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Geomorphological Mapping and Morphometric Analysis of Sukhna Choe Watershed in Chandigarh-Panchkula

Vikramjeet

Assistant Professor in Geography, DNPG College, Hisar, Haryana

Abstract

Sukhna Choe Watershed is located between Chandigarh and Haryana, and this study aims to investigate its geomorphic and morphometric characteristics. The analysis was based on primary and secondary data sources. For calculating the various parameters such as geomorphic features, stream order, stream frequency, drainage density, bifurcation ratio, stream number, length ratio & law of stream length, law of basin parameter, basin length, and area, topographic map, Cartosat-1, and field visit data were collected and interpreted in ARC GIS and ERDAS software. Morphometric analysis can be completed successfully by using channel gradients, slopes of basins, relief, linear measurements, aerial measurements, drainage density, and length.

Keywords: Sukhna, Geomorphic, Morphometric, Watershed, Choe

1. Introduction

Morphometry is the quantification of morphology in geomorphology (Clarke 1996; Agarwal, 1998). River basin morphology can be interpreted through indicators of watershed morphometry. The best way to identify the relationship between different aspects of a watershed is to perform a morphometric analysis. In watershed hydrology, a drainage system is a natural hydrological entity from which surface runoff flows to a drainage channel, stream, or river. The morphology of drainage basins is widely known to reflect various geological and geomorphological processes over time, as shown by various molecular studies of slope (Horton, 1932; Hurtrez et al. 1999; Chorley et al. 1984). The analysis of drainage basins or watersheds based on morphometric parameters is an essential part of watershed planning, since it provides information on slopes, topography, soil conditions, runoff characteristics, surface water potential, etc. Watershed morphometry helps us to understand linear, area, and relief parameters (Nautiyal, 1994; Magesh et al 2012). Watersheds receive information on land surface processes through hydrologic and geomorphic processes occurring within them (Dar et al., 2013). The purpose of the morphometric analysis is to acquire accurate information about the stream network of the drainage basin. The size, shape, slope, drainage density, and length of contributories can all be correlated with certain hydrological phenomena in an area with physiographic characteristics (Rastogi and Sharma, 1976). For drainage basin morphometry, remote sensing provides a convenient method since satellite images provide a synoptic view of a large area (Kumar S. & Singh R., 2021; Kumar S., 2018). To determine the morphometric parameters of the area, a digital elevation model (DEM) of the area had to be generated. The DEM was used to calculate drainage basin areas, drainage density, drainage orders, reliefs, and network diameters when used in GIS applications. GIS makes it easy to identify (Arvind at al., 2022), and discriminate drainage areas by combining satellite data, hydrological and spatial analysis (Kumar S. & Kumar G., 2019; Pirasteh et al. 2000; Rao et al., 2010: Kumar S., 2018). With the help of remote sensing and GIS technology (Kumar S., 2017), the present study aims to calculate morphometric parameters and morphological parameters of Sukhna Choe Watershed in Chandigarh-Panchkula.

2. Study Area

It is located in the Siwalik Hills of the Himalayas (Johal and Tandon, 1983). There are parts of this stream in Panchkula in Haryana, as well as Chandigarh. Streams flow from the Siwalik Hills during the summer. This seasonal stream is also the source of water for Sukhna lake. Sukhna Choe covers an area of 22.43 square kilometres and lies between 45’0” N to 49’0” N Latitude and 49’0” E to 53’0’’E Longitude (Bansal and Grewal, 1987).About 20 km of forest separates the hills from the lake (Jindal and Ghezta, 1989). In this area, the elevation ranges from 300 to 580 meters (Bansal and Mishra, 1982). Summers are very hot, and winters are mild due to the humid subtropical climate. The majority of the area is covered with trees, shrubs, climbers, and grasses. Along with the natural vegetation, a variety of other species have been planted. Deep forests are home to diverse animals and plants, which have grown in size over the past five decades. The study area has steep slopes and undulating hills. The most common components of hills are sand, silt, and clay, and the hills lack carbon on their surfaces. The location map of the study area can be found in Figure 2.1. and a satellite view of the study area can be seen in figure 2.2.

