



RESEARCH ARTICLE

# Prioritization of subwatersheds in the Jajmau basin, Kanpur, via drainage morphometry

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## Abstract

Advanced, reliable and cost-effective tools such as GIS and remote sensing play very important roles in prioritizing and extracting drainage in basins. In the present study, thirty-two morphometric aspects, including linear, aerial and relief parameters with standard formulae, are considered and computed to prioritize the sub watersheds. The toposheet (1:50000 scale) downloaded from the SOI and SRTM DEM (30 m resolution) from the Earth Explorer were used to extract drainage and delineate the watershed and sub watershed of the basin via ArcGIS 10.8 software (Spatial Analysis tools). The drainage of any region depends on topography, slope, hillshade, aspect, vegetation cover and many more. The results revealed that drainage is dendritic to sub-dendritic, which shows that the study area has homogenous *i.e* very gentle slope and uniform soil *i.e* alluvial soil throughout. The Jajmau Basin is divided into four sub watersheds and prioritized via the compound value and ranking methods. Sub watershed SW-1 needs high priority and immediate attention in terms of management aspects, whereas SW-4 needs the least attention. Hence, the prioritize watershed would be beneficial and attract decision makers, policy formers and management planners for the effective planning of resources at the parcel level in a more precise manner.

## Keywords

DEM; GIS; morphometric analysis; remote sensing; watershed

## Introduction

With alarming growth in population, natural resources such as water and soil are being overused and utilized in an indiscriminate manner which reduces their quality for future use. In India, the maximum percentage of topsoil is lost in soil erosion or other land degradation activities. In our country, more than 2500 tanneries are in the Uttar Pradesh state. And more than 80 % of them are involved in chrome tanning process. Jajmau (Kanpur) is one of the major leather processing centers in the state and more than 18 % tanning industries are located at Jajmau. Therefore, planning and managing natural resources in a sustainable manner for increasing population is a major challenge. The streams and drains of the area and flow of water depend on several factors like slope, topography, aspect, hillshade, geology, parent material and vegetation cover. But most of the factors are controlled by the nature of the soil of the area. The physiographic characteristics like scale, texture and gradient of the basin bear an interrelationship with various hydrological phenomena. Morphometry means the measurement of shapes and is used to express quantitative landforms.

The watershed is an optimal unit for the sustainable development and management of natural resources (1). The traditional method of analyzing morphometric parameters is very laborious and consumes considerable time. However, with the advancements in geospatial and computational technologies, such as Geographic Information System (GIS) and Remote Sensing (RS) techniques, more precise and accurate assessments can be performed easily. Many researchers use Digital Elevation Models (DEMs) to derive topographic properties (2-5).

Morphological parameters play a very crucial role in the proper understanding of any watershed and its management. It is largely affected by parent material, lithology and geology. Thus, information on the above properties is very helpful for understanding the drainage pattern of a basin (6). Many researchers have used advanced techniques to study the drainage morphometry of basins (7-9). DEMs are freely available and can be explored to obtain a more detailed topography of the study area. Most researchers have used the 30 m resolution Shuttle Radar Topographic Mission (SRTM) DEM and the CARTOSAT DEM to extract morphometric parameters (10-11). With the advancement of computer technology and high-resolution imagery, these data provide more reliable results for any basin in less time. The prioritization of watersheds was based on the linear, aerial and relief criteria which represent the one, two and three-dimensional properties of watersheds, respectively. These aspects of morphometry help to identify severely eroded zones, which is an important step in the process of management planning. The compound value scoring method is the simplest way to prioritize sub watersheds. Detailed knowledge about basin drainage is extremely helpful in hydrological modeling, delineation of management zones and conservation and restoration of natural resources (12, 13). The present study highlights the usefulness of advanced tools such as GIS and remote sensing in prioritizing sub watersheds in the Jajmau basin. The main objectives of the study were analysis of morphometry of the basin, compound scoring for identification of sub watershed of high priority for management planning.

