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# Prioritization of Upper Krishna River Sub Basin Mini Watershed Based on Morphometric Characteristics Using Geographical Information System, Satara District Maharashtra.

Mr. Anirudha Bhosale, Dr. Vinod Veer
*Research Student S.G.M. College, Karad*
*Associate Professor & Head Department of Geography Kisan Veer Mahavidyalaya, Wai*

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**ABSTRACT:** Watershed prioritization has gained importance in natural resources management, especially in the context of watershed management. Delineation of watersheds within a large drainage basin and their prioritization is required for proper planning and management of natural resources for sustainable development. Delineation of potential zones for implementation of conservation measures above the entire watershed at similar occurrence is inaccessible as well as uneconomical; therefore it is a prerequisite to apply viable technique for prioritization of sub watersheds (SW). The present research paper attempted to study various morphological characteristics and to implement Geographical Information System (GIS) for identification of critical sub mini watersheds situated in transaction zone between mountainous and water scarcity region of Upper Krishna River Sub Basin Mini Watershed, Maharashtra. The morphometric characterization was obtained through the measurement of three distinct linear, areal and relief aspects over the Ninteen sub-watersheds. The morphometric characterization showed vital role in distinguishing the topographical and hydrological behavior of the watershed. Each morphometric parameters were ranked with respect to the value and weightings obtained by deriving the relationships between the morphometric parameters. Upper Krishna River Sub Basin Mini Watershed were evaluated and divided into three prioritization zones: Low, medium and high classes.

**Keywords**: Prioritization, Morphometric, Geographic Information System.

## I. INTRODUCTION

A drainage basin or watershed is an extent or an area of land where surface water from rain, melting snow, or ice converges to a single point at a lower elevation, usually the exit of the basin, where the waters join another water body, such as a river, lake, reservoir, estuary, wetland, sea, or ocean. The water shed plays a dominant role in the development of landforms and therefore, the study of drainage basin has a great significance in geomorphic studies. A watershed is an ideal unit for management of Natural resources like land and water and for mitigation of the impact of natural disasters for achieving sustainable development. The watershed management concept recognizes the interrelationships among the linkages between uplands, low lands, land use, geomorphology, slope and soil.

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Agarwal, 1998; Obi Reddy et al., 2002). A major emphasis in geomorphology over the past several decades has been on the development of quantitative physiographic methods to describe the evolution and behaviour of surface drainage networks (Horton, 1945; Leopold & Maddock, 1953). Morphometric analysis of a watershed provides a quantitative description of the drainage system, which is an important aspect of the characterization of watersheds (Strahler, 1964). Pioneering work on the drainage basin morphometry has been carried out by Horton (1932, 1945), Miller (1953), Smith (1950), Strahler (1964) and others. In India, some of the recent studies on morphometric analysis using remote sensing technique were carried out by Natuiay (1994), Srivastava (1997), Nag (1998) and Srinivasa et al (2004). In the earlier researches, prioritization of watershed was accomplished through different approaches to instance soil erosion or sediment yield indexing (SYI), morphological characterization, socio-economic aspects, etc. some other studies focused on soil erosion and SYI modelling aspects by classifying the erosion affected priority areas (Suresh et al., 2004; Ratnam et al., 2005; Kalin and Hantush, 2009; Pandey et al., 2009; Niraula et al., 2011; Pai et al., 2011).

Land deterioration as well as land use change impacts were also measured for evaluation of prospective zones of watersheds (Adinarayana, 2003; Deb and Talukdar, 2010; Kanth and Hassan, 2010; Javed et al., 2011; Sarma and Saikia, 2011). The remote sensing and GIS technique is a convenient method for morphometric analysis as the satellite images provides a synoptic view of a large area and is very useful in the analysis of drainage basin morphometry. GIS and remote sensing (RS) techniques are proved to be proficient tools for morphometric characterization of subwatersheds (Singh, 1994; Grohmann, 2004; Sreedevi et al., 2009; Aher et al., 2010; Rao et al., 2011). Mishra et al. (2007) carried out prioritization of sub-watersheds through morphological characteristics by using Soil and Water Assessment Tool (SWAT) model in the small multi-vegetated watershed of a sub-humid subtropical region in India. In recent research on prioritization of watersheds using multi-criteria evaluation through fuzzy analytical hierarchy process (Aher, P. D., 2013). Assessment of different vulnerability producing factors is the decision making process associated with formation of system knowledge database which involves multiple criteria and alternatives, which results in great degree of complexity. Therefore, in this research an attempt has been made for prioritization of sub-watersheds through analysis of the natural drainage.

