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ANALYSIS OF RELIEF ASPECTS OF BASIN MORPHOMETRY OF THE SAPTLINGI BASIN USING GIS FOR SUSTAINABLE WATERSHED MANAGEMENT

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Abstract

The quantitative measurement and analysis of the physical parameters of a drainage basin or catchment area is known as basin morphometry. Relief aspects of basin morphometry focus on the elevation and vertical differences within the basin. Relief is a crucial factor in understanding the landscape's topographic complexity and has significant implications for various natural processes and human activities. The Ratnagiri district's Saptlingi Basin in the Sangmeshwar Taluka has been selected as the study region for the current research. The primary objective of the present research is to investigate the relief morphometry of the Saptlingi basin using ArcGIS and ASTER GDEM data. The study reveals that the study region has the typical type of relative relief.

Keywords: *ASTER-GDEM, Relief Aspects.*

Introduction:

Basin morphometry refers to the quantitative measurement and analysis of the physical characteristics of a basin or watershed, such as its size, shape, slope, and other related parameters (Patil & Yadav, 2012). Relief aspects of basin morphometry focus on the elevation and vertical differences within the basin. Relief is a crucial factor in understanding the landscape's topographic complexity and has significant implications for various natural processes and human activities (Narozhnyaya, 2021). The relief aspects of the drainage basins are related to the study of the three-dimensional feature of the basin involving area, volume, and altitude of vertical dimension of landforms wherein different Morphometric methods are used to analyze terrain characteristics, which are the result of basin processes (S. Singh, 1998). Thus, this aspect includes the analysis of the relation between area altitude, altitude and slope angle, average ground slope, relative reliefs, relief ratio, dissection index, profile of terrains and the rivers etc. The researcher has attempted to analyze a few relief aspects with the view to creating a base for sustainable watershed management.

The Study Region:

The present research work focuses on the Saptlingi basin located in Sangameshwar Taluka of Ratnagiri District. The Saptlingi basin situated in the centre of the Sangmeshwar Taluka divides the taluka into two equal parts. The study region is bordered by the Shastri to the north and the Bav Basin to the south (Patil, 2014).

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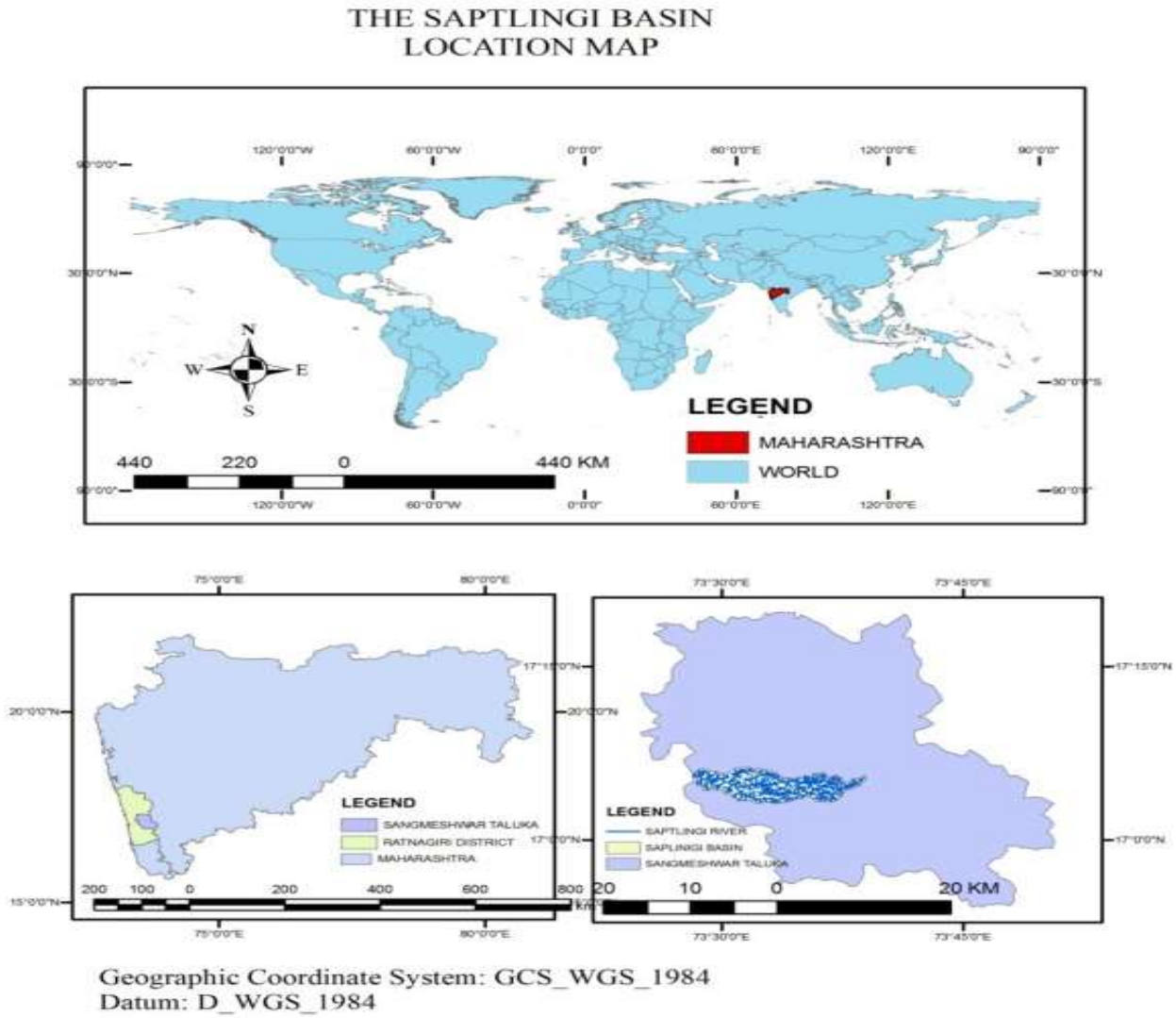

