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MORPHOMETRIC ANALYSIS: A GIS APPROACH

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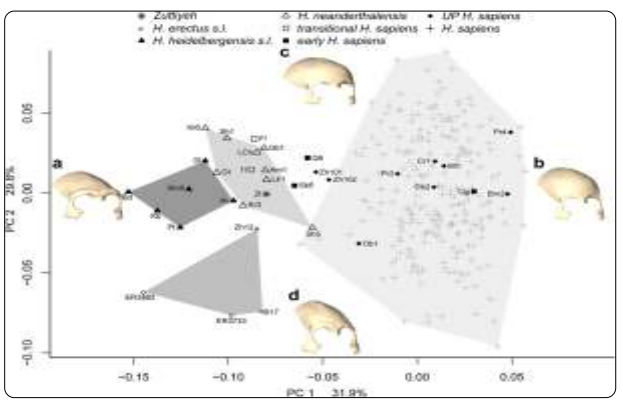
ABSTRACT

Over Morphometric analysis has been carried out to determine the drainage basins characteristics of the river. In the present study the Bori, Ajani, Bhokad & Mor which are tributaries of the Tapi river are used for morphometric analysis by using Remote sensing and Geographic Information System (GIS) techniques. An evaluation of morphometric characteristics of a drainage basin requires preparation of drainage map, length of drainage channels, ordering of various streams and measurements of catchment area and the then drainage density, bifurcation ratio, drainage frequency which help to understand the nature of drainage basin. On the basis of study of these watersheds, Drainage density of upper and lower has been detect the change from 2.15 to 1.82 and 1.85 to 1.62 respectively. In the present study update the drainages using LISS IV (5.8 mt. Resolution) image and calculate morphometry. GIS (Geographical information system) & RS (Remote sensing) have been proved to be efficient tools in drainage delineation and updation.



KEY WORDS: *Morphometric analysis, Georeferencing, Image rectification, Image inhansment, GIS, RS.*

INTRODUCTION

Morphometric Analysis

Morphometry is termed as measurement of the shape, or geometry of any natural form. Morphometric analysis, quantitative description and analysis of landforms as practiced in

geomorphology that may be applied to a particular kind of landform or to drainage basin and large regions generally.

Morphometric analysis is of fundamental importance in planning, design, and management of river. Morphometric techniques should be applied for the interpretation of salient features of drainage basin. These techniques are of immense important to correlate morphometric elements with hydrological behavior of the basin.

Morphometric study involves evaluation of streams through the measurement of various stream properties. Analysis of various drainage parameters namely ordering of various streams and measurement of area of basins, length of drainage channel, drainage density(Dd),stream frequency(Fu), bifurcation ratio(Rb).

AIMS AND OBJECTIVES

- Understanding the morphometric behavior of the Bori, Ajani, Mor and Bhokad drainages.
- Find out the changing pattern of drainage using Toposheet and LISS IV satellite Image.
- Comparison of data obtained from LISS IV satellite image with SOI Toposheet.

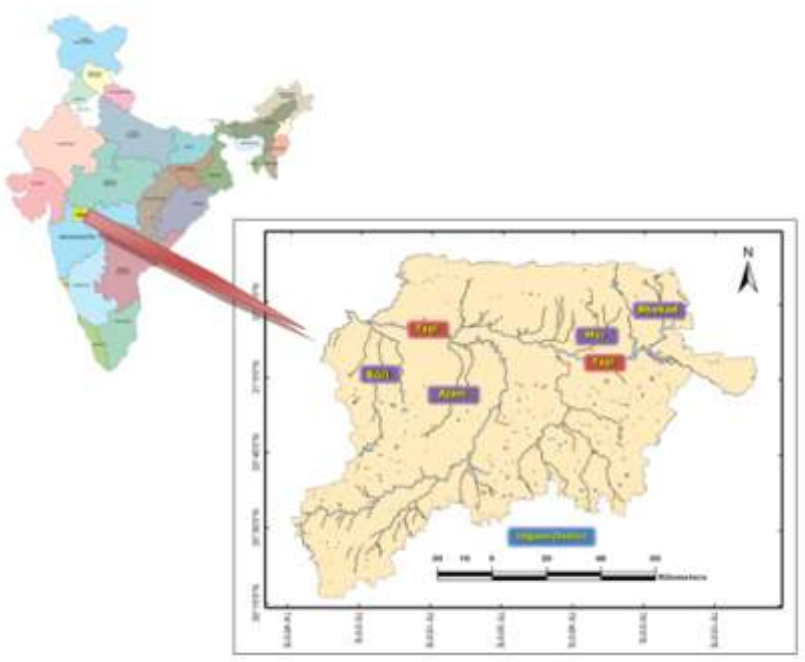
STUDY AREA

4.1 LOCATION

Jalgaon District is located in western India, in the north-west region of the state Maharashtra on the northern Deccan Plateau. Jalgaon is bounded by various districts and state from all sides. They are in north direction by the state of Madhya Pradesh, in east direction by Buldhana District of Maharashtra, in west direction by Nasik and Dhulia Districts of Maharashtra, and in south direction by Aurangabad District of Maharashtra. Geographical Extent of area under study is as fallows,

Latitude - 20° 16' 32" to 21° 24' 56" N
Longitude - 75° 45' 30" to 76° 24' 2" E
Total area - 11,765 sq. km

Location Map of Study Area



DATABASE

Two types of data base were used in this study:-

1. Primary database 2. Secondary database

5.1 Primary database (satellite image)

Table 5.1: Details of IRS-P6 LISS IV Images (Resolution 5.8 mt.)