**Study Region**

The study area selected for the present study is upper Krishna sub basin in a part of Wai taluka. This basin drains Wai taluka of Satara district comprising 113 villages. Study region Comprise 554.20 Sq.km. Area and lies between $17^0$ 45’ N to $18^0$ 05’ N Latitude and $73^0$ 35’ E to $74^0$ 05’ E Longitude. The region has diversified physiography whose western border is demarcated by Western Ghats. Minimum elevation of the area is 942 meter and maximum is 1400 meter. A vast plain area of river Krishna valley sloping east ward and southeast ward is noted in the central part of the region. A western part, north and south border area is hilly with rugged topography. Climate of study region is subtropical monsoon type. There is rapid decrease in rainfall from west to east. Western part of study region receives average 2124 mm rainfall while eastern part receives only 300 mm rainfall.

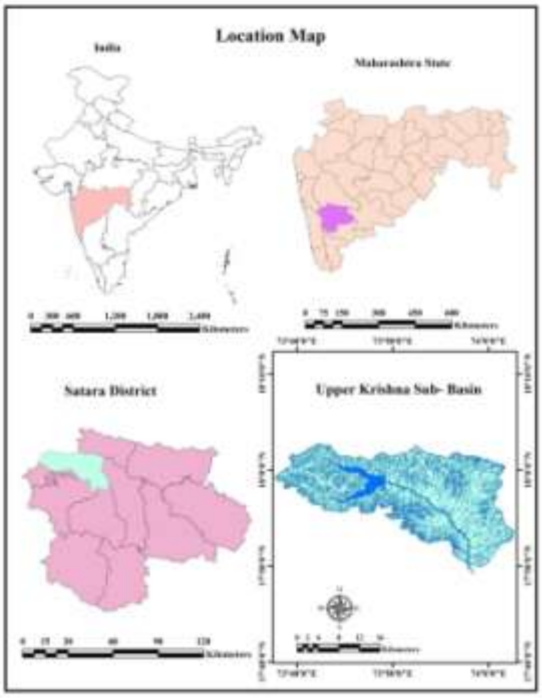


**Fig: 1**

**Objectives of the Study**

To suggest Prioritization of mini watershed by considering morphometric characteristics of upper Krishna river sub-basin.

**Data Base**

The entire study work is based on primary as well as secondary data. Primary data was collected at the time of field work with help of GPS and questionnaire. GPS data was acquired for watershed structure. To get knowledge about problems, needs, views and expectation of the local people twelve villages of the study region were surveyed by applying stratified random sampling method. Here Elevation and Physiography was considered as strata for selection. To suggest treatment measures and suitable site for water conservation structure intensive field survey was carried out however ground control points as well as signature sampling and training sites data is generated by applying GPS Technique.

The secondary data was collected from various Government offices such as Water Resources Department, Government of Maharashtra., State Irrigation Department, Government of Maharashtra, Taluka/Village Revenue offices, Soil and Water Conservation and Survey Department, Government of Maharashtra., National Bureau of Soil Survey & Land Use Planning (NBSS & LUP), Nagpur etc. Published reports and documents like District Census Handbook of Satara District, Socio Economic Review and District Statistical Abstract of Satara District, Reports of Agriculture Office of Wai taluka were used for required secondary data. Landsat imageries were acquired from Global Land Cover Facility Data Center website http://glcf.umiacs.umd.edu/ data.