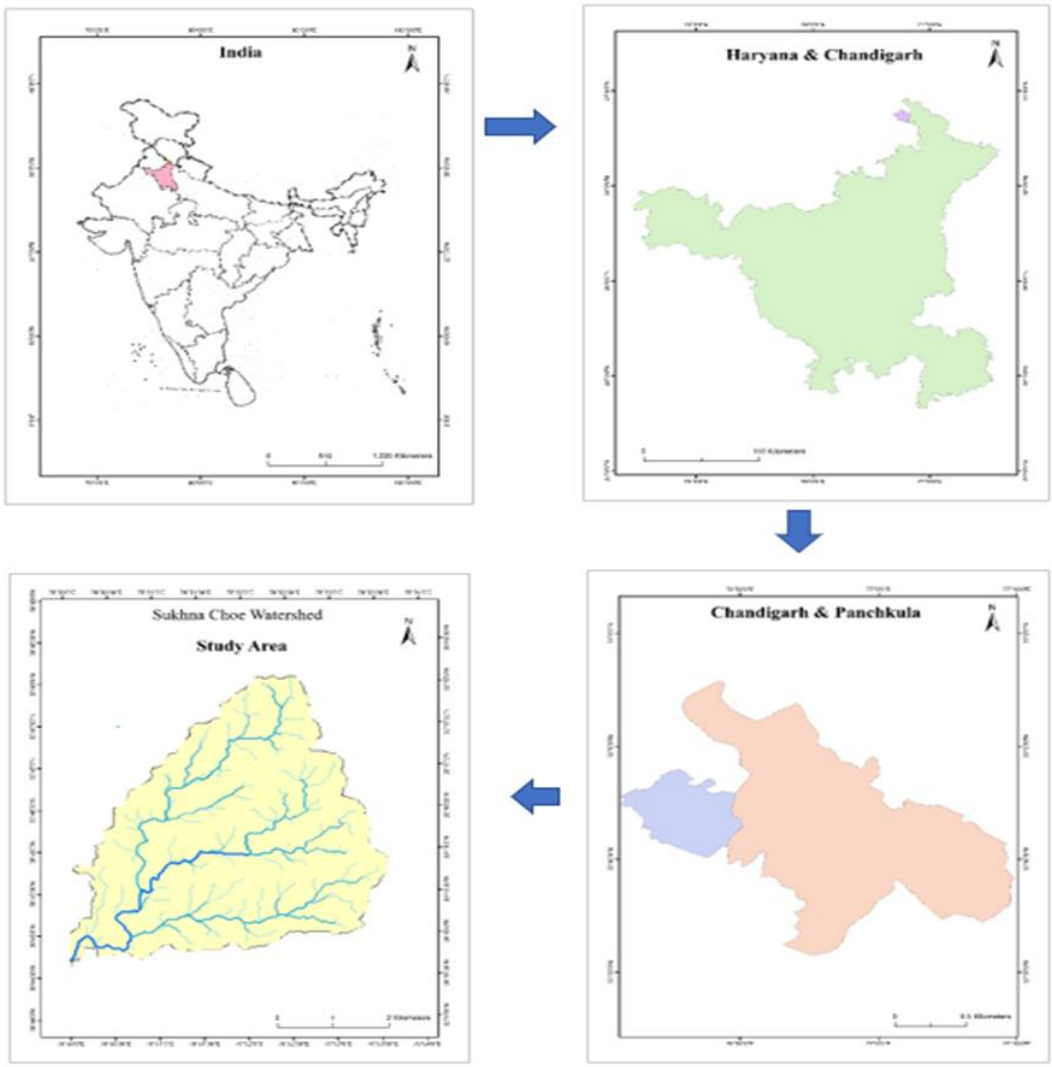

Fig. 2.1: Location Map of the study area

Fig. 2.2: Satellite view of the study area

3. Database and Methodology

The present study is based on primary and secondary data have been collected from filed visit and various data sources. SOI topographical sheet No. 53b-14 used for contour mapping, vegetation and other physical and cultural aspects. Google Earth images have been used to understand the relief of the study area. Cartosat-1 data (30 m resolution) have been used for DEM generation. Some field visits and observation have also been done to interpret and analyse the data and strengthens the study. In an attempt to study the geomorphic and morphometric characteristics of Sukhna Choe. The delineation of Sukhna Choe watershed is done from Cartosat DEM by ERDAS software and surface operations were carried out by Arc GIS 10.3. Sukhna Choe demarcated on the basis of water divides. The study was carried out by using the various parameters terrain or relief chrematistics (Field visit), linear and areal morphometric parameters like as geomorphic features, stream order, stream frequency, drainage density, bifurcation ratio, stream number, length ratio & law of stream length, law of basin parameter, basin length and area. Equations used for linear and morphometric parameters are given in table no. 3.1.

Table 3.1: Morphometric parameters details

Parameters		**Method**	**References**
Linear	Stream order	Ranks assign hierarchically	Strahler A.N. (1964)
