Abstract:
The geographical information system (GIS) has been emerged as an efficient and very effective tool in delineation of drainage patterns of river basin, its planning and management. The morphometric parameters of basins can address linear, areal and relief aspects. The study deals with the integrated basin management of Naina – Gorma basin, located in the Rewa district of Madhya Pradesh, India. Morphometric analysis in hydrological field is an important aspect in the determination of linear, areal and relief parameters that indicative of fairly good significance. The low value of the bifurcation ratio revealed that the drainage pattern has not been distorted by structural disturbance while high value of the elongation ratio compared to the circulatory ratio indicates an elongated shape of the river basin. The high value of drainage density and stream frequency shows that the region has impermeable subsoil material under poor vegetative cover with a low relief factor whereas low value of drainage density and stream frequency is indicative of permeable subsoil and thick vegetative cover. The morphometric parameters of relief ratio and relative relief show that the river basin can be treated using GIS techniques to determine the presence of dendritic to sub-dendritic drainage pattern, help to selecting the soil and water conservation measures.

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Introduction

The Catchment delineation refers to the demarcation of basin boundary for the Characterization and computation of its activity and features in terms of drainage networks with the help GIS mapping tool. It is entirely based on topographic and river network information. The drainage network of a basin is a well defined geomorphic unit. Network analysis of drainage basin is related to geometric and topological characteristics of tributary patterns of drainage basin. Morphometry is defined as the measurement of the shape. Morphometric studies in the field of hydrology were first initiated by Horton (1940) and Strahler (1950). The quantitative morphometric analysis of the drainage basin and channel network plays an important role in understanding the geo-hydrological behavior of drainage basin and expresses its prevailing climate,
geology, geomorphology, structure etc. In the present study, morphometric analysis has been carried out using remote sensing and Geographical Information System (GIS) techniques to assess the geo-hydrological characteristics of the basin that present in eastern part of Rewa district, Madhya Pradesh. The morphometric parameters of the basin were discussed with respect to linear, areal and relief aspects. The all sub-basin, characterized by dendritic to sub-dendritic drainage pattern. The high values of Bifurcation Ratio (Rb) indicate the possibilities of structural control over the drainage pattern.

**Study Area**
The study area lies on the eastern part of the Rewa district of M.P. India. The river basin covers almost 1420 km² area. Naina - Gorma is the tributary of river belan (fig.1).

![Fig: 1 – The Study Area](image)

Geologically the study the study region comprises of Upper Vindhyan groups viz. Bhander, Rewa and Kaimur series and the Archaean consist of granites and gneisses besides recent alluvium. The Naina - Gorma basin has varying topography and physiographic conditions. Therefore climate of the region is not uniform. It varies from region to region in the study area. The small central-northern portion of the region is on higher elevation covered with hills and forest, hence the climate of this part is relatively cooler than the other portion of the region which has rocky and barren terrain.
Methodology

In this study, the principal source of the data is the Survey of India (SOI) Topographical maps 63H/9, H/10, H/13, H/14, L/1, L/2 at the scale of 1:50,000. The satellite data of the Indian Remote Sensing (IRS) Satellite series1-C (LISS III Data) on scale 1:50,000, 2008 also have been used. For the study purpose of the quantitative fluvial morphometry of the river basin, drainage map of the river basin was prepared with the help of Survey of India topographic sheets. All streams were digitized with the help of ILWIS 3.3 software, according to Strahler (1964) Stream ordering method while stream lengths were measured according to Hortonian method (1945). The stream numbers of various orders were counted, while the stream segment length, total basin length, area and perimeter were measured with the help of Arc GIS 9.3 software.

