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ANALYSIS OF MAHI AND SABARMATI RIVER WATERSHEDS' MORPHOMETRIC PROPERTIES AND LULC ANALYSIS OF SABARMATI WATERSHED

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ABSTRACT

The physical attributes and dimensions of the geographical area drained by a river and its tributaries are examined in a morphometric analysis of a river watershed. It aids in comprehending the size, form, and other characteristics of the basin, which can offer important insights for environmental planning, flood risk assessment, and watershed management. A comparison of the morphometric analyses for the Mahi and Sabarmati river watersheds is carried out in this paper. Researchers and environmental planners can learn a great deal about the hydrological behavior of the river basin, possible flood hazards, erosion susceptibility, and ecological significance by looking at these morphometric features. For the sake of conservation and sustainable river basin management, this knowledge is essential. Management of the Sabarmati River's land cover and use has also been carried out. Use of land and the management of water resources has been greatly influenced by land cover. Land use planning that incorporates water resource considerations can guarantee that developments are sited and planned to avoid adverse effects on water resources. An investigation of the Sabarmati watershed's land use and land cover has also been done in this study. The development of water resources is positively impacted, as the results demonstrate.

Keywords: Morphometric Analysis, River, Watershed, Environmental planning.

INTRODUCTION

A thorough examination of the physical attributes and dimensions of the geographical area drained by a river and its tributaries is known as morphometric analysis of a river basin. Numerous agencies and organizations engaged in environmental evaluation, disaster management, and water resource management find morphometry analysis to be beneficial.(Matew & Shekar, 2022). Important information about the topography, hydrological behavior, and possible environmental management of the basin is provided by this analysis. A thorough summary of the important morphometric characteristics is provided below.

The entire land area that the river and its tributaries drain is represented by the parameter called "basin area." It is a key indicator that affects many different facets of the hydrology of the basin. During rainstorm events, larger basin areas usually result in higher runoff quantities.

The distance of a river from its source to its outflow is known as its basin length. It facilitates comprehension of the river's path and its relationship to the surrounding environment. The longitudinal extent of a river basin or watershed along its primary flow path is measured as its basin length. It may also allude to the primary channel's length. It provides information on the extent and size of the drainage area. Singh, Vijay P. (2017). The length of the main channel is the distance measured along the center line of the principal or main stream within a network of rivers.(Garde R.J., 2006)

Drainage Density: The entire length of streams in a basin is divided by the basin area to determine the drainage density. It can show how well water is moved within the basin and quantifies the amount of stream bifurcation.

Stream Order: A hierarchical classification of river segments is known as stream order. Higher-order streams arise when first-order streams merge, with first-order streams being the smallest. This parameter facilitates the analysis of the connectivity and structure of the river.

Stream Frequency: This indicator counts how often streams in the basin cross a certain area. It sheds light on the dense river system.

Basin Shape: Metrics for describing the geometry of a basin can have an impact on flood patterns and water flow. A circular basin, for instance, can have different hydrological properties than an elongated one.

Relief: The elevation difference between the basin's highest and lowest points is measured. It affects how quickly and how much water flows through the network of rivers.

Slope: Slope analysis looks at how steep the basin's terrain is. Faster water flow and erosion can result from steeper slopes.

Lithology: Predicting the kinds of rocks and sediments that can affect the quality of the water can be made easier by knowing the geological makeup of the basin's surface.

Analyzing the basin's land use and land cover reveals regions with urbanization, agriculture, forests, and other land uses.

Hydrological Response Unit (HRU): By breaking the basin up into smaller subareas, differences in soil type, slope, and land cover may be taken into account for a more thorough examination.

Environmental planning, flood risk assessment, and river basin management all depend on morphometric analysis. It contributes to our understanding of the ecology, flood susceptibility, erosion risks, and basin behavior. Conservation and sustainable management of water resources are aided by this understanding. The current study's goals are to perform and determine the Sabarmati and Mahi Watersheds' morphometric properties. also to use morphometric and LULC analysis to determine the Sabarmati Basin's potential.

