Supplementary Figures

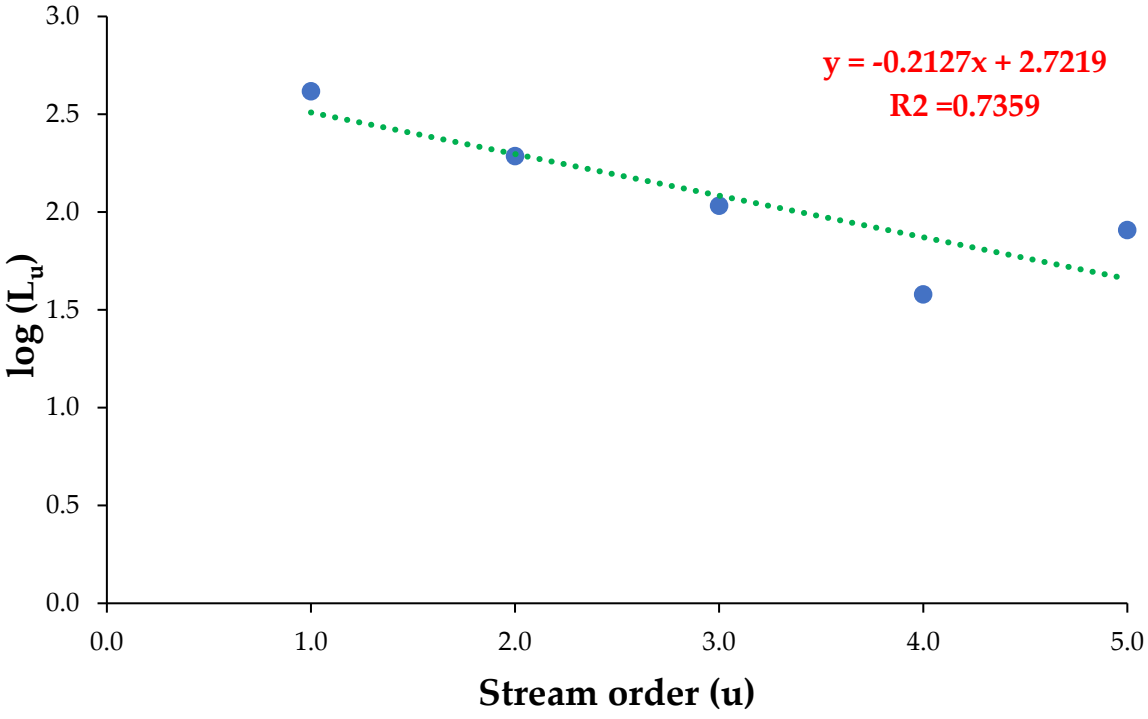

Figure S1. Scatter plot for normalized stream length ratio computation in the Nandhour-Kalish River watershed.