## Materials and Methods

### Study Area

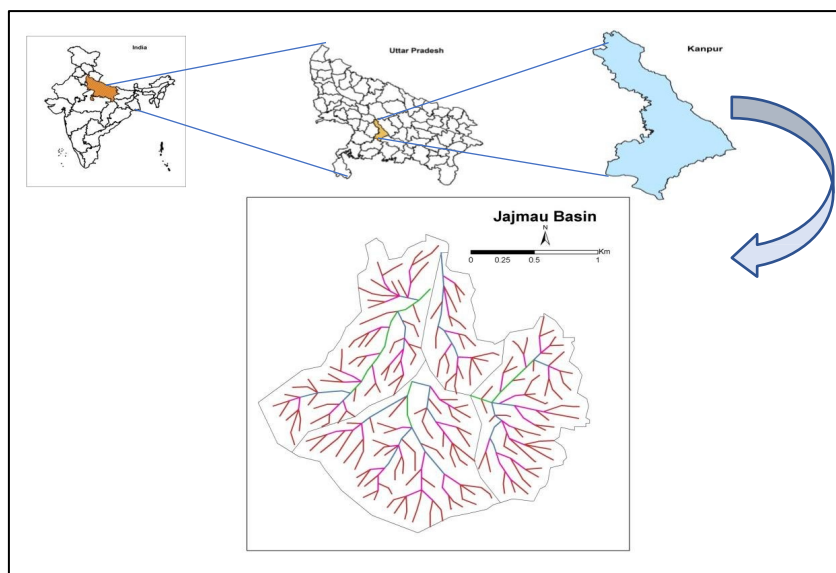
The study area, Jajmau (26.38 N latitude and 80.44 E longitude), is in one of the industrial areas of Kanpur, Uttar Pradesh, India (Fig. 1). It is situated on the left bank of the Ganga River and the right bank of its tributary Panku River. About 400 tanneries are located at Jajmau, which is one of the highly polluted zones. In long term, treated and untreated wastewater is used for irrigation in agricultural lands, which comprises nearly 10 villages. The slope of this area is nearly level and slope percentage vary from 1 to 3. The average annual temperature varies from 22-25 °C and two types of monsoons, i.e., southwest (June-September) and northeast (October-December), prevail in this region. Jajmau experiences the extremes of temperature, ranging from 3 °C in the winter months between December to February, to 48 °C in summer between May to June. It has subtropical humid climate, with an average annual rainfall of 800 mm. Monsoon rainfall is the main source for storage sectors and occurs at a maximum during south-western monsoon periods. The cropping pattern has changed from cereal to vegetables including cauliflower in many areas. Flower cultivation is also carried out in a few places in the region.

### Data collection

In this paper, the drainage morphometrics of the area was discussed by dividing the watershed into number of sub-watersheds and identification of management zone by priority. The main data used are Shuttle Radar Topographic Mission (STRM) digital elevation model DEM (30 m resolution) downloaded from earth explorer (<https://earthexplorer.usgs.gov/>) and 1:50000 scale toposheets (63B/7, 63B/8) collected from Survey of India (SOI).

### Extraction of the drainage network

The downloaded toposheets were converted to Tiff format, georeferenced and rectified via ArcGIS 10.8 software. The georeferenced toposheets are mosaiced and then clipped to the study area via the Arc Toolbox. Using these tools, the fill sinks, flow direction, flow accumulation, stream order and



**Fig. 1.** Location map of the study area.

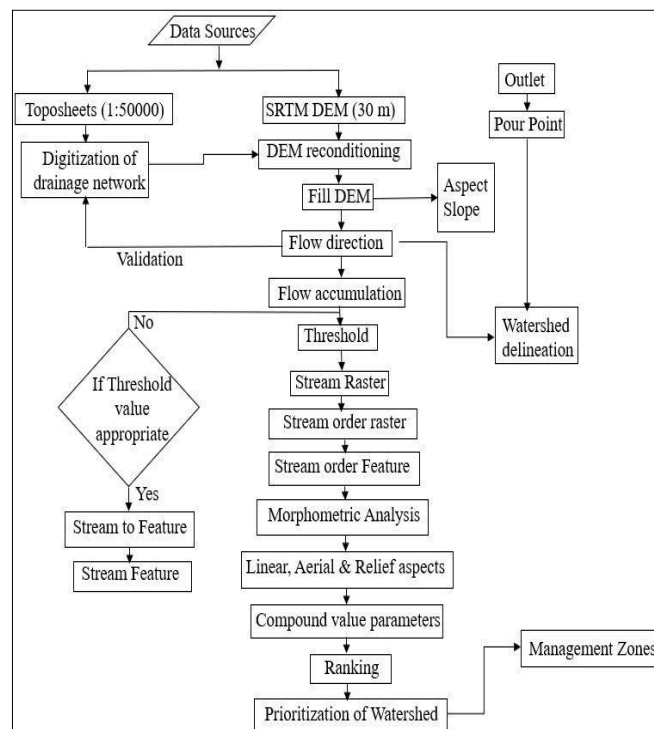
drainage network of the basin are derived. The extracted drainage was cross-checked with a mosaiced toposheet. Strahler's (14) stream ordering method was followed and the area was divided into four sub-watersheds on the basis of pour points of the basin. The results obtained with the DEM data were clipped to the boundary of the Jajmau basin and projected into the WGS84 UTM system. Slope and aspect maps were generated both from the SRTM DEM (30 m). The different thematic layers (basin and subbasin boundaries, drainage, relief, slope and aspect) were projected on the same spatial reference system (WGS-84/UTM) for overlay analysis in ArcGIS. The flowchart of the database and methodology is shown in Fig. 2.