Series No.	Date of Collection	Date of Generation	Number of Images
1	26 Feb 2008	10 Dec 2009	2
2	16 Mar 2008	10 Dec 2009	4
3	23 Oct 2008	10 Dec 2009	6
4	28 Oct 2008	10 Dec 2009	1
5	21 Nov 2008	10 Dec 2009	4
6	27 Jan 2009	10 Dec 2009	5
7	20 Jan 2009	11Dec 2009	5
8	14 Apr 2009	11Dec 2009	4
9	1 Dec 2009	11Dec 2009	2

"Primary database is information that has to be collected through field surveys to fill data gaps and data obtained for the first time and used specifically for the particular problem or issue under study." Although these Toposheet provided good plan metric controls and height information, but the available Toposheet were surveyed in different years quite some time back. Therefore, latest information about river courses was obtained using satellite images of latest available.

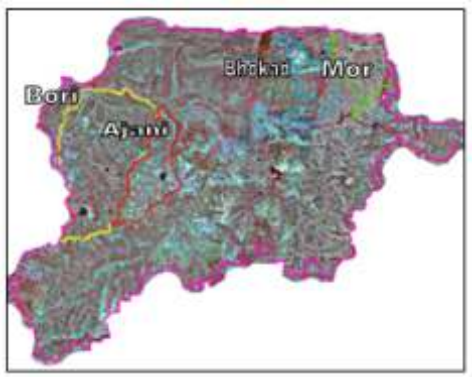


Figure 5.1: LISS- IV image of Jalgaon District

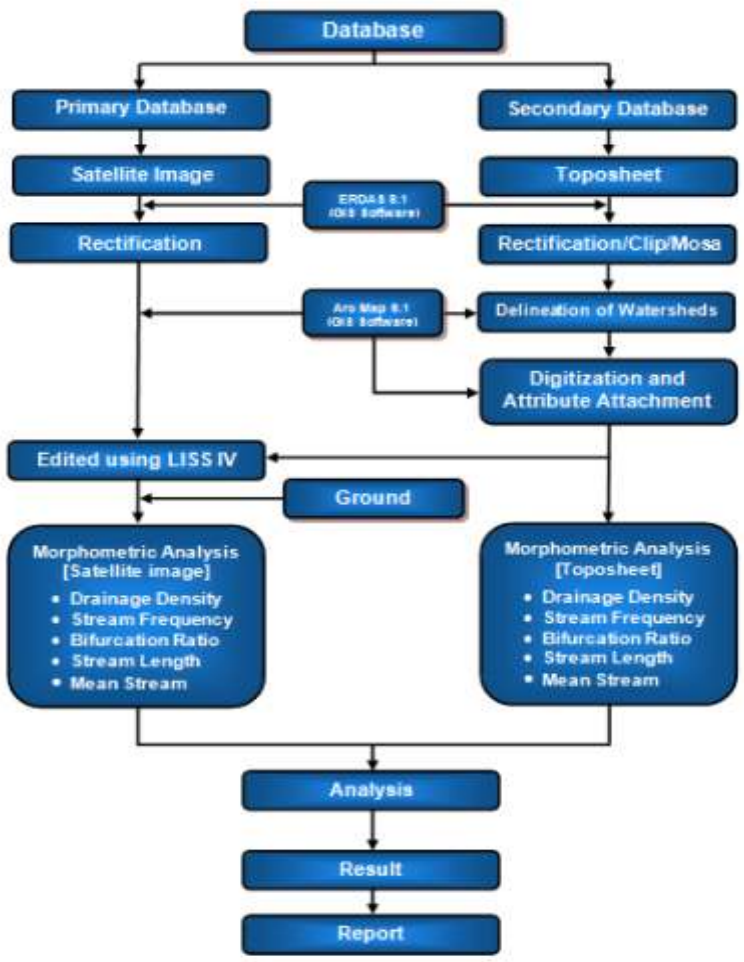
5.2 Secondary database (Toposheet)

Survey of India Toposheet at the scale of 1:50,000 were used in the study. Toposheet nos. 55 C4, 55 C3, 46 O15, 46 O16, 46 O4, 46 P1, 46 O8 and 46 P5 at 1:50,000 scales were used to collect spatial and topographical characteristics of the area. Toposheet at 1:50,000 scales provided better details and information about the area included. Although these Toposheet Provided good plan metric controls and height information, but the available Toposheet Were surveyed in different years quite some time back. This SOI sheet comprises data derived from surveys conducted between 1847 and 1895. Hence the base year information dates back over 100 years. Therefore, latest information about roads and river courses were obtained using satellite images of latest available Dates to get the updated spatial data about the project areas.

5.3 Software Used

- ERDAS Imagine 9.1
- Arc Map 9.1
- Microsoft Office 2007

METHODOLOGY:



MAPS :