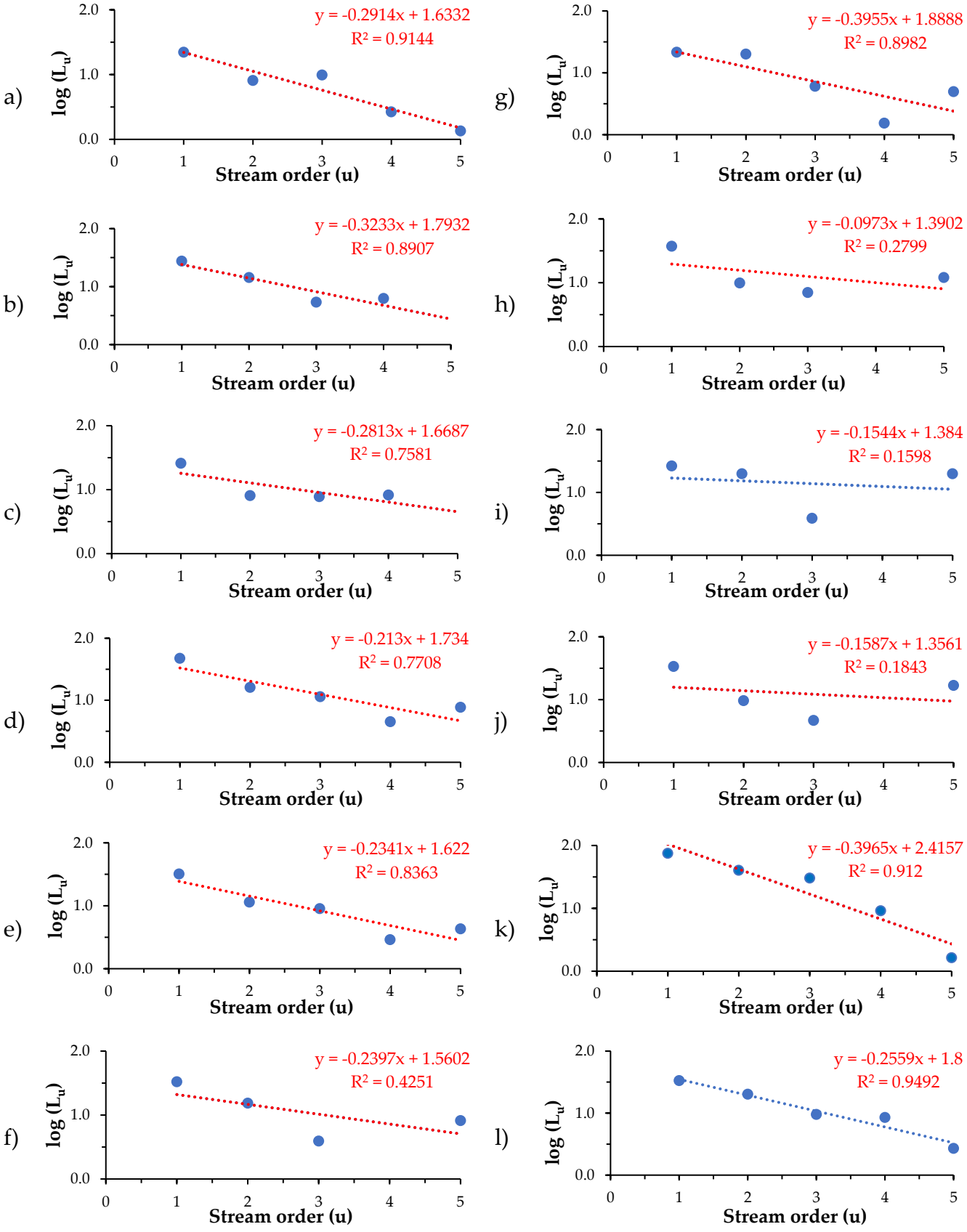

Figure S2. Scatter plot for normalized stream length ratio computation in the sub-watershed (a) to (l) SWS1-SWS-12, respectively.