	Bifurcation ratio	Stream Numbers of order/ stream number in next order	Horton E. R. (1945)
	Length Ratio & law of stream length	total length/ stream total length in next order	Strahler A.N. (1964)
Areal	Stream frequency	Total Stream order/area	Horton E. R. (1945)
	Drainage Density	Total length of stream/area	Strahler A.N. (1964)

4. Results and Discussion

Based on various data sources following results have been prepared:

4.1 Geomorphic Features

In this paper, geomorphic features of Sukhna Choe watershed are analysed. Gulley's, choes, hogback ridges, knife edge ridges, and choe terraces are identified as major or prominent geomorphic features in the study area. Wind and running water have produced these features through erosional and depositional actions. The purpose of this chapter is to observe and interpret various geomorphic features produced by various gulley's, channels, and other climatic conditions as well as wind. This area has a 'badland topography', as observed during field visits. Figure 4.1 shows the field observations point for geomorphic observation of Sukhna Choe watershed.

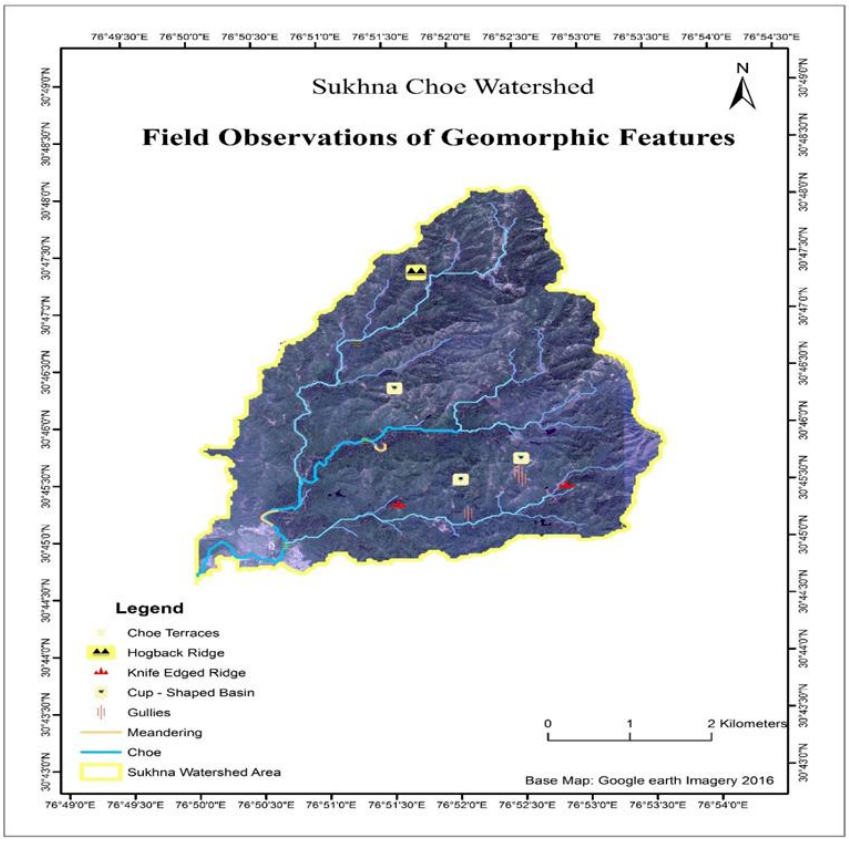

Figure 4.1: Filed observation points

4.2 Erosional features

There are various landforms which are developed by running water which makes this area highly dissected. In the study area during the field observation, various features were observed and it is found that this area is having a badland topography of semi-arid region. All the observed features discussed below:-

