Morphometric Analysis of Shipra River Sub-Basin, India, Remote Sensing and GIS Approach

[1]Pradeepika Kaushik, [2]Parthapratim Ghosh
[1]DST-INSPIR SRF, [2]Assistant Professor
[1]Dept.of Geology, CAS
[1]Banaras Hindu University, India

Abstract: Morphometric analysis is the best quantitative parameter in the analysis of drainage characteristics of a river basin for watershed management plans in developing country. Morphometry is the overall calculations and mathematical analysis of the different configuration of the Earth's sub-surface, shape and dimensions of its landforms. Shipra River occupies in 5611 sq. km area with perimeter of 500 km and it's a tributary of Chambal River. Shipra River is of 5th order stream and has a mainly dendritic and rectangular channel pattern which controlled by structural, physiographic and lithological conditions. Morphometric analysis of Shipra sub-basin has been conducted using SRTM DEM (90m, 3 arc-seconds resolution) data in Arc-GIS 10.3. Shipra River originates from Indore district at latitude 22°38'21.39"N and longitude 76° 2'9.81"E with an elevation of 1839 ft on Malwa plateau and it has completed its 214 km journey with confluence in Chambal river at latitude 23°55'4.70"N and longitude 75°27'39.54"E, at the elevation of 1375 ft. Overall drainage density in the basin is 0.35 km/km-2. The 5th order Shipra River shows stream frequency of 0.55 that indicates low water velocity in Shipra River. The mean bifurcation ratio (Rbm) is 4.15, indicates that the drainage pattern of the basin is moderately affected by structural disturbance. The stream length ratio [<LN>/<LN-1>, where <LM> is the mean length of streams of order M] increases significantly with stream order, a result that is often interpreted as indicative of a late-stage of landscape evolution. The drainage density (Dd=0.35km/km2) reveals that the Shipra sub-basin has moderately permeable river bed. The lemniscates (k=4.5) value defines that the sub-basin has moderately affected by soil erosion. The lateral cutting is high as compare to down cutting in Shipra sub-basin. The longitudinal profile reveals the average channel gradient of 1.58 (appx.). Channels throughout the basin, of all stream orders, show strong linearity. However, the small scale lineaments show structural control over reaches in the sub-basin suggests that the stream length ratio may reflect structure more than the stage of landscape evolution. This result has implications for the interpretation of morphological analyses of river networks. In addition, strengthened understanding of patterns of sediment storage and the geomorphic evolution of the sub-basin is informative for managing the hydrological resources of this area.

***Keywords* -: Drainage network analysis, Relief and Aerial analysis, Shipra sub-basin, Lineament, SRTM DEM, GIS, Remote sensing**

I. INTRODUCTION

The drainage basin forms different geomorphic unit and represents beautiful interpretation between sub surface landforms and drainage networks of basin. It is the analysis of landforms and Shipra drainage network. In case of geomorphology the valley development in Fluvial, Aeolian landforms can be analyzed by computing different geometric and morphometric parameters. The drainage network and various geomorphic analysis of various basins or sub-basins has been done by so many geologist and geomorphologist on conventional scale and with using remote sensing data of high spatial resolution and GIS software and tool methods. The beautiful framework of drainage stream of sub-basin is delineated by digitization of different toposheet on 1:50,000 scale in 20m contour intervals. The Shipra sub-basin analysis is carried out at large scale with an entire drainage morphometric analysis. This research is based on quantitative morphometric parameters of the Shipra River sub-basin like linear, relief and areal aspects.

II. STUDY AREA

The Shipra River is 214 km long tributary of Chambal River in Madhya Pradesh and Gangdhar district of Rajasthan (Fig.1). The Shipra River occupies a catchment area of 5611 sq. km with perimeter of 500 km. The Shipra sub-basin includes different SOI toposheetof 1:50,000 scale at 20m contour intervals (See table.1);

Table.1: SOI Toposheet included in different states

46M/5, 46M/9	MadhyaPradesh, Rajasthan
46M/6, 46M/7, 46M/10, 46M/11, 46M/12, 46M1/4 46M/15 , 46M/16	Madhya Pradesh,
46N/9, 46N/10, 46N/11, 46N/13, 46N/14	Madhya Pradesh

55A/4	Madhya Pradesh
55B/1, 55B/2	Madhya Pradesh

It has originated from Indore district (toposheet no. 55B/2) from Malwa Plateau terrain at latitude 25°12'50.40"N and longitude 75°18'13.09"E an elevation of 1687 ft and completes its 214 km flow journey with confluence (toposheet no. 45M/5) in Chambal River between the district boundary of Alot district of Madhya Pradesh and Gangdhar district of Rajasthan at latitude 25°40'30.73"N and longitude 76°17'34.18"E with elevation of 709 ft in the lower Cretaceous Deccan Trap associated with intra-trappean bed of Madhya Pradesh and Rajasthan state. The Shipra River is flowing towards the northern direction on regional slope that's why dendritic pattern drainage network is seen at large scale. There is one small tributary Gambhir river pouring into the left bank of Shipra River near Mundla village around Mehidpur district and didn't find any major tributaries on the right bank of Shipra River. The geology of Shipra sub-basin has studied on the basis of Geological Survey of India which was proposed by team GSI in 1988. Afterwards, this map is digitized in Arc-GIS 10.3 software. In this research studies, we see that the Shipra River is flowing over only Deccan Trap terrain which is characterized by compacted columnar joints, but further at mature to older stage the Shipra River bed changes its lithologies to associate with inter-trappean beds. The small scale lineaments in Shipra River show some tectonic disturbance effect in river flow directions.