Appendix B

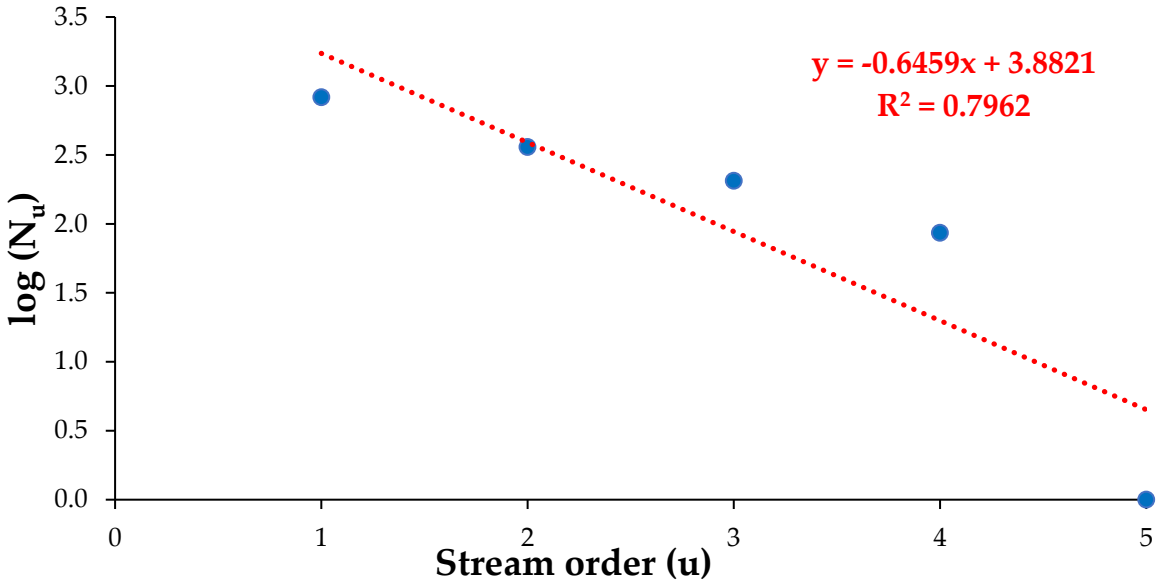

Figure S3. Scatter plot for computation of normalized bifurcation ratio in Nandhour-Kalish River watershed.

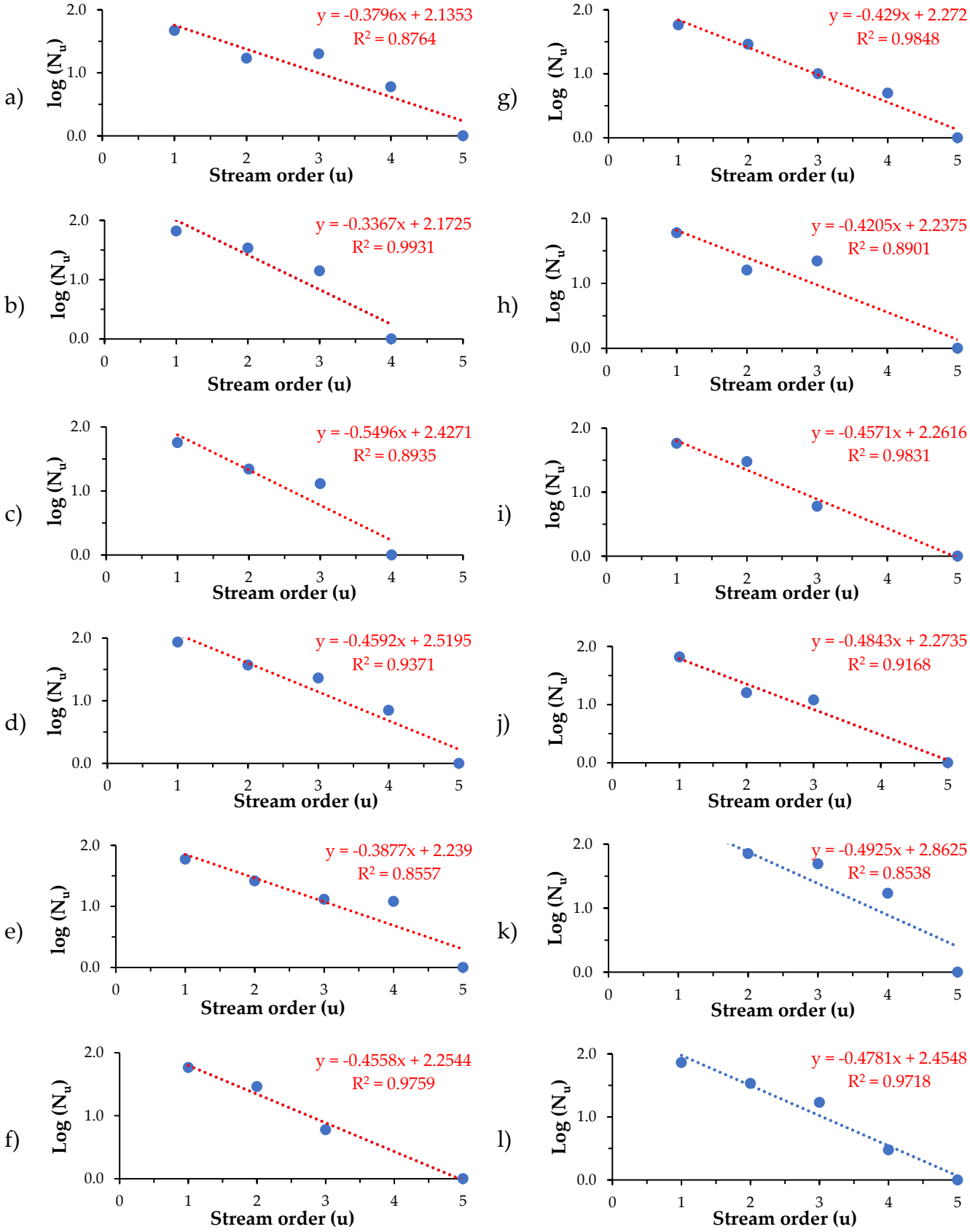

Figure S4. Scatter plot for computation of normalized bifurcation ratio in sub-watershed (a) to (l) SWS1-SWS-12, respectively.

