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MORPHOMETRIC ANALYSIS OF TWO MAJOR SUB-BASINS OF HELMAND RIVER, AFGHANISTAN BASED ON GIS APPROACH

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ABSTRACT

An effort has been done to analyze morphometric parameters of the two major sub-basins of Helmand river viz. Upper, Middle Helmand sub basin, and Arghandab sub basin that cover about 61,260 km^2 and 76,583 km^2, respectively. These sub-basins further sub-divided into five and six sub-watersheds. Morphometric analysis is carried out for the sub-watersheds using ASTER DEM data and by means of geo processing tools in Arc-GIS. Twenty-one morphometric parameters are estimated for the study areas and are compared. The stream orders of the sub-basins are in the range of 7 and 8 and are mostly controlled by lower order streams. Bifurcation ratios for sub watersheds are in the rage of 3.9 to 4.5 that indicate that areas have suffered less structural disturbances. Form factor and elongation ratio indicate that the sub watersheds are less elongated. Rho coefficients for sub-watersheds are approximately 0.5, thus indicating higher hydrologic storage during the floods and reduction of effects of erosion during higher runoff. Overall, there is no major dissimilarity in the morphometric parameters of Upper & Middle Helmand drainage basin and Arghandab drainage basin. It expected that due to lack of hydrologic data of the basins the morphological analysis could be the basis for management of drainage basins.

Keywords*: Morphometric analysis, Upper and Middle Helmand sub-basin, Arghandab sub-basin, ASTER, DEM, Arc-GIS.*

INTRODUCTION

Afghanistan is a landlocked nation located within South and Central Asia. Its territorial area is 652,000 sq. km. One quarter of the territory lies above 2500 m of the sea level. About 82 % of Afghanistan's total land consists of rangeland and bare land. The forest cover is less than 2 % and about only 10 % of the territory is arable. The population of the country is approximately 32 million, making it the 42nd most populous country in the world. Rain and snowfalls are the main sources of river flow in Afghanistan. It has five major river basins. However, Afghanistan is unable to exploit properly its water potential due to lack of comprehensive strategy plan related to water issues. Different hydrological estimates like surface runoff, flood magnitude, soil erosion, ground water and its movements etc. require detailed watershed characteristics. Morphometry deals with the measurement and mathematical analysis of the configurations of the earth's surface, shape and dimensions of its landforms, Aggarwal et al., (1998). Morphometric studies in the field of hydrology were first initiated by Horton (1940) and Strahler (1950). Physical characteristics of the catchment such as area, shape, slope, and drainage channel patterns are some of the major static characteristics that influence the shape of the runoff hydrograph and volume due to a storm, K Subramanya (2015). The present study is an attempt to understand hydrologic response of Helmand River basin with the help of morphological parameters as record of required data to assess river flow is hardly available.

STUDY AREA

The upper & middle Helmand River and Arghandab river sub-basins have been chosen as the study area. These rivers are two main tributaries of the Helmand River that cover area of about 61,260 km2 and 76,583 km2, respectively (Figure 1).

Upper & middle Helmand river sub-basin is located between latitudes of 31.25 to 34.5 N and longitudes of 64.0 to 68.40 E, with elevations ranging from 738 m to 5020 m above sea level (Figure 2). This river basin originates in a westerly extension of the Hindu Kush mountain range near Paghman about 40 km west of Kabul, Takal et al., (2016). Moreover, travels west to Daykundi and Uruzgan for about 715 km to join with Arghandab River in Qali-e-Bust about 8 km south of Lashkar Gah. Generally, this river is rain/snow feed but rain is the main source of the water at the middle and low altitudes of the catchment. Water of this catchment is used for irrigation for different purposes viz. hydropower and drinking water, etc. There is one major reservoir existing in the upper drainage basin about 117 km upstream from Lashkar Gah with storage capacity of 1,844 Mm3 at the 91.4 m elevation (Whitney et al., 2006). Also at the middle part of Helmand River, a diversion dam is constructed in Gereshk district, which waters about 60,000 hectares land.

Arghandab river sub-basin is located between latitudes of 30.39 to 33.57 N and longitudes of 64.25 to 69.34E, from 735 m to 4584 m high from sea level (Figure 3). Arghandab River has two tributaries viz. Ternak and Arghastan Rivers, both are intermittent rivers in which water flows only in winter and spring season or whenever storm occurs. Arghastan River originates about 35 km from the north east of Gardeez city and travels about 500 km to south-west before joining Tarnak-Arghastan River at south west of Kandahar city. Arghandab River originates about 40km from Harzarjat north-west of Ghazni and travels around 498km before joining Tranak River at south-west of Kandahar city. Dahle is the only dam that has been constructed across Arghandab River by the capacity of 478.6 Mm3. Thought it is fed by both rainfall and snowfall but rainfall is the main source. Figure 1 shows River basins of Afghanistan, Helmand river basin & its two major basins with their sub-basins (SB).

