.005	0.645	1.8
5	9.266	0.926	0.256	

12.Tala waBarfak District

Stream order	stream length (km)	Mean stream length	stream length ratio	Bifurcation ratio
1	912.779	1.621		2.491
2	373.090	1.650	0.408	1.248
3	238.818	1.319	0.640	2.445
4	86.050	1.162	0.360	2.312
5	30.021	0.938	0.348	1.333
6	21.120	0.880	0.703	

density, and more susceptibility to soil erosion.

Areal Aspects

Basin area, basin perimeter, and basin length 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 constant channel maintenance (C), length of overland flow (Lg), elongation ratio (Re), circulatory ratio (Rc), form factor (Rf), texture ratio (T), stream frequency (Fs), and drainage density (Dd).

Basin area

The calculation of different sub-watershed basins of the study area has been used ArcGIS 10.4.1 software, which is summarized in Table 4. The total area of the whole basin (Baghlan) was calculated as 21105.45 Km^2. Among the different sub-watersheds, the Kahmard and Pul-i-Khumri are the biggest (3545.89km^2) and smallest (704.47 km^2) basin areas.

Basin perimeter (P)

The basin perimeter is the outsideborder of the basin that surrounds its area. The perimeter of the individual sub-watersheds of the study area has been calculatedby ArcGIS 10.4.1. The linear measurement of the basin is basin perimeter that showsthe size and is mainly affiliated with the basin's topography. Among all the sub-watersheds, the Pul-i-Khumri observed the smallest perimeter (123.17 Km), and Kahmard showed the largest perimeter (258.73 Km), as shown in Table 4.

Basin length

Different researchers define basin length in different ways. However, in a simple way, the longest length in the basin, which starts from the catchment of point to the convergence point, is called basin length (Prabhakaran and Raj, 2018). Whereas the (Schumn, 1956) method, basin lengths of different sub-watersheds were calculated, the results of which have been summarized in Table 4. The results revealed that Pul-i-Khumri Has the shortest (40.47 Km) and Kahmard has the longest (111.31 Km) basin lengths. The basin length provides useful information regarding the basin's shape and size.

Drainage density (DD)

Drainage density varies with relief, rock properties, climate and vegetation, soil, and landscape evolution processes (Chorley and Morgan, 1962); (Kelson and Wells, 1989); (Oghchi, 1997); (Moglen *et al.*, 1998)). For example, the area with feeble and impermeable subsurface materials with high relief and less greenery indicate that the area has a high drainage density, whereas high permeable subsoil materials under heavy vegetation cover and low relief indicate that drainage density is low (Das *et al.*, 2012). To calculate the drainage density, ArcGIS-10.4.1 was used; the results have been shown in Table 5. Khost Wa Firing district observed the lowest Dd of 0.588 km/$km^{2,}$ and Baghlan City district showed the highest Dd of 0.963 km/km^2, which suggests that the drainage density is very coarse and the region is highly permeable in nature.

Table 3. Relief aspects of Baghlan province.

Baghlan Province				
No	Name of District	Relief Ratio Rh (m)	Ruggedness Number Rn (m)	Basin Relief (Bh) (m)
1	Andarab	0.063	2.36645	3772
2	BaghlanJadid	0.037	1.40689	1476
3	Baghlancity	0.047	1.46030	1515
4	Burka	0.094	2.58140	3449
5	Dahana-i-Ghori	0.066	2.58233	3394
6	Doshi	0.045	2.57268	3474
7	Kahmard	0.037	1.88067	2808
8	Khinjan	0.089	2.30622	3881
9	KhostWa Firing	0.060	2.41263	4099
10	Nahrin	0.061	2.28646	3451
11	Pul-i-Khumri	0.069	1.94225	2286
12	Tala WaBarfak	0.068	2.31549	4025

Stream frequency (FS)

The area with impermeable subsoil and steep gradients has high stream frequency with rapid surface runoff and consequently less time for infiltration. The stream frequency in the present study is low in the range of 0.274 to 0.651 in Burka district and Baghlan City district, respectively Table 5. The low stream frequencies in the study areas are characteristic of areas having low relief and high penetration volume of the underlying rock layer.

Tecture ratio (T)

The fundamental texture ratio depends on the penetration volume, rock layer, and relief aspects. In this study, the texture ratio is highest for Kahmard district (6.265) and lowest for Pul-i-Khumri district (2.679), as shown in Table 5, indicating high runoff and low penetrationvolume.

Form factor (RF)

The value varies in the form factor indicate that 0 are (highly elongated basin) and 1 (perfectly circular basin). In this study,the calculated form factor for 12 sub-watershed has been summarized in Table 5. The range of form factor values from 0.213 (Doshi district) to 0.600 (BaghlanJadid) shows that the formation of the basins is highly elongated to slightly elongated.