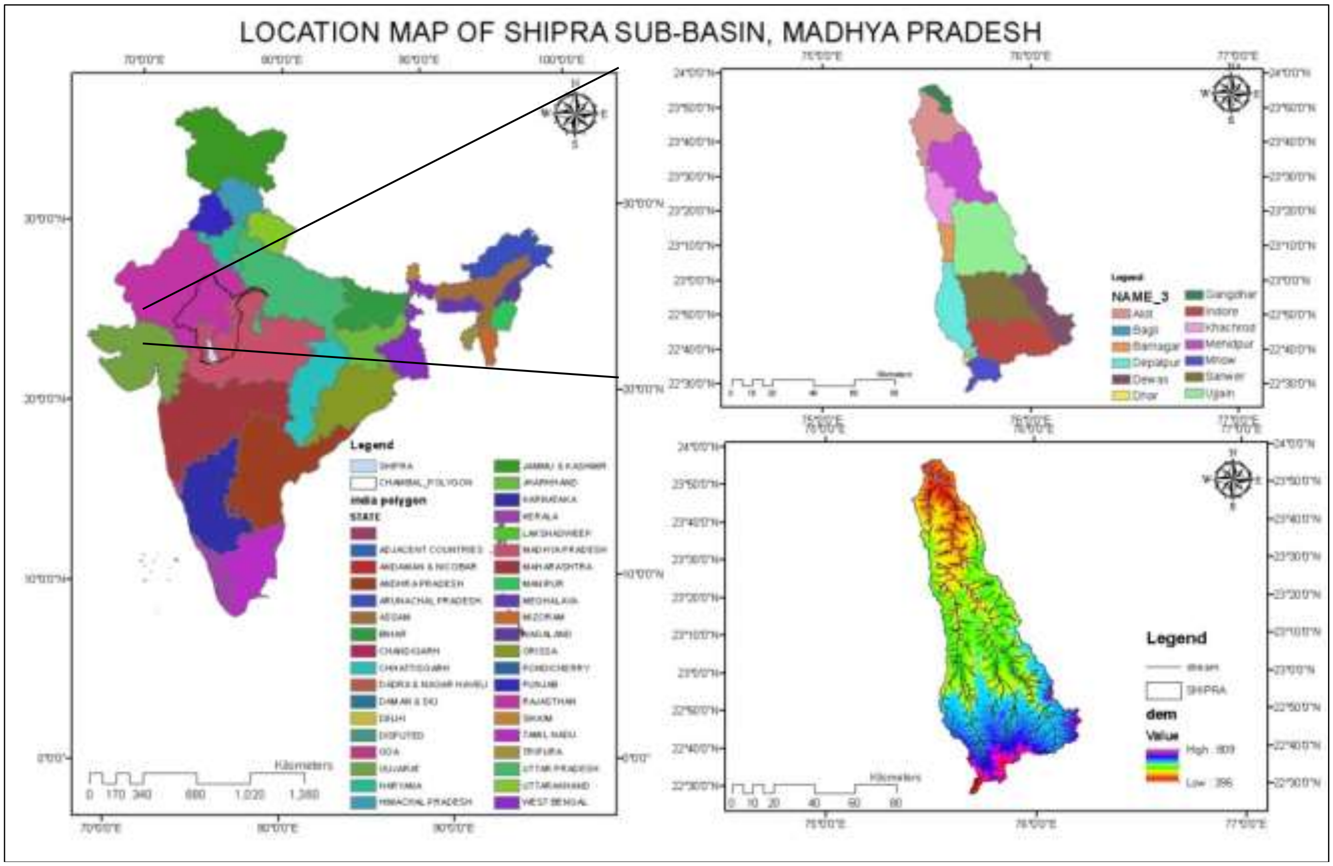

Fig.1: Location map of Shipra River sub-basin

Geomorphologically and climatologically, the Shipra sub-basin area shows some eroded structural and denudational landforms associated with compacted columnar joint in basaltic river bed. These compact columnar joints were formed due to contraction and extension by the increase and decrease of temperatures in that area. This area is also covered by less vegetation and wasteland. The sediment deposition is taken place in the form of lateral and channel bars. Because of low sinuosity index, the river shows straight flow. Other information with respect to spatial distribution of watershed management planning and its utilization on the regional scale can be study by this. The drainage stream pattern and land use and land cover pattern of Shipra sub-basin area is a reflection of the complex sub surfaces physical processes which plays a vital role in impact of climatic changes, geological and topographical conditions. The different distribution of Madhya Pradesh and Rajasthan soils, vegetation and occurrence of water have also analyzed for better development and management of the sub-basin areas. Climatic condition of Shipra sub-basin belongs to semi-arid climate and tropical dry and wet climate. Origin of Shipra River is occurring in tropical dry and wet climate; afterwards river carries its remaining path till confluence in semi-arid climate. We can say that the dominating climate in Shipra River sub-basin is semi-arid (Fig.2). In semi-arid region in Madhya Pradesh and Rajasthan the localized people depends on the groundwater and other anthropogenic factors like ponds, dams, tanks etc.