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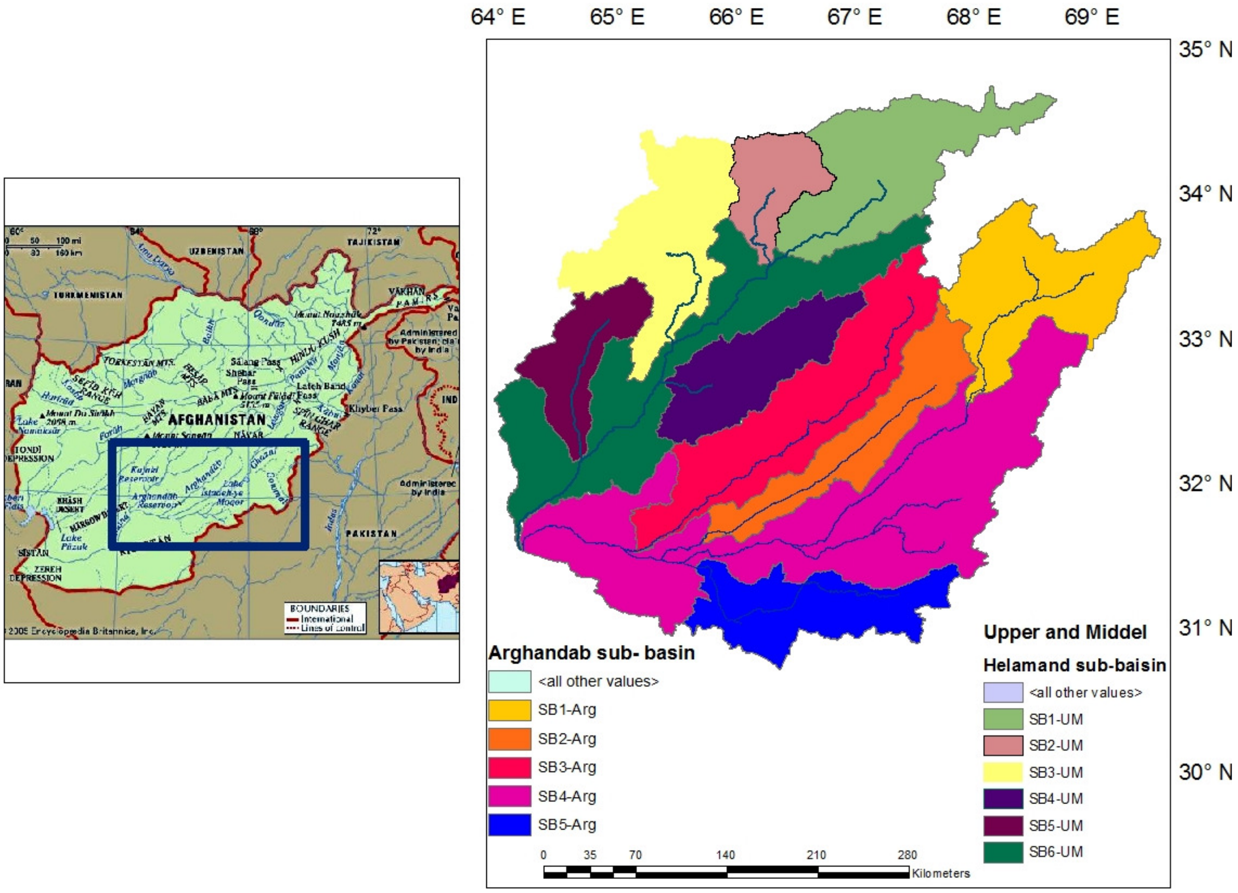

Fig. 1: Helmand river basin, Afghanistan & its two major sub-basins with their number of sub-watersheds