Circulatory ratio (RC)

The circulatory ratio is affected by several factors such as underlying lithology, slope, relief of the basin gradient, and stream discharge (Schumn, 1956); Strahler, 1964). In the circulatory ratio, high, medium, and low values reveal that the youth mature and old stage of tributary in the basin, respectively. Table 5 summarizes the circulatory ratio of different sub-watersheds of area, where the circulatory ratio

Table 4. Parameters for quantitative morphometry of basin.
Baghlan Province

No	Name of District	Basin Area km^2	Basin Perimeter (km)	Basin Length (km)
1	Andarab	2229.42	241.711	80.63
2	BaghlanJadid	1612.33	186.826	51.82
3	Baghlancity	785.33	135.731	42.23
4	Burka	803.77	135.577	44.92
5	Dahana-i-Ghori	1352.96	167.193	61.13
6	Doshi	1738.91	217.089	90.35
7	Kahmard	3545.89	258.73	111.31
8	Khinjan	1223.35	140.542	54.24
9	KhostWa Firing	2556.6	218.72	89.85
10	Nahrin	1663.59	177.52	70.16
11	Pul-i-Khumri	704.47	123.17	40.47
12	Tala WaBarfak	2888.83	226.87	74.63

Table 5. Areal aspects of Morphometric Analysis.
Baghlan Province

No	Name of District	Ddkm/km^2	Fs	T	Rf	Rc	Re	Lg	C
1	Andarab	0.627	0.401	3.698	0.342	0.479	1.037	0.313	1.593
2	BaghlanJadid	0.953	0.631	5.448	0.600	0.580	1.373	0.476	1.049
3	Baghlancity	0.963	0.651	3.860	0.440	0.535	1.175	0.481	1.037
4	Burka	0.748	0.274	2.703	0.398	0.533	1.118	0.374	1.336
5	Dahana-i-Ghori	0.760	0.442	3.582	0.362	0.607	1.066	0.380	1.314
6	Doshi	0.740	0.533	4.274	0.213	0.463	0.817	0.370	1.350
7	Kahmard	0.669	0.457	6.265	0.286	0.665	0.947	0.334	1.493
8	Khinjan	0.594	0.411	3.578	0.415	0.777	1.142	0.297	1.682
9	KhostWa Firing	0.588	0.390	4.567	0.316	0.671	0.997	0.294	1.698
10	Nahrin	0.662	0.427	4.005	0.337	0.663	1.030	0.331	1.509
11	Pul-i-Khumri	0.849	0.468	2.679	0.430	0.583	1.162	0.424	1.176
12	Tala WaBarfak	0.5752	0.380	4.848	0.518	0.704	1.276	0.287	1.738

ranges from 0.463 (Doshi) to 0.777 (Khinjan), indicating youth stage topography and elongated basins.

Elongation Ratio (RE)

Table 6 shows the basin shape in relation to the elongation ratio. Usually, values between 0.6-0.8 are commonly relatedto high relief and steep basins. Sub-watersheds of the area observed the ranges of elongation ratio between 0.817 (Doshi district) to 1.373 (BaghlanJadid district), as shown in Table 5, revealing that they are more elongated in nature.

Length of overland flow (LG)

Less value of overland flow indicates that the streams are short and integrated, 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 stream spacing, flow over longer lengths before draining into the mainstream and results in less erodibility (Patton and Baker, 1976). The results of this study (Table 5) exposed that the (Lg) in the sub-watershed level ranges between 0.287 to 0.481 in Tala Wa Barfak district and Baghlan City district, respectively. Nearly all or 12 district (Baghlan) has less susceptibility to erosion.

Constant channel maintenance (C)

The constant of channel maintenance (C) is the inverse of drainage density and is given as kilometer persquarekilometer (km/km^2) (Schumn, 1956). Mostly, the higher the values of constant channel maintenance, the greater is the rock permeability of the region. The calculated values of constant channel maintenance for different sub-watershed of the study area have been given in Table 5. The Baghlan City district observed the smallest values of constant channel maintenance as 1.037 km/km^2 and Tala Wa Barfak district as highest value as 1.738 km/km^2; it shows that Baghlan province has less permeability and high structural disturbance with high runoff conditions and high steep slopes.

Table 6. Elongation ratio and basin shape

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

Conclusion

The morphometric analysis in Baghlan province based on RS and GIS method are more appropriate because the calculation of morphometric parameters and the hydrological characteristics are helpful for the watershed level. GIS application help to find and evaluate the different parameters and shows the relationship between hydrological characteristics and morphometry drainage. Faulting and thrusting in the basin show the different variations of the elongated shapes. If the Rcof the basin is less than 1, it indicates that the penetration rate changed all over the basin. The Burka, Khost Wa Firing, and Tala Wa Barfak districts have low F_s, indicating that flow duration is shorter and main flow is longer. High F_s in Baghlan Jadid, Baghlan city, Doshi, and Pul-i-Khumri districts indicate that flow duration is longer and main flow is shorter. Tala Wa Barfak district constant channel maintenance is high compared to the other 11 sub-watershed, and it shows that runoff condition and disturbance structural is less. Khinjan, Khost Wa Firing, and Tala Wa Barfak districts have high values ofB_h, and it indicates that the basin has water infiltration is low, and the condition of runoff is high. The Rn value in the Burka, Doshi, Khinjan, Khost Wa Firing, and Nahrin districts is high, indicating that soil erosion susceptibility is higher. On the other hand, Baghlan Jadid, Baghlan city, and Pul-i-Khumri have high R_e and F_s. Andarab, Burka, Doshi, Khinjan, Khost Wa Firing having high B_h, and R_n. It shows which peak discharges and soil erosion are high. Thus, for the decreased peak discharge on the main channel, dams will support it.

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