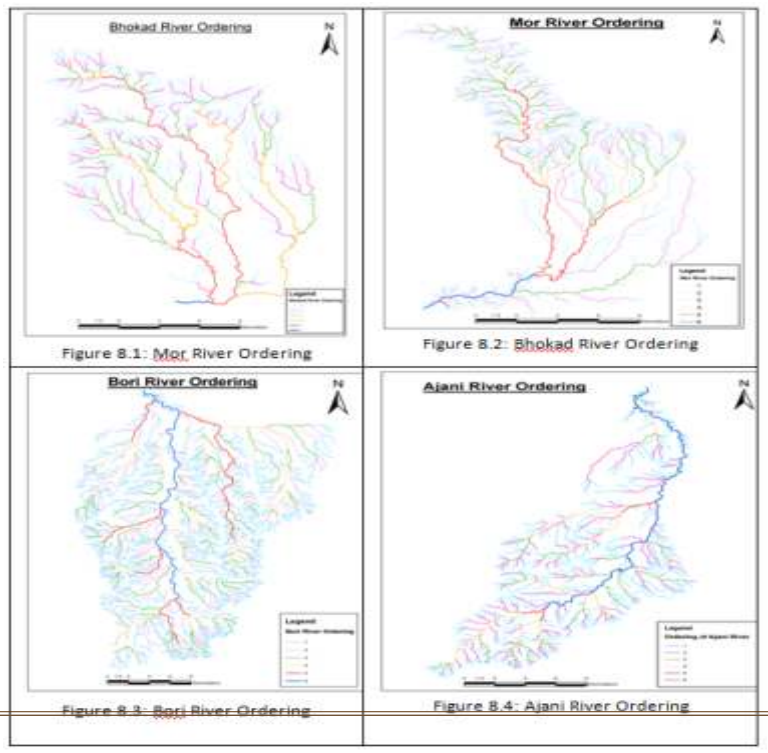


Figure 8.1: Mor River Ordering

Figure 8.2: Bhokad River Ordering

Figure 8.3: Bori River Ordering

Figure 8.4: Ajani River Ordering

Upper Basin				
Stream order	Toposheet Drainage(New)		LISS IV image Drainage(Old)	
	Bhokad	Mor	Bhokad	Mor
1	706	788	461	737
2	199	201	110	168
3	54	43	30	34
4	12	15	7	9
5	3	3	2	3
6	1	1	1	1
7	0	0	0	0
Total	**975**	**1051**	**611**	**952**

Table: 9.2

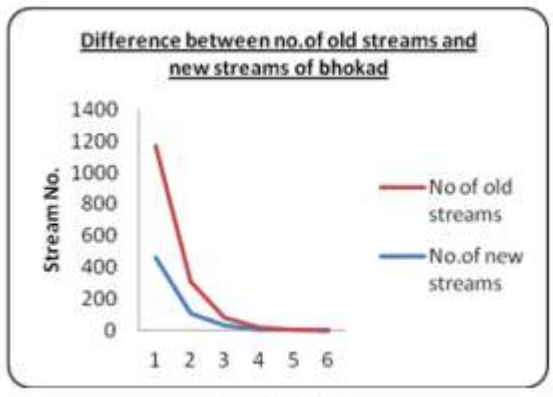


Figure 9.3

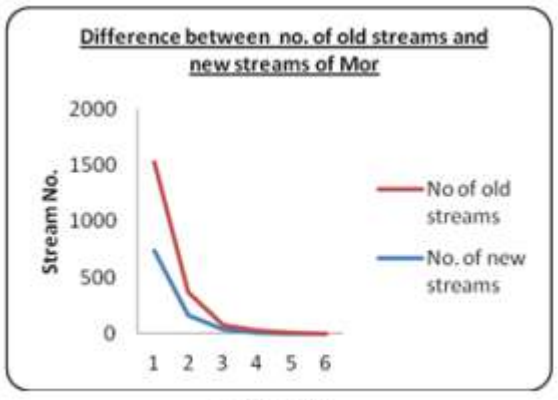


Figure 9.4

The stream data gain from the to posheets depicts that the total number of streams in the Bhokad and Mor basin accounts for 975 and 1051 respectively. The stream data extracted from LISS IV images shows that the total number of streams in Bhokad and Mor basin accounts for 611 and 952 respectively. Stream number analysis reveals that as the stream order increases, number of stream decreases. There is negative correlation between stream order and stream number which justifies Strahler's stream order method.

Difference between numbers of streams in Percentage:

Lower Basin								
Stream order	BORI				AJANI			
	No. of new streams	No. of old streams	Difference	Difference (%)	No. of new streams	No. of old streams	Difference	Difference (%)
1	1406	2340	934	73.36	619	706	87	66.41
2	377	607	230	18.06	150	183	33	25.19
3	96	173	77	6.04	34	43	9	6.87
4	22	44	22	1.72	10	12	2	1.52
5	6	13	7	0.54	3	3	0	0
6	1	3	2	0.15	1	1	0	0
7	0	1	1	0.07	0	0	0	0
Total	**1908**	**3181**	**1273**	**100**	**817**	**948**	**131**	**100**

Table: 9.3

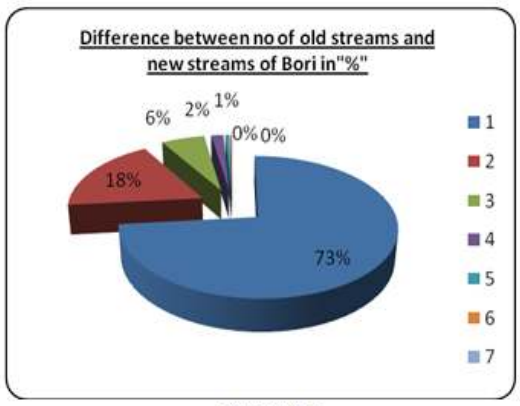


Figure 9.5

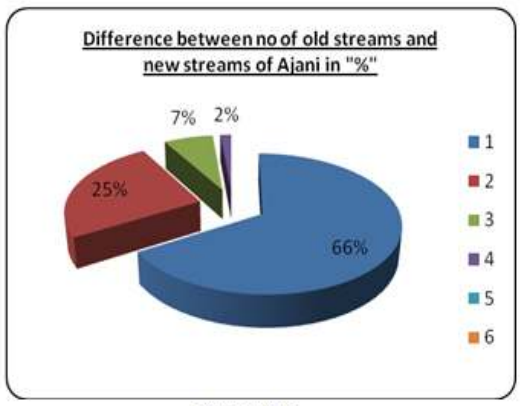


Figure 9.6

The stream data extract from the toposheets depicts that the total numbers of streams in the Bhokad basin are 975 and the stream data extracted from LISS IV image shows that the total number of streams in Bhokad basin accounts for 611.The difference between total number of streams in Bhokad basin extracted from Toposheet and LISS IV image is 364 which is approximately 67% in the first order and 0% in sixth order. The ratio of difference between no. of streams and stream order of Bhokad is inversely in proportion. Such as the difference decreases with increasing steam order.

