

Effect of Terrain on Stream Junctions and Drainage Density: A Study of Kadvi River Basin, Maharashtra

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Abstract

Background/Objectives: The present research study focuses the drainage characteristics of river Kadvi of Maharashtra. Surface run off also influencing by the basin characteristics of river. Various types of soil, gradient of basin, shape and size of river basin also affects on the runoffs and directly or indirectly influencing on the drainage densities of the river basins. **Methods/Analysis:** The analysis of drainage densities and river patterns of Kadvi river basin has attempted on the basis of Topographic maps of 47G-16, 47H-13 and 47L-1 at the scale of 1:50,000. Maps for drainage density were prepared using ERDAS IMAGINE 9.1 software and Arc GIS software. **Findings:** The higher drainage densities are associated with the steep slopes of the landscapes. Present study also reveals that, Stream flow and direction is closely related with hydrology of the river. Stream flow and direction indicate the topographic pattern, soil structure, rock formation of the basin. **Applications/Improvements:** In view of hydrological studies, the analytical results can help for the proper management of Kadvi river basin. The investigation techniques using geoinformatics can be applied to the other river basins also.

Keywords: Drainage Density, Drainage Network, Drainage Pattern, GIS technique, Stream Flow, Stream Junctions (Nodes)

1. Introduction

In river basin area, small water flows; runoffs and flow lines are highly influenced by topography and terrain of the basin. Even, changes in the climatic factors resulting for the transformation of terrain that indirectly modify the drainage system of the river basin. The topography of river basin and its land slopes are highly influencing on the stream density¹. That means the steep slopes of the land slopes with steep river gradients comes with the powerful river energy. Rivers are naturally changing from time to time with the interruption of human activities also²⁻⁶. All such changes in river regime are also the outcome of natural fluvial processes and climate change. All these processes are interrelated with hydrology and drainage characteristics of the basin. Effect of climate change on the runoff; use of morphometry for groundwater potential zone and mapping have attempted by many research scholars⁷⁻¹⁰. Geospatial techniques using remote sensing have been applied by many authors for morpho-

metric analysis of river basins for the proper management of irrigation potential and better planning of water supply schemes¹¹⁻¹⁸. The result of morpho metric analysis of Wadi Aurnah drainage system also very much useful to study the stream behavior and inter relation between connected streams². The author in his research study area applied the result for hydrological study and also for flood mitigation by using drainage density map, stream flow direction and stream junction map². Similar case study by adopting similar methodologies has also attempted for the Kadvi river basin of Maharashtra.

The Study area for the present research has includes Kadvi River Basin, located on the Deccan tract of Maharashtra as shown in Figure 1. Kadvi is the main tributary of Warna River in its upper basin. Kadvi River originates at an altitude of 1026.57 m from msl in the hilly region near Amba village and flow eastward for 48.45 km to join Warna river near Thergaon village. Basin area of Kadvi river is about 428.81 sq km. Potphogi river, Ambardi river and Shali river are the sub tributaries of

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Kadvi river. Kadvi river basin is mostly covered by hills and undulating landscapes in Figure 2. The geology of the basin is characterized by basaltic rock. High rainfall rate, black and red soil, hilly region, dense mixed forest of this region is directly affects on the river behaviour¹⁹.

The aim of this study to analyze the morphometric characteristic of Kadvi river. Some of the morphometric characteristics show the changing behaviour of river with respect to climate change, topographic changes etc. This information can be used in distribution of water management in Kadvi river basin.

LOCATION MAP OF KADVI RIVER BASIN

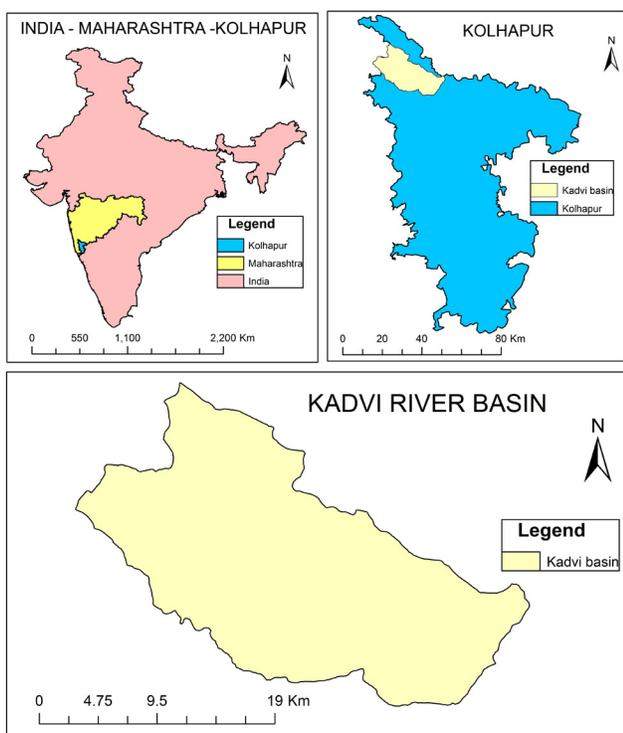


Figure 1. Location map.

