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Morphometric Analysis of Mousam River Basins, Maharashtra, India

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ABSTRACT

Drainage network quantification with respect to the climate, tectonics, lithology and geomorphology provides significant evidence of the drainage development, hydro-geomorphic and denudation characteristics of an area. The present study was carried out to study the drainage morphometry and its influence on the hydrological characteristics of Mousam basins in Maharashtra, India. Results of the morphometric analysis reveal that the catchment of Mousam can be described as of 6th order drainage basins, encompassing an area of 790 sq.km,Additionally, Mousam basin is characterized by relatively higher mean bifurcation ratio. indicative of higher structural control and steeper gradient in Mousam basin. Lower drainage density and stream frequency afrm availability of permeable sub-surface material and homogeneous lithological characteristics. The shape parameters shows Mousam basin is elongated with dendritic and sub-dendritic drainage pattern. The relief parameters of Mousam suggest that basin is characterised by very high relief and steep slope in source region and moderate slope in middle and lower stage. Analysis of all morphometric parameters indicates that drainage development of the study area is progressing towards maturity stage.

Keywords: Morphometric analysis, Western Ghats, Geo-Spatial Techniques, Mousam Basin.

INTRODUCTION:

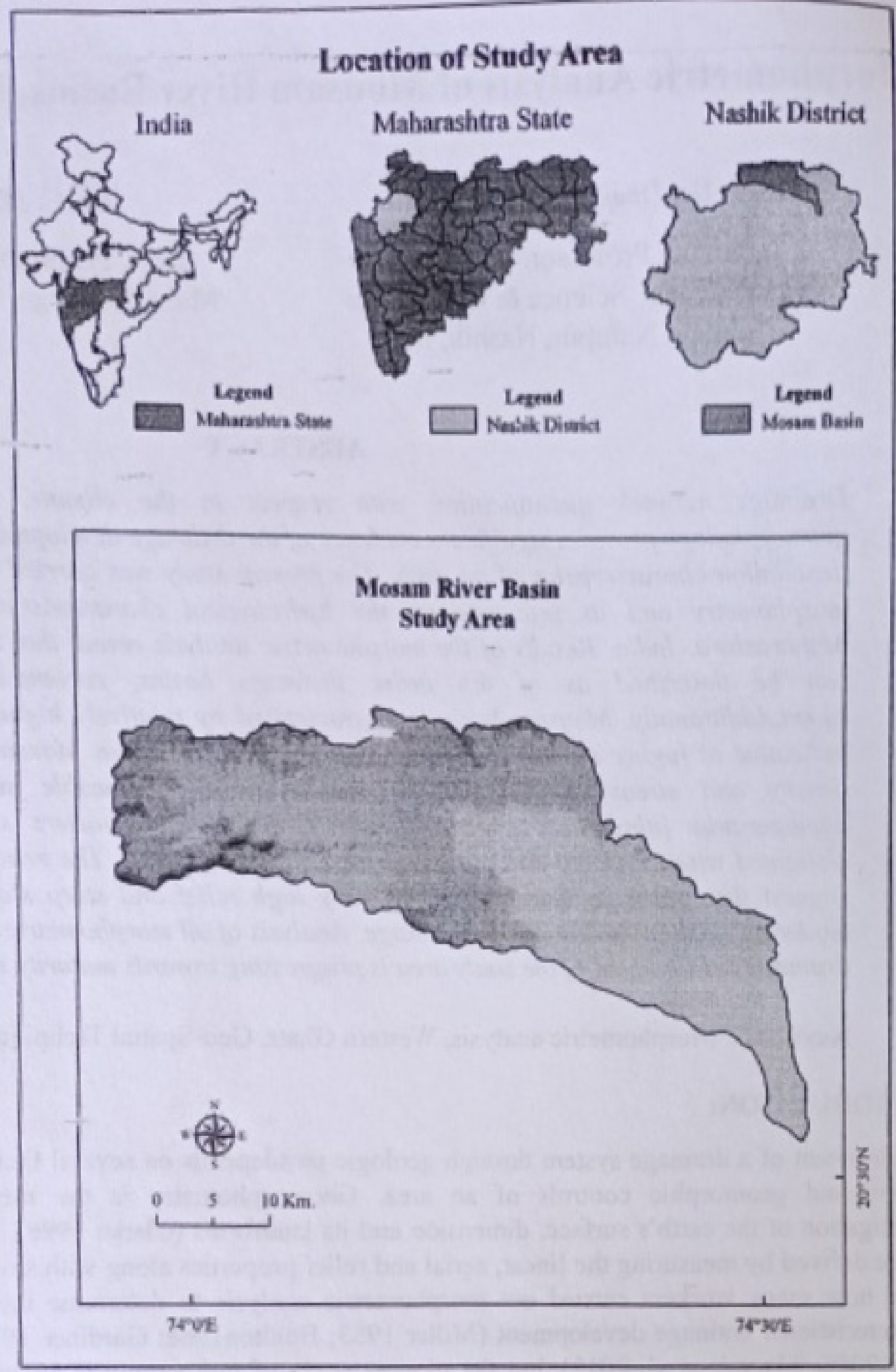
Development of a drainage system through geologic pastdepends on several factors such as climate, lithology, tectonicsand geomorphic controls of an area. Geomorphometry is the measurement and mathematical investigation of the earth's surface, dimension and its landforms (Clarke 1996). The morphometric parameters can be derived by measuring the linear, aerial and relief properties along with slope of the basin (Nautiyal1994; Since now many workers carried out morphometric analysis to determine the drainage network and basin characteristicsof drainage development (Miller 1953; Boulton1968; Gardiner 1975; Costa 1987; Moussa2003; Mesa 2006; Magesh et al. 2012), but the pioneer study of morphometric analysis was conducted by Horton (1932, 1945), Miller (1953) and Strahler (1964). In the present study attempt has been made to analysis the nature and structure of Mousam basin by applying various morphometric techniques. The morphometric analysis of the drainage basin and channel network play a vital role for understanding the hydrological behavior of drainage basin and to analyze flood, geological and geomorphologicalstructure.

