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STREAM ORDERS OF CANACONA-GOA: GEOGRAPHICAL ANALYSIS

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Abstract

The existence of humans is primarily because of rivers. Our history proves that the human civilizations are built on rivers as its foundation. Rivers simply continue to flow without stopping and they transport water and nutrients throughout the globe. Rivers have a great place in the in functioning of hydrological cycle.

Nearly 75% of the earth's land surface is drained by rivers of different stream orders. Stream order is nothing but it is a procedure of assigning links in a stream network a numerical order. Streams can be identified and grouped in the following order based on the number of tributaries they have. One can deduce some characteristics of streams by simply knowing their order. Canacona taluka though geographically it is small but acts as a source region for many small and big streams. Hence, this paper makes an in-depth analysis of stream order of Canacona taluka.

Keywords : Drainage system, Stream order, River, Drainage Density, Drainage Pattern

Introduction:

Geography and Earth Sciences use the term "fluvial" to describe the processes of rivers, streams, and other bodies of water. Fluvial Geomorphology is one of the important and fastest growing branches of Physical Geography.

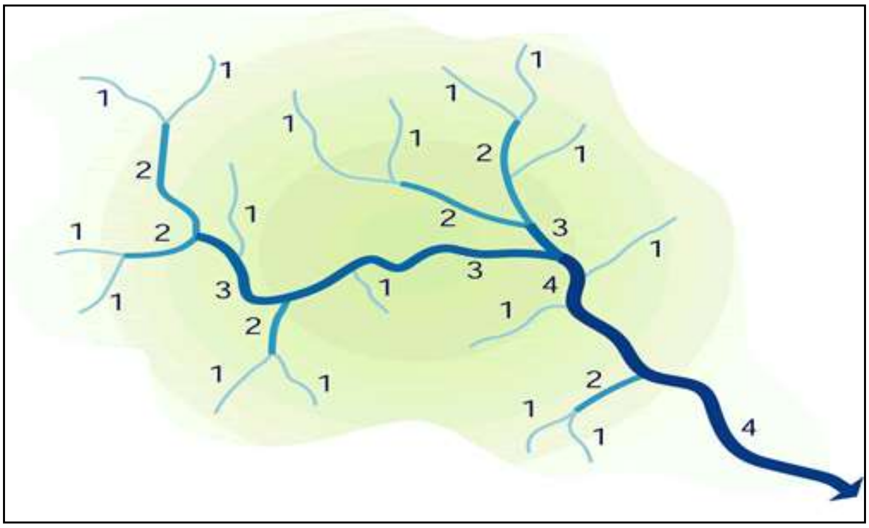
A river is a natural, typically freshwater watercourse that flows toward the ocean, a lake, the sea, or another river. Before reaching another body of water, a river may simply disappear into the ground or completely dry up. Some other names for small rivers include stream, creek, brook, rivulet, tributary, and rill (H. and Strahler, 2003).

A river is part of the hydrological cycle. Water within a river is generally collected from precipitation through surface runoff, groundwater recharge, springs, and the release of stored water in natural ice and snow packs (Trewartha and Hammond, 1961).

A drainage system is a pattern created by a drainage basin's streams, rivers, and lakes. They are influenced by the topography, including the gradient of the land and whether a particular region is dominated by soft or hard rocks. The drainage pattern is the spatial relationship of all streams in a drainage system. The specific design that each stream course collectively creates is referred to as the drainage pattern(Harrel, 1966).

Hydrologists and geomorphologists frequently consider streams to be part of drainage basins. The topographic region from which a stream receives runoff, through flow, and groundwater flow is known as a drainage basin. A watershed, which is a topographic barrier, separates drainage basins. All of the tributaries of a stream that lead to a specific point along the channel are represented by a watershed. The topography of a region affects the number, size, and shape of drainage basins (Manjare, Padhye and Girhe, 2014).

Horton developed a method for classifying or ordering the natural channel hierarchy within a watershed (1945). There have been a number of proposals to change the original stream ordering scheme, but Strahler's modified system from 1957 is probably the most widely used one today. A well-known classification system based on relationships between streams and tributaries is Strahler's stream ordering system(Werner, 1970).