2. Methods

The morpho metric analysis is based on Topographic maps of 47-G/16, 47-H/13 and 47-L/1 at the scale of 1:50,000. The SOI toposheets were georeferenced using ERDAS IMAGINE 9.1 software and digitization work is carried out using Arc GIS software. Morphometry of drainage basin replicate a variety of geological and geo morphological processes over a period of time that have attempted by many scholars for various morpho metric studies. The major parameters of drainage basin morphometry i.e.

stream number, stream order, stream length, river basin area, drainage density, stream frequency have attempted using various methods of morphometry²⁰⁻²⁴. Therefore an attempt has been made to study the responses of terrain characteristics to the drainage characteristics of the Kadvi river basin. The present study is based on the analysis of drainage densities and stream junction characteristics that has attempted using remote sensing and GIS techniques which is accurate technique for morpho metric study of the basin. In the present research work more emphasis has been taken to generate the basin characteristics maps on the basis of quantitative techniques of Kadvi river morphometry.

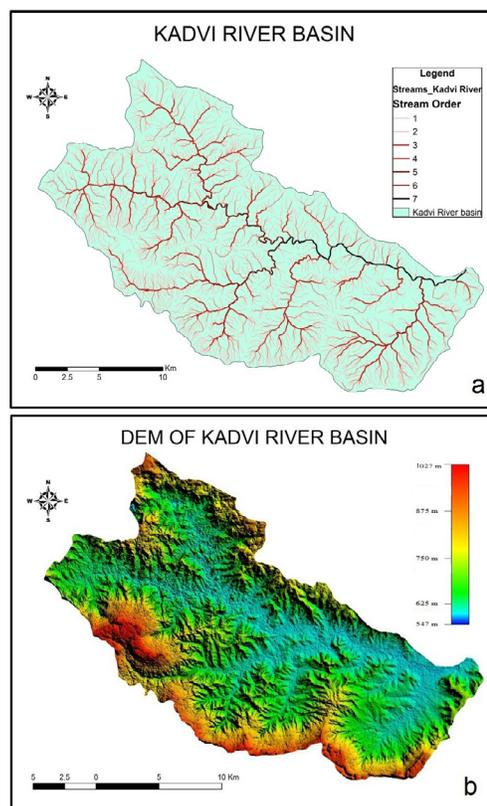


Figure 2. (a) Kadvi river basin and (b) DEM of Kadvi river.

3. Discussions and Results

3.1 Drainage Density

The drainage density is the ratio between the total length of all streams within the drainage basin and the total area of the basin¹. In the present research work, drainage densities were calculated using GIS technique. Arc

map 9.3 software used for measurement of total length of all streams and total area. On the basis of calculated drainage densities, the total drainage density system was classified in to grids of 2km x 2km. For the construction of the drainage density map, the total length of stream in each grid (4 sq. km) was measured using Arc map 9.3 and drainage density was calculated and value of particular grid was plotted in the middle of the grid. The average drainage density of Kadvi river basin is 3.2 km per square km. Kadvi river basin is having high altitude areas with South and South west part. This area is covered by hilly region and undulating topography. Drainage density map in Figure 3 shows that high drainage densities are found in south and south-west part of the basin, pockets of higher drainage densities in a series along the southern-west part may be seen. In the same part of the basin area larger number of stream junction points also seen. Complex geological structure have also observed in this part that indicates the effect of terrain on river stream numbers, stream junction points, drainage density and river flow. The lower and higher values of drainage densities also depends on the infiltration rate of the soil. In the basin area the rate of rainfall and temperature tends