Objective of the study:

The main objective of the present work is analyzing the morphometric characteristics of Mousam basin using Geo-spatial techniques.

Location of Study Area:

The Mousam Basin extends between 20°31´N L to 20°52´N L and 73°-33´, EL. The Mousam Basin covers an area of 750 sq.kms. of the Maharashtra Basin, which belongs to the Satana and Malegaon Tehsils of Nasik District (Map. No.1). The river Mousam originates from a spring in the cave Salher peak (1567 M) of the Sahyadri Mountain, which is the second ranking of the peak in Maharashtra. The area of the Dang, Gujarat and Bangalan were connected by six routes. These could be seen from the top of the fort and a vigil was kept on them as spies used them. Hence in Marathi it came to be known as Saha (six) + Her (spy). The fortified area is about 1.5 sq.kms. with "Gangasagar" lake inside. The source of the Mousam river is mythically related to this holy lake on Salher Fort.



RESULT AND DISCUSSION:

Quantitative analysis of drainage basin and channel networks, developed from qualitative and deductive studies subsequent to the valuable contribution of Horton (1945), Strahler (1957), Morisawa (1959), Melton (1957), Leopold and Miller (1956). The analysis of basins as either single unit or group of units comprises a distinct morphological region and it has particular relevance to geomorphology (Doornkamp and Cuchlaine 1971).

The linear aspect of the drainage network morphometry incorporates stream order, stream length, drainage density, drainage frequency and bifurcation ratio etc. The aerial aspect of the drainage network morphometry incorporates basin area, stream frequency, constant of channel maintenance, texture ratio, Elongation Ratio, circulatory ratio and form factor etc. Relief aspects

Linear aspects of the basin:

Linear aspects, Stream order (Nu), stream length (Lu), stream length ratio, mean stream length, and bifurcation ratio (Rb) are linear aspects that were determined and results have been discussed in the present paper

Stream order:

In the present study, first step is to determine the stream orders for the drainage analysis (Table 1).

Table 1: Stream Order, Number of Stream, and Stream Length

River Basin	Stream order (u)	Number of Stream (Nu)	Total Length of Stream in km(Lu)	Stream Length Ratio (Rl)
Mousam	I	1905	985.26	0.3159
	II	459	311.25	0.7156
	III	111	222.75	0.6914
	IV	31	154.02	0.1351
	V	3	20.82	3.6503
	VI	1	76	

Average Stream Length (Lu):

The second law of Horton states that the average length of streams of the different order in drainage basin tends closely to approximate to a direct geometric series in which the first term is the average length of the streams of the first order.