### Computation of morphometric properties

The morphometric analysis provides physiological and methodical information about the drainage basin. The parameters of the basin area, perimeter, length and width, as well as the number and length of streams in various stream orders, are automatically extracted through ArcGIS tools. Standard formulae adopted from (14-17) (Table 1) are used to compute linear, areal and relief aspects for prioritization of sub-watersheds.

**Table 1.** Formulae for computing morphometric parameters

| S.No.                    | Morphometric parameters            | Formula/relationship                                                                                                     | References |
|--------------------------|------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Basic parameters</b>  |                                    |                                                                                                                          |            |
| 1.                       | Area (A)                           | GIS analysis/DEM                                                                                                         |            |
| 2.                       | Perimeter (P)                      | GIS analysis/DEM                                                                                                         |            |
| 3.                       | Basin length (Lb)                  | $Lb=1.312A^{0.568}$                                                                                                      | (17)       |
| 4.                       | Mean basic width (Wb)              | $Wb=A/Lb$                                                                                                                | (17)       |
| 5.                       | Stream order (U)                   | Hierachical rank                                                                                                         | (14)       |
| 6.                       | Stream number (Nu)                 | $Nu=N1+ N2+ \dots + Nn$                                                                                                  | (15)       |
| <b>Linear parameters</b> |                                    |                                                                                                                          |            |
| 7.                       | Stream length (Lu)                 | Length of stream                                                                                                         | (15)       |
| 8.                       | Mean stream length (Lsm)           | $Lsm=Lu/Nu$ , where Lu=total stream length of order "u", Nu= total no. of stream segments of order "u"                   | (14)       |
| 9.                       | Stream length ratio (Lur)          | $Lur =Lu/Lu-1$ , where Lu=total stream length of order "u", Lu-1= the total stream length of its next lower order        | (15)       |
| 10.                      | Mean stream length ratio (Rslm)    | $Rslm=\sum Lur/n$                                                                                                        | (17)       |
| 11.                      | Bifurcation ratio (Rb)             | $Rb=Nu/Nu+1$ , where Nu=total no. of stream segments of order "u", Nu+1= No. of stream segments of the next higher order | (17)       |
| 12.                      | Mean bifurcation ratio (Rbm)       | Rbm=average of the bifurcation ratio of all order                                                                        | (18)       |
| 13.                      | Rho coefficient (ρ)                | $\rho = Rslm/Rbm$                                                                                                        |            |
| <b>Aerial parameters</b> |                                    |                                                                                                                          |            |
| 14.                      | Drainage texture (Dt)              | $Dt=Nu/P$ , where Nu is the total no. of streams of all order, P is the perimeter of the basin                           | (15)       |
| 15.                      | Texture ratio (Rt)                 | $Rt=N1/P$ , where N1 is the total no. of first order streams                                                             | (19)       |
| 16.                      | Drainage density (Dd)              | $Dd=Lu/A$ , where Lu is the total stream length of all orders, A is the total area of the basin in km <sup>2</sup>       | (19)       |
| 17.                      | Stream frequency (Fs)              | $Fs=Nu/A$ , where Nu is the total number of streams of all order, A is basin area                                        | (19)       |
| 18.                      | Drainage intensity (Di)            | $Di=Fs/Dd$ where Fs is the stream frequency, Dd is the drainage density                                                  | (19)       |
| 19.                      | Infiltration number (If)           | $If= Fs \cdot Dd$ where Fs is the stream frequency, Dd is the drainage density                                           | (19)       |
| 20.                      | Length of overland flow (Lof)      | $Lof =1/(Dd \cdot 2)$ , where Dd is the drainage density                                                                 | (15)       |
| 21.                      | Form factor (Ff)                   | $Ff=A/Lb$ where A is basin area, Lb is the square of the basin length                                                    | (19)       |
| 22.                      | Circulatory ratio (Rc)             | $Rc=4\pi A/P^2$ where A is basin area, P is the perimeter of the basin                                                   | (16)       |
| 23.                      | Elongation ratio (Re)              | $Re=2 \sqrt{\pi A}/Lb$ , A is basin area, Lb is basin length                                                             | (17)       |
| 24.                      | Constant channel maintenance (C)   | Inverse of drainage density                                                                                              | (17)       |
| 25.                      | Shape factor (Sf)                  | Reciprocal of form factor                                                                                                | (19)       |
| 26.                      | Compactness constant (Cc)          | $Cc= 0.282 P/A^{0.5}$ where P is the perimeter of the basin, A is basin area                                             | (19)       |
| <b>Relief aspects</b>    |                                    |                                                                                                                          |            |
| 27.                      | Elevation of the basin outlet (z)  | GIS analysis/DEM                                                                                                         |            |
| 28.                      | Maximum elevation of the basin (Z) | GIS analysis/DEM                                                                                                         |            |
| 29.                      | Total basin Relief (H)             | $H=Z-z$                                                                                                                  | (17)       |
| 30.                      | Relief ratio (Rh)                  | $Rh=H/Lb$ where H is relief, Lb is basin length                                                                          | (17)       |
| 31.                      | Relative Relief (Rr)               | $Rr=H/P$ where H is relief, P is perimeter                                                                               | (20)       |
| 32.                      | Ruggedness number (Rn)             | $Rn=H \cdot D$ , where H is relief, D is drainage density                                                                | (14)       |