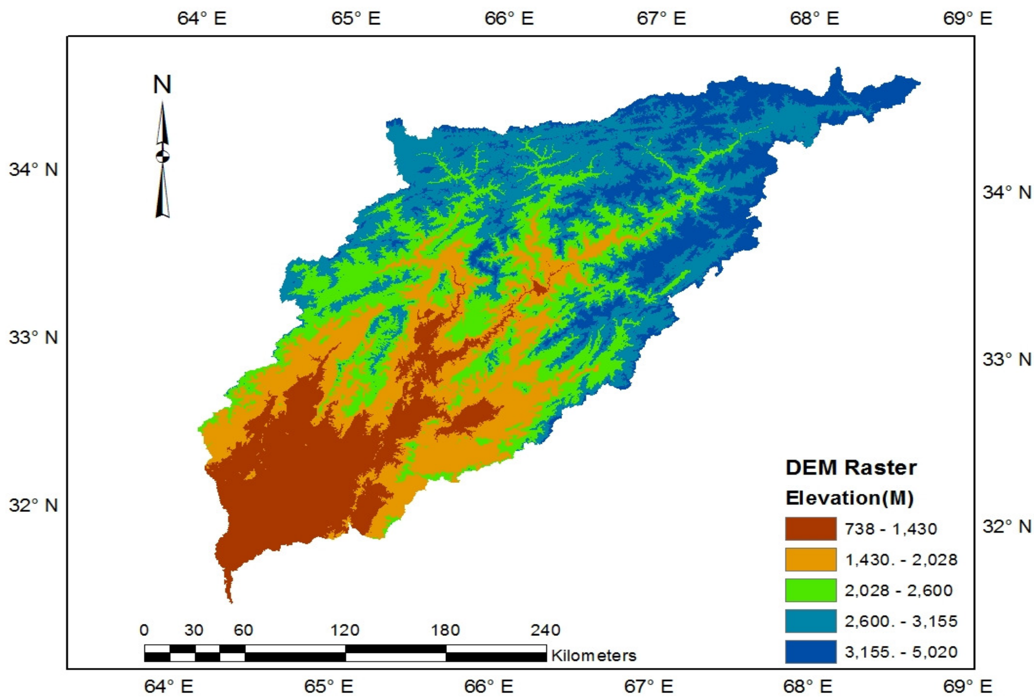

Fig. 2: Upper and Middle Helmand sub-watershed

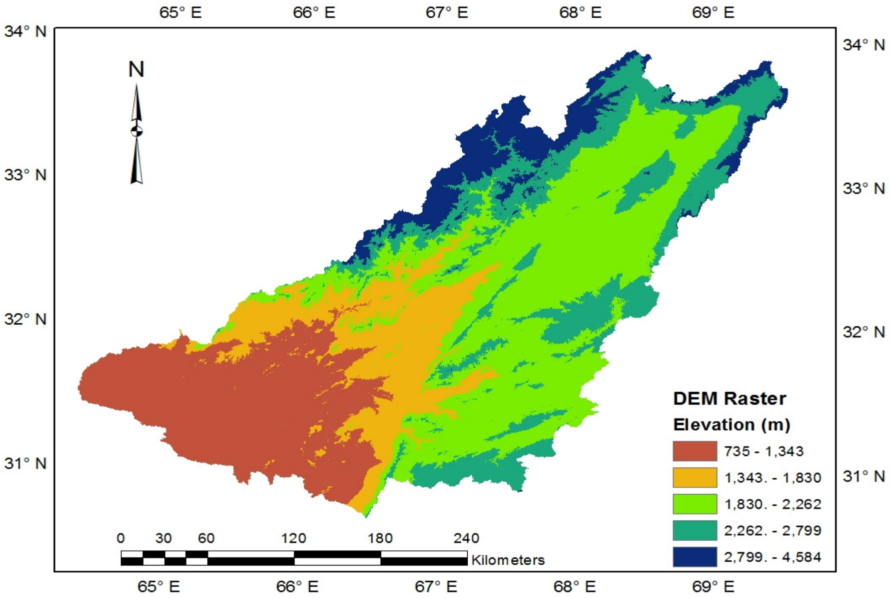

Fig. 3: Arghandab sub-watershed

METHODOLOGY

Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) digital elevation model (DEM) data has been used for the drainage map analysis of the study area. DEM data is having spatial resolution of 30 m and have been downloaded from freely available USGS website. Arc-GIS10.2 software is used for computing different morphometric parameters of the watershed. For many parameters, geo-processing menu Spatial Analysis tools are used whereas for longest flow path Arc-Hydro tool is used. Strahler's method is used for classification of stream order. Different mathematical relationships adopted for quantitative analysis of the different morphometric parameters are mentioned in Table 1. The symbols A, P and L used in the table are the area, perimeter and length of the basin. H and h are used for height and lowest elevations (outlet) of the basin.

