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Morphometric Analysis and Prioritisation of Purinabal Watershed of Sind

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ABSTRACT- Prioritization of watersheds has grown in importance in natural resource management, particularly in the context of watershed management. The prioritizing approach finds the most important watersheds for management. Morphometric analysis has been widely used to prioritize watersheds since a basin's watershed features indicate its physical and morphological traits, which are used to synthesize its hydrological response. The current work attempts to prioritize micro-watersheds in the Sindh Catchment of Ganderbal district, Jammu and Kashmir, using morphometric metricsand GIS methodologies. Various morphometric characteristics, namely linear and shape parameters, were obtained for each micro-watershed using Survey of India (SOI) top of sheets at 1:50,000 scale and assigned rankings based on value relationship to arrive at a computed value for a final ranking of the micro-watersheds. The investigation found that the overall number and length of stream segments are greatest in first order streams and decrease as stream order increases.

KEYWORDS- morphometry, prioritization, watershed.

I. INTRODUCTION

The systematic study of the drainage encompasses within its bounds numerous aspects of its distributional and erosional character such as drainage patterns, drainage density i.e., the measure of the texture of dissection, drainage frequency, profile characteristics of the main and sub-streams, etc., guided by the controlling elements, such as, the degree of flatness of the area, the rock altitudes, structure and finally the climatic and biotic factors. Drainage lines of an area explain the existing three dimensional geometry of the region and help to describe its morphometric evolution process[1]. In geomorphology, morphometry is dedicated to the quantification of morphology[2]. Shape indices used in drainage basin morphometry relate to the quantification of basin shape and provide a means for describing the hydrological characteristics of a river basin and it is an important aspect of characteristic of watershed[3] .The morphometric study of the drainage basin provides accurate information of measurable features of stream network of the river basin. The various morphometric parameters like area, altitude, volume, slope, profile and texture of landforms comprise important parameters of study[4]. It could be used for prioritization of small sub-watersheds[5]. It is well recognized that the influence of drainage morphometry is very vital in understanding the topographical and landform developments, soil and erosional characteristics and also helps in any hydrological study like evaluation of groundwater potential and its management, basin management and environmental assessment. Drainage analysis is also very significant for watershed development and planning and also it provides knowledge about the basin characteristics in terms topographical and soil characteristics, runoff behavior, surface water potential etc[6]. Systematics study of drainage morphometric provides a quantitative description of the basin geometry to understand its geological and geomorphic history of drainage basin [3]and also provide useful evidence about the hydrological behavior of the rocks exposed within the river basin or watershed. Urban expansion and population growth in countries like India, leads to increasing stress on surface and ground water resources, because of continuous demand of water for irrigation and industrial requirements[7]. The latest geospatial technology i.e. remote sensing, GIS, and GPS has significant tools to overwhelmed most of the problems of land and water resources planning and proper development on the account of tradition of conventional methods of data process. There have been significant decreases in water storage in mountain glaciers and northern hemisphere snow cover. Shifts in the amplitude and timing of runoff in glaciers and snowmelt fed rivers and ice related phenomena in the rivers and lakes have been observed. Based on simulation of eleven glaciers in various regions, a volume loss of 60% of these glaciers is projected by 2050 thus reducing water availability during warm and dry periods in regions supplied by melt water from major mountain ranges. Globally, the areas of land classified as very dry has more than doubled since 1970s.

II. OBJECTIVE OF THE STUDY

The objectives of the present study are

- The main objective of this study is to estimate drainage basin morphometric characteristics for various parameters and analyses the impact of structural control on the drainage pattern of the basin.

- To utilize the geospatial technology towards visualizing the spatial dimension of land, climate and topographical data and to reveal the trends and their interrelationships.
- To identify the priority areas within the watershed for soil and water conservation.