Fig. 1

The Saptlingi River has its source close to Harpude, and it joins the River Bav close to Musalmanvadi. The Saptlingi Basin has a latitudinal extent of 17°4'48.92" to 17°5'42.11" north and a longitudinal extent of 73°27'29.63" to 73°39'14.42" east. The river's total length is 22.48 km, and it drains an area of roughly 67.69 sq. km. (Fig. 1). The Saptlingi Basin is home to 34 settlements. The Devrukh is an important town located on the bank of the Saptlingi River (Patil & Yadav, 2012).

The research area's altitude from Mean Sea Level (MSL) varies from 7 metres to 324 metres. The east-west length of the study region is 18.94 km while the north-south width is 5.085 km, on average(Patil & Yadav, 2012). According to the 2011 census, the population of the study region is 42451 persons (Government of India, 2011).

Objectives:

The research focuses light on the relief aspects of the Saptlingi Basin and sustainable watershed management. The main objective of the present

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research work is to analyze the relief aspects of basin morphometry of the Saptlingi basin.

Research Methodology:

Methods of Data Collection:

Both primary and secondary data are used to support the current study. The primary data is gathered through extensive fieldwork in the research area. The Oregon 550 GPS from GARMIN is used to track the Saptlingi River. Additionally, it is used to verify data from remote sensing. Secondary data primarily comes from data collected through remote sensing. To meet the needs of the research, the Global Digital Elevation Model (GDEM) data from the Advanced Space-Borne Thermal Emission and Reflection Radiometer (ASTER) with 1.5 arc view second is downloaded from the internet.

Methods of Data Analysis:

The shape file of the Sangmeshwar Taluka is geo-referenced in Arc GIS 10.4 software. The Global Mapper 13.0 and Arc-GIS 10.4 software are used for the analysis of data. In the Spatial Analyst Tool, the hydrology tool is used for the processing of ASTER-GDEM data. The following tree diagram depicts the research methodology involved in the research.