4.2.1 Gullies

Typically found on hillside surfaces, gullies are formed by running water eroding soil sharply. During gully formation, the water flow rate can be substantial, causing significant deep cutting action into soil. Gullies generally resemble large ditches or small valleys, but are meters in depth and tens of meters wide. Figure 4.2.1 shows gully features in the study area.

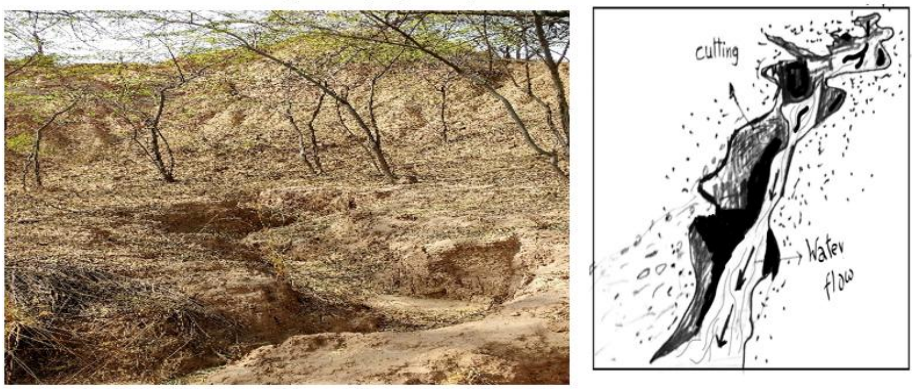

Fig. 4.2.1: Gully feature and the diagrammatic process(right)

4.2.2 Hogbacks Ridges

Hogbacks are steep ridges formed by erosion along highly tilted strata's broken edges. In this study area the hogback ridges are a result of extensive and intensive erosions of the very dense network of streams (Figure.4.2.2)