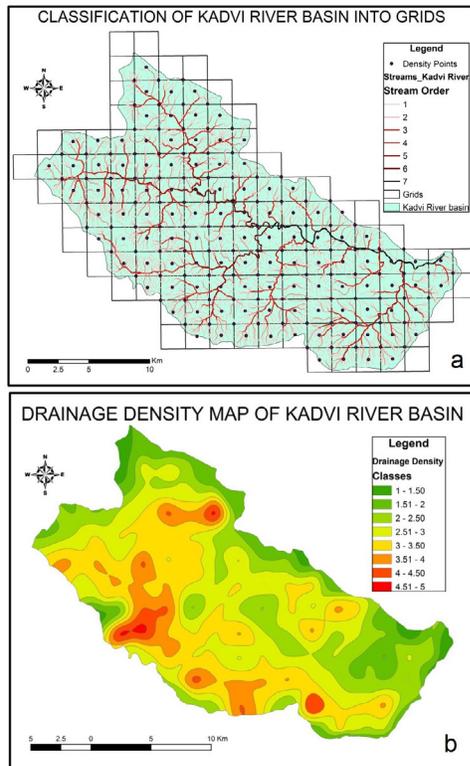


Figure 3. (a) Classification of kadvi river basin into grids and (b) Drainage Density map.

to influence on the vegetation growth that affects on the soil thickness and its infiltration capacity. Author²⁵ in his research study also concluded that lower rainfall, high temperature, higher rate of evapotranspiration increasing aridity resulting for decrease in vegetation cover over the thickness on the soil layer. And these factors are responsible for the variation of infiltration capacity of the earth surface and variation in drainage densities.

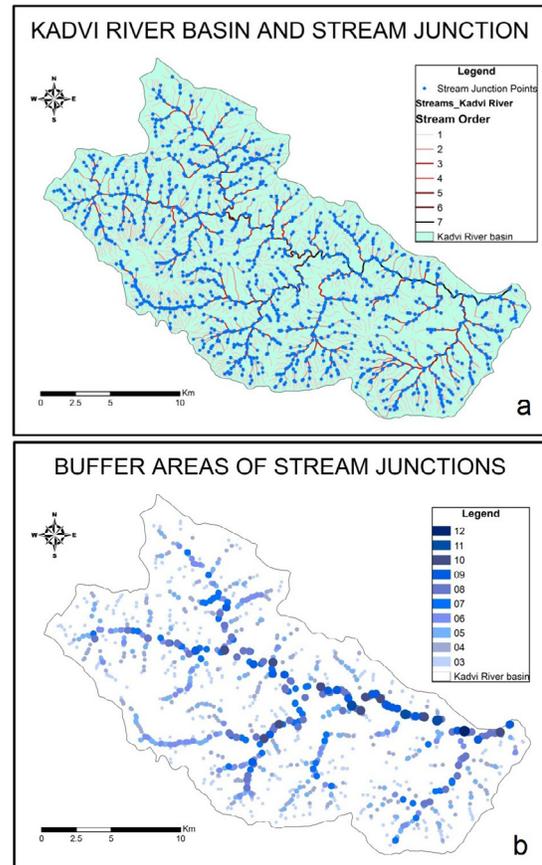


Figure 4. (a) Kadvi river basin- stream junctions and (b) Buffer areas

3.2 Stream Junction

The connection between two streams is an effect on the drainage pattern of river. Topography of the river basin indicates the ratio of stream junctions' density in Figure 4a. Less number of stream junctions describes the different landform, soil structure, rock formation and vegetations etc. In this technique the stream junctions are represented by nodes. These nodes are plotted using Arc-GIS software. Every node indicates the total amount of stream number. For the present study, node is indicated by the sum total

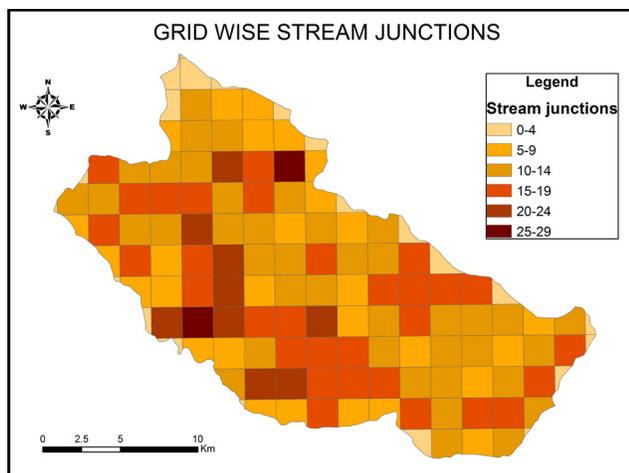


Figure 5. Grid wise stream junctions.



Figure 6. (a) Stream junction (Node) at Warul Village Bridge; (b) Stream junction (Node) – at Nile-Kadve K.T.Weir.

of two streams for example, Sum of 2nd stream order and 3rd stream order considered as the value 5. It has considered the wet area around the particular node and these all areas are rich with high water availability. Besides this, Buffer zone has drawn around the nodes with the help of Arc-GIS software. Buffer zones were drawn as per the

value of nodes in Figure 4b. These buffers are overlapping each other and indicate the stream junction density. Map for grid wise junction also prepared as shown in Figure 5, where stream junctions have classified in 6 categories. Every grid indicates its own density of stream junctions. Figure 6a, indicates the stream junction (Node) at Warul Village Bridge; and Figure 6b shows the stream junction (Node) at Nile-Kadve K.T.Weir.