III. PHYSIOGRAPHY OF STUDY AREA

The West Lidder catchment is located in the south eastern section of the Kashmir valley, between3409"01"N–3414'00"Nand7506'00"E–7523'29"E.(Figure1).The study area, which is located in the middle Himalayas and lies between the Pir Panjal range in the south and south east, the north Kashmir range in the north east, and the Zanskar range in the south west, has a unique geo-environmental setting that makes it a suitable niche for many important glaciers such as Kolahoi. West Lidder River, a left bank tributary of River Lidder that eventually drains as a right bank tributary of River Jhelum,carvedout the West Lidder watershed. It has a catchment area of 350.6 km2, which accounts for about 27.80% of the entire catchment area of the Lidder. The valley originates at the base of the Kolahoi snow field, giving birth to the West Lidder catchment. The latter connects to the East Lidder, which originates in another snow field named Sheshnag near the popular tourist destination of Pahalgam. From this point on, it is known as the River Lidder. After 70 kilometres [30 miles], the latter enters the Jhelum (upper stream of the Indus River) near Gur Village. The combined activity of glaciers and rivers has created a distinct topography in the West Lidder basin. At the Pahalgam rain gauge station, the average annual precipitation is 1267.2mm. The maximum rainfall of 1629mm was reported in 1994, and the lowest of 899.9 mm was recorded in 2000. The region experiences the most precipitation in March (208.8mm) and the least in October (45.9 mm). This sort of climatic regime is unique to the sub-Mediterranean climate. Further more,70% of its yearly precipitation falls between the winter and spring months. The Lidder Valley is located in the Pahalgam tehsil of the Anantnag district.. The Lidder River runs through the valley, passing through various natural features and tourist destinations including as Aru, Pahalgam, Betab Valley, and Akad. Mandlan, Laripora, Phraslun, Ashmuqam, and Seer Hamdan are the principal settlements in the Lidder Valley.

Figure. 1: Lidder catchment

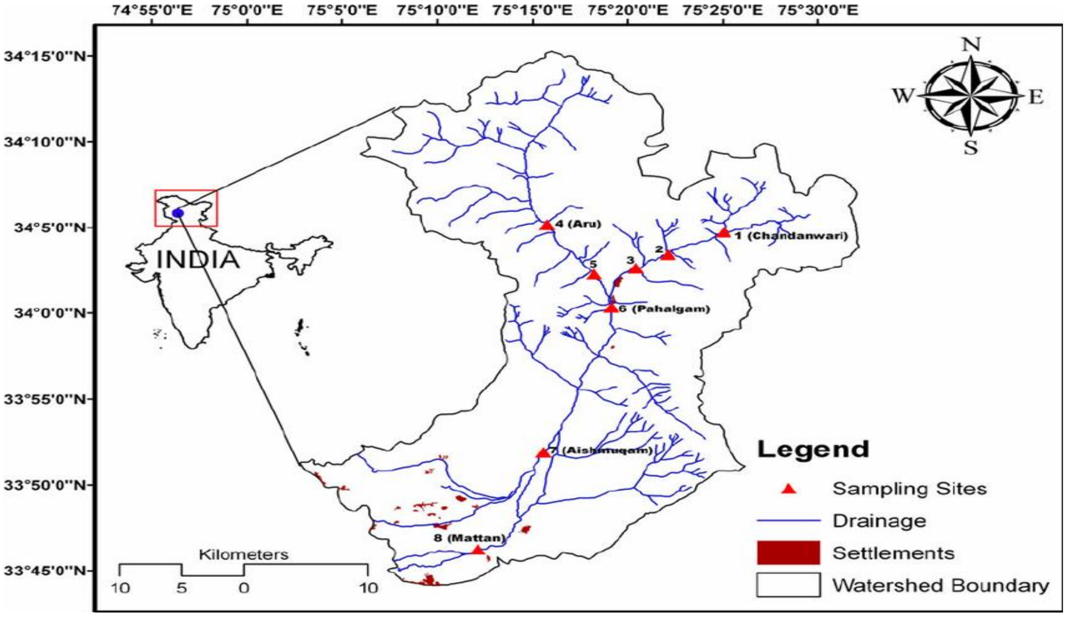

Figure. 2: Location map of the lidder basin

IV. METHODOLOGY

The detail of the data used and methodology adopted for accomplishing the research objectives are briefly discussed below