Straller’s Stream Order Figure 1

First-order streams are the highest-level channels in a drainage network—headwater channels without upstream tributaries up to their first confluence. Below where two first-order channels meet, a second-order stream emerges. When two second-order channels join together, and so on, third-order streams are formed. The fact that a channel intersects with a lower-order channel does not change the order of the stream below the intersection (for instance, a fourth-order stream intersecting with a second-order stream remains a fourth-order stream below the intersection) is shown in the figure. The relationship between stream order and other basin parameters, like drainage area or channel length, is strong within a given drainage basin. As a result, knowing a stream's order can reveal other characteristics like its longitudinal zone and the relative size and depth of its channels (Harrel, 1966) (Figure 1).

Area of Investigation:

The present study is carried out under the jurisdiction of Canacona Taluka which is one of Goa's most important talukas located in the extreme south. Canacona taluka covers an area of 352.02 sq. km, and it is inhabited by 43997 as per 2001 Census.

Figure 2

Canacona is located in the southernmost part of Goa between the latitudes of 14^0 55’00” to 15^0 10’ 00” North of the equator and 73^0 55’ 00” to 74^0 15’ 00” to the east of Greenwich (Figure 2). Canacona taluka is blessed by three important rivers namely River Galgibag, River Talpona and River Saleri (Figure 3).

Saleri River System:

The 12-kilometre-long River Saleri originates near Barcem and Gocoldem. The main tributaries of this river are Padi Nalla (4 km), Agonda Nalla (7.5 km), and Molorem Nalla (6 km). Additionally, this river has developed a small spit close to its mouth.

Talpona River System:

The Canacona taluka's most well-known river is the Talpona. It emerges from Rivona Dongar's impenetrable forest. This river system has a catchment area of 40 hectares and a length of nearly 31 kilometers. The Nadke Nalla is 15 kilometers long, the Gaondongrem Nalla is 15 kilometers long, the Bhatpal Nalla is 6 kilometers long, and the Khalwade Nalla is 6 kilometers long. Near its mouth, the River Talpona has developed a spit and a bar. Mangroves grow thickly and abundantly on the bank of this river.

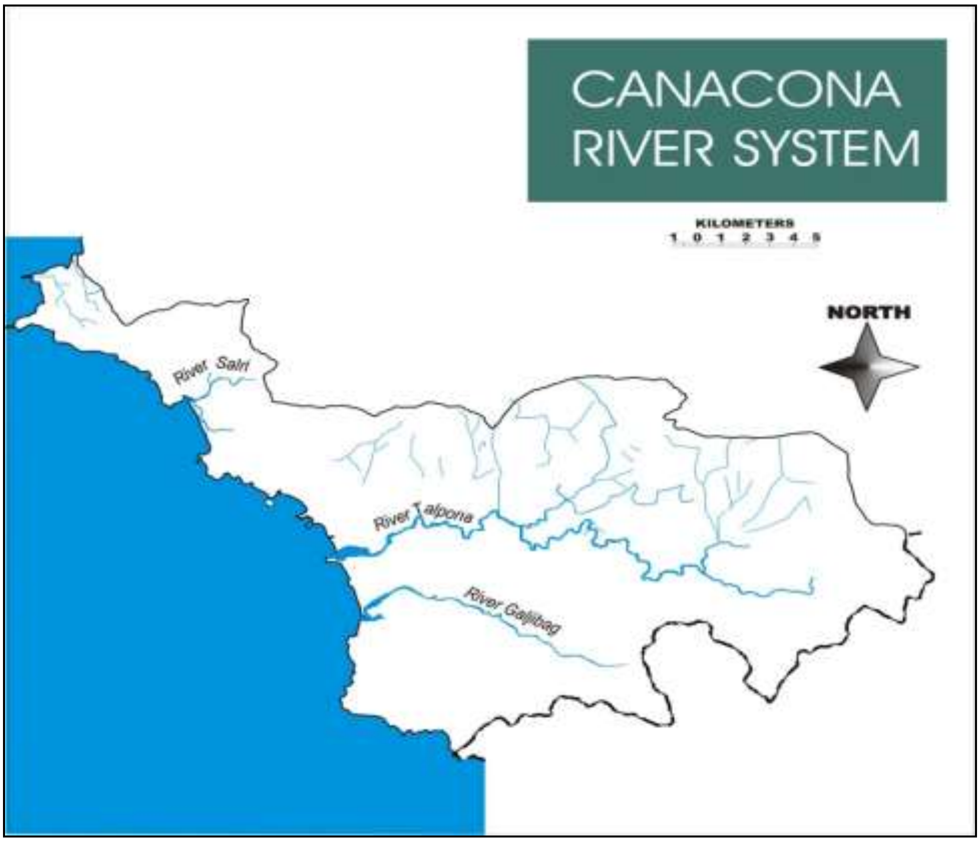


Figure 3

Galgibag River System:

This is yet another major Canacona river system that originates in Karnataka. The catchment of the river is 20 hectares, and its length is only about 15 kilometers. The most important tributaries of the River Galgibag are Loliem Nalla (2.5 km long) and Maxem Nalla (10 km long). A hook near the mouth of the River Galgibag is one of the rare coastal features.