Result and Discussion

This section dealt with result and discussion of the present study (table 1&2). The order wise total number of stream segments is known as the stream number. The count of stream channels in its order is known as stream number (Horton, 1945). Stream number is directly proportional to size of the contributing river basin, to channel dimensions and inversely proportional to stream order, means number of streams decreases as the stream order increases. As like basin area, Basin perimeter (P) is important parameter in the calculation of basin geometry, it is the outer boundary of the basin or watershed that enclosed its area.
variable trends over varying geological structures (Singh et.al 1984). The reciprocal of drainage density as a property termed Constant of Channel Maintenance. It is inverse of drainage density. Gardiner (1975) defined the basin length as the length of the line from a basin mouth to a point on the perimeter equidistant from the basin mouth in either direction around the perimeter. Horton (1932), introduced the drainage density (Dd) is an important indicator of the linear scale of landform elements in stream eroded topography. It is the ratio of total channel segment lengths cumulated for all orders within a basin to the basin area, which is expressed in terms of km/sq. km. Fig. 2 shows the drainage order map of the basin.

The number of streams (N_u) in per unit area (A) is known as stream frequency of the basin, if stream frequency is high, indicator of greater surface run-off and steep ground surface (Horton 1932, 1945, Subba Rao, 2009). According to Schummm (1956) elongation ratio is the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin. A circular basin appears to be more efficient in the discharge of run-off than that of an elongated basin (Singh, 1997). It is a very significant index in the analysis of basin shape which helps to give an idea about the hydrological character of a drainage basin.

Table 1: Farmuleae used for calculation of Morphometric Parameters

<table>
<thead>
<tr>
<th>S.No</th>
<th>Morphometric Parameters</th>
<th>Symbols</th>
<th>Formula</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Stream Order</td>
<td>u</td>
<td>Hierarchical rank</td>
<td>Strahler(1964)</td>
</tr>
<tr>
<td>2.</td>
<td>Total No. of Stream</td>
<td>Nu</td>
<td>Nu = N1+N2…..Nn</td>
<td>Horton (1945)</td>
</tr>
<tr>
<td>3.</td>
<td>Stream Length</td>
<td>Lu</td>
<td>Lu = L1+L2+Ln…..</td>
<td>Horton (1945)</td>
</tr>
<tr>
<td>4.</td>
<td>Mean Stream Length</td>
<td>Lsm</td>
<td>Lsm =Lu/Nu Where, Lsm = Mean stream length Lu= The total stream length of order u Nu= The no. of stream segments of order u</td>
<td>Strahler(1964)</td>
</tr>
<tr>
<td>5.</td>
<td>Mean Bifurcation Ratio</td>
<td>Rbm</td>
<td>Rbm=Average of bifurcation Ratio of all orders</td>
<td>Strahler(1957)</td>
</tr>
<tr>
<td>6.</td>
<td>Length of Overland Flow</td>
<td>Lg</td>
<td>Lg = 1/D^2 Where,Lg = Length of overland flow D = Drainage density</td>
<td>Horton(1945)</td>
</tr>
<tr>
<td>7.</td>
<td>Constant Channel</td>
<td>C</td>
<td>C=1/D Where, C= Constant channel maintenance D= Drainage density</td>
<td>Schumn(1956)</td>
</tr>
</tbody>
</table>
Miller (1953) defined a dimensionless circularity ratio \( (R_c) \) as the ratio of basin area to the area of circle having the same perimeter as the basin. The circularity ratio value of the basin is 0.43 which indicates that basins are more or less in elongated shape. Meandering ratio \( (Mr) \) is the ratio of maximum straight stream length to stream curve length, so it is calculated to express the ratio between straight to curved lengths of the primary (major) stream within the drainage system. It reveals how the real stream length is larger than the straight stream, which is indicative to stage maturity.