Upper Basin								
Stream order	Bhokad				Mor			
	No. of new streams	No. of old streams	Difference	Difference (%)	No. of new streams	No. of old streams	Difference	Difference (%)
1	461	706	245	67.31	737	788	51	51.52
2	110	199	89	24.45	168	201	33	33.33
3	30	54	24	6.59	34	43	9	9.09
4	7	12	5	1.37	9	15	6	6.06
5	2	3	1	0.27	3	3	0	0
6	1	1	0	0	1	1	0	0
7	--	--	--	--	0	0	0	0
Total	**611**	**975**	**364**	**100**	**952**	**1051**	**99**	**100**

Table: 9.4

Figure 9.7

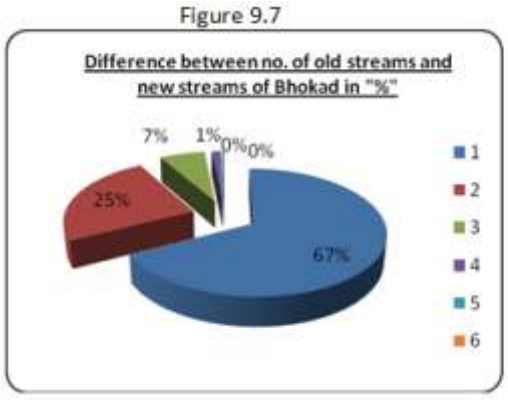
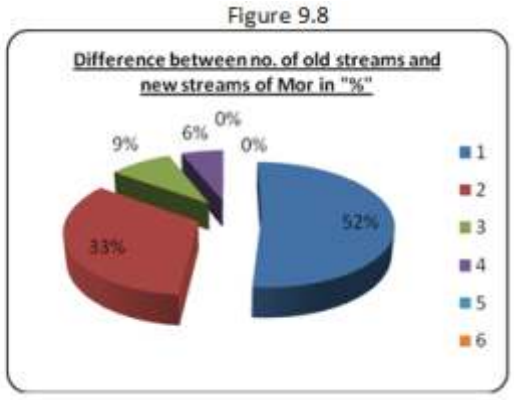


Figure 9.8



The stream data extract from the toposheets depicts that the total numbers of streams in the Bhokad basin are 975 and the stream data extracted from LISS IV image shows that the total number of streams in Bhokad basin accounts for 611.The difference between total number of streams in Bhokad basin extracted from Toposheet and LISS IV image is 364 which is approximately 67% in the first order and 0% in sixth order. The ratio of difference between no. of streams and stream order of Bhokad is inversely in proportion. As per the upper basin lower basin also difference decreases with increasing steam order.

Drainage Density

Lower Basin			
Toposheet Drainage (Old)		LISS IV image Drainage (New)	
Bori	Ajani	Bori	Ajani
1.91	1.8	1.52	1.71

Table : 9.5

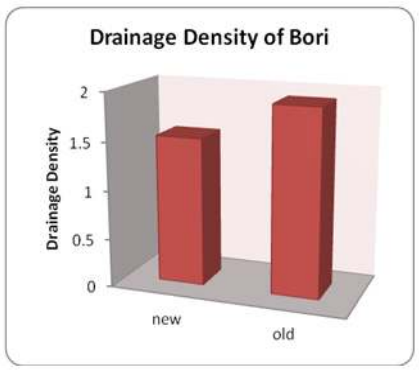


Figure 9.9

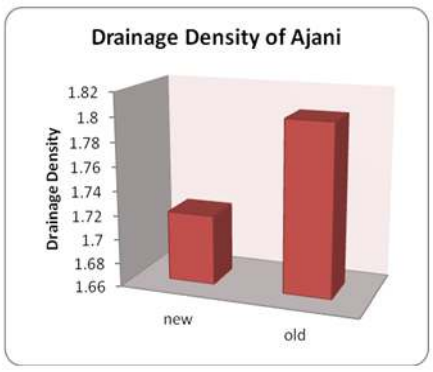


Figure 9.10

Low Drainage Density generally results in the areas of highly resistance or permeable sub-soil material, dense vegetation and low relief. High drainage density is the result of weak or impermeable sub-surface material, sparse vegetation and mountainous relief. Low density leads to coarse drainage texture while high density leads to fine drainage texture.

The stream data extracted from toposheets shows that, in the Bori basin of the study area are 1.91.where drainage density of Ajani Basin is 1.8.By the way of illustration, the stream data extracted from LISS IV images is the drainage density of Bori basin is 1.5 and drainage density of Ajani is 1.71 suggesting low drainage density in both new and old analysis of basins of Bori and Ajani. The basins having low drainage density is highly resistance or highly permeable sub soil material under dense vegetation cover and low relief.