Therefore, some major districts like Dhar, Sewai, Gangdhar, Mehdipur, Ujjain, Alot, Barnagar, Bagli, Depalpur, Dewas, Senwar, Mhow, Khachrod and its villages depend on such water resources river in which Shipra River is one of them.

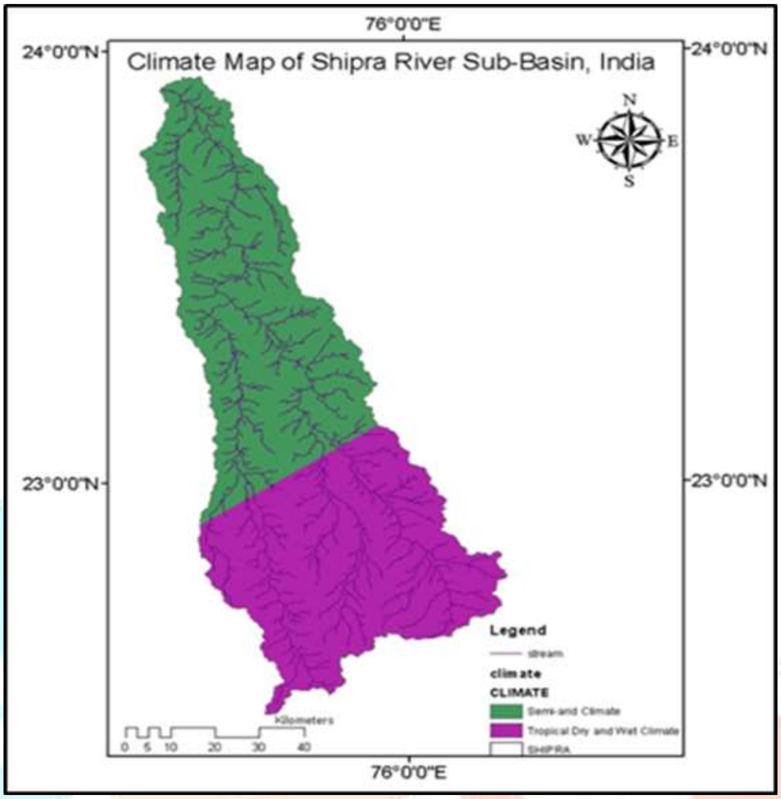

Fig.2: Climate map of Shipra sub-basin research

III. DATA USED AND METHODOLOGY

The morphometric characteristics at the basin contain scale important information regarding its geological and geomorphological formation and valley development. Morphometric analysis of the Shipra Sub-basin is done by computed different climatologically, hydrological, geomorphological and geological aspect. Drainage network analysis of Shipra sub-basin explains the soil permeability, water storage capacity of rock in terms of aquifer and gives the different yield of the basin. The satellite data used in this research is fast and cheap way for regional and fluvial geomorphological. The geo-database required for prepared quantitative morphometric analysis map of Shipra sub-basin and geological map, rail map, settlement map, road map and topographical map prepared by Survey of India (1:50,000 and 1:250,000 scale toposheet,. The SRTM (DEM) elevation map prepared at 90m spatial resolution. These different quantative geo-morphometric analysis is studied based aerial aspect, linear aspect, relief factors like Hillshade, contours, aspect, fill, flow direction, flow accumulation, stream order, sub-basin area, slope, longitudinal, topographical and transverse profiles of Shipra sub-basin. (table.2).

Table.2

Data used / Software	**Resolution**	**Sources**
SRTM DEM data	90 m Resolution	Cgir.com/download
Landsat Image	79m Resolution	Landsat.org, GLCF website
SOI Toposheet	1:50,000 scale and 1:250,000	Survey of India of different year 1971-1975
GIS Software	ArcGIS 10.3	Remote sensing lab facility of Department of Geology, BHU

IV. RESULT AND DISCUSSION

Geographic Information Systems and remote sensing, is very important tools in delineation of drainage network stream pattern and different geometric morphometric analysis by different methodology of geomorphological and watershed management. So, GIS has been widely used on large scale in several flood management, and environmental applications (Kaushik.P, Ghosh.P.2015). The SRTM-DEM map has been prepared of 5611 km area with the perimeter of 500 km. The the drainage network of basin have been discussed by runoff processes The valley development of drainage network is basically depend on geological, geomorphological and lineaments mapping which is formed by endogenetic and exogenetic processes. The quantitative morphometric analysis is helpful in understanding the fluvial river basin geomorphic evolution. The morphometric analysis of the Shipra sub-basin was computed by different SOI toposheets of Survey of India and SRTM-DEM 90m spatial resolution in Arc-GIS 10.3 software. The linear aspect method is the first method to interpret the drainage network of river. These methods were used by Chorley (1957), Horton (1945), Strahler (1953). The second one was aerial aspects using those of Schumm (1956), Strahler (1956, 1968), Miller (1953), and Horton (1932), and relief aspects represent the landform elevation with evolution data . This method is given by Horton (1945), Broscoe (1959), Melton (1957), Schumm (1954), Strahler (1952), and Pareta (2004) have been used. The average slope analysis of the basin was done by using Wentworth (1930) method. The Fluvial geomorphology of Chambal River basin and its tributaries Mej River is so vast in terminology; therefore remote sensing and GIS application and technique to analyzing the whole Mej sub-basin geomorphology in interval of space and time has been used (Kaushik.P, Ghosh.P.2015).