**Fig. 2.** Flowchart of the data sources and methodology for morphometric analysis.

### Prioritization of subwatersheds

In this study, the prioritization of subwatersheds is based on allotting the ranks to each morphometric parameter. The compound values of all the parameters are derived by calculating the means of the assigned ranks. Soil degradation is directly related to linear and relief aspects but inversely related to aerial parameters. Thus, the prioritization of subwatersheds is based on higher values of linear and relief parameters and lower values of aerial parameters and vice versa. The high priority indicates an urgent action plan for the protection, conservation and management of soil.

## Results and Discussion

Using SRTM DEM data, the whole study area is divided based on pour points into four sub-watersheds (SW), SW-1 to SW-4, as shown in Fig. 3 (a). The drainage pattern ranges from dentritic to sub-dentritic type of the basin (Fig. 3 (b)), which indicates that the study area has homogenous and uniform soil and rocks. The morphometric analysis of the Jajmau Basin is explained in three different aspects (linear, aerial and relief) obtained via the methods and formulae mentioned in Table 1. The slope, hillshade and aspect of the basin are also evaluated, which can help in understanding watershed management (Fig. 4).

### Basic parameters

The area (A) of the watershed, ranges from 1.306 to 0.445 km<sup>2</sup>, affects the volume of runoff, with SW-4 being the largest and SW-1 being the smallest. The outside edge of the watershed that encloses its area is called the perimeter (P). The smallest

and largest sub-watershed perimeters values are 3.269 km (SW-1) and 5.732 km (SW-2) in size, respectively. Many researchers have given varying descriptions of basin length. It is derived using the mathematical formula in Table 1 in this instance, with SW-4 having the longest value (3907.45 m) and SW-1 having the shortest value (2119.81 m).

The basin width explains the distance of the line that is drawn perpendicular to the basin length. In this study, the basin width is longest for SW-4 (334.37 m) and shortest for SW -1 (210 m).