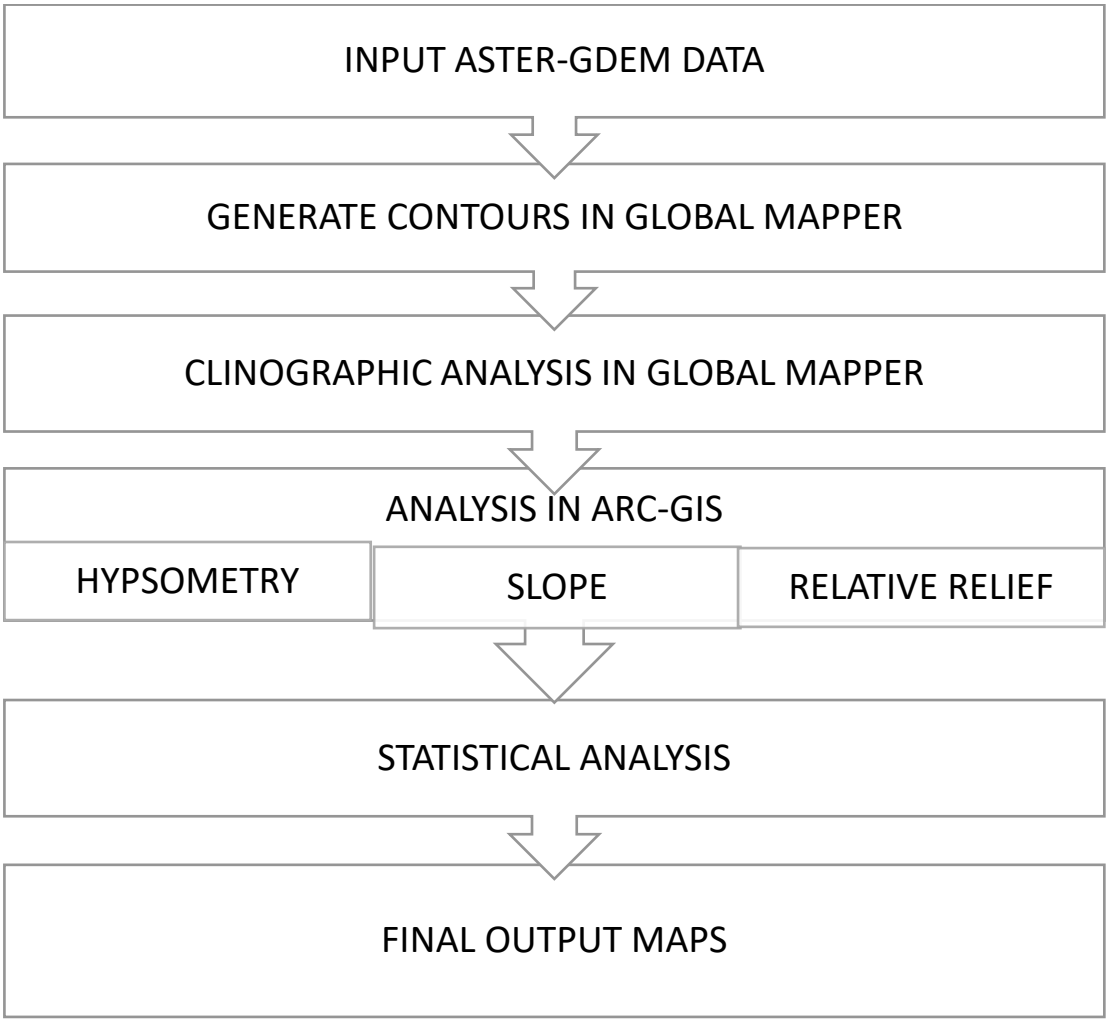

Fig. 2: Research Methodology

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Discussion And Results:

Hypsometric Analysis:

Hypsometric analysis, also known as hypsometry, refers to the study and analysis of elevation or altitude variations over a specific area, such as a region, watershed, or mountain range(Ashwini et al., 2021). This analysis involves the use of hypsometric curves or histograms to represent the distribution of elevations within the given area (Ramu & Mahalingam, 2012). Hypsometry involves the measurement and analysis of the relationship between altitude and basin area(S. Singh, 1998). Area-height curves, hypsometric curves and percentage hypsometric curves are generally used to show the relationships between altitudes and the area of the basin. The equation used by Ramu and Mahalingam (Ramu & Mahalingam, 2012) is used with little modifications to calculate the Hypsometry Index. The modified equation is given below.