1. LINEAR ASPECTS

Linear aspect computation result like stream order, stream number, stream length and various different parameters. These different parameter results are given in table.3.

Stream Number

Horton (1945) proposed that the stream number segments of order wise form an inverse geometric sequence with stream order number. The stream number gradually decreases if the stream orders increase. So, we can say, it has inversely relation to stream order. The total order wise segments of stream are known as stream number (table.3).

Stream Order (Nu)

The Stream order is the first method in geo-quantitative morphometric analysis of the Shipra sub-basin. Firstly, The Horton (1945) proposed stream ordering method to understanding the different position of a stream network. This method was further modified by Strahler (1952). The stream ordering map shows that the Shipra River sub-basin is a 5th order stream. The variation in different order number and stream length is due to structural lineaments and some physiographic movements in study area (table.3).

Stream Length (L)

Stream length of basin of various orders has been computed by used of different scale topographical maps under Arc-GIS (10.3v) software. It is the total length of streams of a particular order. As lengths of streams are increases which show of gentle gradient and coarse texture. Smaller lengths of streams are generally showed of larger slopes and finer texture (table 4). The total stream length of Shipra sub-basin is 1979 km.

Bifurcation Ratio (Rb)

The concept of Bifurcation ratio is given by Horton (1932) to defined the bifurcation ratio as the ratio between the number of streams of any given order (Nu) to the number in the next higher order (Nu+1). Given table.3 show the value of bifurcation ratio of the different order streams in the Shipra sub-basin which shows that it has a constant nature and ranges in between 3 and 5 (Chow,1964). The higher bifurcation ratio (Rb) indicates presence of geological control factor and lower bifurcation ratio shows that the lineament and fault structure does not work on the drainage pattern. The mean bifurcation ratio (Rbm) of the Shipra sub-basin is 4.15, which indicates, it is a columnar joint based dissected sub-basin.

Table.3

Su: Stream order	Nu :Number of streams	Rb: Bifurcation ratios
I	186	
II	74	2.5
III	13	5.6
IV	2	6.5
V	1	2.0

Total	276	16.6
Mean		4.15 (Rbm: mean Rb)

Mean Stream Length

The mean stream length of Shipra sub-basin is the different for streams order of the study area is presented in Table 4. There is strong correlation between stream order and mean stream length. These results followed Horton in 1932 "Law of Stream Length" which defines the length of stream of a given order to stream order and takes the form of a direct geometric series

Stream Length Ratio

The stream length ratio is defines by ratio of mean stream length. The stream length ratio of the Shipra sub-basin is show in table 4. It's calculating by dividing the mean stream length of the next higher order by the lower order stream {Lu/ (Lu-1)}. It is observed that stream length ratio increases as the order of the stream increases.

Table.4

Su: Stream	Lu: Stream length	Lu/Su	Lur: Stream length ratio
I	980	5.2	
II	526	7.1	1.36
III	224	17.2	2.42
IV	170	85.0	4.94
V	79	79	0.92
Total	1979	193.5	9.64
Mean			2.41 (Lurm:Mean stream length ratio)

Sinuosity Index

Sinuosity index of Shipra sub-basin represent the stream which mention the degree of deviation of its original path from expected air distance straight path. However, the calculation is done on the basis of deviation of observed path (OL) from the expected path almost a straight line (EL) of a river from the source to the mouth (Schumm, 1963). A sinuosity index has done by using formula, given in table 5. Schumm (1963) proposed five major sub- categories of channel sinuosity index e.g. straight course when channel sinuosity is 1.0, transitional course, regular course, irregular course and tortuous course (when channel sinuosity is more than 20). Sinuosity index of the Shipra River is 1.40.

2. AREAL ASPECTS

Drainage Area (A)

The basin and catchment area of Shipra sub-basin is 5611 sq.km and this surface area located within the sub-basin boundary. This drainage area can be quite good to encompassing thousands of square kilometers. The size of a Shipra sub-basin area has a significant impact on sub-basin management structures.

Basin Perimeter

The perimeter of the Shipra sub-basin is 500 km and it has been measured from the topographic sheets and SRTM DEM data by using Arc-Hydro tools in Arc-GIS software (10.3v). The drainage network parameters and sub-basin perimeter has strongly correlated to each other. The Perimeter of the Shipra sub-basin increases as the order of the sub-basin increases.

Basin Length

Schumm in 1956 define the Basin Length. The Shipra sub-basin length is computed by SRTM DEM 90 m resolution data under Arc-hydro tool. Therefore, it is observed that Shipra sub-basin length increases as stream order increases. However, Basin length defines as the Maximum length between drainage sub-basin reach and mouth has been considered as sub-basin length (Gregary and Walling, 1973). According to Schumm (1956) the length of Shipra sub-basin is 170 kms.

Drainage Density (Dd)

Drainage density has beautiful relationship with environmental variables. Different research studies show that Dd is the sum of stream lengths per unit area (Horton, 1945). Dd has strongly correlated with rainfall parameters (Tuckers and Bras 1998), precipitation intensity (Gregary and Gardiner (1975 & 1976). In a similar condition of lithological and geological structure, the high Dd is favored in arid regions which show vegetation cover in temperate and tropical regions (Melton, 1957 & Strahler, 1964). The Dd of Shipra sub-basin is 0.35 $km/km^{2.}$ Low Dd shows that the Shipra sub-basin is characterized by highly resistant and permeable sub soil and have dense vegetation cover with low relief.