**Methodology for Morphometry Analysis**

**Stream ordering** by A.N. Strahler Method (1964)

$$\textbf{Bifurcation ratio} = \frac{\text{Number of stream I}^{st}\text{ order}}{\text{Number of stream II}^{nd}\text{ order}}$$

$$\textbf{Drainage Density} = \frac{\text{Cumulative Length of Stream (L) in km.}}{\text{Area of watershed basin sq. km.}}$$

$$\textbf{Stream Frequency} = \frac{\text{Total Number of stream}}{\text{Area of watershed basin sq. km.}}$$

**Sub-Basin Prioritization for watershed development**

Sub-basin wise watershed prioritization provides necessary inputs for action plan for conservation of natural resources like soil, water and for socio-economic development in the basin area. For management of land and water resources drainage basins, catchment and sub catchments are the fundamental units.

"Catchment and watershed has been identified as planning units for administrative purpose to conserve these precious resources" (Honore, 1999). For micro level prioritization accurate knowledge of the basin and intensity of problem is very essential. Geoinformatics techniques provide the necessary accurate, reliable and spatio temporal information of the region. Degraded sub-basin should be given priority for conservation and reclamantion process. This chapter focused on prioritization of mini watersheds of upper Krishna sub-basin for soil conservation. Results of morphometric analysis have been used for creation of final prioritization.

**Table 1:** Mini Watershed Morphometric Aerial Aspects (2D Aspect)

| KRB Sub Watershed | Area (In Sq.km) | Perimeter (In km) | Drainage Density (In km/sq.km) | Drainage Texture | Compactness Coefficients | Stream Frequency (In sq.km) | Basin Length (In km) | Form Factor | Elongation Ratio | Circulatory Ratio |
|---|---|---|---|---|---|---|---|---|---|---|

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|---|---|---|---|---|---|---|---|---|---|---|
| **KRB -1** | 89.97 | 89.97 | 4.60 | 6.65 | 0.56 | 6.65 | 20.38 | 0.22 | 1.41 | 0.14 |
| **KRB-2** | 11.36 | 11.26 | 4.45 | 7.82 | 0.56 | 7.75 | 5.23 | 0.42 | 0.69 | 1.13 |
| **KRB-3** | 26.19 | 26.19 | 4.85 | 7.33 | 0.56 | 7.33 | 9.03 | 0.32 | 0.92 | 0.48 |
| **KRB -4** | 25.25 | 25.25 | 5.68 | 11.25 | 0.56 | 11.25 | 12.02 | 0.17 | 0.67 | 0.50 |
| **KRB -5** | 17.98 | 17.98 | 4.00 | 5.39 | 0.56 | 5.39 | 6.31 | 0.45 | 0.91 | 0.70 |
| **KRB -6** | 6.07 | 6.07 | 5.52 | 7.08 | 0.56 | 7.08 | 2.8 | 0.77 | 0.69 | 2.07 |
| **KRB -7** | 10.53 | 5.36 | 5.28 | 6.90 | 0.29 | 3.51 | 3.27 | 0.98 | 1.03 | 4.60 |
| **KRB -8** | 7.23 | 7.23 | 3.39 | 4.84 | 0.56 | 4.84 | 6.31 | 0.18 | 0.36 | 1.74 |
| **KRB -9** | 7.04 | 7.04 | 1.49 | 1.14 | 0.56 | 1.14 | 3.02 | 0.77 | 0.74 | 1.78 |
| **KRB -10** | 14.45 | 10.47 | 2.12 | 2.67 | 0.41 | 1.94 | 6.39 | 0.35 | 0.72 | 1.66 |
| **KRB -11** | 36.16 | 36.16 | 2.59 | 3.37 | 0.56 | 3.37 | 9.4 | 0.41 | 1.23 | 0.35 |
| **KRB -12** | 17.02 | 17.02 | 2.01 | 1.94 | 0.56 | 1.94 | 6.09 | 0.46 | 0.89 | 0.74 |
| **KRB -13** | 81.9 | 81.9 | 3.62 | 4.90 | 0.56 | 4.90 | 13.89 | 0.42 | 1.88 | 0.15 |
| **KRB -14** | 20.84 | 20.84 | 2.98 | 4.27 | 0.56 | 4.27 | 8.77 | 0.27 | 0.76 | 0.60 |
| **KRB -15** | 23.31 | 23.31 | 3.58 | 4.85 | 0.56 | 4.85 | 10.25 | 0.22 | 0.72 | 0.54 |
| **KRB -16** | 37.57 | 37.57 | 3.32 | 5.03 | 0.56 | 5.03 | 12.09 | 0.26 | 0.99 | 0.33 |
| **KRB -17** | 22.84 | 22.85 | 3.68 | 5.60 | 0.56 | 5.60 | 5.26 | 0.83 | 1.38 | 0.55 |
| **KRB -18** | 17.3 | 17.3 | 3.88 | 4.91 | 0.56 | 4.91 | 5.92 | 0.49 | 0.93 | 0.73 |
| **KRB-19** | 81.19 | 45.82 | 4.45 | 10.28 | 0.32 | 5.80 | 18.34 | 0.24 | 1.41 | 0.49 |
| **KRSB** | 554.2 | 509.59 | 3.91 | 5.97 | 0.52 | 5.59 | 164.77 | 0.2 | 1.07 | 0.03 |