Data Base and Methodology

Data are gathered from both primary and secondary sources for the purpose of analysis. The drainage system and order were extensively studied using Indian Topographical maps with Index Nos. 48 E/16, 48 I/4, and 48 J/1 at a scale of 1:50000. Additionally, the GIS portals Bhuvan Earth, Wikimapia, NASA Wind, and Google Earth were utilized in order to comprehend the river-related aerial topography of the Canacona taluka. The study makes use of a variety of Census of India-prepared maps. Conclusions are drawn using straightforward statistical techniques.

Discussion and Result:

In order to make it easier for us to comprehend, discuss, and investigate the similarities and differences that exist between various stream systems, they have been categorized according to their relative position within a stream network. Because it can be related to drainage area and stream size, stream order is an important feature of stream systems.

There have been a lot of stream-order classification systems created, but no one has been universally accepted. Strahler came up with one of the earliest methods, which is arguably the method that is used the most today. He developed it in 1952. First-order streams are the smallest headwater tributaries in this system. A second-order stream is formed where two first-order streams meet; a third-order stream is formed where two second-order streams meet; and so forth, but the maximum stream order would not exceed 12. The 12th-order river is represented by the Ganga, Amazon, and Nile (Strahler, 1952).

Bifurcation Ratio:

The ordering classification system's hierarchy of stream segments was one of the first attributes to be quantified. It has already been stated that channel segments were arranged numerically from a stream's headwaters to someplace downstream in this system. The tributaries at the stream's headwaters receive the value 1 in numerical order. An order of 2 was given to a stream segment formed by joining two first-order segments. A third-order stream was formed by two streams of the second order, and so on. This data's relationships were interesting to look at. The bifurcation ratio, for instance, is the ratio between the number of stream segments in one order and the number in the next (Table 1).