Stream Frequency (Fs)

Stream or channel frequency is defined as the total number of streams per unit area (Horton, 1945). The stream frequency of Shipra sub-basin is 0.55 $km/km^{2.}$ Stream Frequency (Fs) is also depends on surface material and reflect the different texture of the Shipra sub-basin drainage network. The Stream frequency of the area is computed from SRTM DEM data followed by Horton (1945). Generally the categories divide in the form of stream frequency ie; very poor, poor, moderate, high and very high.

Drainage Texture (T)

Thornbury in 1960 proposed Dt is the relative spacing between the drainage lines. Dt contain Drainage density and Stream frequency (Horton, 1945). Actually, Drainage texture was first introduced by Smith in 1950 computed by using different scale contour on Toposheet, which is divided by the length of the perimeter of the Basin. The abbreviation is 'T', where, T means drainage texture, '∑C' is the total number of crenulations in the contours, and 'Bp' is the perimeter of the sub-basin (Kuldeep.2011). Smith in 1950 defined Dt into five major different categories which based on the drainage density. If the drainage density is less than 2 then it represent very coarse texture in rocks lithologies, if the value occur between 2 and 4 then its coarse, if the value drop in between 4 and 6 is moderate, and between 6 and 8 is fine and more than 8 value indicate very fine. The drainage density values of the Shipra sub-basin is 0.55 (table.5), it indicating very coarse drainage textures The term drainage density, stream frequency and drainage texture is correlate to each other but different in defining the drainage network (Rawat, 2011).

Circularity Ratio (Rc)

The circularity ratio (Rc) has been used as an aerial aspect and is expressed as the ratio of sub-basin area of a circle having the same perimeter as the sub-basin (Strahler, 1964). Circularity ratio values approaching one indicates that the sub-basin shapes are like circular and as a result, it gets scope for uniform infiltration and takes long time to reach excess water at sub-basin outlet. The circularity ratio is affected by geology, slope and land cover. The ratio is more influenced by length, stream frequency and gradient of various orders rather than slope conditions and drainage pattern of the sub-basin. Sub-basin shape determines how rapidly the runoff will reach the main River as well as the outlet. For elongated sub-basins the runoff reaches slowly (longer delay) in the arrival of flow after heavy rains. Studies by Hack (1957) indicate that as the sub-basins enlarge, the stream length increases and the sub-basins become narrower and longer. Therefore, a majority of Rivers have elongated sub-basins (Mulder and Syvitsky, 1996). Miller (1953) has described the sub-basin of the circularity ratios which have a range of 0.4 to 0.7, which indicates strongly elongated and highly permeable homogenous geologic materials. The circularity ratio of the whole Shipra River sub-basin is 0.3325 indicates elongated shape and highly permeable homogenous geologic condition.

Form Factor (Ff)

According the Horton in 1945, Form factor is defined as the ratio of basin area to the square of the basin length. However, the values of form factor are generally less than 0.78 for interpretation of the perfectly for a circular basin. If the low the value of Ff means more elongated will be the sub-basin. The form factor ratio of the Shipra River sub-basin is 0.22 (Table.5) that indicates that the whole sub-basin has elongated in shape (Fig.4).

Compactness Coefficient (Cc)

Gravilius, 1914, define the term Compactness coefficient as the perimeter of basin to circumference of circular area which equal to the area of basin and it's widely used to express the relationship of a hydrology of basin. In the Shipra sub-basin value of compactness coefficient indicates less hazardous sub-basin (Table 5).

Elongation Ratio (Re)

The elongation ratio is defined by Schumm in 1965, as the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin. The parameter of elongation indexes represent the area with high value means the basin is characterized by infiltration capacity and low runoff in sub soil. If Elongation ratio value close to 1.0 are typically of regions of very low relief, whereas elongation ratio values in the range 0.6 to 0.8 are usually associated with high relief and steep ground slope (Strahler, 1964). Therefore, the Elongation ratio of the Shipra sub-basin is 0.36 indicates that the sub-basin falls in the more elongated category and showing high relief and steep ground slope (Table 5).

3. RELIEF ASPECTS

According to Strahler (1968) proposed that relief parameters are important to define the potential energy of the stream drainage network. The Absolute relief also evaluates the highest point on the basin.

Relief Ratio & Relative Relief Ratio

Basin Relief ratio is very important to understand the Denudational landform of basin at various scales, which is well representing in SRTM Digital Elevation Model (DEM) in Figure 5. According to Singh (1999), Relative relief is also classified into 6th categories viz. extremely low relative relief (0-15m), moderately low relative relief (15-30m), low relative relief (30-60m), moderate relative relief (60-120m), moderately high relative relief (120-240m) and high relative relief (above 240m). Relative relief is the difference between the highest (809m) and lowest (396m) points in the sub-basin. Relative relief of the Shipra River sub-basin is 413m, indicating high relative relief

Slope map

Slope parameter is an important dimension to interpret the geomorphological features under different exogenetic and endogenetic processes. In Shipra sub-basin, the Slope is start decreasing from origin of river to mouth. This area is characterized by steep slope which is is observed in the source region to confluence where, the Shipra river met in Chambal river. The direction of the slope on the entire relief of the Shipra River sub-basin is illustrated in Relief map (Fig.5).