Mean length for Mousam basin and its selected ten tributaries are calculated with the help of 1:50,000 toposheet. The mean stream length of lower order segment ranges between 0.8502 (shendriamba) to 1.45 (Chirkad). The lower order segments do not very much as compared to the higher order segments. The mean stream length increases from lower order to higher order segments.

It is clear from the toposheet reading and field observation that mean stream length increases from the high elevated surface of the basin to the lower surface of basin. The variation in the mean length of stream of different order might have happened due to the slope and the stage of landform development of the basin.

The factors like relief, rainfall, and lithological characteristics are also responsible in variation of mean stream length in Mousam basin and its tributaries.The estimated Regression lines of order and average length have been plotted on a semilog graph paper for the Mousam basin and its ten selected tributaries.

The headward extension of the length of first order tributaries is observed at the source region due to the headward erosion near the water divide. But in the lower course the length of the higher order is more like at Nagror and Chirkad. But in the case of Mousam basin the length of higher order i.e. VI order (1.6388) has decreased from V order. (3.9457). It is important to note that river Mousam is captured by Girna river.

Law of Stream Number:

R.E. Horton (1945) defined law of stream number as "The number of stream segments of successively lower order in a given basin which tends to form a geomorphic series beginning with the single segment of the highest order and increasing according to constant bifurcation ratio".

The Mousam basin is the 6th order stream and Bifurcation ratio is 4.5950. The law of stream number was used for Mousam and its ten selected tributaries. According to law of stream number the stream number decreases from lower to higher order.

Length Ratio:

The length ratio can be define as average ratio of average stream length of a given order to average length of streams of next lower order. The length ratio is calculated according to the following equation.

The length ratio of Mousam basin and its ten selected tributaries has been calculated which suggest that the average length ratio of the Mousam basin and its ten selected tributaries ranges between 1.4513 (sind) and 7.60685 (Nagror).

The stream length is inversely related to stream order means stream length decreases from lower order to higher order.

This type of relationship is generally observed in tributaries like Chirkad, Dagadchand, Avlai, Tung Shendriamba, Karanjadi and Nagror, but it is not observed in river Mousam, Bhevri, Sind and Vatoli.

Bifurcation Ratio:

Bifurcation ratio (Rb) is related with the drainage network which is defined as a ratio of the number of streams of a given order (Nu) to the number of streams of a given higher order The bifurcation ratio ranges between 20 to 100 in the Mousam basin as well as its tributaries. There is extreme variation in bifurcation ratio except at Nagror Nala and Dagadchand Nala.

When we compare the lowest order with the highest order segments E. Giusti and W.J. Schneider (1965) have shown that bifurcation ratios decrease with increase in order because as the order increases the percentage of streams that coalesce into higher order tributary, also increases, due to the diminishing amount of area available. This hypothesis doesn't hold true for Mousam basin because majority of selected tributaries show decrease in bifurcation ratio with increase in order except some like Nagror, Chirkar, Avalai, Nalas which show increase in bifurcation ratio with increase in order.

In Mousam basin it is clearly seen that Nagror, Dagadchand, Avalai and Chirkad Nala have less area occupied by higher order but bifurcation ratio is abnormally high. The bifurcation ratio of other streams fluctuates between 2 to 3, and 3 to 5 which is suggestive of drainage development under abnormal conditions.

According to Horton (1945) mean bifurcation ratio varies from about 2.0 for flat or rolling basins to 3.0-4.0 for mountaneous, hilly disselected basins. The streams originating in the mountaneous area on west, south and north of the Mousam basi has disselected the area in large amount.

K Index:

The value of 'k' is perfect under normal condition of drainage development. The abnormal condition of drainage disturbs the value of 'k'. The constant 'k' is estimated for the entire Mousam basin and its ten selected tributaries. The value of k suggests a normal drainage development in Mousam basin.