Upper Basin			
Toposheet Drainage (Old)		LISS IV image Drainage (New)	
Bhokad	Mor	Bhokad	Mor
2.1	2.21	1.54	2.09

Table :9.6

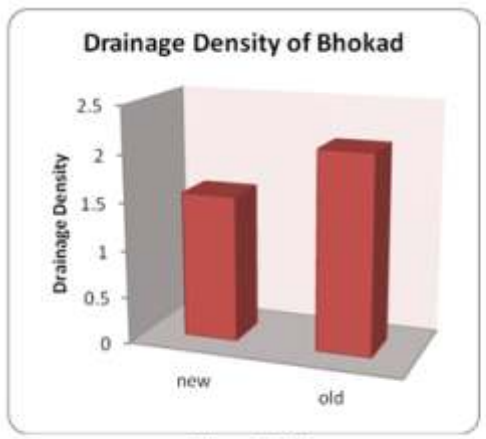


Figure 9.11

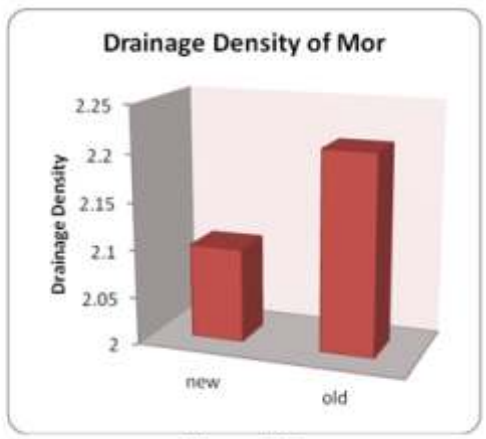


Figure 9.12

Low Drainage Density generally results in the areas of highly resistance or permeable sub-soil material, dense vegetation and low relief. High drainage density is the result of weak or impermeable sub-surface material, sparse vegetation and mountainous relief. Low density leads to coarse drainage

texture while high density leads to fine drainage texture.

The stream data extracted from toposheets shows that, in the Bhokad basin of the study area are 2.1, where drainage density of Mor Basin is 2.21.By the way of illustration, the stream data extracted from LISS IV images is the drainage density of Bhokad basin is 1.54 and drainage density of Mor is 2.09, suggesting low drainage density in both new and old analysis of basins of Bhokad and Mor. The basins having low drainage density is highly resistance or highly permeable sub soil material under dense vegetation cover and low relief.

Bifurcation Ratio

Lower Basin				
Stream Order	Toposheet Drainage (Old)		LISS IV image Drainage (New)	
	Bori	Ajani	Bori	Ajani
1	3.85	3.85	3.72	4.12
2	3.50	4.25	3.92	4.41
3	3.93	3.58	4.36	3.4
4	3.38	4	3.66	3.33
5	4.33	3	6	3
6	3	0	0	0
7	0	0	0	0
Total	**22.01**	**18.69**	**21.68**	**18.27**

Table :9.7

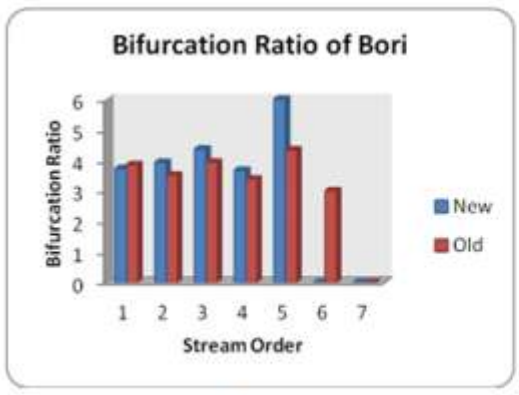


Figure 9.13

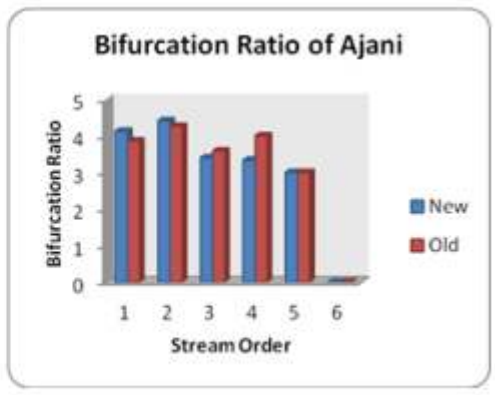


Figure 9.14

Bifurcation ratios of the basin of mountainous and dissected regions are slightly more than the bifurcation ratio of the basin of the flat and rolling surface. This holds the parity with the above analysis as the bifurcation ratio of the basin developed over hilly and dissected region is quite high than other sub basin of flat surfaces. A bifurcation ratio of Bori and Ajani basin has been given in table. .The stream data taken from the toposheets shows that bifurcation ratio of Bori ranges from 3.51 to 4.16 and bifurcation ratio of Ajani ranges from 3.29 to 4.29 the stream data extracted from LISS IV images depicts that bifurcation ratio of Bori ranges from 3.66 to 6 and bifurcation ratio of Ajani ranges from 3 to 4.41.