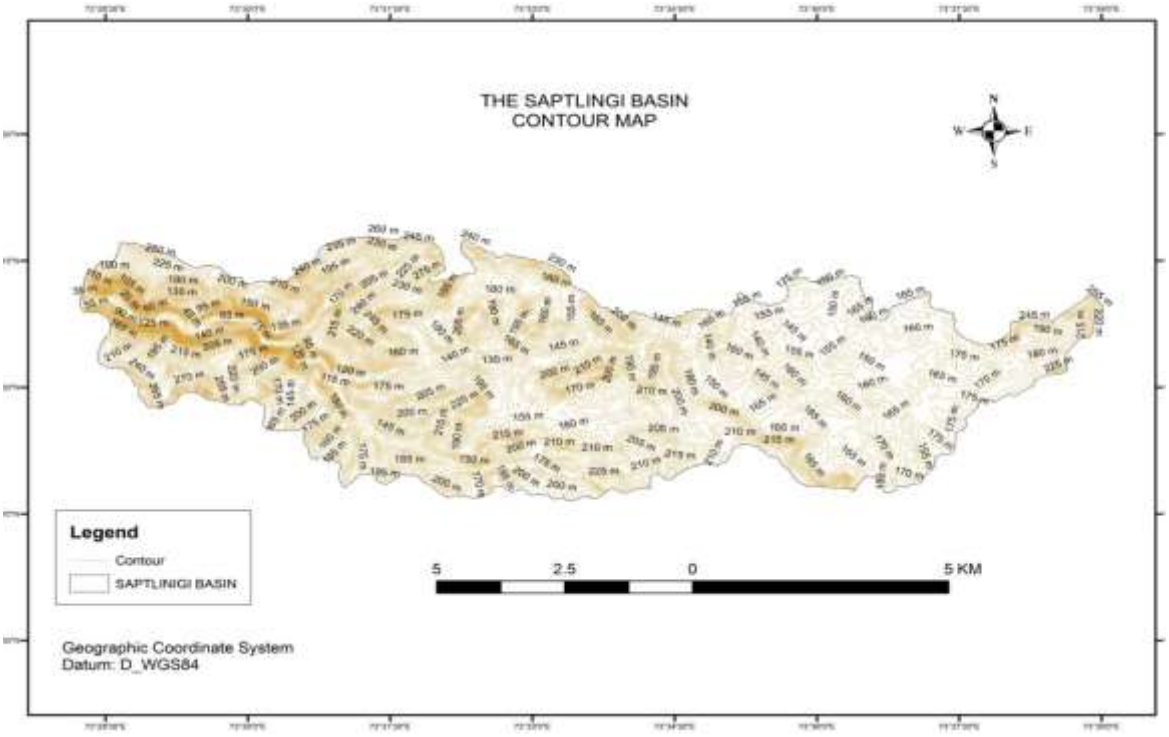

Fig. 3

Source: ASTER GDEM satellite data

$$HI = \frac{\bar{H} - Min\ H}{Max\ H - Min\ H}$$

Whereas,

HI= Hypsometry Index

$\bar{H} = Mean\ Elevation$

$Max\ H = Maximum\ Elevation$

$Min\ H = Minimum\ Elevation$

Based on the above equation the Hypsometry Index of the study region is 0.5. Fig. 3 and 4 give an idea about the Hypsometry of the study region.