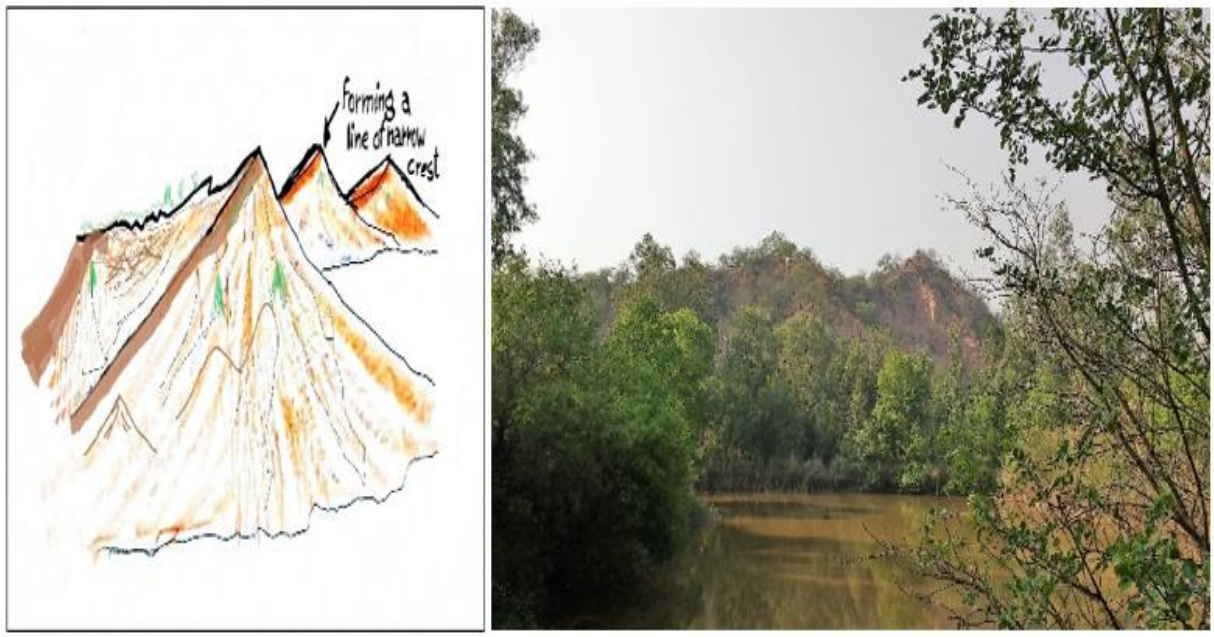

Figure 4.2.2: Diagrammatic representation and field observation of Hog- back Ridges

4.2.3 Knife-Edged Ridges

A number of sharp-edged ridges are observed in the study area (Fig. 4.2.3) where the slope is steep and rill wash is most active and carved out by extreme erosion. Knife edged ridges are formed when hill slopes with little vegetation cover are washed away by heavy rainfalls. The ridges resemble the edges of knives, so they are called Knife edged ridges.

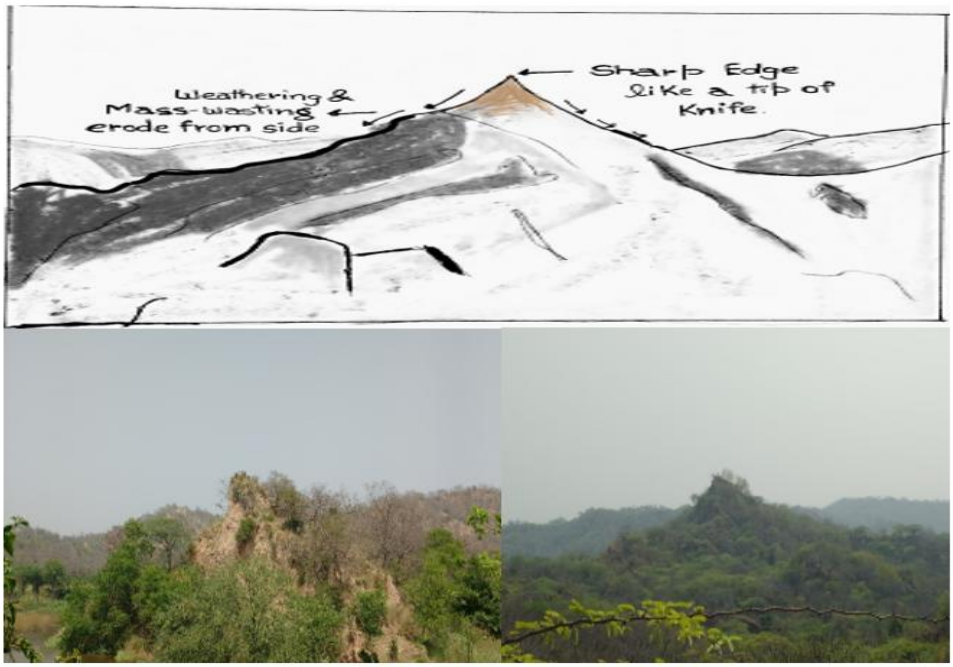

Figure 4.2.3: Knife edged Ridges and diagrammatic representation of knife edged ridge

4.2.4 Cup Shaped Basin

It is common to find basins that have flat beds and are surrounded by ridges that resemble the shape of a cup, with gullies descending from the slopes and forming different patterns. As a result of high rates of mass wasting and weathering, such as sheet erosion and rills, these basins form.(Figure 4.2.4).