Geo referenced standard false colour composite (FCC) of Landsat etm+ data (30m resolution) of band combinations 2 (green), 3 (red) and 4 (near infrared) were downloaded from the website of United States Geological Survey (USGS); Earth Explorer http:// earthexplorer.usgs.gov. ASTER DEM (Digital Elevation Model) of 15m spatial resolution of DEM procured on 28th September 2012 by the TERRA satellite was also downloaded from downloaded from https://wist.echo.nasa.gov/api/ and was consequently developed for preparation of digital elevation model, slope and aspect map of the area. Digital terrain model (DTM) and Triangular

Irregular Network (TIN) model using ASTER DEM is also prepared only for the synoptic view of the Lidder basin . Many of the important basin morphometric characteristics pertain to three dimensional surfaces which are represented by a Digital Elevation. This was interpolated from the contours and spot heights using the ARC GIS-based Triangular Irregular Network (TIN) model extracted from DEM. The TIN-DEM was also converted to a grid model using an optimal grid size of 20 m to retain the maximum accuracy of the terrain characteristics.

Extraction of drainage network and assigning the stream order from Survey of India (SOI) topographical map for a large basin or watershed is a tedious job and it takes too much time to complete the work. To overwhelm this problem, The Arc hydro approach is used for drainage extraction which is more consistent and dependable tool when matched to a manual method[8]. A geo processing model was used for evaluating the morphometric parameters. The Lidder basin boundary and its main sub watershed is delineated from ASTER DEM data by the option given in the Arc GIS spatial analyst tool. The process requires a pour point, a ASTER DEM and user defined drainage areas input parameters for morphometric analysis. The pour point of the basin was chosen at the point where river lidder meets to the river Jhelum in pulwama.

The extracted drainage line will be ordered based on [10]system of classification. The highest stream order in the Lidder basin is computed as sixth order, which is the main Lidder basin River. The result of this process will create a basin/watershed boundary polygon from the flow direction raster data.

Table 1: Linear, areal and relief morphometric parameters used for lidder river basin

S.NO	Parameter	Formula	References	Results
A	Drainage Network			
1	Stream order (U)	Hierarchical rank	Strahler [3]	1 to 6
2	Stream length (Lu)	Length of the stream	Horton [14]	17820.69 km.
3	Mean stream length (Lsm)	Lsm = Lu/Nu	Strahler [3]	120.91 km.
4	Stream length ratio (RL)	RL = Lu/(Lu-1)	Horton [14]	0.48-0.85

5	Bifurcation ratio (Rb)	Rb=Nu/Nu+1	Schumm [15]	2.41-7.0
6	Mean bifurcation ratio (Rbm)	Rbm=average of bifurcation ratios of all order	Strahler [16]	6.31
7	Rho Coefficient (ρ)	Lur/Rb	Horton [14]	0.48
B	Basin Geometry			
8	Bain length (Lb)	Longest diagonal across the basin	Schumn [15]	535.277 km.
9	Basin width (W)	Longest vertical distance across the basin	Schumn [15]	226.39 km.
10	Mean basin width (Wb)	Calculated from average vertical distance across the basin	Horton [17]	128.65 km.
11	Basin perimeter (P)	Calculated from Lidder basin boundary in GIS	Schumn [15]	2520.64 km
11	Basin area (A)	Calculated from Lidder basin boundary in GIS	Schumn [15]	68863 sq.km.
12	Relative parameter (Pr)	Pr=A/P	Schumn [15]	27.32 km.
13	Length area relation (Lar)	Lar=1.4*A0.6	Horton [17]	1119.23
14	Lemniscate's (k)	k-Lb2/A	Chorley et al. [18]	4.16
15	Form factor (Ff)	Ff=A/L2	Horton [14]	0.248
16	Shape factor ratio	Sf=Lb2/A	Horton [14]	4.16
17	Elongation ratio (Re)	Re=D/L=1.128□A/L	Schumm [15]	0.553
18	Circulatory ratio	Rc=4□A/P2	Strahler [3]	0.13
19	Compactness coefficient (Cc)	Cc=0.2841*P/A0.5	Gravelius [19]	2.73
20	Fitness ratio (Rf)	Rf=Cl/P (Main channel length/Perimeter)	Melton [20]	0.31
21	Wandering ratio (Rw)	Rw=Cl/Lb	Smart & Surkan [21]	1.46
22	Watershed eccentricity (τ)	T = [(Lcm2-Wcm2)]0.5Wcm	Black [22]	3.76
C	Drainage Texture Analysis			
23	Drainage density (Dd)	Dd=Lu/A	Horton [14]	0.26
24	Drainage texture (Dt)	Dt=Nu/P	Horton [14]	2.78
25	Stream frequency (Fs)	Fs=Nu/A	Horton [14]	0.26
26	Length of overland flow (Lg)	Lg=1/Dx2	Horton [14]	1.93
27	Infiltration Number (If)	If=Fs*Dd	Faniran [23]	0.26
28	Constant of channel maintenance (Kms2/Km)	C=1/Dd	Schumn [15]	3.86
D	Relief Characteristics			
29	Total basin relief (R)	R=H-h (height of the mouth)	Strahler [10]	1196 m
30	Relief ratio (Rr)	Rr=R/L	Schumm [15]	2.23
31	Maximum relief (Z1)	Calculated from DEM data in GIS		1245
32	Absolute relief (Ra)	Calculated from DEM data in GIS		1245
33	Relative relief ratio (Rhp)	H*100/P	Melton [20]	47.45
34	Dissection index (Dis)	H/Ra	Singh & Dubey [24]	0.96
35	Gradient ratio (Rg)	Z-z/Lb	Sreedevi et al., [25]	2.23