1) K index of sind (1.529050195) suggests a normal development of drainage on the Northern side of river Mousam in the lower course over a flat terrain with uniform slope.
2) All remaining tributaries of Mousam and Mousam river itself suggests that the value of 'k' index is less than one. (Mousam, Nagror, Chirkad, Karanjadi, Dagadchand, Shendriamba, Tungadi, Bhevri, Avalai, Vatoli). A lower value of 'k' index suggests that the bifurcation ratio is higher than expected or normal. B.R. = 6.9 and 'k' index is 0.209482794

A present rejuvenation may have disproportionately increased the number of stream in the lower order segment. This is observed I Vatoli, Tungadi and Mousam, where bifurcation ratio is higher and 'k' index is lower than 0.5000000000. This one can conclude that Mousam and above mentioned for tributaries are structurally controlled.

Geometry of Basin Shape:

The geometry of basin shape is of Paramount significance as it helps in the description and comparisons of different forms of the drainage basins and it is also related with the functioning of the units of the basins and its genesis. Every drainage basin has its specific shape, size, length and area which is influenced by lithology, structure, absolute reliefs, slopes etc.

The drainage network of Mousam basin is elongated in shape from West to East. The elongated shape is due to structural control. There are near about 40 (forty) small and big sized tributaries. Out of these only ten selected tributaries and geometric properties have been measured.

Basin Elongation and Circulatory Index:

The shape of the drainage basin has Been studied by the above mentioned methods and all these methods are discussed separately. The elongation ratio is defined by S.A. Schuman (1956) as the ratio of diameter of a circle of the same area and the maximum basin length.

The value of elongation ratio varies from O(Highly elongation ratio in Mousam basin ranges between 0.30796 (Nagarpr Nala) to 0.6609 (Tungadi Nala) and elongation ratio of Mousam is 0.5410174.Nagaror Nala (0.30796) and Karanjadi Nala (0.3303) bears a low elongation ratio which indicates the elongated shape of these tributaries.

The remaining tributaries and Mousam basin bears an elongation ratio between 0.4107 (vatoli Nala) and 0.6609

(Tungdi Nala) which indicates an oval shape. On the basin of elongation ratio it can be said that tributaries of Mousam basin and main course of Mousam basin is oval in shape except Nagror and Karanjadi nala which are elongated in shape.

These tributaries also show the lowest value of Horton's form factor (F) i.e. Nagror (0.0948) and Karanjadi (0.1091) and other values of 'f' range between 0.0857 (mousam) to 0.22816 (sind nala).

Higher circularily ratio of Index (C) is an important method to study drainage basin shape V.C. Miller (1953) defined circularily ratio as the ratio of basin area to the area of a circle. Having the same perimeter as the basin circularity is calculated with the help of following formula:-

The circularity ratio or index (c) is calculated for mousam basin and its selected tributaries. Circularity Index ranges between 0.2365 (karanjadi) to 0.5846 (shendriamba nala). The value of 'c' varies from 0 to 1.

Higher the value of 'c'. more the circular shape of the basin. The lowest value of Nagror nala 0.3161337, Karanjadi Nala 0.236514461, Mousam 0.2582882 and Tungdi 0.363771833 suggests the elongated shape of the basin. The elongation ratio and circularity Index of chirkad nala, dagadchand nala, avlai, shendriamba nala, sind nala, and Tungdi nala shows oval shape of these basins. The elipticity index of Nagror nala(8.2767) and Karanjadi (7.1928) and lemniscate method (k) of (2.6358) and Karanjadi nala (2.2907) is high indicates the elongates shape of these tributaries.

Generally, it is observed that the basin elongation ratio and circularity ratio are inversely related to each other and circularity ratio is proportional to the square root of Horton's 'F'. But all the tributaries of Mousam basin have not obeyed the general rule between elongation ratio and circularity ratio and Horton's 'F'. Thus it can be said that tributaries of Mousam basin show different tendencies.

It is generally believed that if all the factors controlling drainage basin development remain constant then the shape of the basin becomes more and more circular with the advancement of stages of cycle of erosion and in its late stage of development the basin takes a pear shape. But the shape of the Mousam basin doesn't appear to be the result of basin development as Mousam basin is observed between Galana range in North and Dholbari range in the south. As river mousam it is oval in shape.

Thus it means that topography and structure has played a major role in shaping the Mousam basin.

Relief Aspects of Mousam Basin:

The study or analysis of relief aspects of the basin is important because it helps to understand the three dimensional features of basin. i.e. area, volume and altitude.