LITERATURE REVIEW

Adhikari (2020) investigated the Ghatganga Stream morphometric analysis. He examined the watershed's several morphometric parameters. Chopra et al. (2005) investigated the Gurdaspur sub-watersheds using morphometric analysis. To achieve the same, remote sensing and GIS techniques were used. Dimple R. et al. (2022) used quantity-based morphometric analysis to ascertain the hydrologic behavior of the watershed. The Calabar watershed's morphometric parameters were examined by Eze and Efiong (2010). They also included the hydrological processes' ramifications. Magesh et al. (2011, 2012) evaluated and conducted morphometric analysis for a range of catchments. In their 2016 study, Land Use Land Cove Analysis, Mondal et al. produced a prediction-based conclusion. Using morphometric analysis, Patel et al. (2013) prioritized the Malesari mini-watersheds and provided a viewpoint on the use of remote sensing and GIS. Patel et al. (2010) investigated and examined the application of GIS in the engineering of water resources. In their 2017 study, Rwanga et al. evaluated the LULC categorization using GIS and remote sensing. The Kanhar basin underwent morphometric investigation by Singh et al. (1997). Shekhar et al. (2022) gave the Murredu basin's subwatersheds priority. Shrivastava et al. (2010) used GIS and remote sensing to investigate how urbanization affects LULC change. S.Sukristiyanti et al. (2018), Pancholi et.al. (2017) studied the morphometric and morphotectonic analysis.