36	Watershed Slope (Sw)	Sw =H/Lb	Sreedevi et al., [25]	2.23
37	Ruggedness Number (Rn)	Dd*(H/100)	Patton & Baker, [26]	3.10
38	Melton Ruggedness Number (MRn)	H/A0.5	Melton [20]	4.56

RESULT

The total basin area of the lidder is 68,863 km2. The drainage pattern is dendritic pattern and it is depended by the topography, geological and rainfall condition of the area. Aster DEM is used to make slope, aspect and contour maps of the basin. Based on the stream order, the Lidder basin is designated as sixth order basin to understand the morpho dynamic parameters as given. Five main selected sub-watershed of the Lidder basin river basin is shown in Fig.3

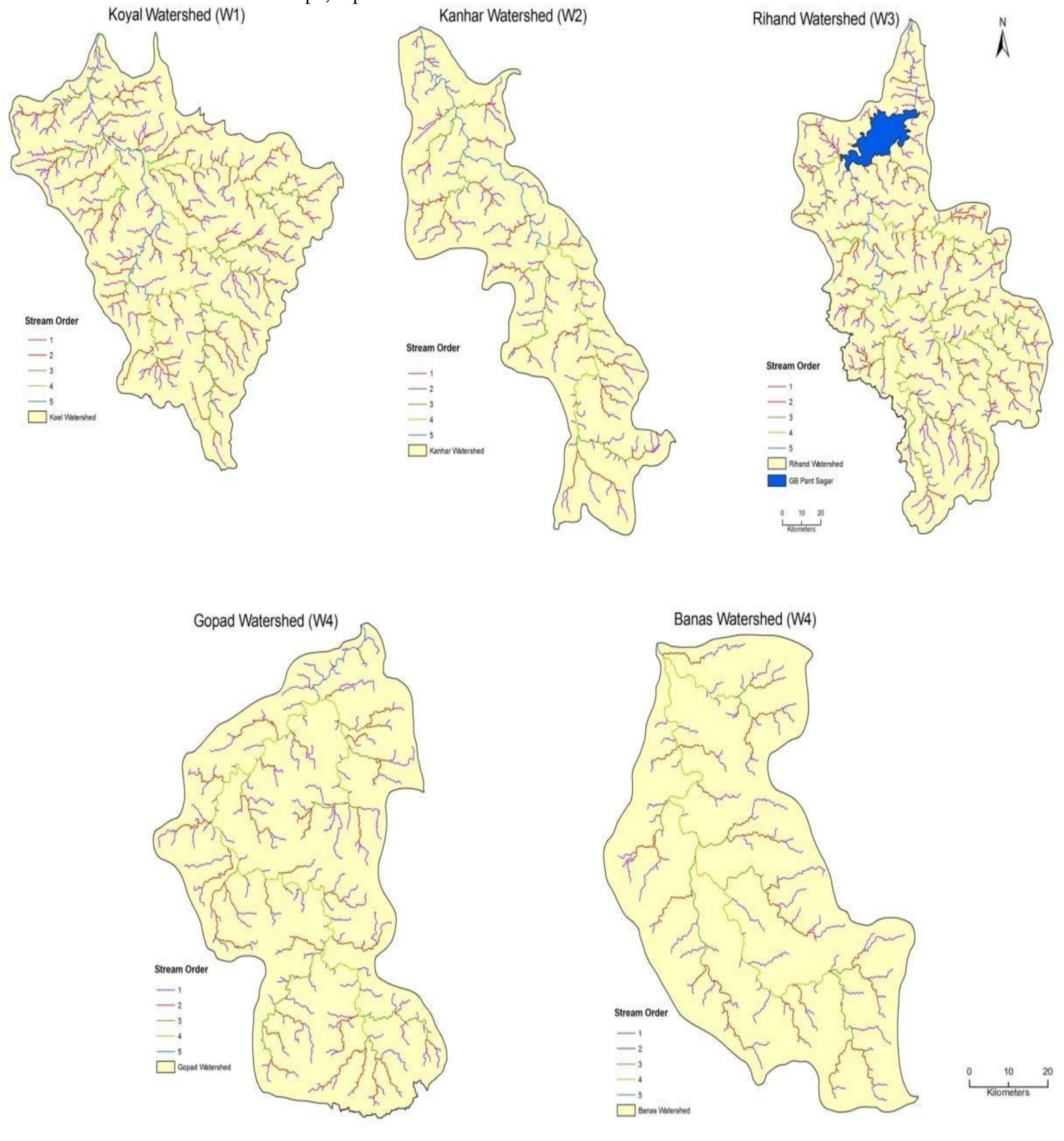

Figure. 3: Five main Sub-watershed of the lidder river basin

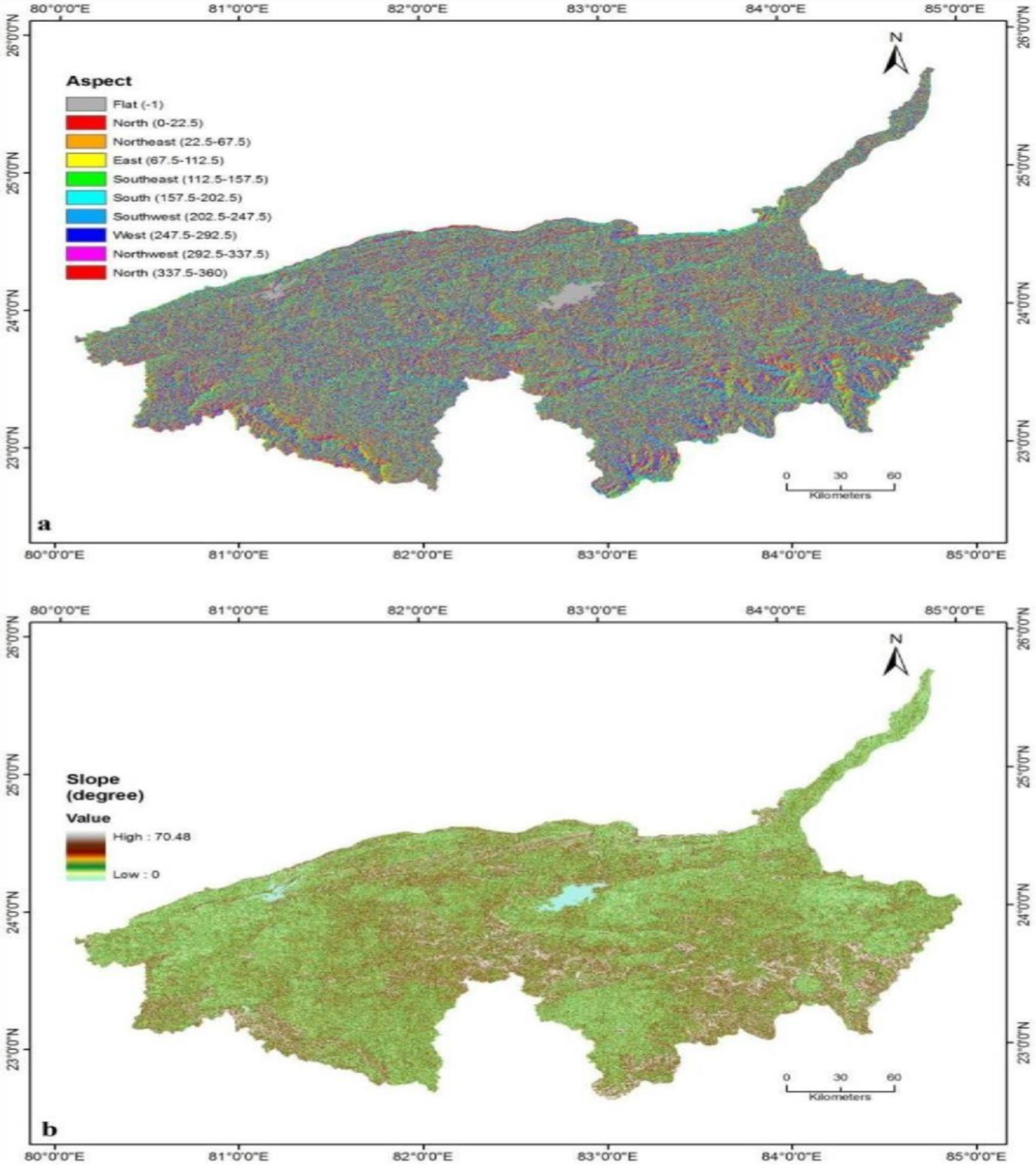

Figure. 4: Aspect (a) and Slope (b) of the lidder basin

