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Watershed Delineation of Bewas River in Sagar District Using GIS and Remote Sensing Techniques

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ABSTRACT

Delineation of watersheds is a fundamental hydrological work. Spatial grids called Digital Elevation Models (DEMs) are employed to automatically determine watershed boundaries. The Bewas River has been studied using DEMs. During the watershed mapping process, several interim findings were generated. This study's findings may be applied to Rainfall-Runoff analyses and other in-depth studies on the catchment region. Additionally, it would aid with decisions about the allocation and management of ground and surface water resources. The project also aimed to gather river water chemistry information for future use. Planning has to do with drinking and agriculture. This research might help with river management as a whole, future food prevention, channel alterations, and property loss planning. The results of this study might be used to develop strategies for water treatment and sustainable land use that include regular monitoring.

Keywords: Bewas River, Sagar, Watershed delineation, Geographical Information System, Digital Elevation Model, Stream order, Basin

Introduction

An ocean, a lake, a sea, and another river are all examples of natural waterways that rivers might flow towards. Rivers in freshwater frequently flow in this way [1]. In rare cases, a river's course may end by simply running into the earth or by drying up completely without joining another body of water. Riverbank erosion is a prevalent geomorphological occurrence in alluvial flood plain rivers [2]. A crucial aspect of human existence that has evolved throughout human history

is the river. The river cycle starts after the elevation of the land mass [3]. While flowing downhill, rivers may not necessarily take the shortest path from their source to their mouth [4]. In this inquiry, we have focused on defining the Bewas River's watershed and charting its basin. It runs through an area of Central India that is prone to drought and dependent on seasonal water variations. The people of Sagar city have access to drinking water from the Bewas River. It serves as the primary home water supply. A thorough investigation was conducted. Pre- and post-monsoon water samples were obtained, and 26 criteria were utilised to determine the water quality [5].

Study area

Delineating a watershed entail drawing a line that symbolises the region that contributes to a certain river outflow. The Bewas River rises in the Vindhya range (Raisen) region, close to the hamlet of Pipalia Katan (349 metres above sea level), and empties into the Sonar River in Madhya Pradesh, north of Narmadapuram. The river runs northeast from the Sagar district of Madhya Pradesh in central India. The Bewas watershed position is seen on the map in (Fig. 1). The watershed is located between 78° 35' and 78° 08' East longitude and 23° 34' to 23° 58' North latitude. In DMS, the river's coordinates are 23°58'59" N and 79°21'01" E (Fig. 1). Its river path passes over the Malwa plateau and is not navigable for about half of its length. The average annual rainfall in the basin is 1234 mm, and from June to September, the southwest monsoon accounts for around 91% of that total. The lowest temperature is 5.9° degrees Celsius in January, while the maximum temperature is 48.8° degrees Celsius in May. The majority of the state is made up of dissected plateaus, dissected hills, and dissected valleys. The majority of the Bewas basin's soils fall under the category of black soil.

The Bewas River reaches the holy Yamuna after being a main tributary of the Sonar River. near Village-Gopalpura in Block-Banda of Tehsil & District-Sagar Madhya Pradesh at Latitude 24° 01' 32.16" & longitude. 79° 03' 37.89" is the river Bewas (a sub-tributary of the Sonar River that meets the Ken River in the Ken basin). The catchment area for the Sagar district as a whole is 1277 km^2. A watershed can be defined using either the conventional approach or a GIS (Geographic Information System). Drawing lines to link elevation points and contour lines is a

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classic way for delineating watersheds from topographic maps. Using a topographic map to correctly delineate watershed borders is a difficult undertaking. The automatic extraction from DEMs (Digital Elevation Models) has taken the role of the human delineation of drainage networks and catchments from topographic maps [6].