Upper Basin				
Stream Order	Toposheet Drainage (Old)		LISS IV image Drainage (New)	
	Bhokad	Mor	Bhokad	Mor
1	3.55	3.92	4.19	4.38
2	3.69	4.67	3.66	4.94
3	4.5	2.86	4.28	3.77
4	4	5	3.5	3
5	3	3	2	3
6	0	0	0	0
7	0	0	0	0
Total	**18.73**	**19.46**	**17.64**	**19.10**

Table :9.8

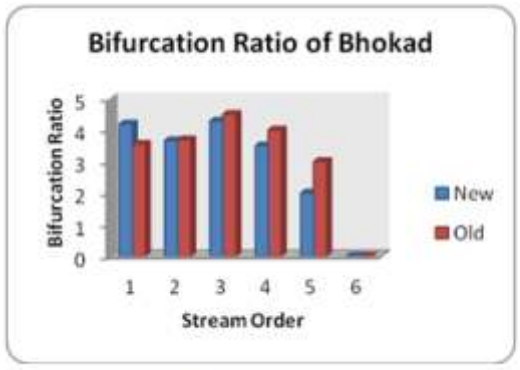


Figure 9.15

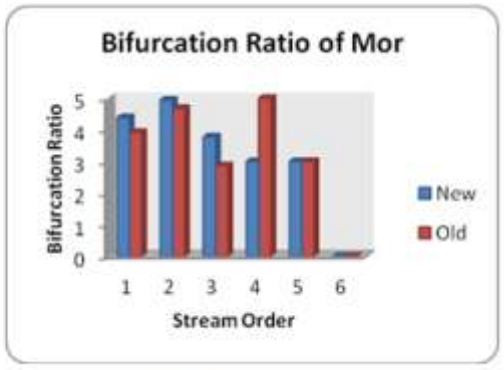


Figure 9.16

Bifurcation ratios of the basin of mountainous and dissected regions are slightly more than the bifurcation ratio of the basin of the flat and rolling surface. This holds the parity with the above analysis as the bifurcation ratio of the basin developed over hilly and dissected region is quite high than other sub basin of flat surfaces. A bifurcation ratio of Bhokad and Mor basin has been given in table. The stream data taken from the toposheets shows that, bifurcation ratio of Bhokad ranges from 3 to 4.5 and bifurcation ratio of Mor ranges from 3 to 5.The stream data extracted from LISS IV images depicts that bifurcation ratio of Bhokad ranges from 2 to 6 and bifurcation ratio of Mor ranges from 3 to 4.41.

Stream Frequency

Lower Basin			
Toposheet Drainage (Old)		LISS IV image Drainage (New)	
Bori	Ajani	Bori	Ajani
2.24	1.89	1.34	1.62

Table : 9.9

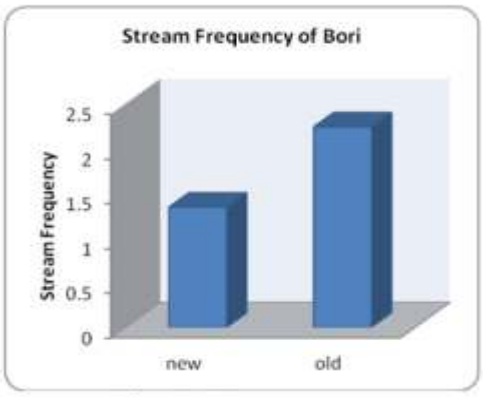


Figure9.17

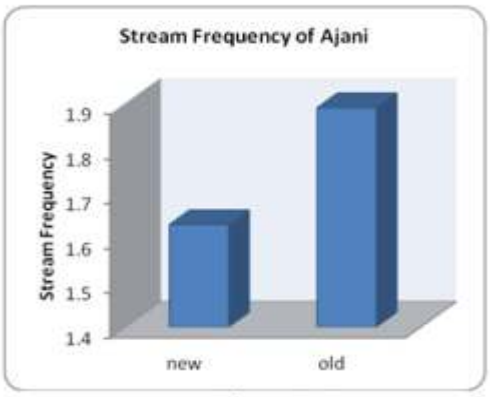


Figure 9.18

Stream frequency is measure of topographic texture expressed as the ratio of the number of streams in a drainage basin to the area of the basin. The stream data acquire from the toposheets depicts that, stream frequency of the Bori basin accounts 2.24 and stream frequency of the Ajani basin accounts 1.89. The stream data extracted from LISS IV images describes that the stream frequency of the Bori basin accounts 1.34 and stream frequency of the Ajani basin accounts 1.62.

Upper Basin			
Toposheet Drainage (New)		LISS IV image Drainage (Old)	
Bhokad	Mor	Bhokad	Mor
2.41	2.87	1.51	2.61

Table : 9.10

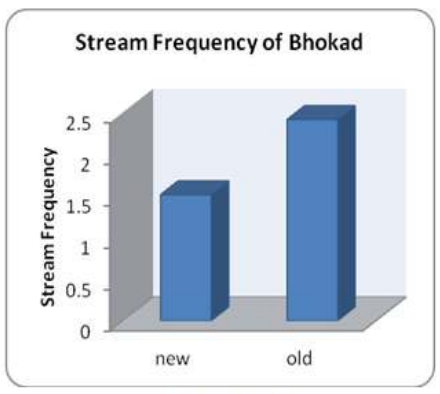


Figure 9.19

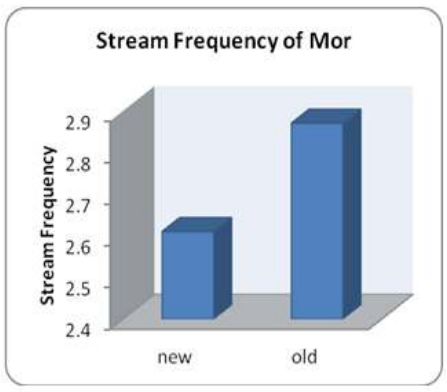


Figure 9.20

Stream frequency is measure of topographic texture expressed as the ratio of the number of streams in a drainage basin to the area of the basin. The stream data acquire from the toposheets depicts that, stream frequency of the Bhokad basin accounts 2.41 and stream frequency of the Mor basin accounts 2.87. The stream data extracted from LISS IV images describes that the stream frequency of the Bhokad basin accounts 1.51 and stream frequency of the Mor basin accounts 2.61.