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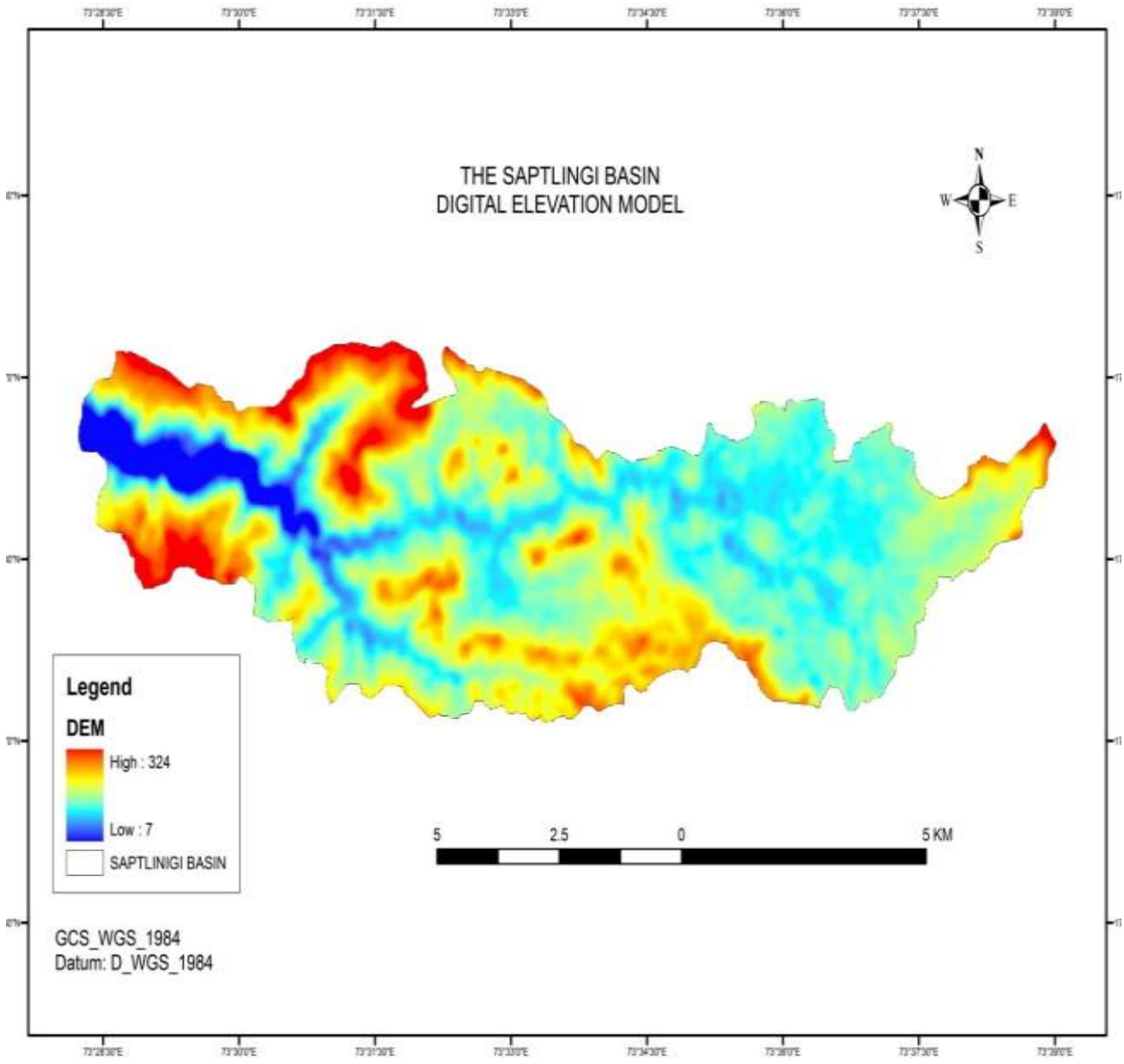

Fig. 4

Clinographic Analysis:

Clinographic curves (Narozhnyaya, 2021) represent average slopes between successive contours and thus present a panoramic view of the terrain (Gaurav Singh & Singh, 2022; Patil & Yadav, 2012; S. Singh, 1998). Unlike area-height and hypsometric curves, clinographic curves reveal the breaks in slope and sudden changes in the relief of the area and they present the general trend of the surfaces (S. Singh, 1998). The construction of clinographic curves requires data on slope angles between successive contours, contour lengths, height, and the area between successive contours, for which many techniques have been suggested by various researchers. However, here an attempt is made to prepare cross-section profiles at selected locations for the clinographic analysis by using GIS technology. Fig. 5 depicts information related to clinographic analysis.