Relief aspects include the analysis of relationship between area and altitude. (hypsometric analysis) relative relief, relief ratio, dissection index and roughness index.

Hypsometric Analysis:

Hypsometric analysis is the measurement and analysis of relationship between altitude and basin area to understand the degree of dissection and stages of cycle of erosion. Hypsometric analysis is completed by using area height cures hypsometric curves and percentage hypsometric curve.

Area height curve:

The area height curve shows the actual area of land between two adjacent contours. Area height curves hypsometric curves an percentage hypsometric curves are considered and drawn while studying the relief aspects of Mousam basin and its selected tributaries. Percentage hypsometric curve is more relevant here as area height curves and hypsometric curves do not give the actual picture of the terrain.

Percentage Hypsometric Curve:

Percentage hypsometric curve has been suggested by A.N. Strahler in 1952. It is used to study the cycle of erosion in Mousam basin and its tributaries. While analyzing the hypsometric curves separately for each basin, it has been observed that the curves show several irregularities which represent structural and lithological variations.

The hypsometric curve of the Mousam shows vertical slope at the source region which indicates that the source region occupies less area. It further shows concavity and in the lower part it shows convexity. During field observation it was clear that Mousam has originated from second highest peak in the western ghat and has descended in a somewhat straight line. It later flows on a moderate steep slope surface.

In the middle part of Mousam the slopes gentle and then it descends down taking a convex curve. The hypsometrical integral of Mousam is 0.39 which indicates old or late matured stage of landform development.

In general it is observed that the tributaries present on the southern side except Karanjadi have high on no side. It can be said that these tributaries are younger than southern tributaries.
Tributaries of more length and originating i.. Galana hills and western ghat show hypsometrical integ between 0.39 to 0.46.

Relief:
Relief can be defined as the difference in elevation of any part of the surface (Moore). Relief can be expressed in two ways:

1) **Absolute Relief** 2) **Relative Relief**

1) Absolute relief:
Absolute relief for Mousam basin was obtain with the help of Isopleth map. The absolute relief of Mousam basin is divided into five categories. The absolute relief of Mouam basin ranges between 420 mts to 1567 mts. It is clear from the table that maximum area (40.1265%) comes under 400-600 mts. Category, and 34.0506% area comes under 600-800 mts. Category. In Mousam basin 74.1771% of area is at a height between 400 to 800 mts. A high elevated area, means area above 1200mts, is very less (i.e. 3.4177) which is on the southern northern and western water divide of Mousam basin.

2) Relative Relief:
Relative relief is the difference between highest and lowest height in one which square grid. Relative relief is also termed as amplitude of relative relief or local relief. W.S. Glock (1932) used the term amplitude or relief and defined it as the 'the vertical distance from a horizontal fairly flat upland down to the initial grade of the streams'.
While analyzing the relative relief on Mousam readings from isopleth mapwas calculated. The data of relative relief was divided in 06 categories. The relative relief of Mousam basin is divided in to 6 categories,

Constant of Channel Maintenance:
A measure of reciprocal of drainage density used by Schumn (1956) is termed as constant of channel . It is an inverse function of drainage density. It is a significant genetic, connotation of the landform. It is an useful indication of erosional dynamics of the drainage basin. Values obtain suggest that the constant of channel maintenance ranges between 0.019145481 (mousam) to 0.28877551 (Avlai). The average value fluctuates around 0.1928. It means that 1 km. of stream requires 0.1928 sq. km. of an area to feed.
It is found that in the semi-arid climatic environment the constant of channel maintenance is fairly high. The constant of channel maintenance is comparatively higher in the upper reaches of Mousam basin than in the middle and lower reaches.
There is a possibility of higher infiltration. In the middle and lower reaches which has been associated h gentle slope and lithological characteristics. The occurrence of alluvial deposits in the middle course and flat ten in with lesser amount of thin layered soil is responsible for a level infiltration. Thus a high constant of channel maintenance is observed in the middle and lower course.