Extraction of drainage network

For extraction of drainage network, filling of the DEM image, flow direction, and flow accumulation are done first respectively by using hydrology tools. To extract artificial stream network from a flow accumulation map, it is necessary to determine precisely a threshold, which is the percent of watershed total cells poured into the target cell. Choosing a low threshold leads to a high number of streams (smaller sub

Table 1: Morphometric parameters, mathematical relationships and reference

SN	Morphometric Parameters	Mathematical Relationship	References
1	Stream number(Nu)		Horton* (1945)
2	Stream length (Lu)	Lu= L1+L2+….+Ln	Horton* (1945)
3	Mean stream length (Lsm)		Strahler* (1964)
4	Drainage density (Dd)		Horton*(1945)
5	Stream length ratio (RL)		Horton*(1945)
6	Bifurcation ration (Rb)		Schumm* (1956)
7	Stream density(Fs)		Horton*(1945)
8	Total basin Relief (R), m		Strahler*(1952)
9	Form factor (Ff)		Horton* (1945)
10	Circularity ratio (Rc)		Strahler* (1964)
11	Elongation ratio (Re)		Schumm*(1956)
12	Rho coefficient (ρ)		Horton*(1945)
13	Lemniscate (K)		Chorley* (1957)
14	Fitness ratio(Rf)		Melton* (1957)
15	Drainage texture(Dt)		Horton* (1945)
16	Infiltration number(If)		Faniran* (1968)
17	Mean basin width(Wb)		Horton* (1945)

*Pareta & Pareta, 2011. "Quantitative Morphometric Analysis of a Watershed of Yamuna Basin, India using ASTER (DEM) Data and GIS", International of Geomatics and Geosciences, 2 (1), 248-268.

basins), and, on the contrary, choosing a high threshold will generate a small number of streams (larger sub basins). Therefore, the thresholds of 0.00368% (2500 cells) were employed for the extraction of stream network in this study. After delineation of watershed different parameters like area, shape length, stream order, slope map, aspect map, etc. are obtained by geo process tools. By the help of arc-hydro tools, the longest flow path is calculated for both the sub-basins. For stream ordering (Strahler, 1952) stream classification system was used where waterways are given an 'order' according to the number of additional tributaries associated with each waterway.

RESULT AND DISCUSSION

The total drainage area of both Upper and Middle Helmand as well as Arghandab river basin is about 137, 843km^2. The Upper and Middle Helmand river basin has been further subdivided in six sub-basins namely SB1-UM, SB2-UM, SB3-UM, SB4-UM, SB5-UM and SB6-UM as shown in Figure 1. Similarly, the Arghandab river basin has been further subdivided in five sub-basins namely SB1-Arg, SB2-Arg, SB3- Arg, SB4- Arg, and SB5- Arg as shown in Figure 1. The drainage patterns, which are influenced by the geology and topography of the area, for both basins are dendritic at higher elevations and at lower elevations are parallel to sub-parallel. The morphometric characteristics of any watershed aids in understanding the transmission pattern of hydrological regime and sediment load carried through the entire basin (Kumar et al., 2013). The morphometric parameters viz. linear, areal and slope aspects for both the drainage basins have been estimated and described in the subsequent sections.

(i) Liner Aspects of Drainage Basin

Liner aspect for the study area consists of stream order, stream number, stream length, mean stream length, mean stream length ratio and bifurcation ratio.

(a) Stream order

Stream order expresses the hierarchical relationship (Strahler, 1964) of the streams with respect to the main stream. The lowest permanent streams without any branch are called first order. Two first order streams link to form second order; two second order streams join to form a third order and so on. Smaller order streams joining a higher ordered stream do not change its order number. For Upper and Middle Helmand river basin, the stream order ranges from 1 to 7, while for the Arghandab river basin the stream order ranges from 1 to 8. The order segments are too high for first order stream and it decreases and becomes one segment at the highest order. Different orders of streams in different sub-watersheds of Upper and Middle Helmand as well as Arghandab river basins have been presented in Table 2 and 3.

(b) Stream number

The total number of streams in a particular order is called stream number of that order. The numbers of streams for each order in different sub-watersheds of Upper and Middle Helmand as well as Arghandab river basins have been given in Table 2 and 3. It can be seen that the number of streams decreases with increase in the order of the stream.