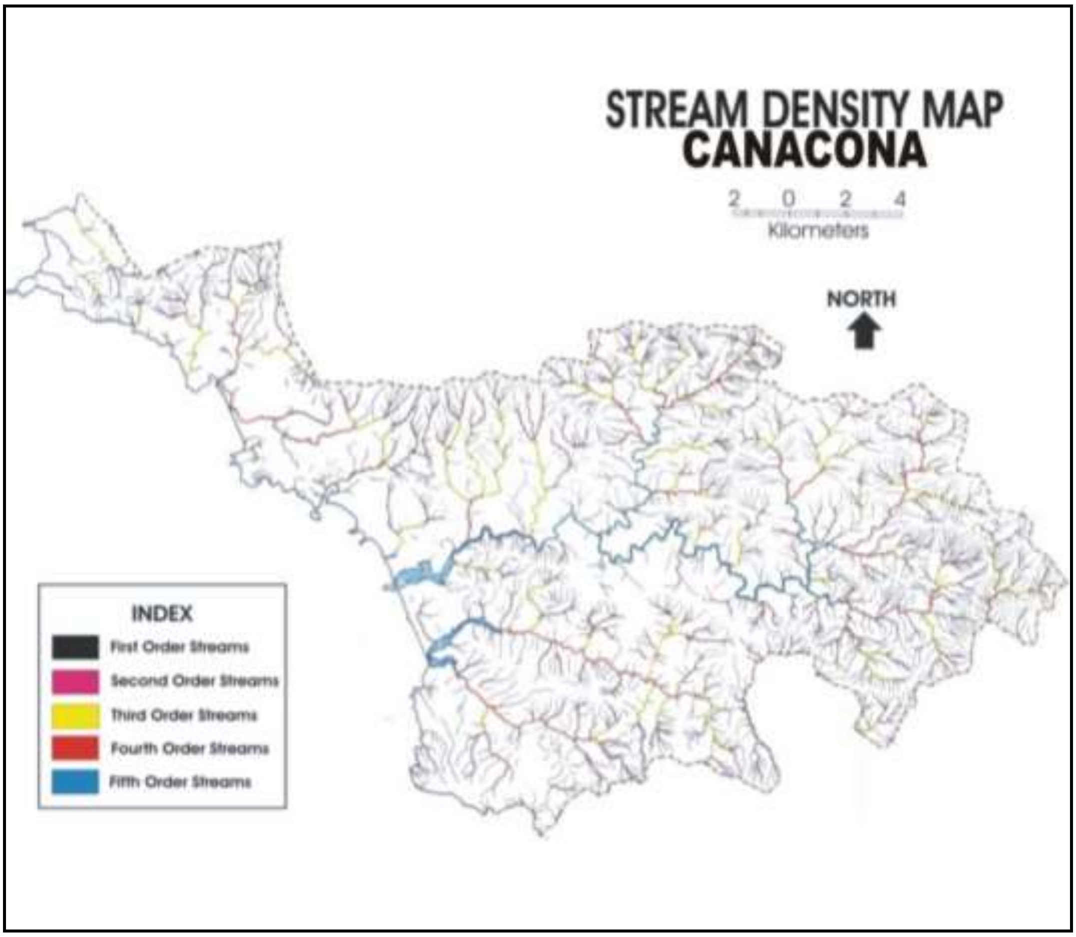


Figure 4

Because the Canacona taluka is geographically small and all of the rivers are short-flowing, they represent streams of first to fifth order. They plunge into the Arabian Sea shortly after giving birth in the Western Ghats. The streams in Canacona are broken down into three main rivers, as shown in Table 1:

Table 1
Classification of Stream Order for the Rivers of Canacona

River	First Order	Second Order	Third Order	Fourth Order	Fifth Order	Total Streams
Saleri	64 (67.37)	21 (22.11)	7 (7.37)	2 (2.11)	1 (1.05)	95 (100)
Talpona	327 (70.63)	75 (16.20)	40 (8.64)	15 (3.24)	6 (1.30)	463 (100)
Galgibag	262 (72.98)	70 (19.50)	21 (5.85)	5 (1.39)	1 (0.28)	359 (100)

Source: Calculated using the Toposheets

The first order streams make up about 70% of Canacona's streams, the second order streams make up 20%, and the third, fourth, and fifth order streams make up 10%.

There are approximately 95 streams in the Saleri River System, a poorly developed river system with orders ranging from first to fifth. Figures 13 and 14 show that first-order streams account for 67.37 percent of the data, followed by second-order streams (22.11 percent), third-order streams (7.37%), fourth-order streams (2.11%), and fifth-order streams (1.05%) (Figure 5).