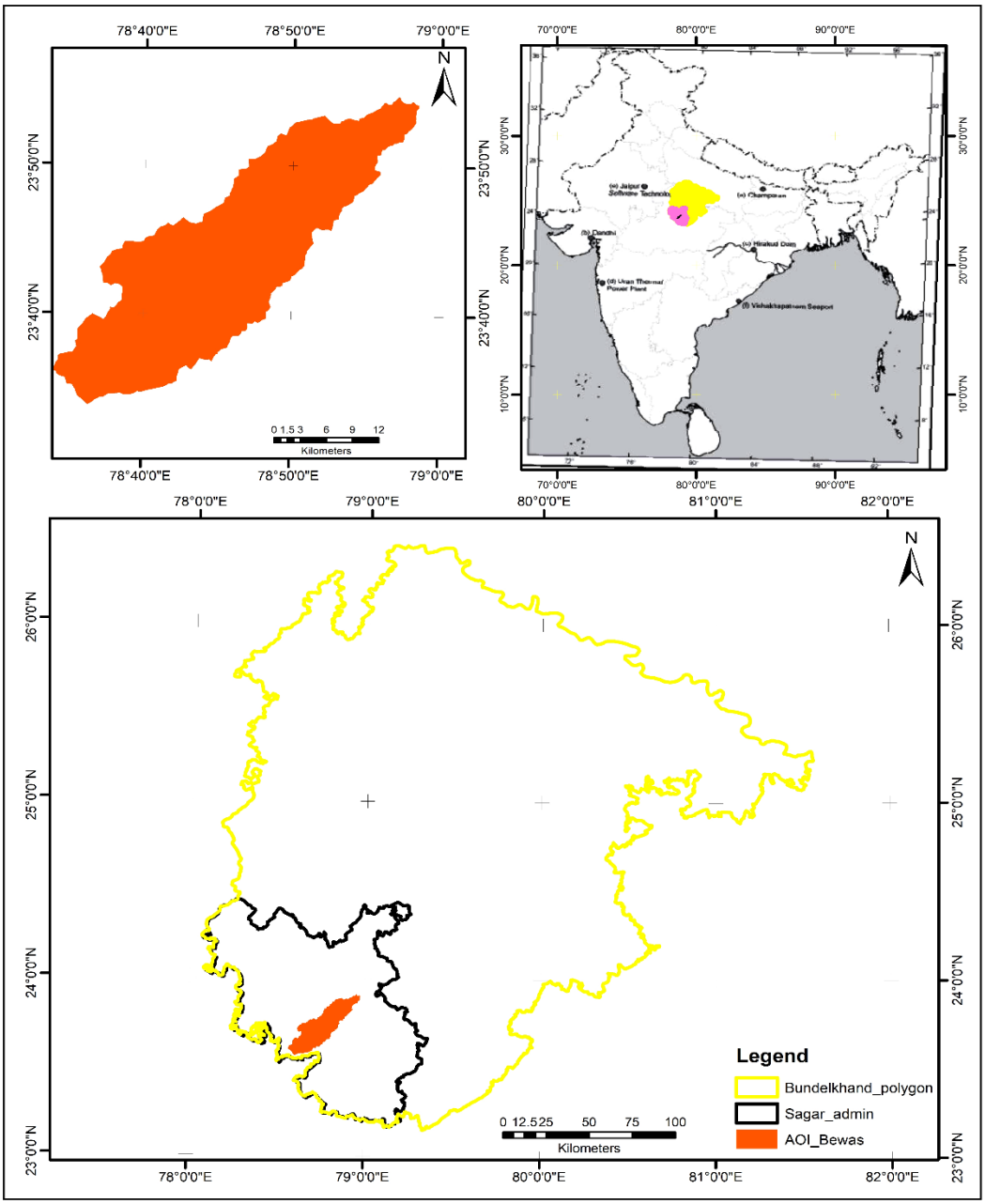

Figure 1. Location map of study area Bewas River, Narmadapuram, Sagar district, Madhya Pradesh, India

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For this, a DEM with a resolution of 30 m from Bhuvan Cartosat-1 was employed. The selection criteria were strong secondary flow demarcation and improved tertiary flow demarcation that exhibits a natural pattern. IRS satellite picture, is now often used to get details about the topography, including its slope, gradient, aspect, and contour line. The management of the watershed depends heavily on the precise definition of the watershed [7]. At both the global and national levels, the use of research is crucial to the management of today's water resources. Therefore, it is important to describe the fundamental characteristics of a river and its catchment region using current methodologies and procedures so that the findings may be used to future study and decision-making. The goal of this study is to establish the fundamental characteristics of the Bewas River and its watershed for use in this region's Rainfall-Runoff analysis and other planning activities connected to agriculture and drinking.