Sheet and Rill erosion acting as major agent of weathering

Fig. 4.2.4: Cup shaped basin and diagrammatic representation (Right)

4.3 Morphometric analysis

Aerial aspects of Sukhna Choe are examined in this study. A basin area is one of the most important morphometric attributes since it influences the spatial distribution of a number of important attributes including drainage density, drainage frequency, and so forth (given in table 4.3.1). Based on water divides, the basin is delineated. It includes studying the area of the drainage basin, the geometry of closed links, the area of the basin, the frequency of streams, etc. The results after analysis shows that the Sukhnachoe watershed area is having a 4th level stream order (Fig. 4.3.1). The stream frequency of the study area is 6.41 per square km. Therefore, the study area is characterized by high stream frequency. Basin area, basin perimeter and basin length are 22.43 km², 29.58 km and 6.18 km. The drainage Density of the basin is moderate and has impermeable surface material. The value of bifurcation ratio for Sukhna catchment varies from 1.5 to 5.75. The stream length varies from 6.18 km to 36.07 km. In Sukhna catchment length ratio varies from 1.40 to 2.10. The channel sinuosity of Sukhnachoe = 6.18/3.96 = 1.56 (Fig. 4.3.2).

Table:4.3.1: Morphometric analysis

Basin area	22.43 km²		**Stream frequency**		
Basin perimeter	29.58 km		**Nμ**	**A**	**Fs**
Basin length	6.18 km		144	22.43 km²	6.41
Sinuosity Index		1.56	**Drainage Density**		
			70.32 km	22.43 km²	3.135
Stream Ordering			04		
Stream Order	Number of Streams	Bifurcation Ratio	Stream length	Mean stream length	Stream length ratio
1	117	4.87	36.07	0.3082	-
2	23	5.75	14.90	0.6478	2.10
3	3	1.5	13.17	4.39	6.77
4	1	-	6.18	6.18	1.40