Source: Compiled and Computed by Researcher

**Table 2:** Mini Watershed Relief Aspects (3D Aspect)

| KRB Sub Watershed | Absolute Relief | Basin Relief | Relative Relief | Watershed Slope | Ruggedness Number | Dissection Index |
|---|---|---|---|---|---|---|
| **KRB -1** | 1022 | 283 | 0.032 | 0.01 | 1.30 | 0.28 |
| **KRB-2** | 961 | 247 | 0.022 | 0.05 | 1.10 | 0.26 |
| **KRB-3** | 942 | 246 | 0.009 | 0.27 | 1.19 | 0.26 |
| **KRB -4** | 1051 | 356 | 0.014 | 0.30 | 2.02 | 0.34 |
| **KRB -5** | 1044 | 352 | 0.020 | 0.56 | 1.41 | 0.34 |
| **KRB -6** | 1007 | 326 | 0.049 | 1.16 | 1.80 | 0.32 |
| **KRB -7** | 870 | 195 | 0.036 | 0.60 | 1.03 | 0.22 |
| **KRB -8** | 740 | 69 | 0.010 | 0.11 | 0.23 | 0.09 |
| **KRB -9** | 700 | 32 | 0.005 | 0.11 | 0.05 | 0.05 |
| **KRB -10** | 836 | 169 | 0.016 | 0.26 | 0.36 | 0.20 |
| **KRB -11** | 1132 | 462 | 0.013 | 0.49 | 1.20 | 0.41 |
| **KRB -12** | 1058 | 384 | 0.023 | 0.63 | 0.77 | 0.36 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **KRB -13** | 1238 | 558 | 0.007 | 0.40 | 2.02 | 0.45 |
| **KRB -14** | 1085 | 405 | 0.020 | 0.46 | 1.21 | 0.37 |
| **KRB -15** | 1199 | 518 | 0.022 | 0.51 | 1.85 | 0.43 |
| **KRB -16** | 1234 | 535 | 0.014 | 0.44 | 1.77 | 0.43 |
| **KRB -17** | 1124 | 413 | 0.018 | 0.79 | 1.52 | 0.37 |
| **KRB -18** | 1296 | 590 | 0.034 | 1.00 | 2.29 | 0.46 |
| **KRB-19** | 1216 | 475 | 0.010 | 0.26 | 2.11 | 0.39 |
| **KRSB** | 1336 | 668 | 0.001 | 0.04 | 2.61 | 0.50 |