3.3 Drainage Pattern

3.3.1 Herringbone Drainage Pattern

This drainage pattern also known as ‘rib pattern’. It is developed in mountainous areas or between two parallel ridges having steep slopes. The courses of the tributaries are straightened because of slope factor and shorter distance between the parallel ridges²⁶⁻²⁷. Herringbone drainage pattern is found in the upper side of Shali River of Kadvi river basin in Figure 7.

3.3.2 Rectangular Drainage Pattern

This pattern develops on the joint rocky pattern. Tributaries are more spaced in this pattern compared to other patterns. In Kadvi river basin this pattern developed near the mouth of Kadvi river.

3.3.3 Dendritic Drainage Pattern

This is most common drainage pattern found in the basin area. Shape of this pattern is like a tree. Dendritic drainage pattern mostly found in uniform bedrock and gentle slopping area. In Kadvi river basin this pattern is found at the origin of Kadvi River and Ambardi river. This river makes dendritic drainage pattern in upper side of river.

3.4 Stream Flow

Stream flow and direction is closely related with hydrology of river. Stream flow and direction indicate the topographic pattern, soil structure, rock formation of the basin. Here in stream flow map, Kadvi river basin is divided in to 6 sub basins as shown in Figure 8. These basins are divided by stream flow and stream direction. Major streams are considered (4th to 7th order streams) to indicate stream direction. Basin no. 1 and 2 shown stream direction NW to SE, whereas basin 4, 6 and 7 are having there flow direction from S to N direction of stream. Because southern side of Kadvi basin almost dominated

by hilly region. There is a continuous line of ridge extending from south-west to east in southern side of basin, having an altitude with 900m to 1000m.

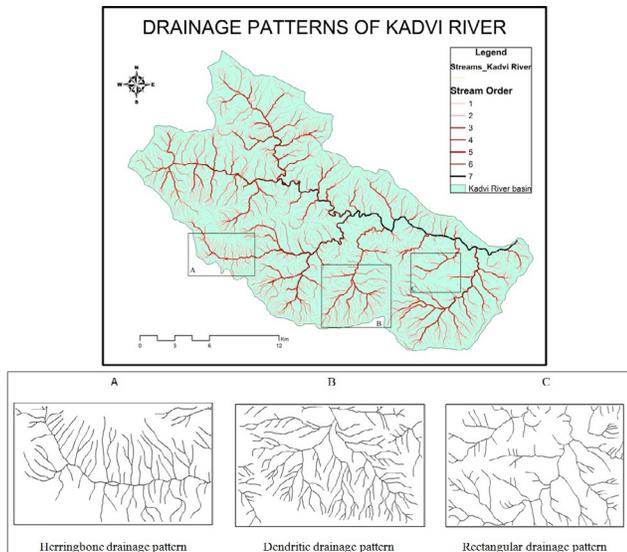


Figure 7. Drainage patterns of Kadvi river.

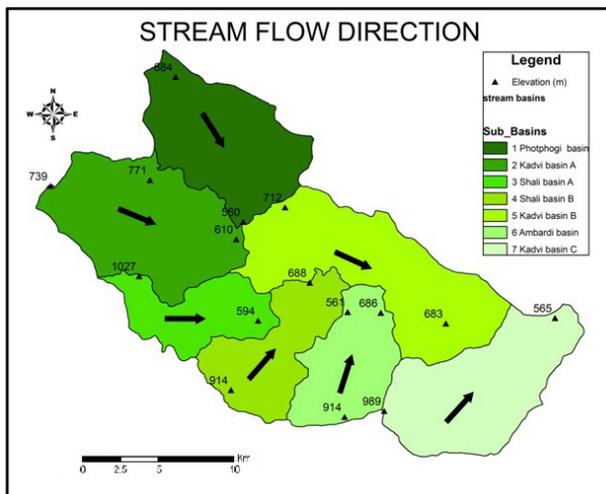


Figure 8. Stream flow direction.

4. Conclusion

The result using drainage density maps and stream junction studies reflects the complex characteristics of Kadvi river basin. The higher drainage densities are associated with the steep slopes of the landscapes. Differentiate terrain characteristics are highly influencing on the variation in drainage densities in the river basin, also reflecting the geological characteristics and relief properties.

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