Study Area

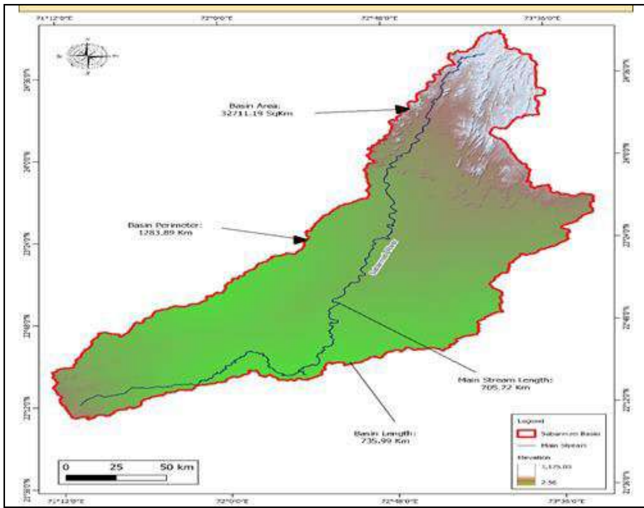


Figure1: Sabarmati Watershed

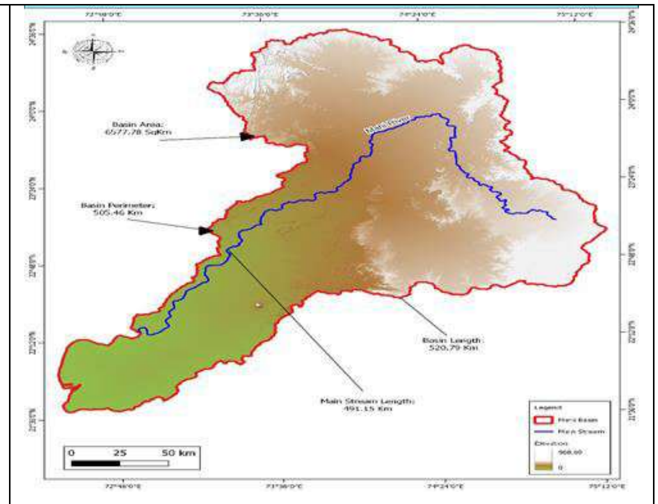


Figure 2: Mahi Watershed

Situated in western India, the Sabarmati River Basin holds historical, environmental, and developmental importance. Length: From its source in the Aravalli Range to its confluence with the Gulf of Khambhat (Arabian Sea), the Sabarmati River travels a distance of around 371 kilometers (230 miles). The drainage area of the basin is roughly 21,674 square kilometers, or 8,372 square miles. The region that empties into the Sabarmati River and its tributaries is included in this section. Riverfront Development: One amazing example of urban revitalization in Ahmedabad is the Sabarmati Riverfront Development Project. With parks, promenades, and cultural attractions, it has changed the riverbanks into a lively and sustainable public area. This project provides a global paradigm for revitalizing urban rivers.

The Mahi River Basin is a major river system with distinct proportions that is located in western India. Length: The Mahi River originates in the Indian state of Madhya Pradesh and flows for about 533 kilometers (about 331 miles) before joining the Arabian Sea in the Gulf of Khambhat. Drainage region: At about 34,842 square kilometers (or 13,457 square miles), the Mahi River Basin is a sizable land region. The regions that drain into the Mahi River and its tributaries are included in this large basin. Tributaries: There are several rivers that feed the Mahi River, but some of the larger ones are the Som, Panam, Anas, and Veda rivers. The Mahi River's overall size and flow are influenced by these tributaries.

Use of Morphometry & Mapping Remote Sensing

Morphometry analysis is used in hydrological research to evaluate and quantify the shape, size, and slope characteristics of river basins. It helps in forecasting patterns of erosion or floods, assessing runoff capacity, and comprehending the hydrological response of a watershed (Salvi et al., 2017). Understanding and analyzing the features of river networks, watersheds, and flood dynamics is made possible with the help of remote sensing and geographic information systems (GIS). It makes it possible to accurately define watersheds, extract and map river networks, estimate streamflow and discharge, and keep an eye out for flooding. Hydrologists can get critical insights for flood prediction, early warning systems, and water resource management by employing remote sensing (RS) data, such as satellite imaging and SAR (Mangan et al., 2019). In hydrology, morphometry analysis is essential because it allows for a thorough understanding of watersheds. It helps with the implementation of soil conservation measures and flood risk prediction by providing crucial information about slope features. Furthermore, morphometry analysis offers insights into the paths and connections of water flow when analysing a watershed's drainage pattern. Numerous agencies and organizations engaged in environmental evaluation, disaster management, and water resource management find morphometry analysis to be beneficial (Matew & Shekhar, 2022).

METHODOLOGY

Obtaining Data (Data Sources) SRTM DEM data with a spatial resolution of 30 meters were used in this investigation. Data Products: USGS Earth Explorer (used at no cost), 30m spatial resolution SRTM DEM, The boundary of the Sabarkanti Basin was drawn using Indian government data. Morphometric analysis of Sabarmati Basin image pre-processing (QGIS 3.10 with Plugin). The Sabarmati Basin data obtained from USGS Earth Explorer (SRTM DEM) has been appropriately georeferenced and reprojected. Using the supplied grey band, mosaics of the Different 7 Tiles were created using the QGIS program. After noise reduction and histogram matching, the images were trimmed using the research area shape file to define the area prefix. The DEM values were adjusted using the fill sink process to improve stream generation and UTM projection accuracy.

DATA ANALYSIS AND RESULTS

The morphometric study results for the Mahi and Sabarmati river basins are displayed in Tables 1 (A, B) and Table 2 (A, B), respectively. The comparative statements and specifics of both basins come after the results.