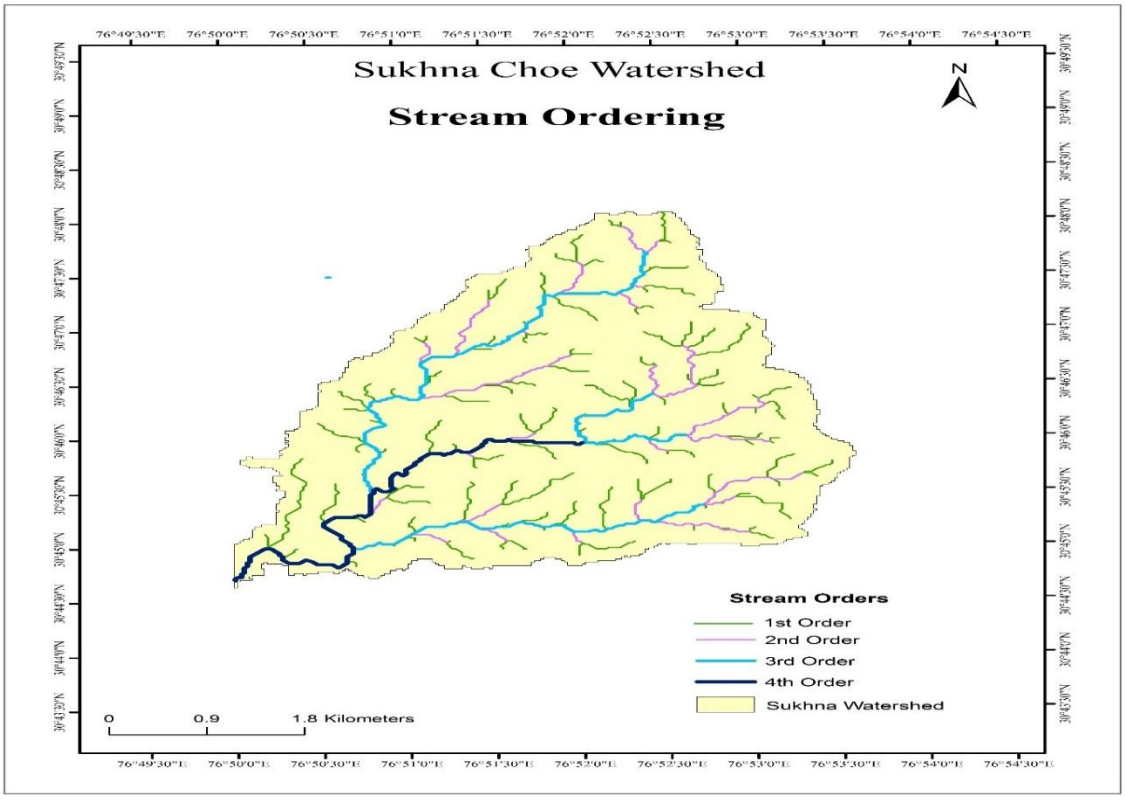

Fig. 4.3.1: Stream orders in the Sukhnachoe watershed area

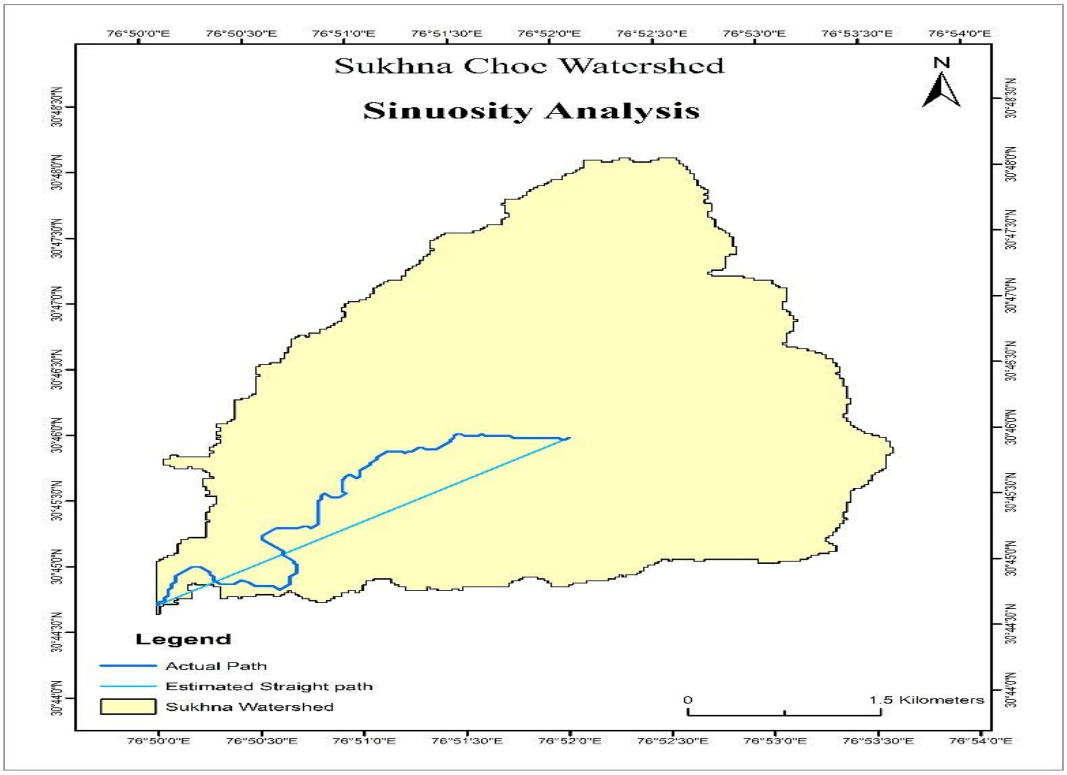

Fig. 4.3.2: Sinuosity of the choe in watershed

Conclusion

As a result of the present study, we are able to understand the inter-relationship between natural processes on the land surface and the resistance to those natural processes, which are further influenced by the characteristics of the specific area in terms of climate, soil compositions, and vegetation distribution. Accordingly, a study of various features of the watershed area of the Sukhna chao in the Siwaliks Hills indicated that it was a badland topography due to the rock material present. One thing that was observed was that these features were formed by erosional forces, mostly by rainwater but also by the wind during dry seasons. A watershed morphometric study enables us to identify the areas that are suffering from various kinds of land degradation and provides the parameters necessary for the assessment of groundwater potential zones, the identification of water harvesting structures, the management of water resources, runoff, and drainage system geographic characteristics. A high erosion rate, sparse vegetation, and other problems have been observed in this field study, putting soil degradation and ecological disturbance at risk.

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