(a) (b)

Figure S5. A basic structure of (a) farm ponds and (b) check dams.

Supplementary Tables

Table S1. Details of various datasets used for developing thematic maps in the study.

S. No.	Type of data	Details of data	Source of data
1	Toposheet	53O11, 53O12, 53O15, 53O16, 53P9, 53P13 On a scale of 1: 50,000	Survey of India (SOI), Dehradun, Uttarakhand
2	DEM (Digital Elevation Model)	ASTER DEM data (12.5m x 12.5m resolution)	Alaska Satellite Facility (ASF)
3	Soil	Northern India (Plate 199)	National Atlas & Thematic Mapping Organization, Department of Science & Technology, Government of India
4	Land use and land cover	Copernicus Global Land Cover Layers (2020)	United Nations (UN) and Food and Agriculture Organization (FAO)

Table S2. Drainage density categorization.

Drainage density (Km/Km²)	Drainage texture
Less than 2	Very coarse
2 to 4	Coarse
4 to 6	Moderate
6 to 8	Fine
Greater than 8	Very fine

Table S3. Categorization of the length of overland flow.

Value	Length of overland flow
Less than 0.2	Low

0.2 to 0.3	Medium
More than 0.3	High

Table S4. Basin shape classification based on elongation ratio.

Elongation ratio	Shape of basin
Less than 0.7	Elongated
0.7 to 0.8	Less elongated
0.8 to 0.9	Oval
Greater than 0.9	Circular

Table S5. Watershed Classification based on HI.

HI value	Watershed development stage
Greater or equal to 0.60	Youthful or In-equilibrium stage
0.60 to 0.35	Equilibrium or Mature stage
Less than 0.35	Monadnock or Old stage

Table S6. Recommended potential locations of water conservation structures.

Structure(s)	Slope (%)	Runoff potential	Stream order	Catchment area (ha)	Soil type
Farm pond	0 to 5	Moderate/High	1st	1 to 2	Sandy clay loam
Check dam	Less than 15	Moderate/High	1st to 4th	Greater than 25	Sandy clay loam

Table S7. The area, perimeter, and basin length of the Nandhour-Kailash River watershed and sub-watersheds.

Sub watersheds (Name)	Area (Km^2)	Perimeter (Km)	Basin length (L, Km)
SWS1 (Aligad)	29.092	31.05	8.899
SWS2 (Kundal)	36.809	41.45	10.171

SWS3 (Lowarnala North)	31.193	42.52	9.258
SWS4 (Lobchla West)	54.529	52.85	12.715
SWS5 (Deotar)	35.719	37.57	9.999
SWS6 (Bhalseni)	38.332	38.95	10.408
SWS7 (Uparla Gauniyarao)	33.158	45.20	9.585
SWS8 (Balot South)	34.900	52.17	9.860
SWS9 (Nandhour)	32.662	65.52	9.504
SWS10 (Nakoliy)	32.319	60.75	9.447
SWS11 (Saraunj)	76.062	99.77	15.361
SWS12 (Odra)	40.408	52.12	10.725
BASIN (Nandhour-Kalish)	474.094	276.20	43.433

Table S8. Linear aspects of Nandhour-Kailash River watershed and its sub-watersheds.