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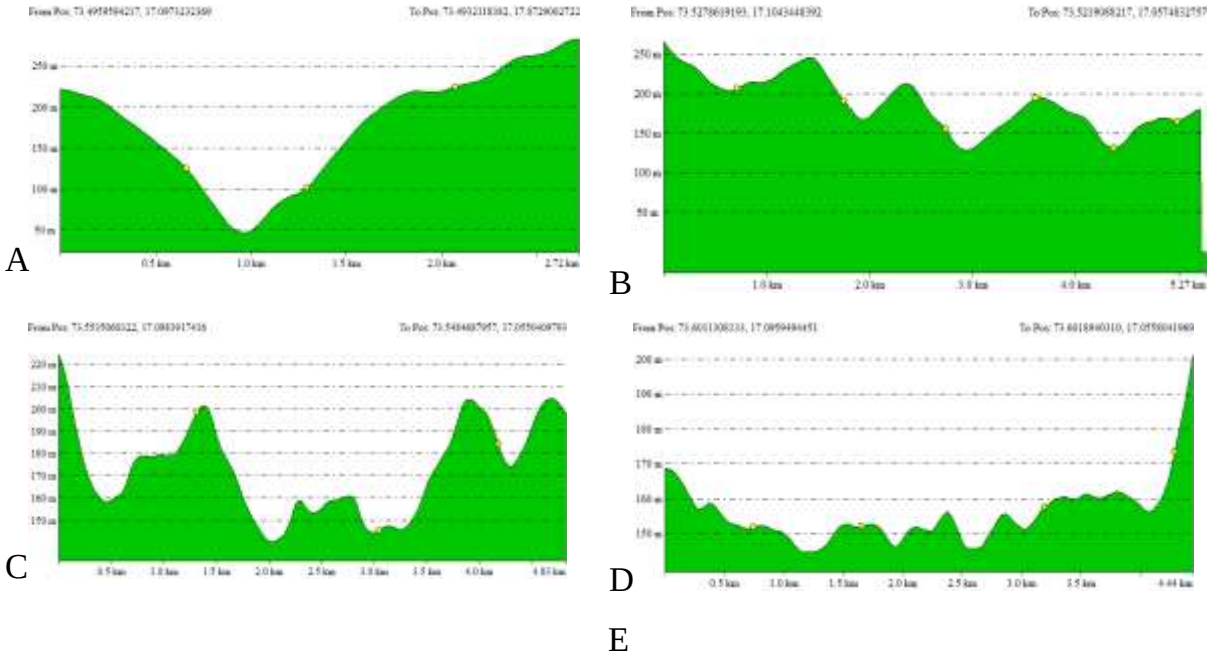
THE SAPTLINGI BASIN

CLINOGRAPHIC ANALYSIS



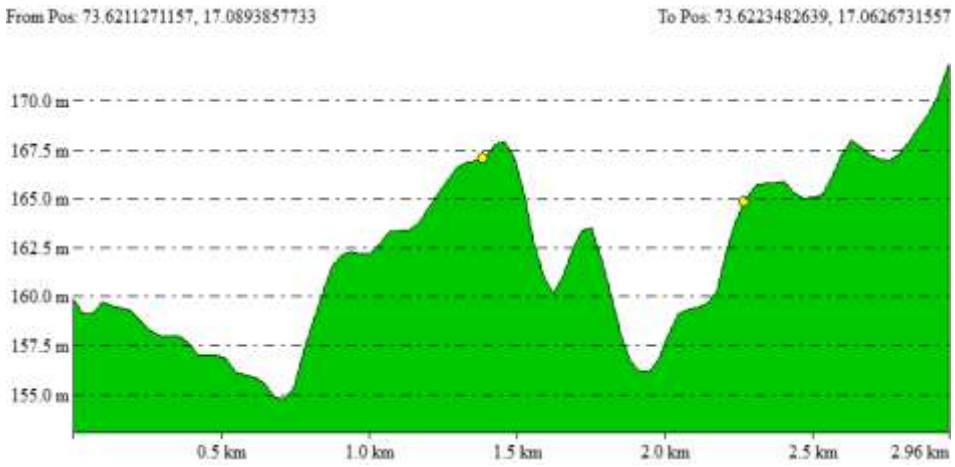


Fig. 5

Slope:

Slopes, defined as the angular inclination of terrain between hilltops and valley bottoms (S. Singh, 1998), resulting from the combination of many causative factors like geological structure, absolute and relative reliefs, climate, vegetation cover, drainage texture and frequency, dissection index etc. are significant Morphometric attributes in the study of landforms of a drainage basin (Gaurav Singh & Singh, 2022; Prakash et al., 2017; Rai et al., 2018; Saha & Singh, 2017; Sharma et al., 2022; A. P. Singh et al., 2020; P. Singh et al., 2013; S. Singh, 1998, 2022; Singh S and Singh M C, 1997)