### Linear Parameters

Stream order is defined by the arrangement of the channels. In current research, the Jajmau Basin adheres to Strahler's classification of streams, which defines the simplest unbranched tributaries as first-order streams and the merging of two first-order streams results into a second order stream (Table 2). The stream order of the watershed is assigned to the stream of highest order (fourth order). Stream number (Nu) classifies the surface runoff characteristics, meaning a greater number of first-order streams represents increased erodibility and more permeable topography (21). It is obtained via the method (15) followed the "law of stream numbers" which postulates a negative correlation between the order of stream and stream number, meaning as the stream order increases the quantity of streams decreases. In this study SW-4 (50) contains the highest stream count and SW-1 (18) contains the lowest stream count. The stream length is defined as the total length of all subsequent stream segments within the basin (22).

The aggregate length of the streams is maximized in the first order and then diminishes with the progression of stream order as per the Second Law of Stream Length (15). Results show that SW-2 had the longest stream length at 12458 m while SW-1 had the shortest at 4974 m. Highly uneven terrain greatly influences the mean stream length ratio, with the slope being between 0.40 and 0.7.

This suggests there were strong resistant rocks that almost flattened the basin's outline and the configuration of surface flow. The bifurcation ratios from 3 to 5 are indicative of a natural-drainage system existing within uniform rock (23). More bifurcation denotes better dissection of drainage basins (15), which reduces the probability of flood and erosion (24). In this case, the values were between 1.79-3.25.

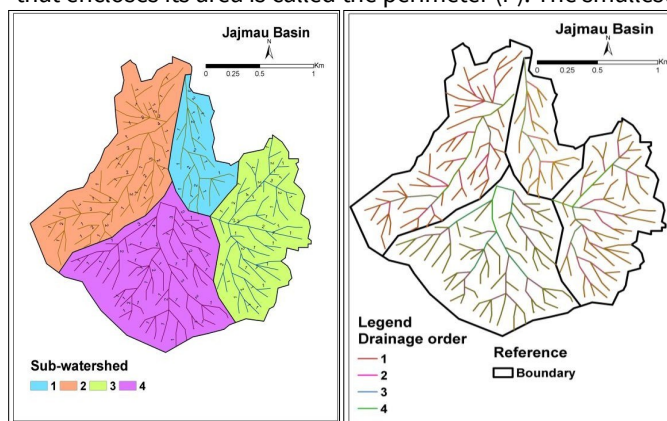


Fig. 3. (a) Subwatershed and (b) drainage order of the Jajmau basin.

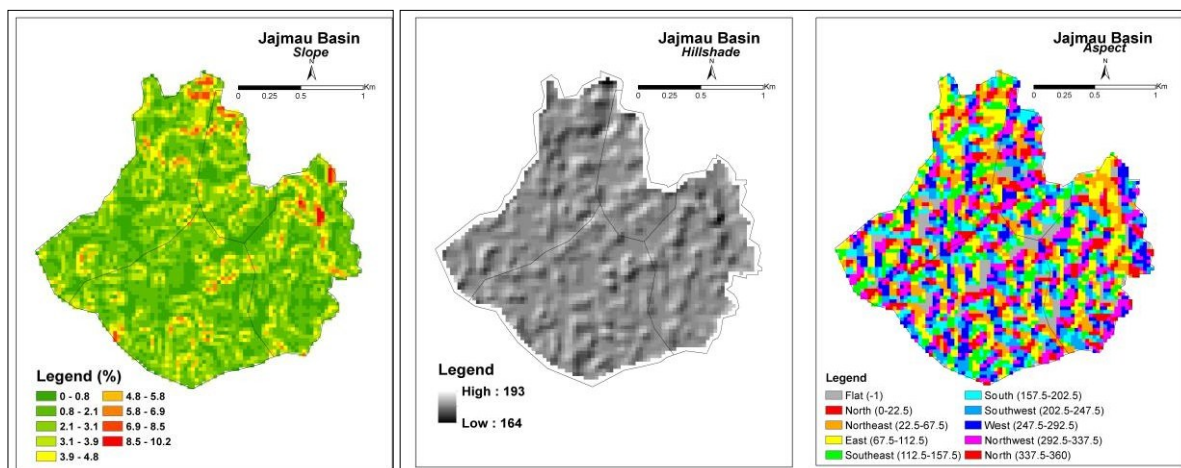


Fig. 4. Slope, hillshade and aspect of the Jajmau basin.