Table 1(A): Parameter Tables for Sabarmati River watershed

Parameter							**Sum**	**Unit**
Stream Order	1st	2nd	3rd	4th	5th	6th	-	-
Stream Length	7262	3988	2042	1238	433	35	14998	Km
Stream Number	16801	9386	4183	3106	896	92	34464	-

Table 1 (B): Linear and Areal Parameters: Sabarmati River watershed

Parameter	**Value**	**Unit**
Main Channel Length	492	Km
Area of basin	32711	Sq Km
Perimeter of Basin	1284	Km
Maximum height	1175	Meters
Minimum height	2.5	Meters
Basin Relief	1172.5	Meters
Relief Ratio	0.0024	-
Basin Length	736	Km

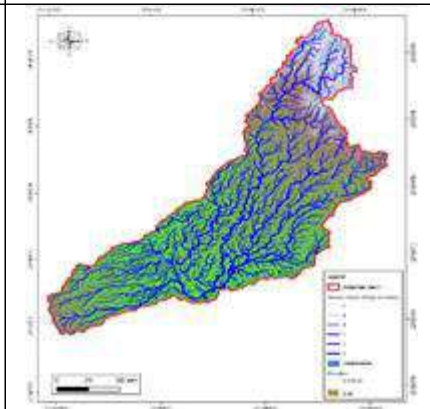
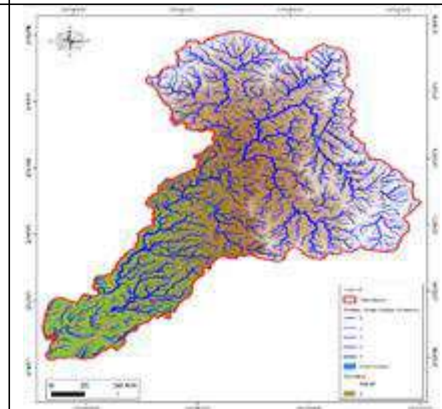
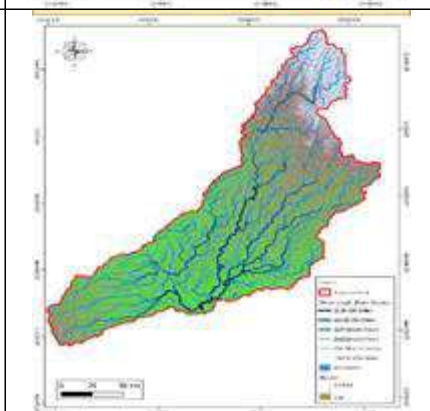
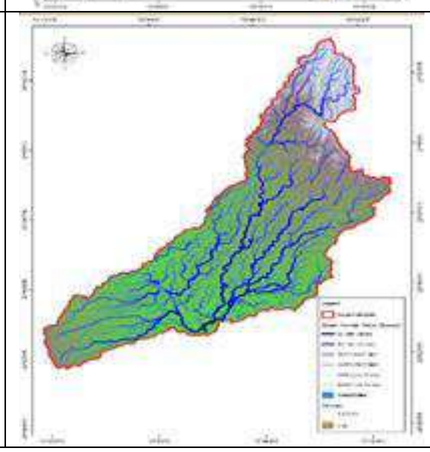
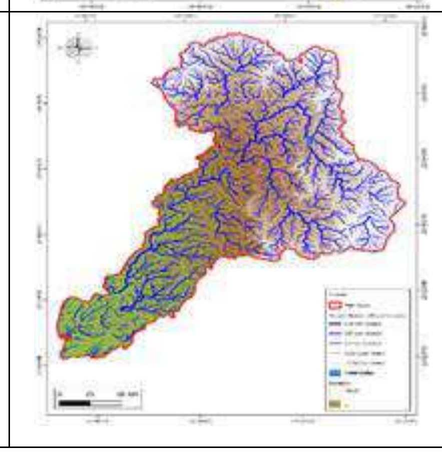
Table 2 (A): Parameter Tables for Mahi River watershed