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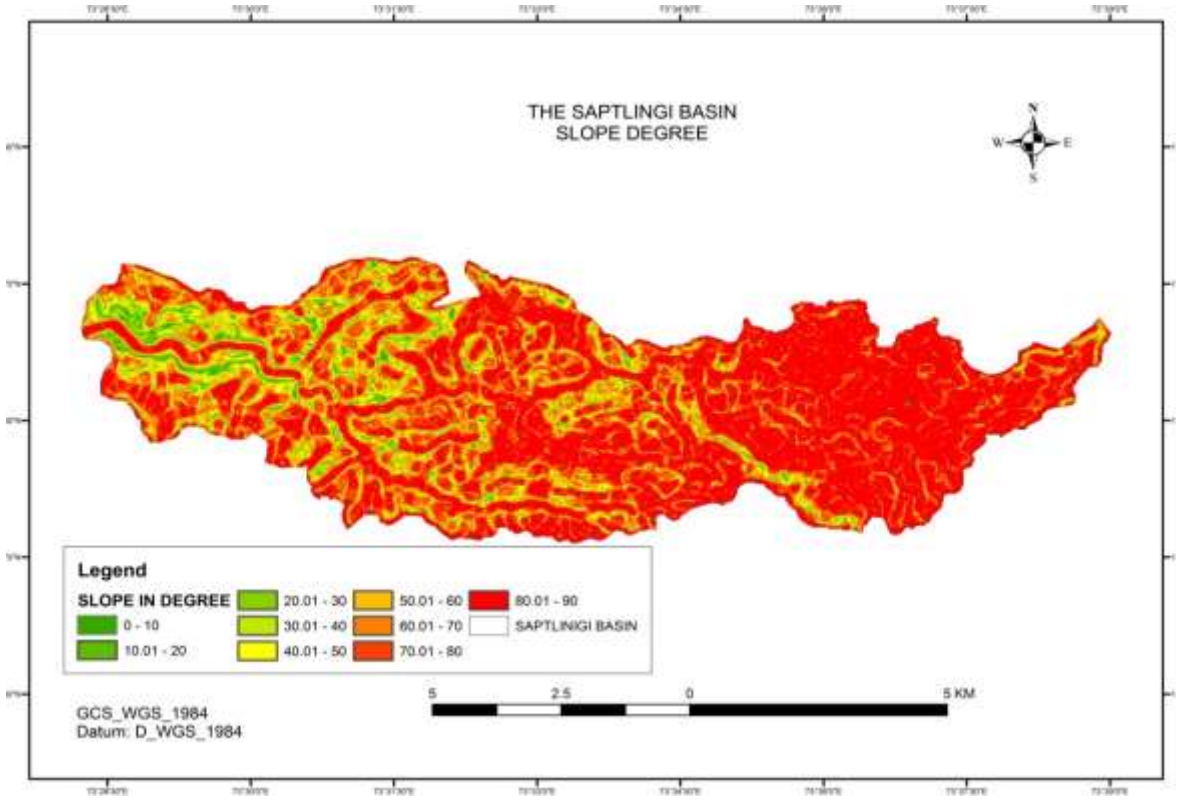

Fig. 6

Computation of slope angles from topographical maps or through field measurement involves tedious and time-consuming procedures. The statistical technique developed by Wentworth is also time-consuming. Thus, in the present research work, Geo-Spatial technology is used to study the slope of the Saptlingi Basin.

In the western part of the study region, the slope angle is less than 40 degrees whereas in the eastern part, it is more than 50 degrees at most of the sites. The study region is part of the Konkan thus, the high degree slope is being observed at most of the locations. Fig. 6 gives an idea about the slope angle observed in the study region.

Relative Reliefs:

Relative relief also termed as 'amplitude of available relief' or 'local relief' is defined as the difference in height between the highest and the lowest point (height) in a unit area (S. Singh, 1998). Relative relief is an important Morphometric variable, which is used for the overall assessment of morphological characteristics of terrain and degree of dissection. By considering time constraints the equation given by Maxwell (1960) is used to calculate the relative relief.

$$RR = \frac{MR}{BP}$$

Whereas,

RR = Relative Relief

MR = Maximum Relief

BP = Basin Perimeter

The study reveals that the relative relief ratio of the study region is 5.63.

Watershed Management:

Relief aspects of basin morphometry are an important consideration in hydrology and water resources management. Basin morphometry refers to the

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quantitative description of the physical characteristics of a drainage basin, including its shape, size, slope, and relief (S. Singh, 1998). Watershed management, on the other hand, involves the sustainable and integrated management of land and water resources within a specific drainage basin to achieve various objectives, such as flood control, water supply, erosion prevention, and ecosystem protection (Patil & Tendolkar, 2013).

The relief aspects of basin morphometry play a significant role in shaping the hydrological processes and influencing the effectiveness of watershed management strategies (Ismail et al., 2022; Mandale & Bansod, 2019; Nirmala et al., 2020; Tukura et al., 2021). The researcher has attempted to analyze the correlation between the relief aspects and the watershed delineation, and he has demarcated 69 micro watersheds in the basin.