(c) Stream length

Stream length is the parameter, which provides the important information about drainage texture and slope of the area. Streams of comparatively smaller lengths specify drainage area with larger slopes and finer textures. While lengthier lengths of streams are generally indicative of flatter gradients (Sreedevi et al., 2012). On perusal of Table 2 and 3, it is observed that the stream length is higher for the first order stream and it decreases with increase in order.

Table 2: Linear Aspect parameters for Arghandab sub- watershed

SN	Parameter	SB1-Arg							SB2-Arg							
1	Stream order	I	II	III	IV	V	VI	VII	I	II	III	IV	V		VI	
2	Stream number	1765	427	101	23	5	1		1104	282	67	17	4		1	
3	Stream Length km (SL)	4607	2292	1168	541	238	186		3365	1643	727	197	87		306	
4	Mean SL, km	2.61	5.37	11.56	23.52	47.60	186		3.0	5.8	10.9	11.6	21.8		306	
5	Stream length ratio		2.06	2.15	2.03	2.02	3.91			1.9	1.9	1.1	1.9		14	
6	Bifurcation ratio		4.13	4.23	4.39	4.60	5			3.91	4.21	3.94	4.25		4	
SN	Parameter	SB3-Arg							SB4-Arg							
1	Stream order	I	II	III	IV	V	VI		I	II	III	IV	V		VI	
2	Stream number	2013	415	93	21	2	1		4036	1023	211	44	9		1	
3	Stream Length km (SL)	5038	2455	1168	548	243	269		11440	5802	2492	1154	925		446	
4	Mean SL, km	2.50	5.92	12.56	26.10	121.5	269		2.83	5.67	11.81	26.23	102.8		446	
5	Stream length ratio		2.36	2.12	2.08	4.66	2.21			2.00	2.08	2.22	3.92		4.34	
6	Bifurcation ratio		4.85	4.46	4.43	10.50	2			3.95	4.85	4.80	4.89		9	
SN	Parameter	SB5-Arg							whole basin							
1	Stream order	I	II	III	IV	V	VI	VII	I	II	III	IV	V	VI	VII	VIII
2	Stream number	1193	296	75	19	5	2	1	10841	2317	537	128	25	6	2	1
3	Stream Length km (SL)	3268	1654	688	347	193	124	80	27945	14027	6198	2858	1541	1038	461	198
4	Mean SL, km	2.74	5.59	9.17	18.26	38.6	62	80	2.58	6.05	11.54	22.33	61.64	173	230.5	198
5	Stream length ratio		2.04	1.64	1.99	2.11	1.61	1.3		2.35	1.91	1.93	2.76	2.81	1.332	0.86
6	Bifurcation ratio		4.03	3.95	3.95	3.80	2.5	2		4.68	4.31	4.20	5.12	4.17	3.0	2.0

Table 3: Linear Aspect parameters for Upper and Middle Helmand sub watershed

3:PA:	Parameter	SB1-UM						SB2-UM						
1	Stream order	I	II	III	IV	V	VI	I	II	III	IV	V	VI	
2	Stream number	1367	183	72	19	5	1	545	113	29	5	2	1	
3	Stream Length km (SL)	4097	1722	910	449	199	220	1488	694	423	103	68	124	
4	Mean SL, km	3.00	9.41	12.64	23.63	39.80	220	2.7	6.1	14.6	20.6	34.0	124	
5	Stream length ratio		3.14	1.34	1.87	1.68	5.53		2.25	2.37	1.41	1.65	4	
6	Bifurcation ratio		7.47	2.54	3.79	3.80	5.00		4.82	3.90	5.80	2.50	2.00	
SN	Parameter	SB3-UM						SB4-UM						
1	Stream order	I	II	III	IV	V	VI	I	II	III	IV	V	VI	
2	Stream number	1297	315	75	18	5	1	1007	242	51	13	4	1	
3	Stream Length km (SL)	3782	1768	882	330	250	295	2940	1341	753	318	81	166	
4	Mean SL, km	2.9	5.6	11.8	18.3	50.0	295	2.9	5.5	14.8	24.5	20.3	166	
5	Stream length ratio		1.92	2.10	1.56	2.73	6	0.46	0.56	0.42	0.25	2.05	0	
6	Bifurcation ratio		4.12	4.20	4.17	3.60	5.00		4.16	4.75	3.92	3.25	4.00	
SN	Parameter	SB5-UM						SB6-UM						
1	Stream order	I	II	III	IV	V	VI	I	II	III	IV	V	VI	VII
2	Stream number	783	167	41	12	3	1	1869	525	107	22	5	2	1
3	Stream Length km (SL)	1938	1051	459	222	124	125	6542	3158	1537	766	184	154	299
4	Mean SL, km	2.48	6.29	11.20	18.50	41.33	125	3.5	6.0	14.4	34.8	36.8	77.0	299
5	Stream length ratio		2.54	1.78	1.65	2.23	3.02		1.72	2.39	2.42	1.06	2.09	4
6	Bifurcation ratio		4.69	4.07	3.42	4.00	3.00		3.56	4.91	4.86	4.40	2.50	2