Aspect of the basin

The aspect of topography is the direction to which it faces [11]. Aspect effects vegetation type, precipitation system, snow melt and wind contact. The aspect of the Lidder basin is shown in Fig.4a. In this study, it is clearly seen that the north -west (N-W) and north-east (N-E) facing slopes mainly occur in the lidder basin. Maximum part of the watershed shows east facing. As a result, these elevations have a higher viscosity and a lesser evaporation rate than the rest of the basin's slopes, which are more often west facing. The northern section of the plot is west facing, indicating that the slopes of these watersheds are drier and have a greater rate of evaporation. This has a significant impact on the distribution of vegetation and bio-diversity in the research region and is extremely beneficial to agricultural growth in the watershed

Slope of the basin

The gradient components are then assessed by climate -morphogenic mechanisms in places with varied resistance to rock .The elevation is related to the run-off speed, altering the time necessary for rain water to join the river beds that comprise the river basin network [12]. Slope evaluation is critical in morphometric and geo morphological investigations of the lidder basin. The elevation of the lidder basin ranges from 1.37° to >70.44°. (Fig. 4b). The lidder basin slope map is created in GIS using ASTER DEM data. A slope map gives information for watershed management for settlements, agriculture, deforestation, afforestation, planning of building of water collecting structures, engineering structures, morpho-conservation activities, and so on .