Stream Length

Lower Basin				
Stream order	Toposheet Drainage (Old)		LISS IV image Drainage (New)	
	Bori	Ajani	Bori	Ajani
1	1382.49	484.66	1051.37	468.51
2	645.55	199.91	562.36	190.51
3	342.03	98.19	260.70	82.39
4	197.83	61.59	147.36	58.60
5	98.39	9.08	84.45	9.03
6	35.11	50.21	52.60	52.63
7	52.52	0	0	0
Total	**2753.93**	**903.67**	**2158.85**	**861.69**

Table : 9.11

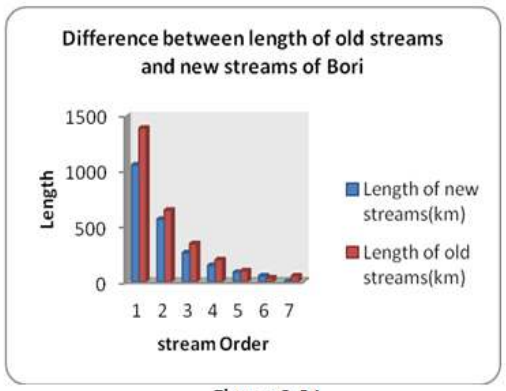


Figure 9.21

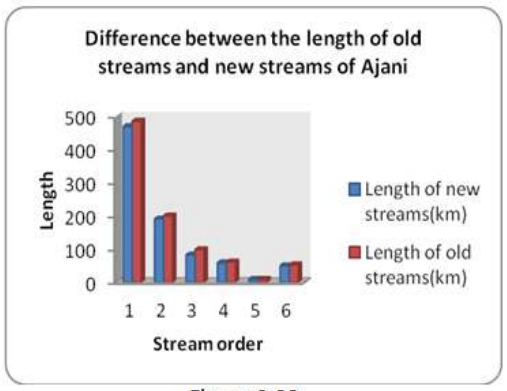


Figure 9.22

The stream data taken from the toposheets shows that, total stream length of the Bori basin accounts for 2753.93 km. Stream length of first order is 1382.49 km which accounts highest in the basin and total stream length of the Ajani basin accounts for 903.67 km. Stream length of first order is 484.66 km which accounts highest in the basin. By the way of illustration, the stream data extracted from LISS IV images is the total stream length of the Bori basin accounts for 2158.85 km and Stream length of first order is 1051.37 km which accounts highest in the basin. And total stream length of the Ajani basin accounts for 861.69 km and Stream length of first order is 468.51 km which accounts highest in the basin.

Upper Basin				
Stream Order	Toposheet Drainage (Old)		LISS IV image Drainage (New)	
	Bhokad	Mor	Bhokad	Mor
1	419.09	421.56	302.35	404.27
2	198.68	180.79	126.02	173.78
3	92.39	104.01	84.80	100.27
4	58.91	42.07	63.49	29.25
5	62.01	35.56	44.31	46.09
6	14.71	22.26	2.83	10.86
7	0	0	0	0
Total	**845.78**	**806.26**	**623.83**	**764.54**

Table : 9.12

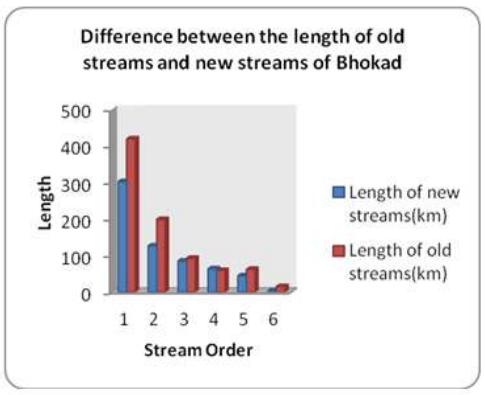


Figure 9.23

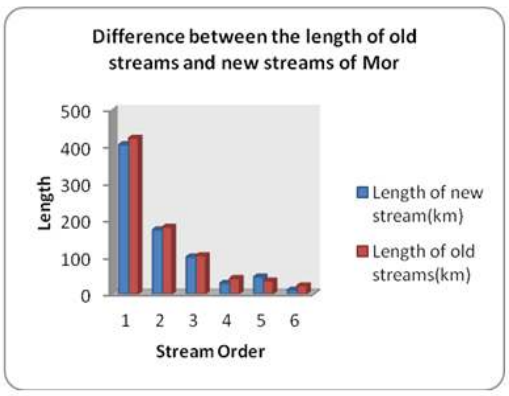


Figure 9.24

The stream data taken from the toposheets shows that, total stream length of the Bhokad basin accounts for 845.78 km. Stream length of first order is 419.09 km which accounts highest in the basin and total stream length of the Mor basin accounts for 806.26 km. Stream length of first order is 421.56 km which accounts highest in the basin. By the way of illustration, the stream data extracted from LISS IV images is the total stream length of the Bori basin accounts for 623.83km and Stream length of first order is 302.35 km which accounts highest in the basin. And total stream length of the Mor basin accounts for 764.54 km and Stream length of first order is 404.27 km which accounts highest in the basin.