**Table 2.** Stream orders and stream numbers of subwatersheds in the Jajmau basin

| Stream order                    | SW-1 | SW-2  | SW-3  | SW-4  |
|---------------------------------|------|-------|-------|-------|
| <b>Stream number (Nu)</b>       |      |       |       |       |
| 1 <sup>st</sup> Order (Nu1)     | 18   | 48    | 43    | 50    |
| 2 <sup>nd</sup> Order (Nu2)     | 7    | 19    | 17    | 24    |
| 3 <sup>rd</sup> Order (Nu3)     | 7    | 8     | 8     | 11    |
| 4 <sup>th</sup> Order (Nu4)     |      | 9     | 6     | 2     |
| Total                           | 32   | 84    | 74    | 87    |
| <b>Stream length (Lu)</b>       |      |       |       |       |
| 1 <sup>st</sup> Order (Lu1)     | 3165 | 8029  | 6988  | 9206  |
| 2 <sup>nd</sup> Order (Lu2)     | 847  | 2289  | 2582  | 2700  |
| 3 <sup>rd</sup> Order (Lu3)     | 962  | 994   | 894   | 1814  |
| 4 <sup>th</sup> Order (Lu4)     |      | 1146  | 682   | 414   |
| Total                           | 4974 | 12458 | 11146 | 14134 |
| <b>Bifurcation ratio (Rb)</b>   |      |       |       |       |
| Nu1/Nu2 (Rb1)                   | 2.57 | 2.53  | 2.53  | 2.08  |
| Nu2/Nu3 (Rb2)                   | 1    | 2.38  | 2.12  | 2.18  |
| Nu3/Nu4 (Rb3)                   | -    | 0.88  | 1.33  | 5.5   |
| Total                           | 3.57 | 5.79  | 5.98  | 9.76  |
| <b>Stream length ratio (Rl)</b> |      |       |       |       |
| Lu2/ Lu1 (Rl1)                  | 0.27 | 0.29  | 0.37  | 0.29  |
| Lu3/ Lu2 (Rl2)                  | 1.13 | 0.43  | 0.35  | 0.67  |
| Lu4/ Lu3 (Rl3)                  | -    | 1.15  | 0.76  | 0.23  |
| Total                           | 1.4  | 1.87  | 1.48  | 1.19  |

The Rho coefficient ( $\rho$ ) reflects the storage capacity of the basin (25). In this case, SW-1 exhibited the greatest value while SW-4 showed the least value in Table 3.

#### Aerial parameters

The measurement of drainage density (Dd) indicates the length of streams in relation to the total area of land. In the case of Jajmau basin, the drainage density is measured between 10.8 - 11.3  $\text{km}^{-1}$  with the highest value reported at SW-3 and the lowest value at SW-4. These low values of drainage density are due to the region having gentle slopes, soil cover and runoff. (Fs), the frequency of the stream, is defined as the ratio of the total number of stream segments associated with a selected area to the area of the watershed. The values of Fs ranges from 66.58  $\text{km}^{-2}$  (SW-4) to 75.3  $\text{km}^{-2}$  (SW-3), drainage pattern is highly dependent on these values. The spacing of the streams describes the drainage texture. It can be classified into five different textures, along with very coarse (<2), coarse (2-4), moderate (4-6), fine (6-8) and very fine (>8). The drainage texture is computed as the ratio of total length of streams to area and indicates the density of streams, which is very fine > 8, ranging from 9.78 - 17.87  $\text{km}^{-1}$ . Another important parameter of the basin is the infiltration number which is an indicator of infiltration and surface runoff numbers. A higher number indicates greater surface runoff and little infiltration rate in all subwatersheds of Jajmau basin. The length of overland flow is one of the important parameters affecting both the geographical and hydrological evolution of a watershed (26). The length of overland flow is between 0.044-0.046. The drainage intensity is indicative of the effectiveness of both the drainage density and the stream frequency on surface denudation of any watershed. It ranges from 6.16-6.77, where it is highest at SW-2 and lowest at SW-4. The texture ratio of different sub-watersheds ranges from 5.51 to 10.27. The FF ratio is defined as the ratio of the basin area to the square of the basin length (19). However, in most of the studies the form factor ranges from zero (extremely