Source: Compiled and Computed by Researcher

**Prioritization on the basis of Morphometric Analysis**

Analyses of morphometric characteristics have great importance in river basin evaluation. It has immense utility in watershed prioritization for soil and water conservation and management of natural resource at micro level. "Geology, relief and climate are the key determines of running water ecosystems functioning at the basin scale" (Frissel et.al; 1986). Watershed prioritization is used for assigning priority for implementation of treatment and soil conservation measures for different sub-watersheds. Different linear and areal characteristics of the watershed could be used for prioritization of micro watersheds without the availability of soil maps (Biswar et.al; 1999). In present chapter sub-basin prioritization on the basis of the result of Areal, linear and relief aspects has given for soil conservation. Erosion risk assessment parameters like drainage density, bifurcation ratio, stream frequency, elongation ratio, form factor have been used for priotize watershed. The linear aspects and soil erosion have the direct relationship with each other. Higher value of linear aspects parameter indicates the higher possibility of soil erosion. The sub-basins with high values of drainage density, stream frequency and bifurcation ratio are more susceptible for soil erosion.Therefore, ranking is given on the basis of decending order i.e.higher value was rated as rank first; second highest value was ranked second and so on. "Shape parameters such as elongation ratio, from factor and basin shape have inverse relationship with soil erosion" (Nooka, R, et al., 2005). Hence, higher value of shape parameter is indication of lower risk of soil erosion. Therefore, ranking is given on the basis of ascending order i.e. lower value was rated as rank first. For prioritized classification the ranking values of all parameters were added to assign final weightage. Prioritized classification has been done as per table 4.4 the final priority weightage have been divided into High priority class, Modrate priority class and Low priority class. The final priority analysis reviles that, mini watershed KRB-1, KRB-2, KRB-3, KRB-4 and KRB-19 have observed highest priority to soil erosion prevention measures for watershed development. Highest priority indicates the higher soil erosion in this mini watershed and it is essential to develop soil conversation structures.

**Table 3**: Sub-basin Morphometric Prioritization

| KRB Mini Watershed | Mean RB | Dd | Fs | T | Ff | Rc | Cc | Re | Compound Parameter | Final Priority |
|---|---|---|---|---|---|---|---|---|---|---|
| KRB -1 | 2 | 5 | 5 | 7 | 3 | 1 | 4 | 17 | 5.5 | 1 |
| KRB-2 | 13 | 6 | 2 | 3 | 11 | 14 | 4 | 3 | 7.0 | 1 |
| KRB-3 | 5 | 4 | 3 | 4 | 8 | 5 | 4 | 11 | 5.5 | 1 |
| KRB -4 | 7 | 1 | 1 | 1 | 1 | 7 | 4 | 2 | 3.0 | 1 |
| KRB -5 | 9 | 8 | 8 | 9 | 13 | 11 | 4 | 10 | 9.0 | 2 |
| KRB -6 | 15 | 2 | 4 | 5 | 17 | 18 | 4 | 3 | 8.5 | 2 |
| KRB -7 | 6 | 3 | 15 | 6 | 19 | 19 | 1 | 14 | 10.4 | 3 |
| KRB -8 | 17 | 13 | 13 | 14 | 2 | 16 | 4 | 1 | 10.0 | 3 |
| KRB -9 | 19 | 19 | 19 | 19 | 16 | 17 | 4 | 7 | 15.0 | 3 |
| KRB -10 | 16 | 17 | 17 | 17 | 9 | 15 | 3 | 5 | 12.4 | 3 |
| KRB -11 | 12 | 16 | 16 | 16 | 10 | 4 | 4 | 15 | 11.6 | 3 |
| KRB -12 | 18 | 18 | 17 | 18 | 14 | 13 | 4 | 9 | 13.9 | 3 |
| KRB -13 | 1 | 11 | 11 | 12 | 11 | 2 | 4 | 19 | 8.9 | 2 |
| KRB -14 | 10 | 15 | 14 | 15 | 7 | 10 | 4 | 8 | 10.4 | 3 |
| KRB -15 | 14 | 12 | 12 | 13 | 3 | 8 | 4 | 5 | 8.9 | 2 |
| KRB -16 | 8 | 14 | 9 | 10 | 6 | 3 | 4 | 13 | 8.4 | 2 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| KRB -17 | 3 | 10 | 7 | 8 | 18 | 9 | 4 | 16 | 9.4 | 2 |
| KRB -18 | 11 | 9 | 10 | 11 | 15 | 12 | 4 | 12 | 10.5 | 3 |
| KRB-19 | 3 | 6 | 6 | 2 | 5 | 6 | 2 | 17 | 5.9 | 1 |

Source: Morphometry Analysis & Compiled by researcher

**Table 4**: Sub-basin Prioritization classes

| Compound Parameter Value | Priority Class |
|---|---|
| Less than 7.5 | High Priority |
| 7.51-10.00 | Medium Priority |
| More than 10.00 | Low Priority |