Mean Stream Length

Lower basin				
Stream Order	Using Toposheet (Old)		Edited by LISS IV image (New)	
	Bori	Ajani	Bori	Ajani
1	0.59	0.68	0.74	0.75
2	1.06	1.09	1.49	1.27
3	1.98	2.28	2.71	2.42
4	4.5	5.13	6.69	5.86
5	7.57	3.02	14.07	3.01
6	11.7	50.21	52.60	52.63
7	52.52	0	0	0
Total	**79.92**	**62.44**	**78.33**	**65.95**

Table : 9.13

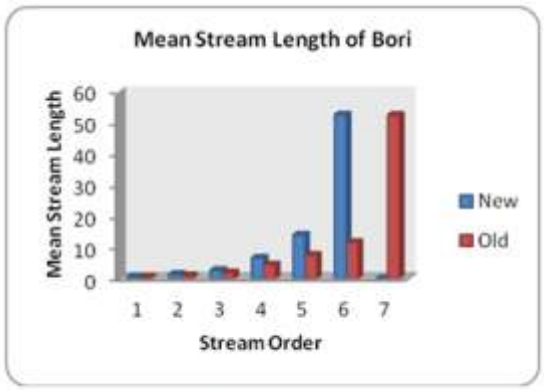


Figure 9.25

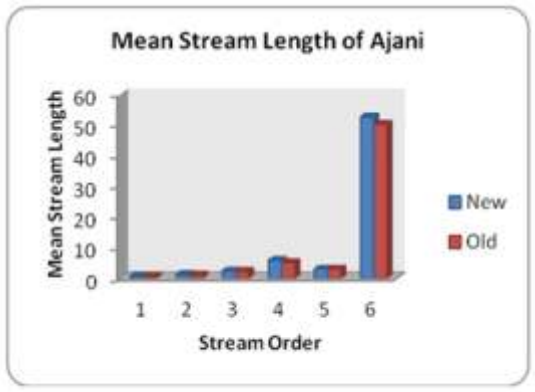


Figure 9.26

Mean stream length analysis reveals that the average length of stream segments increases proportionally with stream number. The stream data extracted from toposheets shows that, the total mean stream length of the Bori basin is 79.92 km and total mean stream length of the Ajani basin is 62.44 km. The stream data extracted from LISS IV images depicts that the total mean stream length of the Bhokad basin accounts 78.33 km and total mean stream length of the Ajani basin accounts 65.95 km.

Upper Basin				
Stream Order	Using Toposheet (Old)		Edited using LISS IV image (New)	
	Bhokad	Mor	Bhokad	Mor
1	0.59	0.53	0.65	0.54
2	1	0.89	1.14	1.03
3	1.71	2.41	2.82	2.94
4	4.91	2.80	9.07	3.25
5	20.67	11.85	22.15	15.36
6	14.71	22.26	2.83	10.86
7	0	0	0	0
Total	**43.59**	**40.77**	**38.69**	**34.01**

Table : 9.14

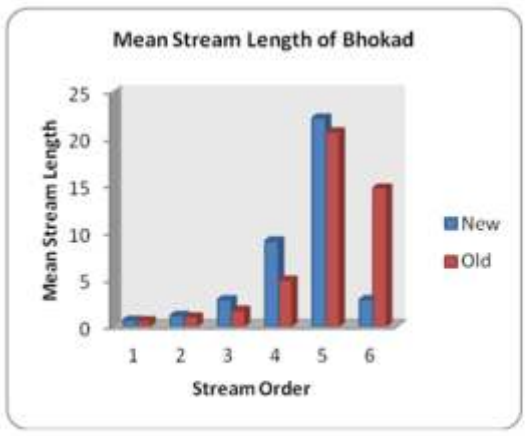


Figure 9.27

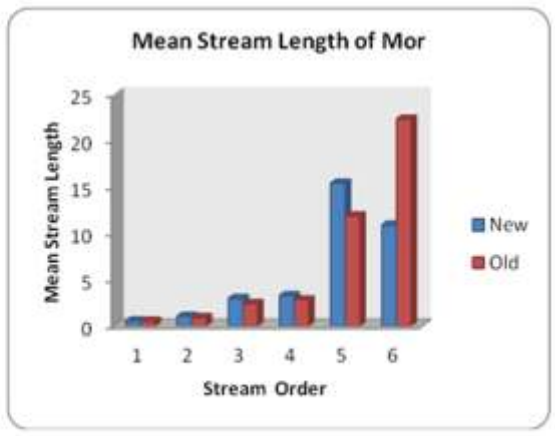


Figure 9.28

Mean stream length analysis reveals that the average length of stream segments increases proportionally with stream number. The stream data extracted from toposheets shows that, the total mean stream length of the Bhokad basin is 43.59 km and total mean stream length of the Mor basin is 40.77 km. The stream data extracted from LISS IV images depicts that the total mean stream length of the Bhokad basin accounts 38.69 km and total mean stream length of the Mor basin accounts 34.01

CONCLUSIONS

Remote sensing and Geographic Information System are very efficient, time-saving and accurate calculation tools for the morphometric analysis.

The drainage pattern of study area is mainly dendritic to sub dendritic and a little parallel. As per this study we conclude that, we find out the difference between the traditional method of morphometric analysis which calculates using Toposheets and another calculates using LISS IV satellite image. Generally geographers and planning officers used the traditional method for Morphometric analysis using Toposheets which survey in the period of 1970 to 80, so it is not perfect applicable for present of future planning. But using this study we can calculate perfect morphometric analysis, which can be perfect applicable for planning. It will be also helps to site selection and type of water harvesting structures.

Drainage density of upper basins is changing from 2.16 to 1.82 km/km2 and in the lower basin is changing from 1.86 to 1.62 km/km2. Also in the Bifurcation ratio, Stream length, stream frequency found the variation.

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