**Table 3.** Computed morphometric parameters of subwatersheds

| Parameters                            | SW-1     | SW-2     | SW-3     | SW-4     |
|---------------------------------------|----------|----------|----------|----------|
| Area ( $\text{km}^2$ )                | 0.445171 | 1.148320 | 0.982121 | 1.306550 |
| Perimeter (km)                        | 3.269    | 5.732    | 4.682    | 4.867    |
| Basin length (m)                      | 2119.81  | 3631.19  | 3322.64  | 3907.45  |
| Mean basin width (m)                  | 210      | 316.23   | 295.58   | 334.37   |
| Stream order                          | 3        | 4        | 4        | 4        |
| Stream number (Nu)                    | 32       | 84       | 74       | 87       |
| Stream length (m)                     | 4974     | 12458    | 11146    | 14134    |
| Mean stream length (m)                | 155.44   | 148.31   | 150.62   | 162.45   |
| Mean stream length ratio (Rslm)       | 0.7      | 0.62     | 0.49     | 0.40     |
| Mean bifurcation ratio (Rb)           | 1.79     | 1.93     | 2.00     | 3.25     |
| Rho coefficient ( $\rho$ )            | 0.39     | 0.32     | 0.25     | 0.12     |
| Drainage density ( $\text{km}^{-1}$ ) | 11.2     | 10.8     | 11.3     | 10.8     |
| Stream frequency ( $\text{km}^{-2}$ ) | 71.89    | 73.15    | 75.3     | 66.58    |
| Drainage texture ( $\text{km}^{-1}$ ) | 9.78     | 14.65    | 15.80    | 17.87    |
| Infiltration number                   | 805.17   | 790.02   | 850.89   | 719.06   |
| Length of overland flow               | 0.044    | 0.046    | 0.044    | 0.046    |
| Drainage intensity                    | 6.42     | 6.77     | 6.66     | 6.16     |
| Texture ratio                         | 5.51     | 8.37     | 9.18     | 10.27    |
| Form factor ratio (Ff)                | 0.10     | 0.08     | 0.09     | 0.09     |
| Elongation ratio (Re)                 | 0.36     | 0.33     | 0.34     | 0.33     |
| Circulatory ratio (Rc)                | 0.523    | 0.439    | 0.563    | 0.693    |
| Lemniscate's ratio (K)                | 2.52     | 2.87     | 2.81     | 2.92     |
| Compactness constant (Cc)             | 1.38     | 1.50     | 1.33     | 1.20     |
| Shape factor (Sf)                     | 10.08    | 11.48    | 11.24    | 11.68    |
| Constant channel maintenance (C)      | 0.089    | 0.092    | 0.088    | 0.092    |
| Elevation of basin outlet             | 114      | 119      | 123      | 127      |
| Maximum elevation of the basin        | 128      | 129      | 131      | 130      |
| Total basin relief                    | 14       | 10       | 8        | 3        |
| Relief ratio                          | 6.60     | 2.75     | 2.41     | 0.77     |
| Relative relief                       | 4.28     | 1.74     | 1.70     | 0.62     |
| Ruggedness number                     | 156.8    | 108      | 37.45    | 14.60    |

long shape) to unity (round shape). In our study, the form factor ranges from 0.08 to 0.10, which states that all the sub-watersheds are elongated. The value of the elongation ratio may be classified into three types: (a) circular greater than 0.9, (b) oval between 0.9 to 0.8 and (c) elongated less than 0.7. In our research, the elongation ratio ranges between 0.33 and 0.36, which indicates that it is elongated in shape with moderate relief. The circularity ratio is the proportion of watershed area to the area of a circle that has the same circumference as the basin perimeter (27). The ratio values are useful for determining the level of watershed development. For instance, lower values indicate younger stages while middle values indicate more mature ones and higher values indicate older stages of a watershed (28). The values indicate that the basin is less circular and more elongated, ranging between 0.439 and 0.693. Lemniscate's ratio is used to calculate the catchment's slope (29). The values vary from 2.52 to 2.92, with the highest values occurring in SW-4 and the lowest in SW-1. Only the slope (1.20-1.50) affects the compactness coefficient, which is unaffected by the watershed's size. One important characteristic that affects flow and sediment amount is the form factor. Less erosion susceptibility is indicated by lower values and vice versa. The values of SW-1 and SW-4 are 10.08 and 11.68, respectively.