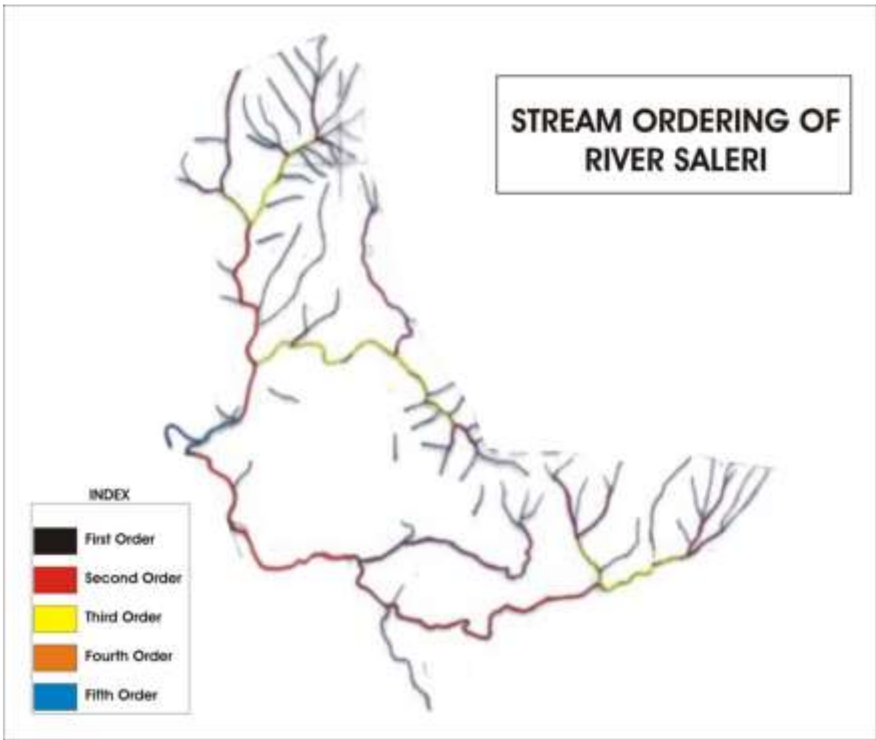


Figure 5

With 463 streams of various orders, the River Talpona System is a good illustration of a developed river system and the largest in Canacona. 70.63 percent, 16.20 percent, 8.64 percent, 3.24 percent, and 1.30 percent, respectively, are accounted for by first-order, second-order, third-order, fourth-order, and fifth-order streams. Figures 6 show that the proportion of third-order streams is slightly higher than that of the Saleri River System.

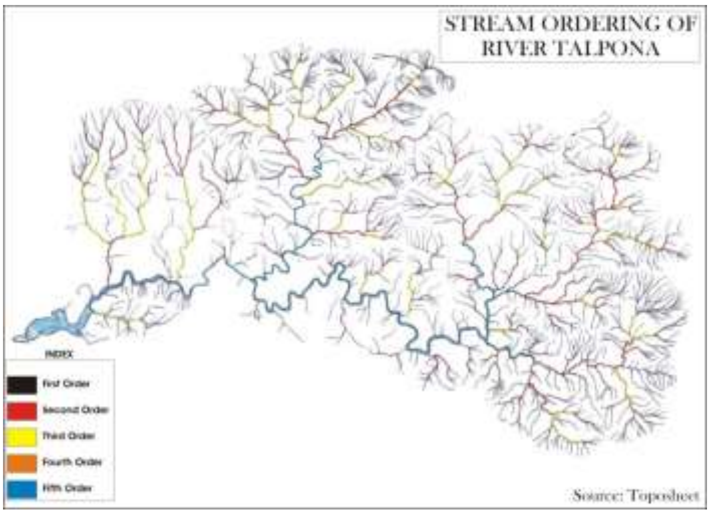


Figure 6

Despite the fact that the Galgibag River does not exhibit a highly developed stream order system, it appears to be similar to the Talpona River with slight variations. Figures 7 show that, out of the 359 streams, 263 (72.98 percent) were first order, 70 (19.50 percent) were second order, 21 (5.85 percent) were third order, 5 (1.39 percent) were fourth order, and 1 (0.28 percent) were fifth order.

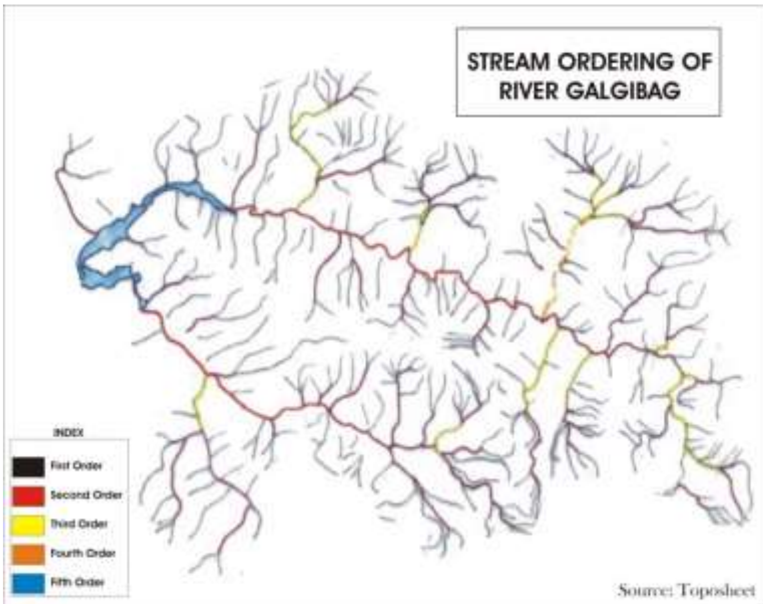


Figure 7

Drainage Density

Figure 19 shows that drainage density is the sum of the lengths of all the streams and rivers in a drainage basin divided by its area. It is a measure of how well or poorly stream channels drain a watershed. It is the same as the reciprocal of two times the length of overland flow and the constant of channel maintenance.