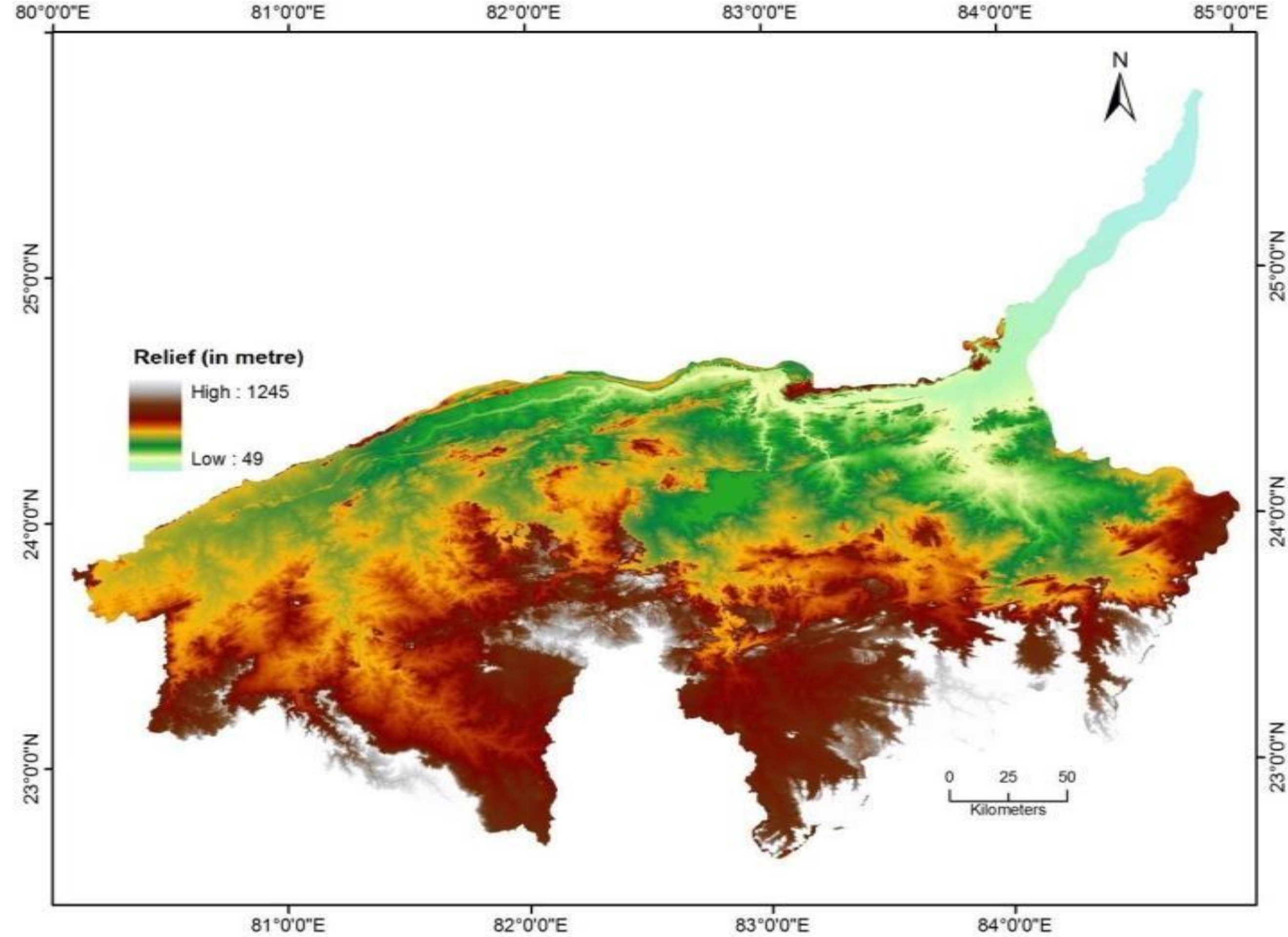

Figure. 5: Relief map of the Lidder basin

Relative relief

Relative relief is a critical morphometric measure for assessing the morphological properties of any terrain [13]. The largest relative relief value is determined to be 1245 m, while the minimum mean is 49 m (Fig. 5). The term "low relief" refers to the northern region of the lidder basin, which is flat to gently sloping. As a result of its flat form basin. The size of the subsidizing watershed, channel dimensions, and stream discharge all have a relationship with stream order .As river water flows from headwater streams to the stream's mouth, the breadth and thickness of the stream grow in proportion to the volume of water discharged .The Lidder basin features a dendritic drainage system that marks the study area's homogeneous subsurface layers. Dendritic drainage features a tree-like spreading pattern with uneven branching of tributaries in all directions and at any angle. Table 2 displays the order of the stream numbers as well as their linear properties.
Details of stream order of several tributaries of the lidder river and their sub watershed area is shown in table 2.

and proximity to water, the land could mostly be used on the agricultural operations along stream banks

Stream orders (Su)

Stream segmentation and hierarchical ordering are required to explain the hydrodynamic features of a drainage