### Relief parameters

The drainage basin's three-dimensional characteristics are known as the relief parameters. Using the ArcGIS platform, the elevation of the basin's highest elevation and its outlet elevation are taken from the SRTM DEM. Because of its low overall relief, the basin is less vulnerable to soil erodibility. Compared to total relief, the relief ratio offers a more accurate representation of the relief features. The relief ratio in this investigation varied between 6.60 (SW-1) to 0.77 (SW-4). SW-1 is more vulnerable to erosion since watersheds are more likely to experience erosion when the relief ratio is higher. Likewise, a watershed's vulnerability to erosion increases with its relative relief. The ruggedness number reflects the roughness of the watershed. The values are found high, indicating a high risk of erosion.

### Prioritization of sub-watersheds

Based on the different morphometric parameters listed on the Table 4, the sub-watershed of the study area is prioritized for management planning. Soil loss or erosivity is directly related to linear and relief parameters and inversely to aerial aspects. Hence, higher values of linear and relief features indicate greater chance of soil erosion. Therefore, the subwatersheds with high values of these parameters are ranked first, followed by those with high values. In case of aerial parameters, the smallest value stands first rank and so on. The aerial parameters with the largest values are ranked last (30, 31). For each aspect, the compound value is calculated by averaging the ranks allotted. Finally, the lowest compound value is rated as the highest priority and so on. Compared with other sub-watersheds, SW-1 needs more attention and observed to be more prone to soil erosion. The SW-4 is the best among all the zones and this zone requires minimum care and attention for management, planning and conservation.

**Table 4.** Subwatershed prioritization based on the ranking of the Jajmau basin

| Parameters                            | SW-1 | SW-2 | SW-3 | SW-4 |
|---------------------------------------|------|------|------|------|
| Mean stream length ratio (Rslm)       | 1    | 2    | 3    | 4    |
| Mean bifurcation ratio (Rb)           | 4    | 3    | 2    | 1    |
| Rho coefficient ( $\rho$ )            | 1    | 2    | 3    | 4    |
| Drainage density ( $\text{km}^{-1}$ ) | 2    | 4    | 1    | 3    |
| Stream frequency ( $\text{km}^{-2}$ ) | 3    | 2    | 1    | 4    |
| Drainage texture ( $\text{km}^{-1}$ ) | 4    | 3    | 2    | 1    |
| Infiltration number                   | 2    | 3    | 1    | 4    |
| Length of overland flow               | 3    | 2    | 4    | 1    |
| Drainage intensity                    | 3    | 1    | 2    | 4    |
| Form factor ratio (Ff)                | 4    | 1    | 3    | 2    |
| Elongation ratio (Re)                 | 4    | 1    | 3    | 2    |
| Circulatory ratio (Rc)                | 2    | 1    | 3    | 4    |
| Lemniscate's ratio (K)                | 1    | 3    | 2    | 4    |
| Compactness constant (Cc)             | 3    | 4    | 2    | 1    |
| Shape factor (Sf)                     | 1    | 3    | 2    | 4    |
| Constant channel maintenance (C)      | 2    | 3    | 1    | 4    |
| Total basin relief                    | 1    | 2    | 3    | 4    |
| Relief ratio                          | 1    | 2    | 3    | 4    |
| Relative relief                       | 1    | 2    | 3    | 4    |
| Ruggedness number                     | 1    | 2    | 3    | 4    |
| Compound value                        | 2.2  | 2.3  | 2.35 | 3.15 |
| Final rank                            | I    | II   | III  | IV   |

### Conclusion

In contrast to traditional methods, modern technologies like GIS and remote sensing are essential, dependable and affordable for assessing the drainage morphometry of the Jajmau Basin. It is particularly helpful to define the features of a basin using the calculated values of the linear, aerial and relief parameters from DEMs, aspects, hillshades and slopes. To setting management priorities for watersheds, the current study offers accurate data for 32 morphometric characteristics. Numerous topographical and geological features can be better understood because of the drainage system's dendritic to subdendritic features. The prioritization of subwatersheds is based on compound value calculations and rankings. The SW-1 needs high priority for management aspects, whereas SW-4 needs the lowest priority. Conservation, planning and management practices should focus on high-priority zones. This study will be highly valuable for planners and decision-makers in sustainable watershed development programs for managing natural resources at the micro level.

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### Authors' contributions

NS, JKS and NKS planned the experiments. RM and MK analyzed the samples and performed the statistical analysis. NS wrote the manuscript. HB contributed to the final correction of the manuscript.

### Compliance with ethical standards

**Conflicts of interest:** The authors declare that they do not have any conflicts of interest.

**Ethical issues:** None

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