Formula for Drainage Density DD = L/A

Where DD is Drainage Density, L is the length of all the streams and rivers and A is the total area of the drainage basin.

The length of all of Canacona's streams and rivers is 77.67 km, and the catchment area of all of them is approximately 34.74 square km. The calculated density ratio would be 2.236. A relatively high stream density would be indicated by a drainage density value that is high. The average density is between 1.5 and 6 mi/mi2. It indicates that Canacona has a drainage density that is close to moderate.

The climate and physical characteristics of the drainage basin both influence drainage density. A watershed's runoff is influenced by the permeability of the soil and the type of rock beneath it; Surface water runoff will rise as a result of impermeable ground or exposed bedrock, resulting in more streams. Canacona has high soil and bedrock permeability and receives rainfall of up to 3000 millimeters per year.

Drainage Pattern

When viewed in plan form (map view), a watershed's drainage pattern is one distinctive feature. The watershed's overall topography and underlying geologic structure are primarily responsible for determining drainage patterns. Four distinct patterns of drainage have been identified. These are the main ones:Dendritic drainage

1. Parallel drainage
2. Rectangular drainage
3. Hanging Streams

Dendritic pattern

The dendritic pattern of drainage, which is also the most common type of drainage system found in various parts of the world, is perfectly demonstrated by the River Talpona. Numerous contributing streams are joined together to form the main river's tributaries in a dendritic drainage pattern. The whole system resembles a leaf, with the main vein in the middle and smaller veins coming from different parts joining it (Figure 8).

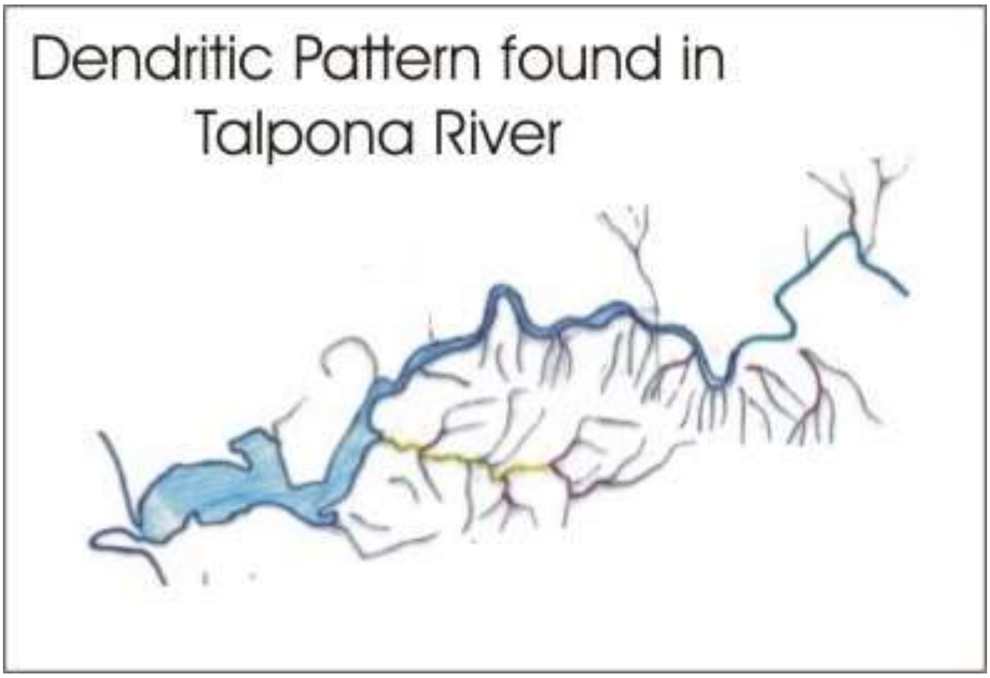


Figure 8

When the river channel follows the slope of the terrain, the dendritic pattern forms. V-shaped valleys are where dendritic systems develop. The numerous "V-shaped valleys" of the Canacona taluka make it famous.

Parallel drainage

A parallel drainage pattern can be seen between the eastern boundary of Canacona taluka, which borders the state of Karnataka, and the northern boundary, which is shared with Quepem taluka. Parallel drainage has a slight difference from the dendritic drainage pattern. In areas with steep slopes, this kind of drainage pattern is common. Figure 9 depicts steep slopes that are more than 35% sloped in the eastern and northern regions of Canacona.