A controlled water supply started after the big reservoir (Rajghat) was constructed on the Bewas river, and lesser rills dried up, forcing population relocation. The reservoir is the only source of water for the adjacent Sagar area. A good water supply was provided to the area around the reservoir, which enhanced agriculture. The river is surrounded by an undulating surface that has been managed to prevent free flow in addition to running over hard rock terrain. The building of the reservoir helps a vast area by meeting the demands of nearby regions through a canal system.

Material and method

The flow chart represents systematically, the way to extract stream network from DEM through Arc GIS. The following steps were involved during delineation and analysis (Fig. 2). Parameters considered and computing method are given in Table 1.

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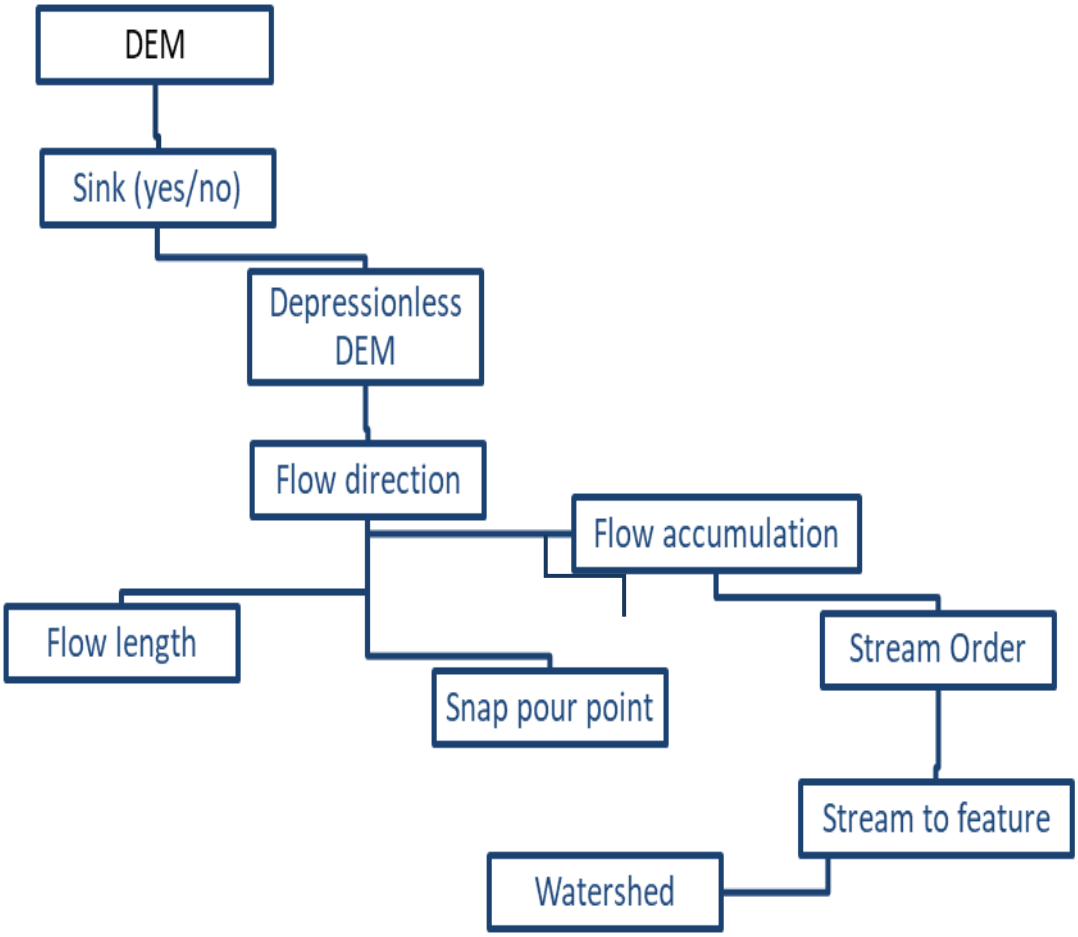