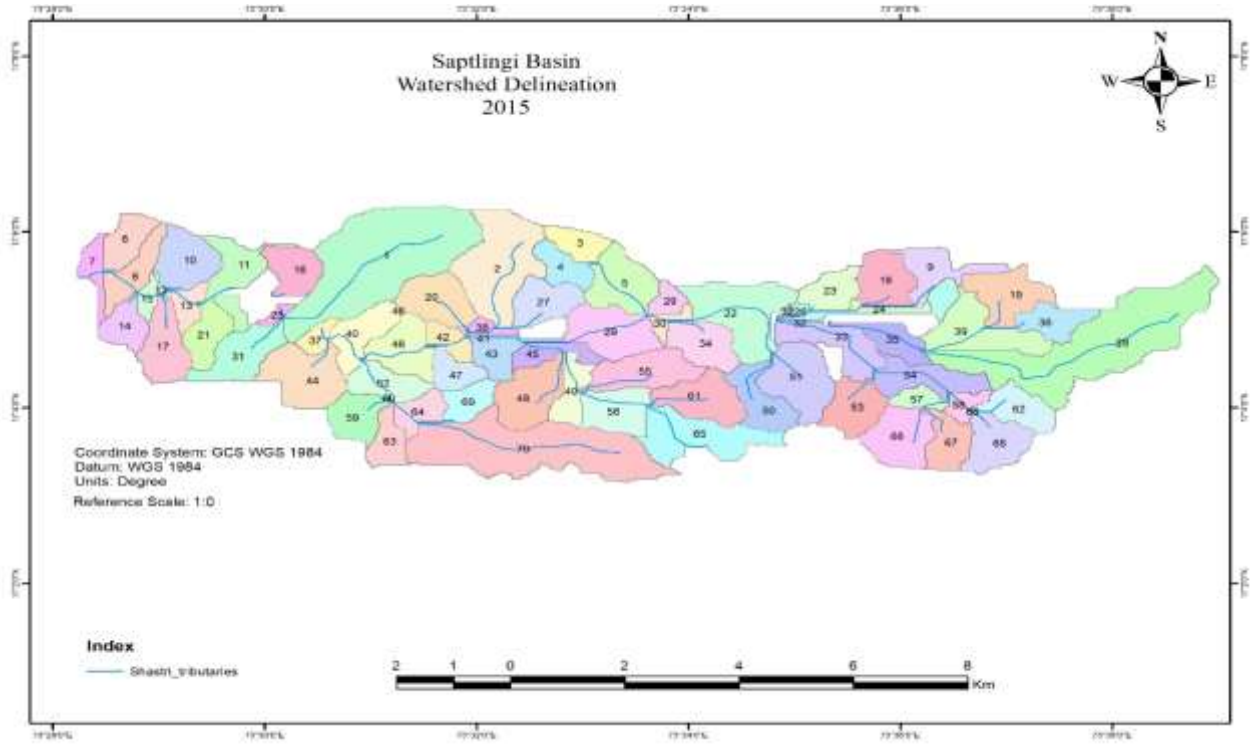

Fig. 7

It is observed that the relief features, such as slope and elevation differences, influence the rate of surface water runoff within a watershed and affect the distribution of water storage within a basin. Steeper slopes in the basin contribute to higher erosion rates as water flows more rapidly, carrying sediment with it. Flood-prone areas within the watershed are absent due to the relief aspects of the basin. Accurate morphometric data improve the reliability of such models and aid in decision-making for watershed management. The relief aspects of a basin influence the distribution of different habitats and ecosystems.

In conclusion, there is a strong correlation between the relief aspects of basin morphometry and watershed management. Understanding the physical characteristics of the basin helps in formulating effective management strategies to address various water-related challenges, ensuring sustainable water use and ecosystem preservation.

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Conclusion:

The study reveals that the Hypsometry Index of the study region is 0.5. The clinographic analysis proves that the Saptlingi basin has spatial variation in the relief features and the undulations are extremely high in the eastern part than the western. The GIS analysis explains that the western part has gentle slopes, and the eastern parts have steep slopes. The relative relief ratio of the study region is 5.63. There is a strong correlation between the relief aspects of basin morphometry and watershed management.

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