Longidutional Profile Analysis

The River profile is important parameter to analyze and interpret the relief and sub-surface lithologies with steep and gentle slope and also explain the evidence of any structural features in terrain. The profile shows elevation against distance downstream. The Longitudinal profile or Valley of Shipra River gives a vivid picture in longitudinal course of the River. Longitudinal profile of the Shipra River sub-basin is created using SRTM DEM data of 90 m spatial resolution under Arc-GIS software. This Longitudinal profile of the Shipra River is ideal to show less gradient. At younger stage the Shipra River has high steep slope with high gravitational potential energy. Then, the River starts to narrow shape valley with down cutting and shows V shaped valley. Further moving, at mature stage this GPE converts into high kinetic energy and starts lateral erosion due to high velocity in stream frequency. Finally, At older or rest stage of River, it has low kinetic energy and River starts to deposit their sediments in the form of flood plain and active flood plain like channel bar, small scale point bar and lateral bar. Therefore, the River shows partially U-shaped valley with River terraces at older stage. Here the River terraces are formed by rejuvenation in River.

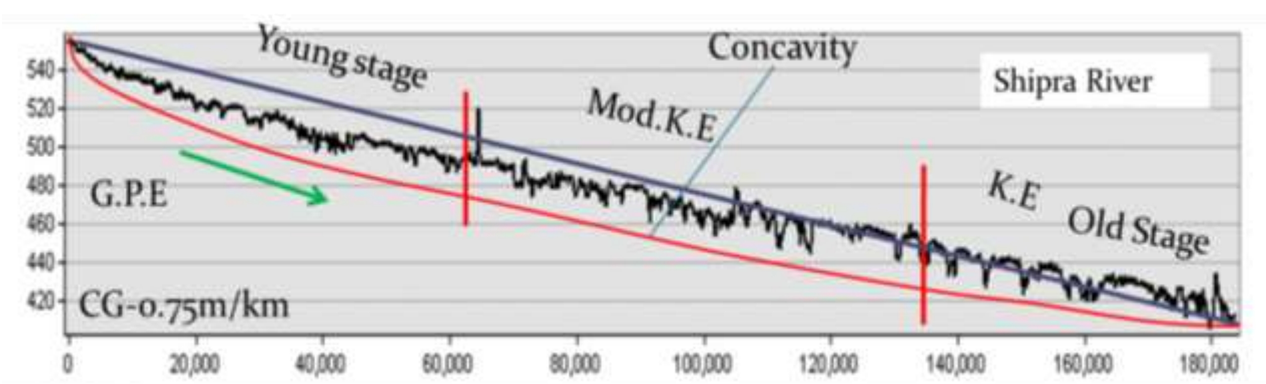

Fig.3: Longitudinal profile of the Shipra River

Table.5: Results of different morphometric parameters of Shipra sub-basin

Morphometric Parameter	Formula	Reference	Results
Drainage Patterns: Dendritic,, Trellis, Rectangular			
Stream Order (Su)	Hierarchical Rank	Strahler (1952)	1to 5
1st Order Stream (Suf)	Suf = N1	Strahler (1952)	186
Stream Number (Nu)	Nu = N1+N2+…Nn	Horton (1945)	276
Stream Length (Lu) Kms	Lu = L1+L2 ……Ln	Strahler (1964)	1979
Stream Length Ratio (Lur)	-	Strahler (1964)	2.15
Mean Stream Length Ratio (Lurm)	-	Horton (1945)	1.40
Bifurcation Ratio (Rb)	Nu/Nu+1	Strahler (1964)	16.6
Mean Bifurcation Ratio (Rbm)	Rb/Su-1	Strahler (1964)	4.15
Main Channel Length (Cl) Kms	GIS Software	-	214
Valley Length (Vl) Kms	GIS SoftwareAnalysis	-	170
Minimum Aerial Distance (Adm)Kms	GIS SoftwareAnalysis	-	152
Channel Index (Ci)	Ci = Cl / Adm (H& TS)	Miller (1968)	.50
Valley Index (Vi)	Vi = Vl / Adm(TS)	Miller (1968)	1.51
Rho Coefficient (ρ)	ρ = Lur / Rb	Horton (1945)	0.44
Basin Length (Lb) Kms	GIS SoftwareAnalysis	Schumm(1956)	152
Mean Basin Width (Wb)	Wb = A / Lb	Horton (1932)	147
Basin Area (A) SqKms	GIS SoftwareAnalysis	Schumm(1956)	5611
Basin Perimeter (P) Kms	GIS SoftwareAnalysis	Schumm(1956)	500
Relative perimeter	Pr= A/P	Schumm (1956)	11.2
Lemniscate's (k)	k = Lb2 / A	Chorley (1957)	44.5
Form Factor Ratio (Rf)	Ff = A / Lb2	Horton (1932)	0.22
Shape Factor Ratio (Rs)	Sf = Lb2 / A	Horton (1956)	44.5
Elongation Ratio (Re)	Re = 2 / Lb * (A /π) 0.5	Schumm(1956)	0.50
Texture Ratio (Rt)	Rt = N1 / P	Schumm(1965)	0.37
Circularity Ratio (Rc)	Rc = 12.57 * (A / P2)	Miller (1953)	0.28
Drainage Texture (Dt)	Dt = Nu / P	Horton (1945)	0.55
Fitness Ratio (Rf)	Rf = Cl / P	Melton (1957)	0.42
Wandering Ratio (Rw)	Rw = Cl / Lb	Smart &Surkan (1967)	1.25
Sinousity Index	Si= CL/AD*	Mueller(1968)	1.40
Stream Frequency (Fs)	Fs = Nu / A	Horton (1932)	0.55
Drainage Density (Dd) Km / Kms2	Dd = Lu / A	Horton (1932)	0.35
Constant of Channel Maintenance(Kms2 / Km)	C = 1 / Dd	Schumm(1956)	2.80
Drainage Intensity (Di)	Di = Fs / Dd	Faniran (1968)	1.57
Infiltration Number (If)	If = Fs * Dd	Faniran (1968)	0.19
Length of Overland Flow (Lg) Kms	Lg = A / 2 * Lu	Horton (1945)	1.41
Height of Basin Mouth (z) m	GIS Analysis /DEM	-	779
Maximum Height of the Basin (Z) m	GIS Analysis /DEM	-	889
Total Basin Relief (H) m	H = Z - z	Strahler (1952)	0.70
Relief Ratio (Rhl)	Rhl = H / Lb	Schumm(1956)	2.4