Figure 2. Methodology flowchart

The study region is covered by toposheets 55I on a scale of 1:250,000 and 55I/9, 55I/10, 55I/11, 55I/13, and 55I/14 on a scale of 1:50000 in the survey of India. The 2012 Liss 3 satellite data on a 50K scale was utilized. Using ERDAS IMAGINE 2010 (Hexagon Geospatial) and ArcGIS 10.1 (Esri), the resultant picture was evaluated. The river basin and other river data are delineated on the toposheets (55I), which have been adjusted for district Sagar's digitalization. Software is then used to digitize the river using the toposheet. After that, the photos are recorded in relation to the toposheets. For this work, a DEM with a spatial resolution of 30 m was given (Fig. 3). WGS_1984_44N_Transverse_Mercator was utilized as the spatial reference.

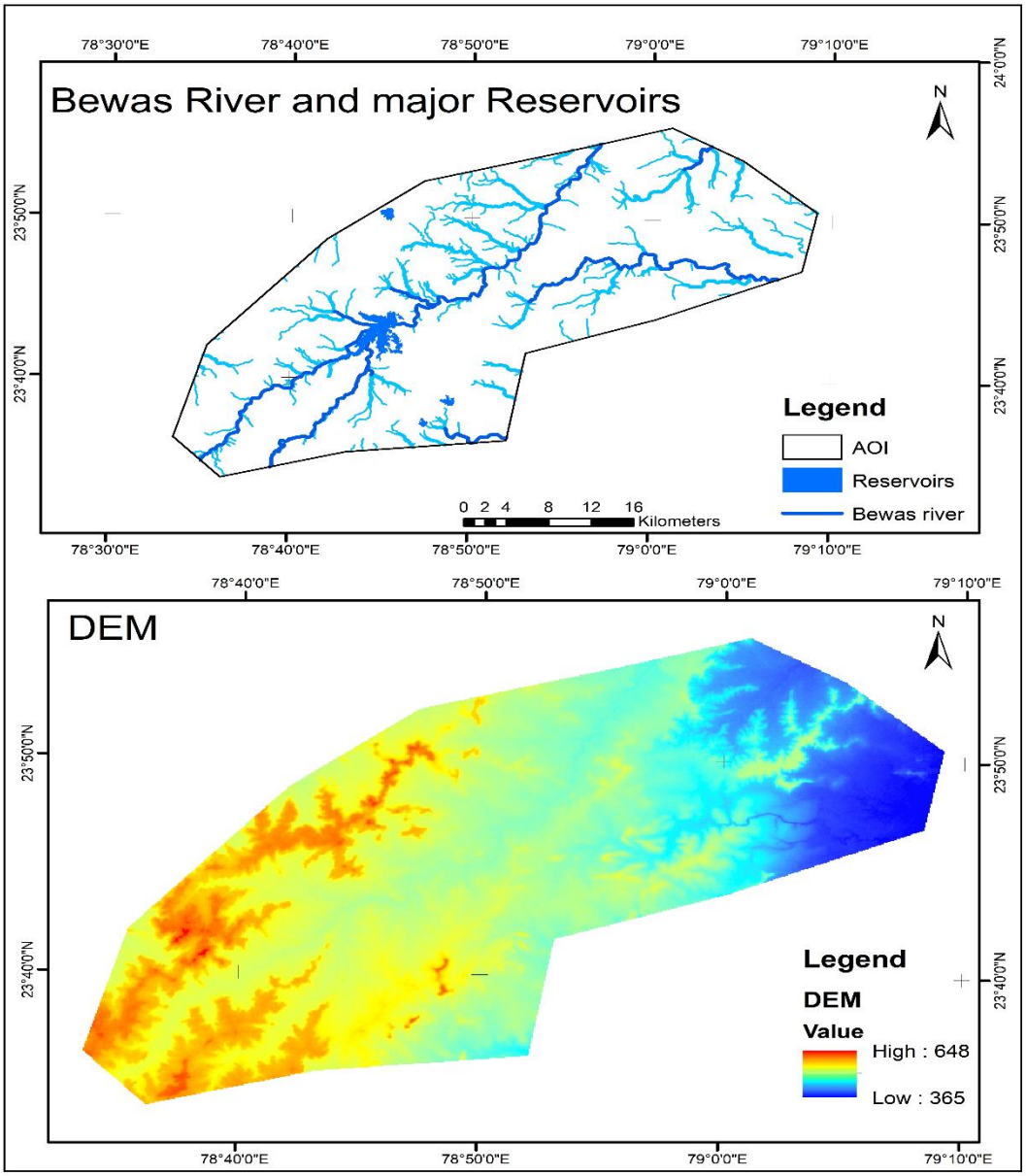

Figure 3 Bewas River extracted from DEM and CartoSat-1 DEM at 30m resolution

Basic characteristics of the Bewas River and its watershed have been identified using ArcGIS. The following flowchart (Fig. 2) is created based on the "ArcGIS Tools" tutorial handbook. DEM is the main type of data used in this model. Numerous intermediate outcomes are produced, including flow accumulation maps, and flow direction maps (Fig. 4).

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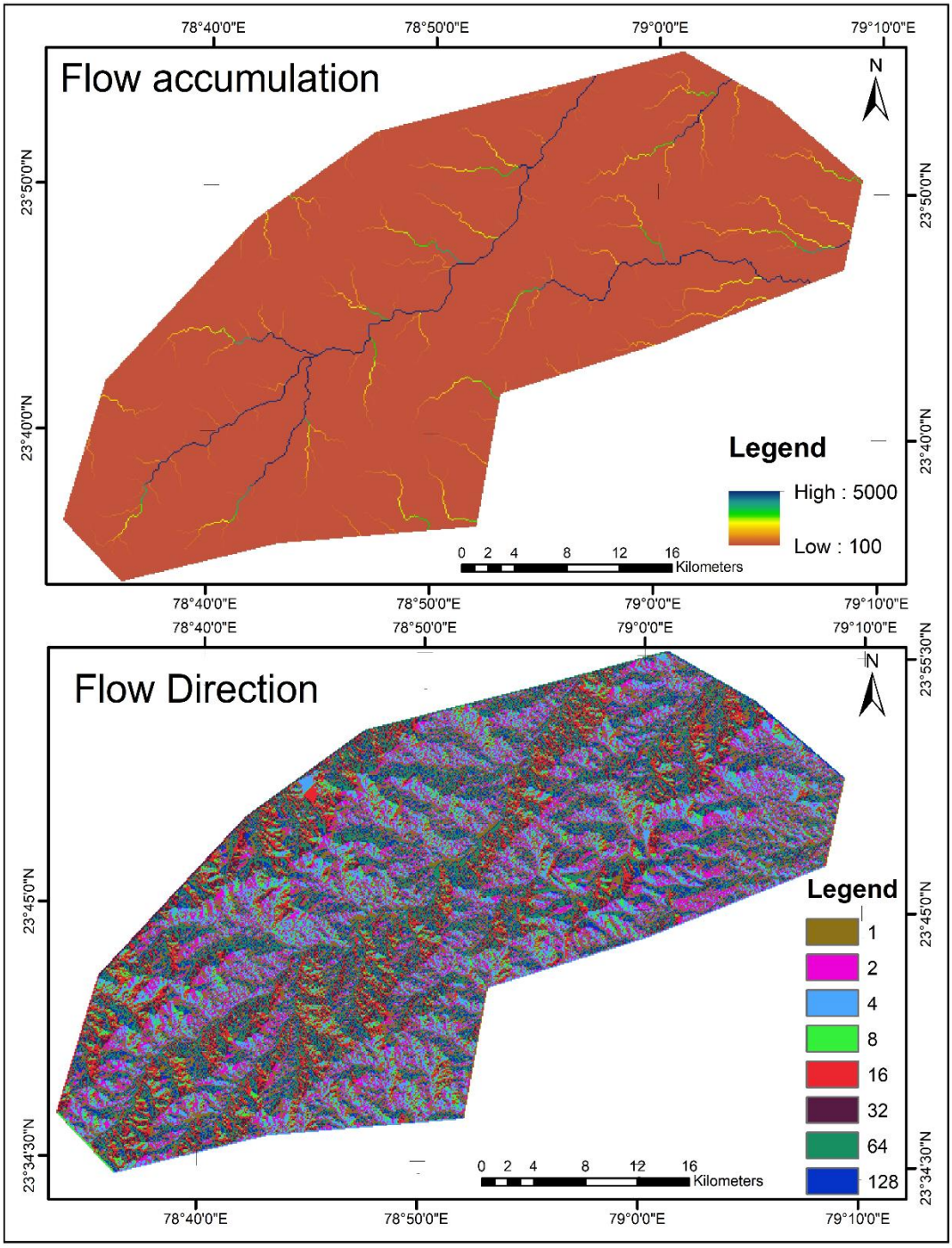