Morphometric parameter		**Formula**	**Value**
Stream order (u)		Hierarchical rank	**-**
Stream number (N_u)		$N_u = N_1+N_2+N_3+....$	**1481**
	1st order	N_1	828
	2nd order	N_2	361
	3rd order	N_3	205
	4th order	N_4	86
	5th order	N_5	1
Stream length (L_u, Km)		Length of Stream	**833.059**
	1st order	L_1	413.904
	2nd order	L_2	193.019
	3rd order	L_3	107.496
	4th order	L_4	37.855

	5th order	L_5	80.785
Average stream length (L_u', Km)		$L_u' = \frac{Lu}{Nu}$	**16.556**
	1st order	L_1'	0.499
	2nd order	L_2'	0.534
	3rd order	L_3'	0.524
	4th order	L_4'	0.440
	5th order	L_5'	80.785
Stream length ratio (R_L)		$R_L = \frac{Lu}{L(u-1)}$	**0.612**
		L_2/L_1	0.466
		L_3/L_2	0.556
		L_4/L_3	0.352
		L_5/L_4	2.134
Bifurcation ratio (R_b)		$R_b = \frac{Nu}{N(u+1)}$	**4.424**
		N_1/N_2	2.293
		N_2/N_3	1.760
		N_3/N_4	2.383
		N_4/N_5	86.00
Basin length (L, Km)		$L = 1.312 \times A^{0.568}$	**43.433**

Table S9. Order-wise number of streams, stream length, and average stream length values of sub-watersheds for the Nandhour-Kailash River watershed. 1

Sub watersheds	No. of streams (N_u)						Stream length (L_u, Km)						Average stream length (L_u', Km)				
	Order No.						Order No.						Order No.				
	1st	2nd	3rd	4th	5th	Total	1st	2nd	3rd	4th	5th	Total	1st	2nd	3rd	4th	5th
SWS1	47	17	20	6	1	91	22.055	8.075	9.839	2.649	1.345	43.963	0.469	0.475	0.492	0.442	1.345
SWS2	66	34	14	1	0	115	27.335	14.280	5.369	6.239	0.00	53.223	0.414	0.420	0.384	6.239	-
SWS3	57	22	13	1	0	93	25.800	8.057	7.758	8.248	0.00	49.868	0.453	0.366	0.597	8.248	-
SWS4	86	37	23	7	1	154	47.254	16.042	11.380	4.496	7.681	86.853	0.549	0.434	0.495	0.642	7.681
SWS5	59	26	13	12	1	111	31.804	11.380	8.952	2.877	4.269	59.260	0.539	0.437	0.689	0.240	4.269
SWS6	58	29	6	0	1	94	32.975	15.298	3.898	0.00	8.167	60.338	0.569	0.528	0.650	-	8.167
SWS7	58	29	10	5	1	103	21.437	20.002	6.057	1.534	4.955	53.985	0.370	0.690	0.606	0.307	4.955
SWS8	60	16	22	0	1	99	37.216	9.860	7.003	0.00	12.039	66.118	0.620	0.616	0.318	-	12.039
SWS9	58	30	6	0	1	95	26.335	19.837	3.869	0.00	19.837	69.898	0.454	0.661	0.645	-	19.837
SWS10	66	16	12	0	1	95	33.601	9.603	4.648	0.00	16.754	64.606	0.509	0.600	0.387	-	16.754
SWS11	142	71	49	17	1	280	74.729	40.181	30.231	9.116	1.633	155.89	0.526	0.566	0.617	0.536	1.633
SWS12	73	34	17	3	1	128	33.339	20.062	9.491	8.487	2.693	74.072	0.457	0.590	0.558	2.829	2.693

Table S10. Stream length and bifurcation ratio values of sub-watersheds for the Nandhour-Kailash River watershed.

Sub watersheds	Stream length ratio (R_L) = L_u/L_{u-1}					Bifurcation ratio (R_B) = Nu/N_{u-1}				
	L_2/L_1	L_3/L_2	L_4/L_3	L_5/L_4	R_L	N_1/N_2	N_2/N_3	N_3/N_4	N_4/N_5	R_B
SWS1	0.366	1.218	0.269	0.508	0.511	2.765	0.850	3.333	6.00	2.396
SWS2	0.522	0.376	1.162	-	0.475	1.941	2.429	14.00	-	2.171
SWS3	0.312	0.963	1.063	-	0.523	2.591	1.692	13.00	-	3.544
SWS4	0.339	0.709	0.395	1.708	0.612	2.324	1.069	3.286	7.00	2.878
SWS5	0.357	0.788	0.321	1.484	0.583	2.269	2.00	1.083	12.00	2.441
SWS6	0.464	0.255	-	-	0.575	2.00	4.833	-	-	2.856
SWS7	0.933	0.303	0.253	3.230	0.402	2.00	2.90	2.00	5.00	2.685
SWS8	0.265	0.710	-	-	0.799	3.750	0.727	-	-	2.633
SWS9	0.753	0.195	-	-	0.700	1.933	5.00	-	-	2.864
SWS10	0.286	0.484	-	-	0.695	4.125	1.333	-	-	3.050
SWS11	0.538	0.752	0.302	0.179	0.401	2.00	1.449	2.882	2.882	3.108
SWS12	0.602	0.473	0.894	0.317	0.554	2.147	2.147	5.667	3.00	3.006