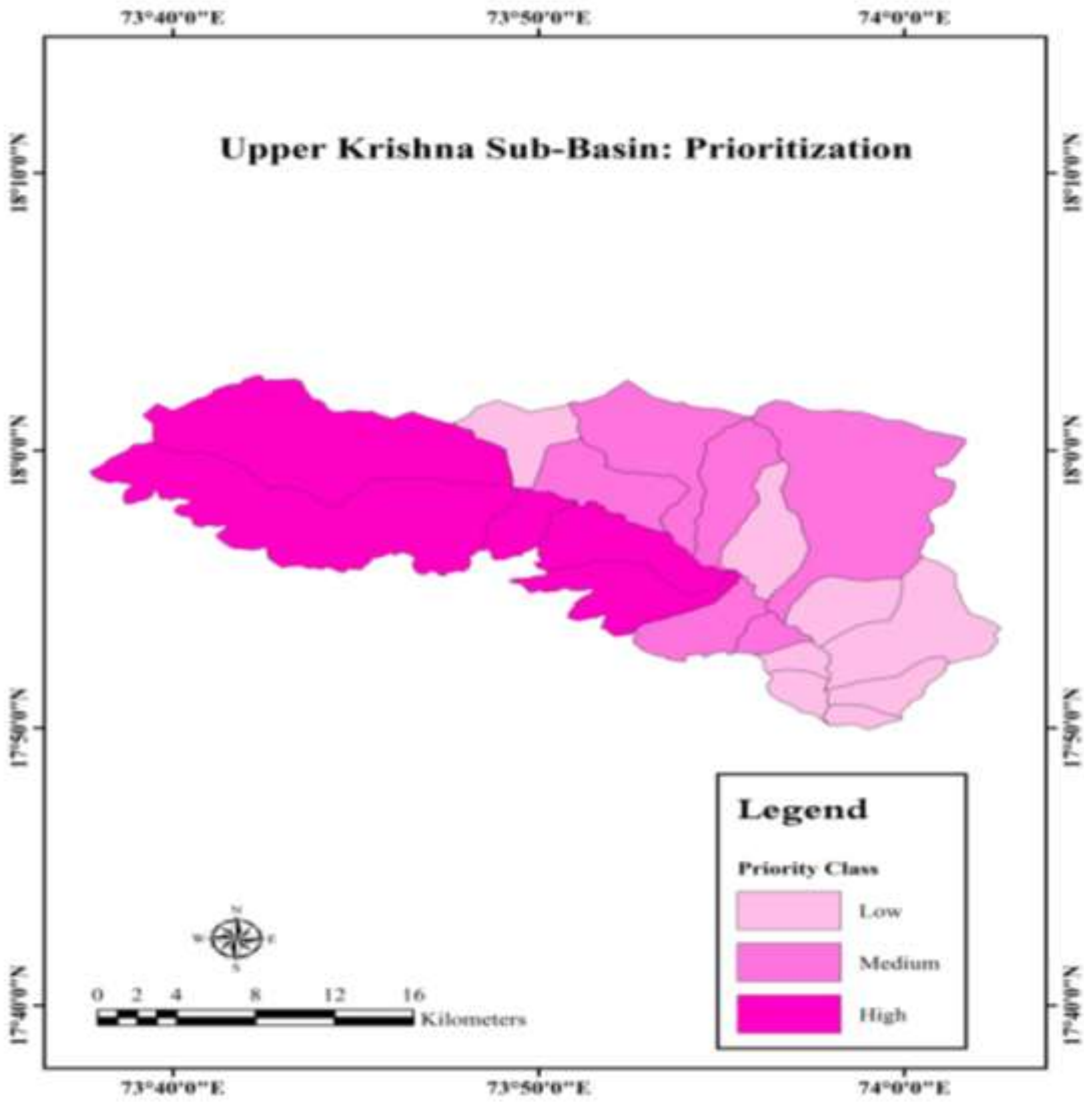


**Fig: 2**

## II. CONCLUSION

The final priority weightage have been divided into High priority class, Moderate priority class and Low priority class. The final priority analysis reviles that, mini watershed KRB-1, KRB-2, KRB-3, KRB-4 and KRB-19 have observed highest priority to soil erosion prevention measures for watershed development. Highest priority indicates the higher soil erosion in this mini watershed and it essential to develop soil conversation structures.

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