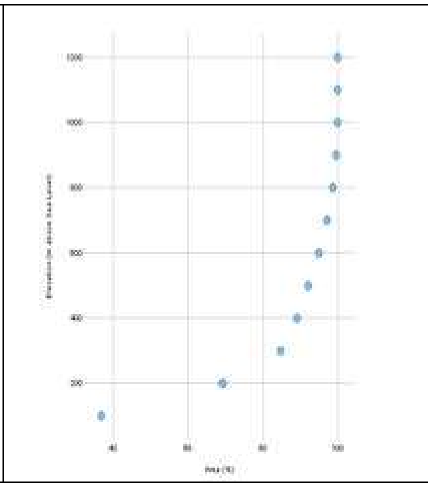
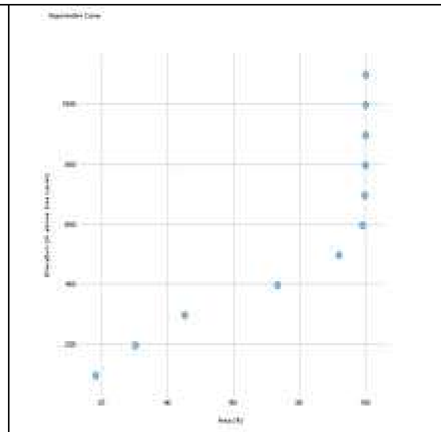
Parameter						**Total**	**Unit**
Stream Order	1	2	3	4	5		
Stream Length	7786	3672	1912	681	273	14324	Km
Stream Number	2132	1011	546	238	119	4046	

Table 2 (B): Linear and Areal Parameters: Mahi River watershed

Parameter	**Value**	**Unit**
Main Channel Length	491	Km
Area of basin	6578	Sq Km
Perimeter of Basin	505	Km
Maximum height	969	Meters
Minimum height	0	Meters
Basin Relief	969	Meters
Relief Ratio	0.0020	-
Basin Length	520	Km

Table 3: Morphometric Analysis of Sabarmati and Mahi Watershed

Parameter	Description	Sabarmati Basin	Mahi Basin
Stream Order	A river system's stream order system is used to categorize and assign numbers to related streams..		
Stream Length	The total distance that a stream or river traverses from its source to its mouth or endpoint is referred to as its "stream length".		
Stream Number	The term "stream number" refers to the total of all individual stream orders in a watershed or river basin.		

Hypsometric Curve*	It offers information on the areas of the watershed that are above or below a given elevation.		

* Information about the areas of the watershed above or below a given elevation is provided by the hypsometric curve. Here, the curve shows that, for the Mahi River Basin and the Sabarmati River Basin, respectively, 20% of the entire area has an elevation of more than 400 meters and 250 meters.

Comparative Statement for Comparing Both Watersheds (Sabarmati and Mahi)

For a variety of reasons, including water resource management, agriculture, and environmental conservation, it is imperative to comprehend the similarities and contrasts between these two river basins, which are important physical and ecological characteristics on the Indian subcontinent.

Geographical Location: The Sabarmati River Basin is mainly in the state of Gujarat in western India and spans an area of around 21,674 square kilometers.

Mahi River Basin: This large region, which spans Gujarat, Rajasthan, and Madhya Pradesh, is also located in western India and is approximately 34,842 square kilometers in size.

Length of River: The Sabarmati River is comparatively shorter, measuring about 371 kilometers in length. Mahi River: Measuring almost 583 kilometers in length, the Mahi River is the longer.

Morphometry: The Sabarmati River has several key characteristics, and its first and second stream orders are somewhat higher than their counterparts, which causes early flooding. There are more higher order streams and longer rivers in the Mahi River Basin. Sabarmati River Basin: The Wakal, Sei, Harnav, and Hathmati rivers are the main tributaries of the Sabarmati. Mahi River Basin: The Som, Anas, Panam, and other smaller streams are among the many tributaries that make up the larger network of the Mahi River Basin. Sabarmati River Water Flow: The Sabarmati River has a more unpredictable flow pattern and notable seasonal fluctuations in water levels. Mahi River: Because it has a bigger catchment area, the Mahi River often has a more steady flow throughout the year.