Channel Gradient (Cg) m / Kms	Cg = H / {(π/2) * Clp}	Broscoe (1959)	0.75
sub-basin slope (Sw)	Sw = H / Lb		1.5
Ruggedness Number (Rn)	Rn = Dd * (H/1000)	Patton &Baker (1976)	0.40
Contour Interval (Cin) m	GIS Software Analysis	-	20

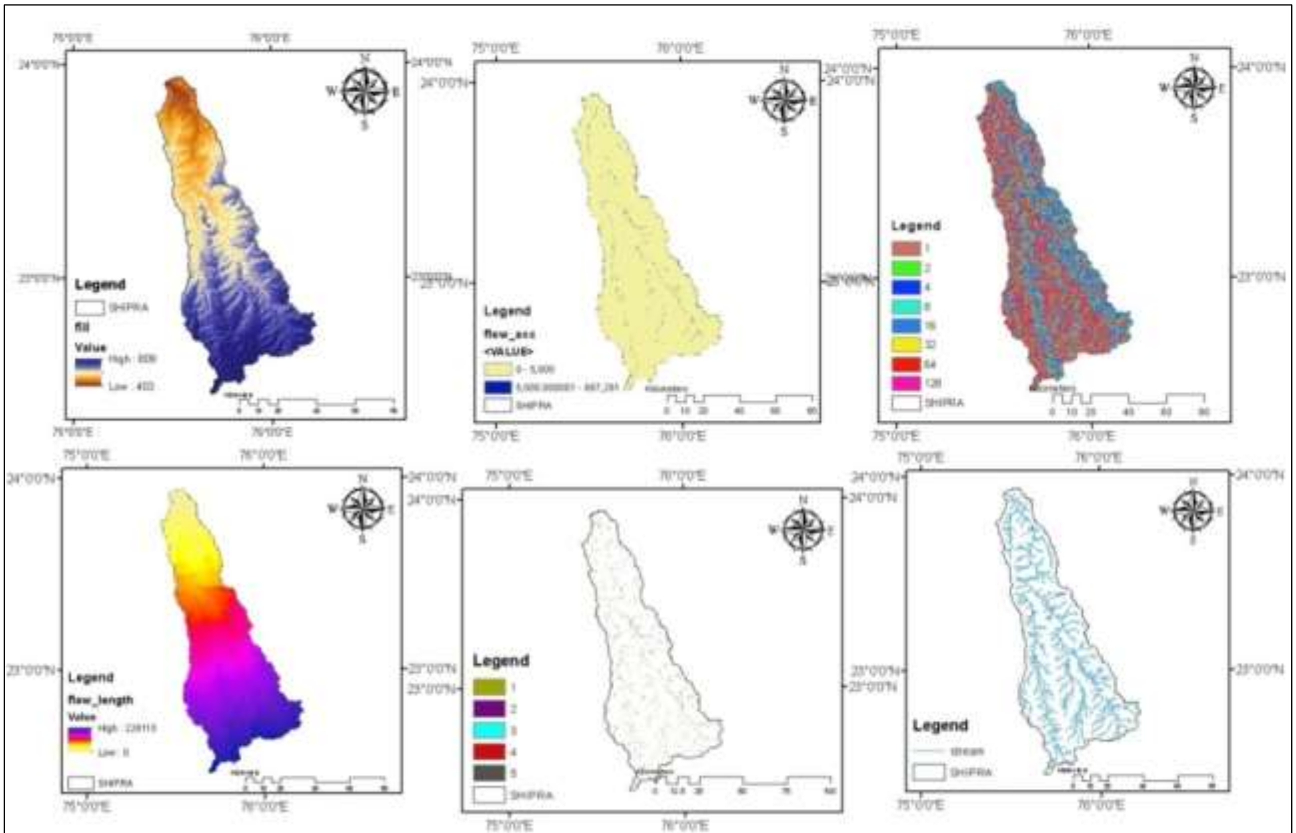

Fig.4. Drainage basin Analysis map of Shipra sub-basin, India

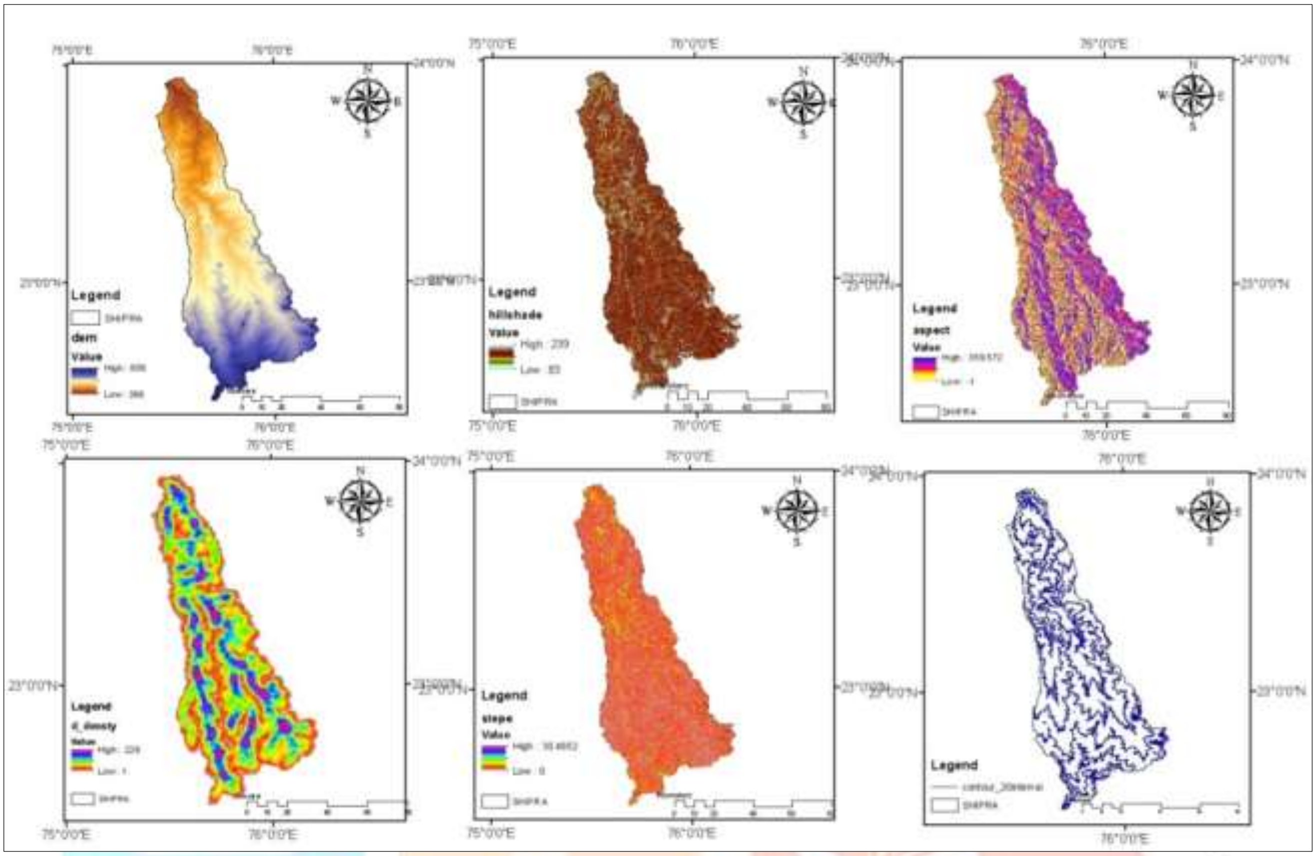

Fig.4. Relief basin Analysis map of Shipra sub-basin, India

CONCLUSION

The Shipra sub-basin is the largest of the left bank feeders of the Chambal River covering an area of 5611 sq. km., which is covered by hard massive basaltic rocks. It is a 5thorder stream with elongated sub-basin shape. The total length of sub-basin is 170 km, which is the direct outcome of drainage development in a particular sub-basin. The shape of drainage sub-basin affects the stream discharge development in a particular sub-basin. The sub-basin contains total 176 numbers of streams with length of 1979 km. Drainage density is a measure of the texture of drainage system within a unit area. It has low drainage density of 0.35 km/km^2 indicating coarse drainage texture due to highly resistant sub-soil material and low relief. The stream frequency is 0.50 km/km^2 indicating poor stream frequency. The mean bifurcation ratio is 4.15 indicates it is a hilly dissected sub-basin. The form factor ratio of the Shipra River sub-basin is 0.2603 indicates that the whole sub-basin has an elongated shape. The circularity ratio the sub-basin is 0.3325 indicates elongated shape and highly permeable homogenous geologic condition. The morphometric analysis of Shipra sub-basin is indicative geographical, hydrological, geomorphological evolution of an area. The different results of linear analysis show that the area is characterized by erosional homogenous weathering. The different relief aspect analysis represents the Shipra sub-basin has low relief and the basin is elongated in shape which shows low runoff with flat flood plain area. However, different morphometric parameters resulted by using remote sensing and GIS approach are very useful to understand the terrain parameters like run-off, infiltration capacity and landforms and geomorphic process with basin evolution. Different geomorphic landforms were also identified in the Shipra sub-basin based on SRTM (DEM) data with 90m spatial resolution, and GIS software.

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