Table 2: Morphometric Parameters of Naina-Gorma basin

<table>
<thead>
<tr>
<th>Morphometric Parameters</th>
<th>Results</th>
<th>Morphometric Parameters</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perimeter ( (P) ) Km</td>
<td>201.57</td>
<td>Elongation ratio ( (R_e) )</td>
<td>0.30</td>
</tr>
<tr>
<td>Number of stream ( (N_\mu) )</td>
<td>2956</td>
<td>Circularity ratio ( (R_c) )</td>
<td>0.43</td>
</tr>
<tr>
<td>Stream order ( (\mu) )</td>
<td>7</td>
<td>Meandering ratio( (Mr) )</td>
<td>0.65</td>
</tr>
<tr>
<td>Basin length ( (L) ) Km</td>
<td>130.52</td>
<td>Constant of channel maintenance ( (C) )</td>
<td>0.60</td>
</tr>
<tr>
<td>Mean bifurcation ratio ( (R_{bm}) )</td>
<td>3.28</td>
<td>Basin shape factor</td>
<td>13.84</td>
</tr>
<tr>
<td>Drainage density ( (D_d) ) ( (Km/Km^2) )</td>
<td>1.64</td>
<td>Length of overland flow ( (L_g) )</td>
<td>0.82</td>
</tr>
<tr>
<td>Stream frequency ( (F_s) )</td>
<td>2.08</td>
<td>Relief ratio ( (R_r) )</td>
<td>0.0027</td>
</tr>
</tbody>
</table>

Relief ratio \( (R_r) \) is the ratio between the basin relief \( (R) \) and the basin length \( (L) \). It is influence by the nature of rocks, slope of the basin, if \( R_r \) value is high, indicate a hilly region and low value relief ratio represent pediplain and valley region (K. Avinash et al. 2011). It is expressed as:

\[
R_r = \frac{R}{L}
\]

An understanding of the slope distribution is essential, because it provides information about settlement planning, agricultural possibilities, aorestation, deforestation, planning of engineering structure etc. (Sreedevi et al.2005, K. Avinash et al. 2011). The relief ratio of Naina-Gorma basin is 0.0027. The length of overland flow depends primarily on the degree of relief fragmentation, and hence on the drainage density. Overland flow is significantly affected by infiltration (exfiltration) and percolation through the soil, both varying in time and space (Schmid, 1997) (table 2). Basin shape factor is also an good indicator to determine the shape of basin of the study region.
Conclusion

Drainage network provides the basis of the determination of structural control, surface erosion, rock hardness, geological and geomorphological characteristics. Linear aspect of the river basin is related to the channel pattern of the drainage network. Stream number and stream order both has inverse relation with each other. Geomorphologically the area has undulating topography and study shows that most of the area are of quite permeable nature. The morphometric analysis of drainage network is dendritic to sub dendritic pattern with sixth order streams in all sub basin except Naina sub basin. The dendritic pattern which indicates the homogeneity in texture and lack of structural control while sub dendritic pattern indicates a gentle, uniform slopes and with less resistant bed rock. Drainage density is moderate to coarse texture. The mean bifurcation ratio (Rbm) represent to the structural control over drainage basin. The constant channel maintenance value addressing strong lithologic rocks with a surface of high permeability. Remote sensing and GIS techniques both are the best efficient tools in drainage delineation and updation of data in the study. The Linear, areal and relief quantitative analysis of morphometric parameters is found to be of best use in river basin evaluation, watershed management & prioritization for soil and water conservation as well as for natural resource management.

So, Remote sensing and GIS is accepted and used as powerful geospatial techniques in preparing the drainage map and understanding the drainage basin morphometric parameters. In this study, the drainage density, stream frequency and drainage texture values indicates that the intensity of the dissection in the area is very low to Low. Drainage densities are often associated with widely spaced streams due to the presence of less resistant materials (lithologies or rock types), or those with high infiltration capacities. This research paper will helps to researcher in delineation and mapping of ground water potential zone to identify the ground water level in the region for irrigation and agriculture purpose. This study will also help to know the geo-hydrological characteristics of the basin.

References

4. Horton, R.E., (1940); An approach toward a physical interpretation of infiltration capacity. Proc. Soil