Agricultural Importance: In order to cultivate crops like cotton, wheat, and oilseeds, both basins are essential to agriculture. Because of its bigger area and more consistent water supply, the Mahi River Basin frequently produces more agricultural goods. Water Resource Management: Due to water scarcity issues in the Sabarmati River Basin, initiatives like the Sabarmati Riverfront Development have been put into place to better manage water resources. Even while the Mahi watershed has water stress in some locations, it benefits from a stronger flow that makes water management there more reliable overall. Environmental Conservation: To safeguard the ecosystems and species connected to the rivers, conservation initiatives are crucial in both basins. The enhancement of the Sabarmati River's biological equilibrium is another goal of the Sabarmati Riverfront Development Project.

LULC Analysis of Sabarmati Watershed:

For this work Landsat 9 data having the 30 meter spatial resolution had been used with 5 bands (Blue, green, Red, NIR & SWIR1). The process for doing a land use land cover analysis is depicted in Figure 3, and the land use land cover map for the Sabarmati river basin is shown in Figure 4.

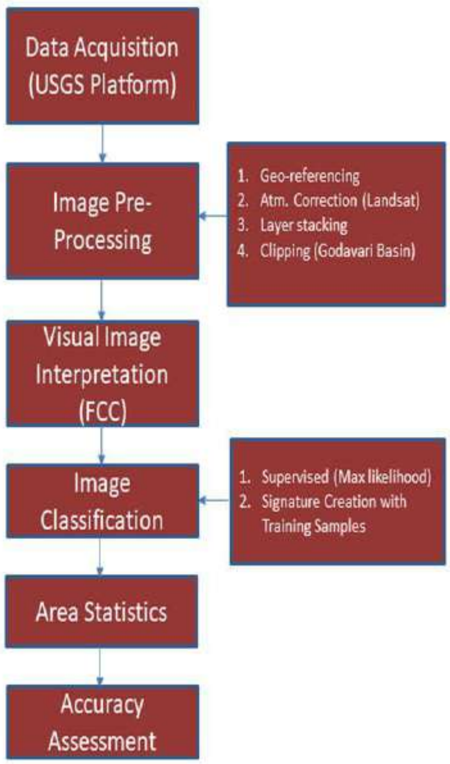


Figure 3: Methodology

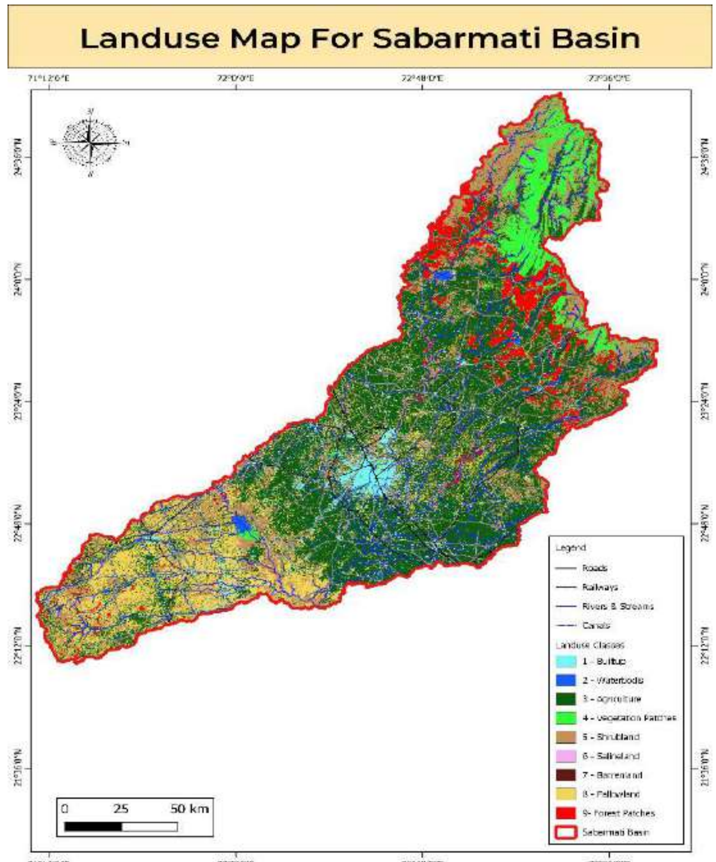


Figure 4: LULC Analysis of Sabarmati Watershed

Table 6 displays the accuracy evaluation of the word done for LULC analysis in QGIS, while Table 5 displays the class-wise LULC analysis for hydrological purposes.

Table 5: LULC Area with user's and producer's accuracy class wise

Landuse Classes	Area (Ha)	%	Producers Accuracy (%)	Users Accuracy (%)
Builtup	142634.0	4.8	100	100
Waterbodies	28033.6	0.94	100	100
Agriculture	1415190.4	47.3	100	96
Vegetation Patches	190002.4	6.3	88	100
Shrubland	587420.3	19.6	89	73
Salineland	3797.5	0.13	100	100
Barrenland	22457.8	0.75	100	100
Fallowland	448780.6	15	73	93
Forest Patches	153423.3	5.18	100.00	100.00
Total	**2991739.8**	**100.00**	**-**	**-**

ACCURACY ASSESSMENT:

Table 5 displays the accuracy evaluation. To achieve data verification for additional categorization and accuracy check purposes utilizing base maps, stratified random sampling was carried out with a minimum of 100 accuracy points for the LULC maps using reliable QGIS plugins. These data were utilized to compare features and satellite data to provide accurate statistics and to verify the accuracy of the supervised categorized map. Following the classification procedure, it is helpful to measure and detect the recorded map inaccuracies by evaluating the accuracy of the land cover categorization. Accuracy evaluation is often carried out by calculating an error matrix that contrasts the map data with reference data for a number of sample areas. Our LULC analysis demonstrated great accuracy (>92%). Overall Accuracy is 92.93 % and Kappa Coefficient is 0.89.