SN	Parameter	Whole Basin						
1	Stream order	I	II	III	IV	V	VI	VII
2	Stream number	8930	1838	414	96	24	5	1
3	Stream Length km (SL)	20809	9581	5063	2156	1062	965	446.6
4	Mean SL, km	2.33	5.21	12.23	22.46	44.25	193	446.6
5	Stream length ratio		2.24	2.35	1.84	1.97	4.36	2.31
6	Bifurcation ratio		4.86	4.44	4.31	4	4.8	5

(d) Stream Length Ratio

Stream length ratio is defined as the ratio of mean lengths of streams of one order to that of the next lower order (Horton, 1945). Stream length ratios for both sub watersheds has been provided in the Table 2 and 3. It is observed that Stream length ratio for Upper and Middle Helmand drainage basin varies from 0.42 to 0.91, whereas for Arghandab drainage basin value varies from 0.43 to 0.67.

(e) Mean Stream Length

Mean stream length is the ratio of total stream length of a particular order to the number of that order. Mean stream lengths for both watersheds are given in Table 2 and 3. For Upper and Middle Helmand sub-watershed value ranges from 2.33 to 446.60, however for Arghandab sub-watershed it ranges between 2.58 to 230.50.

(f) Bifurcation Ratio

Bifurcation ratio (Rb) of a basin is related to the branching shape of a drainage network, and is defined as the ratio between the total numbers of stream of one order to that of the next higher order in a drainage basin. The higher values of Rb show strong structural control in the drainage whereas lower values specify that the watersheds are less affected by structural disturbances (Malik et al. , 2011). For Arghandab sub watershed mean Rb ratio is 3.93 while for Upper and Middle Helmand sub watershed it is 4.57 as shown in Table 2 & 3 respectively. These values indicate that Arghandab sub watershed is less affected by structure disturbances compared to Upper and Middle Helmand river basin.

(ii) Areal Aspects of Drainage Basin

(a) Basin Area and perimeter

Area (A) and perimeter (P) of a basin are very important parameters. Based on these two the characteristics of the basin such as elongation ratio, form factor, circularity ratio etc. are calculated. Area and perimeter of the Arghandab sub watershed are 76583 km^2 and 3037 km respectively and for Upper and Middle Helmand sub watershed; these are 61260 km^2 and 2557 km respectively.

(b) Basin Length

The length of the basin (L) is defined as the length of the main stream measured from the basin outlet to the remotest point of the basin boundary (Subramanya, 2015). Basin length is evaluated for both sub watersheds. The basin flow lengths for Upper and Middle Helmand and Arghandab sub watersheds are 715 km and 829 km respectively.

(c) Basin Width

Basin width(W) is defined as the ratio of basin area to the length of basin (L); $W = A/L$. Basin width of Upper and Middle Helmand and Arghandab sub watershed are 99.8 km and 108.58 km respectively (Table 4 & 5).

(d) Lemniscate

The Lemniscate value (K) (Chorley, 1957) is used to determine the slope of basin. $K = Lb2\pi/4 * A$. The K value for the sub- watersheds are 7.04 and 6.55 respectively (Table 4 & 5).

(e) Form Factor

Form factor (Ff) is defined as the ratio of basin area to the square of the basin length (Horton, 1932). Smaller value of form factor indicates more elongated shape of the basin while larger value of form factor indicates its tendency to be a circular (Aher et al., 2014). Form factor for Upper and Middle Helmand sub watershed is 0.12, while for Arghandab sub watershed is 0.11 that is approximately the same for both (Table 4 & 5). The smaller values of Ff show that the watersheds are relatively elongated and will have flatter peak flow over an extended time.

(f) Circularity Ratio

Miller (1953) stated that circularity ratio is the ratio of the area of the basin (A) to the area of circle whose circumference is equal to that of perimeter of the basin. Circularity ratio designates the dendritic stage of a watershed (Rai et al., 2014).The circularity ratio (Rc) is influenced by the length and frequency of streams, geological structures, land use/land cover, climate, relief and slope of the basin (Vittala et al., 2004). Circularity for Arghandab sub watershed is 0.10 and for Upper and Middle Helmand sub watershed is 0.12 (Table 4 & 5).