Table 2: Five main sub-watershed area of LIDDER basin

Water shed no.	Name of the sub-watershed	Stream Order	Sub watershed Area (km^2)
1	(W1)	V	11961.23
2	(W2)	V	5654.17
3	(W3)	V	13698.60
4	(W4)	V	6091.86
5	(W5)	V	3661.99

Table 3: Stream length of different sub-watershed of LIDDER basin

		Stream Length (km)			
Sub watershed	I	II	III	I V	V
(W1)	1642.67	860.95	37.45	209.41	156.59
(W2)	1315.03	887.73	373.57	204.5	219.49
(W3)	1779.65	747.61	493.71	285.83	136.91
(W4)	838.04	442.92	146.16	116.29	32.29
(W5)	427.61	258.27	99.17	148.36	2.91

Table 4. Mean stream length (km) of sub-watershed of the lidder basin based on stream-order

		Mean Stream Length(km)			
Sub watershed	I	II	III	IV	V
(W1)	2.08	7.827	20.414	41.882	156.590
(W2)	3.82	16.439	31.131	102.250	219.490
(W3)	2.176	8.307	18.989	47.638	68.455
(W4)	1.584	7.637	13.287	38.763	32.290
(W5)	1.572	8.071	9.917	74.180	2.910

The result of order-wise stream length in lidder basin is shown in Table 4. It is clearly recogniz that the cumulative stream length is higher in first-order streams and decreases as the stream order increases. This difference is due to disparities in relief and lithology over which these stream segments occur. Stream length of different order under sub-watersheds of Lidder basin is given in Table 3. It is identified that the watershed shows maximum stream length (1779.65km) for the first order followed by 1642.67). Among all the five sub watershed of the lidder basin, the Banas shows minimum stream length in each order. The length of first order stream is 9232.24 km, second order stream is 4427.32 km., third order stream is 2098.93 km., and fourth order stream is 805 km, fifth order stream is 679.11 km., and sixth order stream 577.49 km. The highest stream order (6th) i.e. for lidder river has a length of 577.49 km. The change may designate flowing of streams from high elevation, lithological or structural difference and moderately steep slopes in the Lidder basin

V. CONCLUSION

The quantitative analysis and area distributional patterns of the primary morphometric features presented have aided in providing a complex picture of the surface in its heterogeneity to some extent. According to the findings of the study, remote sensing data in the assessment of drainage morphometric parameters, a GIS-based technique is preferable to traditional methods. The GIS-based technique allows for the examination of various morphometric parameters as well as the investigation of the link between the drainage morphometric and the features of la forms, soils, and eroded lands. The use of GIS modelling in conjunction with remote sensing has proven to be an efficient tool for understanding any terrain parameters such as the nature of bedrock, infiltration capacity, surface runoff, and soon, which aids in better understanding the status of land forms and their processes, drainage management, and the evolution of groundwater potential for watershed planning and management. The Son basin's calculated morphometric features show that lower order streams dominate this region. The research region has a sixth order (Son river) drainage basin, with first order streams having the longest total length of stream segments. The slope gradient ranges from 0to 70.48°, with a significant degree of slope seen in the research area's south-western and southern regions. It is observed that when stream order rises, stream frequency decreases and vice versa. In the case of first order streams, the largest stream order frequency is seen, followed by second order Streams. Lower order streams dominate the basin. In the basin, a greater stream number suggests reduced permeability and infiltration. The cumulative stream length is clearly characterized as being greater in first-order streams and decreasing as the stream order increases.This disparity is caused by differences in the topography and lithology of the areas where these stream segments occur.The stream length ratio between streams of various orders in the Son basin varies in each sub-watershed due to variations in slope and terrain, showing that the streams of the Lidder Watershed basin are in the late youth stage of geomorphic development.Based on the permeable nature of the subsurface material, the low discharge of runoff , and the low relief character of the terrain deduced from the values of the morphometric parameters, the basin region in general offers some potential for groundwater exploration. The current study is highly useful for basin and watershed development in the Son plateau area, and the extraction model will be used for time efficient analysis of the basin morphometric and aid planners and decision makers in basin development and management studies. The present is also highly beneficial for the long-term development of natural resource management at the Lidder Watershed basin's micro watershed.

CONFLICT OF INTEREST

The Authors declares that there is no conflict of interest

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