CONCLUSIONS:

Finally, morphometric examination of a river basin offers important information about its physical features, hydrological behavior, and environmental importance. The above-mentioned QGIS has been used to obtain several morphometric metrics for both river basins. We may determine a number of important conclusions by examining many factors, including drainage density, length, basin area, and more: Understanding Hydrology: We can obtain a thorough understanding of the water flow across the basin thanks to morphometric analysis. This information is essential for anticipating and handling problems with droughts, flooding, and water shortages. Environmental Assessment: The analysis aids in our evaluation of the effects of changing land cover and usage on the basin's overall health. It helps with conservation efforts by allowing us to detect places that are susceptible to pollution, erosion, and sedimentation. Watershed Management: We can customize management plans to target regions, encouraging sustainable land use practices and reducing environmental degradation, by breaking the basin up into smaller hydrological response units (HRUs). Adaptation to Climate Change: Morphometric analysis is an essential technique for determining how vulnerable the basin is to climate change and for developing adaptable plans to lessen its consequences. In conclusion, morphometric analysis is the cornerstone of well-informed decision-making and environmentally sound river basin management. It gives us the ability to handle the difficult problems related to water resources, land use. For resource planning, land cover and use are crucial. A thorough investigation of land use and land cover has been carried out for the Sabarmati river basin.

The computation yielded good results, with a kappa coefficient of 0.89 and accuracy of 93%. Technological developments, such as GIS, data analytics, and remote sensing, are transforming land use management and enabling data-driven choices for a more sustainable future. management of land use that can adapt to changing conditions, such as population increase and climate change. To sum up, efficient management of land use and land cover is critical to the health of our planet and future generations. To establish a sustainable and peaceful cohabitation between humans and the environment, a diverse, flexible, and inclusive strategy that values technology and local knowledge is required.

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