(g) Elongation Ratio

Schumm (1956) defined elongation ratio (Re) is the ratio between the diameter of the circle (D) of the same area as the drainage basin and the maximum length of that particular basin. The range of elongation ratio (Re) generally vary from 0.6 to 1.0 associated with a wide variety of climate and geology and can be grouped into three categories i.e., circular (>0.9), elongated (0.9–0.8) and less elongated (<0.7) (Javed et al., 2009). Elongation ratios for the two sub- watersheds are 0.39 and 0.38 that indicate approximately the same ratio for both (Table 4 & 5).

(h) RHO coefficient

The Rho coefficient is an important parameter of a basin which facilitate evaluation of storage capacity of drainage network and hence, a cause of ultimate degree of drainage development in a given watershed (Horton 1945). Moreover, it is a ratio between the stream length ratio and bifurcation ratio. The Rho value for Upper and Middle Helmand, and Arghandab river basin are 0.55 and 0.51 respectively, Table (4, 5). These indicate higher hydrologic storage during the floods and reduction of effects of erosion during higher discharges.

(i) Fitness Ratio

Fitness ratio is defined the ratio of main channel length (CI) to perimeter of the watershed (Melton, 1957). The fitness ratio is sued to measure the topographic fitness of watershed. The fitness ratio for upper and middle Helmand sub-watershed is 0.28 and for Arghandab sub watershed is 0.27 (Table 4 & 5).

(j) Stream density

Stream frequency is the total number of stream segments of all orders per unit area of the basin (Horton, 1932). Stream frequency having lower Fs values represents low relief and permeable sub surface material whereas, watersheds with higher Fs values show resistant/low conducting subsurface material, sparse vegetation and high relief (Javed et al., 2009). For Upper and Middle Helmand sub watershed stream density is 0.18, while stream density for Arghandab sub watershed is 0.18 Table (4, 5).

(k) Drainage Density

Drainage density (D) expresses the closeness of spacing of channels. It is the measure of the total length of the stream segment of all orders per unit area (Moneim et al., 2005). From values of drainage density obtained over a wide range of geologic and climatic types, it has been observed that a low drainage density is more expected to occur in areas of highly resistant land surface having permeable subsoil material, dense vegetative cover and low relief. While high drainage density is the resultant of weak or impermeable subsurface material, thin vegetation and mountainous relief (Grohmann et al., 2004). Drainage density for Upper and Middle Helmand sub water is 0.65 and for Arghandab sub watershed is 0.71 (Table 4 & 5).

(l) Drainage Texture

Drainage texture is defined as the ratio of all stream segments order of basin to the perimeter of that basin Horton (1945). In addition, is one of the important concepts of the geomorphology that means that the relative spacing of drainage lines, and is on the underlying lithology, infiltration capacity and relief aspect of the land, Kuldeep Pareta et al., (2011). Smith (1950) has classified drainage texture in to five different textures such as, very coarse less than 2, coarse form 2 to 4, moderate form 4 to 6, fine from 6 to 8, and very fine >8. For Upper and Middle Helmand, and Arghandab sub watershed drainage texture are 4.42 and 4.56 respectively, which show moderate texture for both, Table (4, 5).

(m) Infiltration Number

The infiltration number is the multiplication of drainage density and stream frequency $If = Dd * Sf$. The infiltration number For Upper and Middle Helmand and Arghandab sub watersheds are 0.12 and 0.13 (Table 4 & 5) respectively. High value of infiltration number indicates lower infiltration capacity and higher runoff (Pareta et al., 2011).

(n) Relief

The maximum basin relief is the elevation difference in meters between the catchment outlet and the highest point on the basin perimeter (Subramanya , 2015). Relief for the Upper and Middle Helmand sub watershed was observed about 4302 m and for Arghandab sub watershed was about 3890 m (Table 4 & 5).

(iii) Slope Aspect of Drainage Basin

(a) Slope

Slope is one of the most important and specific feature of the earth's surface form. Soil erosion and flow line of surface water are influenced by slope of that area. Maximum slope is well noticeable in the way of a channel reaching downwards on the ground surface (Rai et al., 2014).