Figure 9

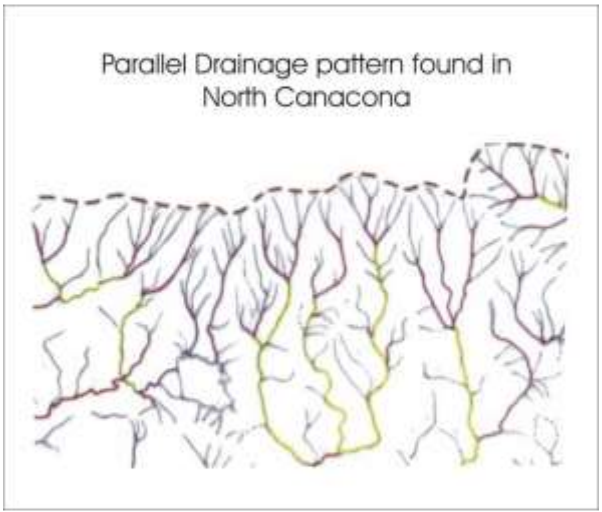


Figure 10

Rectangular drainage

The northern branch of the River Galgibag clearly exhibits a rectangular drainage pattern if one carefully observes it. A significant number of faults are to blame for the drainage's rectangular shape. Figure 10 indicates that the streams are structurally controlled.

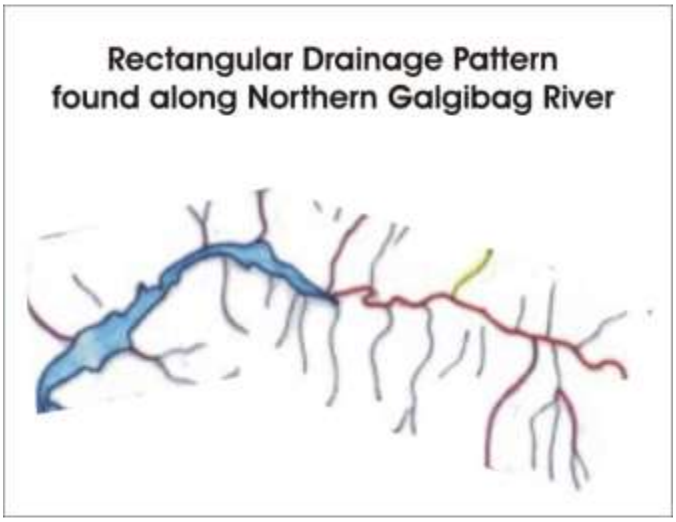


Figure 11

Hanging Streams

A hanging stream is a stream which after taking its birth does not join the nearest water body but disappears on its way. It is very interesting to note that at many places in Canacona taluka, there are good numbers of Hanging Streams (Figure 11). Because of the potential for their behavior to cause landslides, hanging streams can be dangerous. The hanging streams were one of the factors that contributed to the landslides that occurred on October 2, 2009.