Figure 4 Bewas river flow accumaulation and flow direction delineation from DEM

Table: 1 Parameters considered and computing method

Sl.No.	Parameters	Formulas	Reference

1	Watershed delineation	DEM derived	
3	Stream length	Ls=L1+L2+L3+….Ln	Horton (1945)
4	Stream order	Hierarchical rank	Strahler (1954)

Acquisition and processing of data

IRS image of area was also studied for detailed information collection to avoid the quality compromise for future planning and Digital image processing tools were used to process the images. Such as Pre-processing, radiometric corrections and restoration, geometric transformation, picture enhancement, image categorization, and multitemporal analysis etc. were used to achieve this [8]. The image was corrected geometrically to fit the UTM-44 N (Universal Transverse Mercator) projection. After combining the processing of data from several spectral bands, image was ready for categorization and analysis [9]. For image that needed to be rectified, transformation metrics were calculated, ground control points (GCP) were created, and then the pixels of the image were resampled using the transformation metrics.

The verification of the visual and digital interpretation of remote sensing data requires competent field expertise. The ground truth was timed to consider current seasonal data for the research. Then, during the ground truth, the maps were validated and verified. To verify the referenced picture, a ground truth operation employing GPS (Global Positioning System) coordinates was carried out.

Data collection and processing issues:

The implementation of GIS to this investigation requires careful consideration of data quality. Another key aspect of GIS is the availability and calibre of spatial data. One of the main issues in digitizing map data was the lack of consistency in the scale and form of the district across different maps. Therefore, in this instance, the district's authority and the opinions of the locals during the ground-truthing have been considered. They have grown sophisticated and difficult to integrate into the system since they are compiled with varying degrees of accuracy and map size. There were few quality issues in Carto DEM because it is generated with fully automated s/w and DEM errors like match point failure in hill tops and large triangle formation in plain area were exist. Mosaic errors across tiles are also observed.

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Results

Few intermediate results were generated while processing the desired data generation. The number of different layers were also generated for the support with all precision. The outcome layers are shown in the (Fig. 5) and a Table 2 of output data is attribute form is given.

Table 2: Results obtained from Arc-GIS for Bewas watershed.

Sr No.	Name of attribute	Value
1	Area of watershed	585.61 Km^2
2	Perimeter of watershed	143.93 km
3	River length	448.83 km
4	Major reservoir area	13.13 km^2