Table S11. Different Areal aspects of the Nandhour-Kailash River watershed.

S. No.	Parameter	Software/formula	Value
1	Basin area (A, Km^2)	ArcGIS v10.4.1	474.094
2	Basin perimeter (P, Km)	ArcGIS v10.4.1	276.207
3	Drainage density (D_d, Km/Km^2)	$Dd = \frac{L_u}{A}$	1.757
4	Stream frequency (F_s, Km^{-2})	$Fs = \frac{N_u}{A}$	3.123
5	Drainage texture (T, Km^{-1})	$T = D_d \times F_s$	5.489
6	Length of overland flow (L_g, Km)	$L_g = \frac{1}{2D_d}$	0.878
7	Elongation ratio (R_e)	$R_e = \frac{1.128\sqrt{A}}{L}$	0.565
8	Circulatory ratio (R_c)	$R_c = 4\pi\left(\frac{A}{P^2}\right)$	0.078
9	Form factor (F_f)	$F_f = \frac{A}{L^2}$	0.251
10	Compactness coefficient (C_c)	$C_c = 0.2821\frac{P}{A^{0.5}}$	3.578
11	Shape factor (S_f)	$S_f = \frac{L^2}{A}$	3.979

Table S12. Hydrological area aspects of Nandhour-Kailash River sub-watershed.

Sub watersheds	Drainage density	Stream frequency	Drainage texture	Elongation ratio	Length of overland flow
SWS1	1.51	3.12	4.72	0.68	0.33
SWS2	1.44	3.12	4.51	0.67	0.34
SWS3	1.59	2.98	4.76	0.68	0.31
SWS4	1.59	2.82	4.49	0.65	0.31
SWS5	1.65	3.10	5.15	0.67	0.30

SWS6	1.57	2.45	3.86	0.66	0.32
SWS7	1.62	3.10	5.05	0.67	0.30
SWS8	1.89	2.83	5.37	0.68	0.26
SWS9	2.14	2.90	6.22	0.67	0.23
SWS10	1.99	2.93	5.87	0.66	0.25
SWS11	2.04	3.68	7.54	0.64	0.24
SWS12	1.83	3.16	5.80	0.66	0.27

Table S13. Physical areal aspects of Nandhour-Kailash River sub-watershed.

Sub watersheds	Circulatory ratio	Form factor	Compactness coefficient	Shape factor
SWS1	0.37	0.360	1.623	2.722
SWS2	0.26	0.355	1.927	2.810
SWS3	0.21	0.363	2.147	2.747
SWS4	0.24	0.337	2.018	2.964
SWS5	0.31	0.357	1.773	2.799
SWS6	0.32	0.353	1.774	2.826
SWS7	0.20	0.360	2.214	2.770
SWS8	0.16	0.358	2.491	2.785
SWS9	0.09	0.361	3.234	2.765
SWS10	0.10	0.362	3.014	2.761
SWS11	0.09	0.322	3.227	3.102
SWS12	0.18	0.351	2.312	2.846

Table S14. Different relief aspects of the Nandhour-Kailash River watershed.

Aspects	Software/formula	Value

Maximum elevation (H, km)	GIS software analysis	2.084
Minimum elevation (h, km)	GIS software analysis	0.132
Basin relief (km)	H-h	1.951
Relative relief (R_r)	$\frac{H-h}{P} \times 100$	0.706
Relief ratio	$\frac{H-h}{L}$	0.044
Ruggedness number (R_n)	$(H-h) \times D_d$	3.428
Hypsometric integral (HI)	$\frac{\text{Mean elevation} - \text{Minimum elevation}}{\text{Maximum elevation} - \text{Minimum elevation}}$	0.481