Table 4: Areal Aspect parameters for Upper and Middle Helmand sub watershed

SN	Parameters	Upper and Middle Helmand Sub-watershed						
		SB1-UM	SB2-UM	SB3-UM	SB4-UM	SB5-UM	SB6-UM	Entire Basin
1	Area (A) Sq. km	12387	4734	11670	8216	5915	18336	61260
2	Perimeter (p)	1156	499	1135	794	697	2278	2557
3	Basin Length (l)	356	209	351	237	225	606	715
4	Form factor	0.11	0.11	0.09	0.15	0.12	0.05	0.12
5	Circulatory Ratio	0.12	0.24	0.11	0.16	0.15	0.04	0.12
6	Elongation Ratio	0.37	0.37	0.35	0.43	0.39	0.25	0.39
7	Stream density	0.13	0.15	0.15	0.16	0.17	0.14	0.18
8	Drainage density	0.61	0.61	0.63	0.68	0.66	0.69	0.65
9	RHO coefficient	0.60	0.60	0.67	0.76	0.59	0.61	0.55
10	Lemniscate (K)	7.15	7.24	8.29	5.37	6.72	15.72	6.55
11	Fitness Ratio	0.29	0.42	0.31	0.30	0.32	0.27	0.28
12	Drainage Texture	1.42	1.39	1.51	1.66	1.44	1.11	4.42
13	Infiltration number	0.08	0.09	0.09	0.11	0.11	0.10	0.12
14	Basin width	36.87	22.65	33.25	34.67	26.29	30.26	85.68
15	Relief	3599	2762	2878	3047	2394	4081	4302
16	Length area relation	364	204	351	284	233	460	949

Table 5: Areal Aspect parameters for Arghandab sub watershed

SN	Parameters	Arghandab sub watershed					
		SB1-Arg	SB2-Arg	SB3-Arg	SB4-Arg	SB5-Arg	Entire Basin
1	Area (A) Sq. km	12171	8648	15045	31615	9103	76583
2	Perimeter (p)	1151	1112	1395	2931	1224	3037
3	Basin Length (l)	299	386	498	715	360	829
4	Form factor	0.14	0.06	0.06	0.06	0.07	0.11
5	Circulatory Ratio	0.12	0.09	0.10	0.05	0.08	0.10
6	Elongation Ratio	0.42	0.27	0.28	0.27	0.30	0.38
7	Stream density	0.19	0.17	0.17	0.17	0.17	0.18
8	Drainage density	0.74	0.73	0.65	0.70	0.70	0.71
9	RHO coefficients	0.54	1.02	0.51	0.53	0.53	0.51
10	Lemniscate (K)	5.77	13.52	12.94	14.00	11.18	7.04
11	Fitness Ratio	0.26	0.35	0.36	0.26	0.29	0.27
12	Drainage Texture	2.02	1.33	1.82	1.82	1.30	4.56
13	Infiltration number	0.14	0.12	0.11	0.12	0.12	0.13
14	Basin width	40.71	22.40	30.21	42.10	25.29	92.38
15	Relief	2609	2751	3703	2584	2197	3890
16	Length area relation	360	293	409	638	302	1085

(b) Aspect

Aspect is defined as the direction of slope face. The aspect of slope of an area can make very important effects on its local climate conditions as the sun's rays are in the west at the hottest time of day means in the afternoon, and so in most cases a west facing slope will be heater than sheltered east facing slope (Rai et al., 2014).

CONCLUSION

Total 21 morphometric parameters have been analyzed for two main sub- basins of Helmand River using Arc-GIS 10.2. Morphometric analysis demonstrate that the bifurcation ratio for both sub- basins are in the rage from 3.9 to 4.5 which indicate that area has suffered less structural disturbance and the drainage pattern is not distorted. Rho coefficients for both sub-basins are 0.5, hence indicating higher hydrologic storage during the floods and reduction of effects of erosion during elevated discharge. Arghandab sub-basin has infiltration number as 0.13 indicating higher runoff and low infiltration. Upper and Middle Helmand sub-basin is having infiltration number as 0.12. Thus, lower runoff and higher infiltration compared to Arghandab sub-basin. Form factor and elongation ratio values leads to the conclusion that both sub-basins are less elongated and inclined to circularity shape. Drainage density value of Upper and Middle Helmand sub-basin indicate that it has permeable sub soil material with poor drainage. However, Arghandab sub-basin has less permeable sub soil material. Drainage patterns for both sub-basins are dendritic at higher elevations while parallel to sub-parallel in the lower elevations. Overall, there is no major dissimilarity in the morphometric parameters of Upper and Middle Helmand and Arghandab drainage basins. It is expected that due to lack of hydrologic data of the basins the morphological analysis can be the basis for management of drainage basins.

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