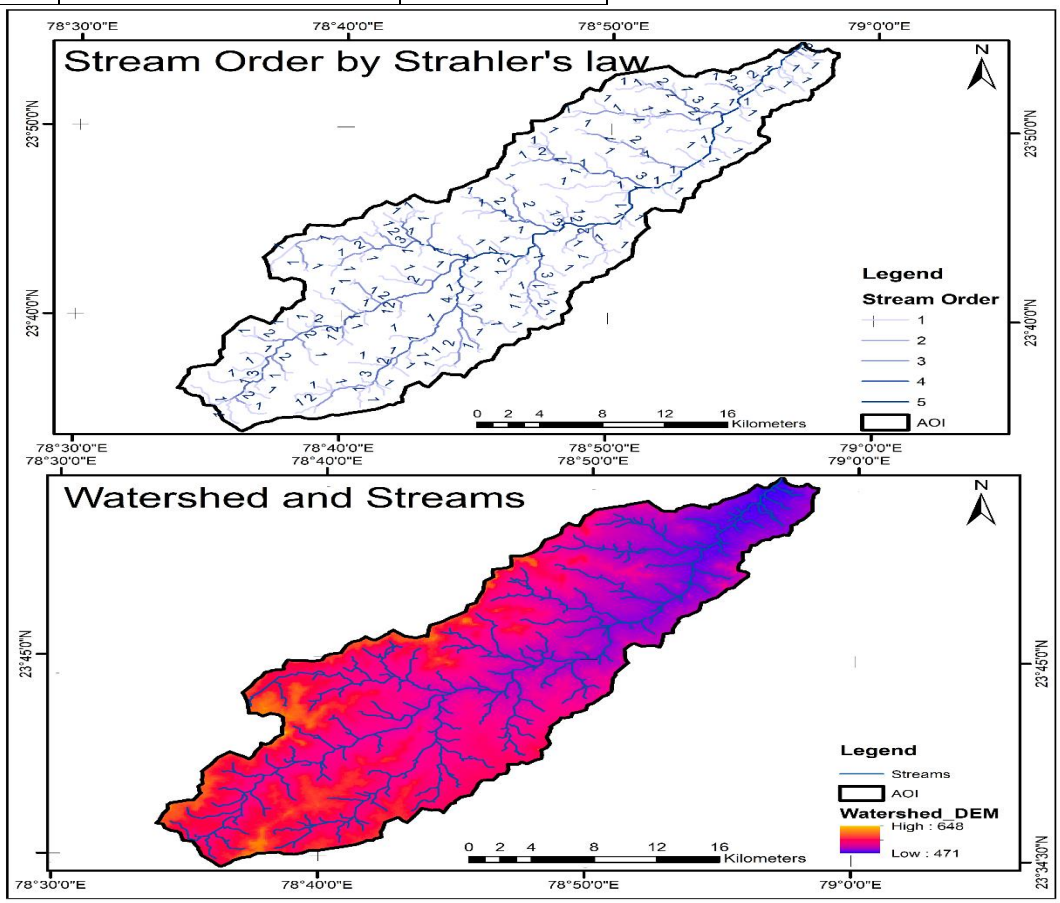

Figure 5. Bewas river stream order and watershed delineation based on methodology

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Discussion

Drainage network analysis is important for environmental and hydrological studies. Drainage patterns are rectangular, dendritic, and radial. Automated map of stream order using Strahler [11] method also has been generated with the help of DEM for watershed delineation and further studies (Fig. 5). This delineated watershed shapefile can be further used to divide basin into sub-basin and calculate their hydrologic and topographic features for developing a rainfall-runoff model, drinking water planning and agriculture supply. In past various studies has performed on watershed delineation [12].

Water quality Data Collection And Environmental Impact:

Based on earlier studies [13] and ground water boards data analysis in Bewas River chemical analysis, Iron and ammonia recorded higher in monsoon which could be due to the acidification of water caused by the elevated microbial degradation of organic debris and concentrated dissolved solids during monsoon. Most of sample shows good quality water for drinking, irrigation, and domestic purposes. Water quality of river is in permissible limits set by the WHO/Indian Standard. However, it can be used for drinking purpose only after disinfection treatment, but water chemical parameters are not constant in all seasons so that the water quality analysis should be carried out on time to time. Human health and plant growth cannot be compromised from the perspective of environmental impact. It is advisable for sustainable planning of nearby area to spread the awareness among human to maintain the river water quality to avoid the future consequences.

Conclusion

The administration, integration, and visualisation of data in the GIS system were all fairly effective. With other quantitative, qualitative, and descriptive information databases, GIS mixes geographical data. This technology provides a framework for analytically capturing, managing, retrieving, analysing, and displaying data. In order to delineate the river watershed, remote sensing and GIS were employed in an integrated manner. Due to its exceptional capability of giving a synoptic picture of a significant portion of the earth's surface and its capability of repeating coverage, remote sensing is one of the best instruments for inventory and analysis of

the environment and its resources. When additional surface water variables that are organised with a GIS and remotely sensed data are joined. The outcome of the observed alterations suggests that the watershed delineation may have significant impact in planning related to drought prone areas. This knowledge will sincerely help with environmental management and related planning. The results of this study will aid the national organisation in ensuring that planning takes appropriate precautions to keep region and community sufferings to a minimum. It has been determined that watershed and basin mapping using supportive information in GIS and Remote Sensing environment may assist the government and local authorities in developing policies.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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