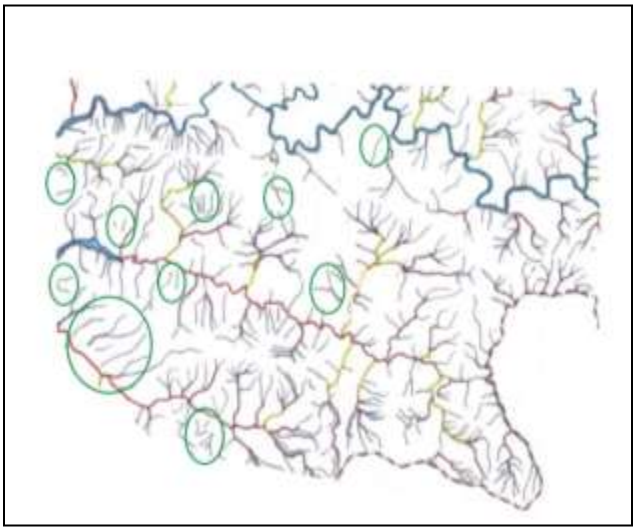


Figure 12

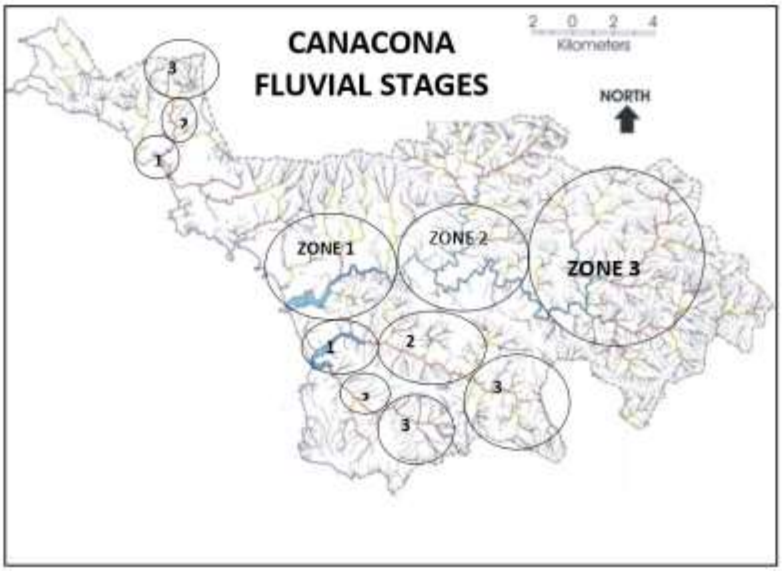


Figure 13

Landforms associated with the Rivers of Canacona:

Even though the Canacona Rivers only run for a short distance, they create beautiful landscapes. The Canacona taluka's important features include the ones listed below.

Estuarine Rivers: All the three major rivers of Canacona are basically estuarine rivers. Estuarine rivers are those rivers that directly plunge into the Seas/Oceans without creating a delta (See photo plate).

Tidal Influence: Not only the rivers are estuarine but they are also tidal rivers. The tidal influence of rivers is found many kilometers hinterland. The tidal impact of River Talpona is up to Ordhphond which is 8 kms from the mouth. Tidal influence of Galgibag River is felt up to Painguinim which is 6 kms away from the mouth. Similarly, the tidal influence in Saleri River is found at 2 kms.

Backwaters: Backwaters have been created in a few places by the rivers of Canacona. Backwaters are bodies of water that carry tide-driven water during high tide. The aesthetic appeal of coastal areas is enhanced by these backwaters. In various parts of India, such as Kerala, numerous backwaters have been developed as tourist destinations.

Waterfalls: There are three stunning seasonal waterfalls in the source region of the River Talpona: the Kuskefall, the Bamanbudofall, and the Kerifall..

Islands: At the third stage of the river i.e., old age, all the three rivers have created tiny islands. These islands are the result of sedimentation due to decrease in the flow of river.

River Meandering: River Talpona is the only river that has developed meandering course.

Valley and Gorge Formations: All the rivers in their initial stages have created beautiful gorges, and valleys.

Flood Plains: One can see flood plains in the low lying areas like Mashem, Galgibag, Painguinim, Delem, Panephoned, Talpona and Sadolexm (See photo plate).

Conclusion:

Though Canacona taluka is very small but geo-ecologically it is highly diversified. Taluka creates a unique ecosystem and vibrant physical landscape as it is sandwiched between Western Ghats and the Arabian Sea. Following are the important findings of the study:

- All the rivers are estuarine rivers.
- Rivers are born is the Westernghats and flow for a very short distance before plunging into the Arabian Sea.
- About 70 percent of the streams of Canacona fall under the first order, about 20 percent of them fall under Second Order and Third, Fourth and Fifth order streams make about 10 percent.
- The total catchment area of all the rivers of Canacona is about 34.74 square miles and length of all the streams and rivers is 77.67 miles. The density ratio worked out would be 2.236.
- The density values typically ranges from 1.5 to 6 mi/mi^2. It means the drainage density of Canacona is nearly moderate.
- Four different drainage patterns have been identified in Canacona. They are Dendritic drainage pattern, Parallel drainage pattern, Rectangular drainage pattern and Hanging Streams
- Canacona Rivers have carved different landforms like waterfalls, flood plains, valley and Gorge, islands, waterfalls, tidal Influence, backwaters and meandering Over the years rivers of Canacona have become shallow. As a result their water carrying capacity has decreased. 2nd October 2009 floods also deposited huge amounts of sediment. It has further compounded the problem of water carrying capacity of the rivers. At many places, during low tide time bed of Talpona and Galgibag River is clearly visible. Hence, dredging of the rivers must be carried out on priority basis.

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