Drainage Basin Area:
The drainage basin area is a total catchment area of that basin drained by the entire network of the same basin. The size of the basin is controlled by lithology, structure, topography, and climate.
The catchment area of Mousam basin and its ten (10) selected tributaries suggests that the size of the drainage basin is 790 sq.km. In the ten (10) selected tributaries the size varies between 19.16 km. (Dagadchand) to 79.56 sq km. (Karanjadi) Karanjadi Nala bears the highest catchment area in all the important ten selected tributaries of Mousam.
Thus with these variations in topography and geological structure it can be suggested that the size of the basin is controlled by geological structure and topographic features.

Basin Perimeter:
Basin perimeter is an important linear aspect of the morphometry. It can be defined as "the length of the divide in the catchment area of the basin". It is also a determinant factor of the size of the drainage basin. It should be nearly uniform in length for some order basin.

The values of basin perimeter indicates that there is great variation in the basin perimeters of tributaries because they do not belong to the same order.The basin perimeter of selected tributaries ranges between 19.5 km to 65.0 km. The basin perimeter of Mousam is 196 km.

Relative perimeter:

The relative perimeter of the basin has been calculated and values obtained suggest that the relative perimeter of ten selected tributaries lie between 14.2390 cm. (sind) to 53.1045 km. (karanjadi) The relative perimeter of mousam is 48.6278 km. the relative perimeter here shows variation in size and perimeters of the basins.

Dissection Index:

Dissection index is the ratio between absolute relief and relative relief of the basin in sq. grid. Dissection index is an important morphometric indicator of the nature and magnitude of dissection of terrain.

To calculate the Dissection index of mousam basin quick and result orienting method suggested by Dov Nir 1957 is considered. This method takes into account the dynamic potential state of the area. And the ratio between relative altitude and the perpendicular distance from the erosion base.

The value of dissection index generally ranges between 0 to1.0. Dissection index value in Mousam basin ranges between 0 to 0.57. Obtain values clearly suggest that nearly 57.06% of area lies in extremely low dissection index category and 19.33% of area lies in the law dissection index category.

These two categories occupy 76.39% of area of the basin which indicates the maximum availability of agricultural dissection index 0.2 to 0.3 occupies 15.2% high dissection index (0.3 to 0.4) occupies 6.13% and very high dissection index (above 0.4) occupies 2.26% of area of the basin.

High dissection index is observed in source area near water divide of Mousam basin. The field survey has made it clear that the area below 0.2 dissection index is concentrated on the northern side than on the southern side of Mousam.

Roughness index:

Roughness index (Mukhopadhayay 1973,1977) has been used to show the characteristics of surface configuration within the basin.

Roughness index values suggest that more than 50% of area i.e. 61.84% comes under extremely low roughness index category.

Drainage Frequency:

To calculate drainage frequency Horton's method was used to obtain drainage frequency. Nearly 45% of the area shows poor drainage frequency, nearly 30% area is covered moderate drainage frequency and 25% covers high frequency. High and Very high is observed at source region. The mean, mode, and Median values are 6.45Kms, 2.87 Km, and 4.04 Km respectively. Standard deviation is 6.35Km.

The drainage frequency shows positive skewness slope, relief and rainfall, which is responsible for asymmetrical distribution of drainage frequency in Mousam Basin. Drainage frequency of Mousam basin is 3.1658 per sq.km. Drainage frequency ranges between 1.7876 (Nagor) to 7.5516 (Shendri Amba Nala) in ten selected tributaries.

Drainage Density:

Drainage density of Mousam basin is 5.2231 Km per sq.km. in the tributaris it ranges between 3.6623 (Chirkad) to 8.0529 (Shendriamba). In the present study area it is observed that most of the area is covered by 3 to 6 streams per.sq.km while second largest area is covered by 6 to 9 streams and rest of the area is covered by reaming categories.

CONCLUSION:

Mousam river basins have been investigated in this is a elongated river. River Mousam is the 6th order basin. Few factors that control the drainage development are climate, geology and relief. The type of shape is obtain by a river due to two mountain ranges very near to main channel in south and north direction. secondly river is capture by River Girna near Malegaon. drainage pattern has been observed in both channels are mainly dendritc in the source region. which are an irregular branching of tributaries from many directions joining to the trunk stream at less than of a right angle. Depending on stream network and basin properties, all the morphometric parameters have been calculated to understand hydrological characteristics of river basins. The study successfully demonstrates ... basin is useful for socio-economic balance of the region.

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