Hypsometric Analysis of Hiranyakeshi Watershed of Belagavi District, Karnataka Using Remote Sensing and GIS Techniques

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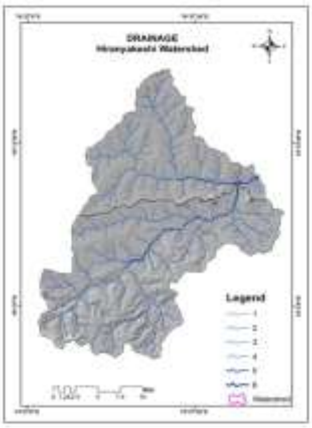
Abstract

Current study gives the estimation of hypsometric curves and profile factor with respect to stream order level (6th, 5th Order) and along the main stream length line for Hiranyakeshi watershed using CARTODEM with 30m resolution. Delineation of catchment was done from ArcGIS 10.1 using Hydrology tool in GIS environment. And those obtained catchment (with respect to stream order level) was again carry out hypsometric analysis.The hypsometric analysis of Hiranyakeshi watershed is carried out and value ofhypsometric integral (Hi) is found 0.5 which indicates the watershed is at Mature stage.

Keywords: *Remote Sensing and GIS, Carto-DEM, Hypsometric Curve, profile factor, Hypsometric Integral, Stream order.*

I. Introduction

Hypsometric analysis aims at developing a relationship between horizontal cross sectional area of the watershed and its elevation in a dimensionless form that permits comparison of watersheds irrespective of scale issues (Dowling et al., 1998). Hypsometric curves and hypsometric integrals are important indicators of watershed conditions (Ritter et al., 2002). Differences in shape of curve and hypsometric integral value are related to degree of disequilibrium in the balance of erosive and tectonic forces (Weissel et al., 1994). Hypsometric analysis was first time introduced by Langbein (1947) to express overall slope and forms of drainage basin. The hypsometric curve is related to the volume of soil mass in the basin and amount of erosion that had occurred in a basin against the remaining mass (Hurteez et al. 1999a). It is a continuous function of non-dimensional distribution of relative basin elevations with the relative area of the drainage basin (Strahler, 1952). Comparison of the shape of the hypsometric curve for different drainage basins under similar hydrologic conditions provides a relative insight into the past soil movement of basins. Thus the shape of the hypsometric curve explains to temporal changes in the slope of the original basin. Strahler (1952) interpreted the shapes of the hypsometric curves by explaining numerous drainage basins and classified the basins as young (convex upwardcurves), mature (S-shaped hypsometric curves which is concave upwards at high elevationsand convex downwards at low elevations) and pediplain or distorted (concave upwardcurves). The hypsometric curve shapes described the stages of the landscape evolution, which also provide an indication of erosion status of the watershed. Convex shapedhypsometric curves indicate that the watershed is stabilized and concave hypsometriccurves indicate more proneness of watershed to erosion process (Hurteez et al. 1999).Hypsometric curves plotted for homogeneous landforms in hundreds of small basins of different regions generally show stable is described as mature. However, there is existence of marginal but distinct differences in the shapes of HC for different watershed regions.



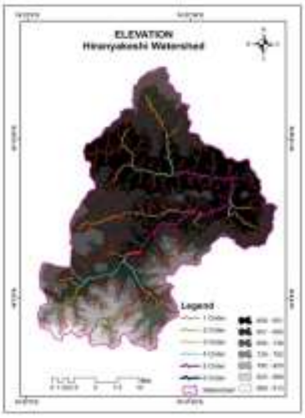


fig (1) fig(2)

fig no 1: elevation map and fig no 2: drainage map of Hiranyakeshi watershed

The hypsometric integral (HI) is a geomorphological parameter classified under the geologic stages of watershed development. It assumes importance in estimation of erosion status of watershed and subsequent prioritization for taking up soil and water conservation activities. The hypsometric integral is also an indication of the 'cycle of erosion' (Strahler, 1952; Garg, 1983). The 'cycle of erosion' is defined as the total time required for reduction of a land topological unit to the base level i.e. the lowest level (Fig.5.13). This entire period or the 'cycle of erosion' can be divided into three stages viz. monandnock (old) (His 0.3), in which watershed is fully stabilized; equilibrium or mature stage (0.3 His 0.6); and in equilibrium or young stage (His 0.6), in which watershed is highly susceptible to erosion (Strahler 1952). The HI is expressed as a percentage which helps in explaining the erosion that had taken place in the watershed during the geological time scale due to hydrological processes and land degradation factors (Bishop et al. 1972). In addition to this, it also provides a simple morphological index with respect to relative height of the elevation distribution within the area considered, which can be used in surface runoff and sediment yield prediction from watersheds (Sarangi and Bhattacharya 2000).

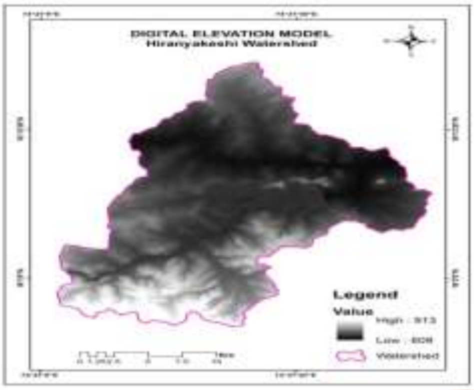


Fig no 3: Digital Elevation Model

II. Study Area

The study area is Hiranyakeshi watershed situated in Belagavi district lies geographically between 74⁰ 27' to 76⁰ 7' East longitude and 16⁰ 3' to 16⁰ 13' North latitude with watershed area of 478.15.km2. Relief from 608m to 913m (As per CARTODEM).Fig.4 shows the location map of the study area delineated based on topography and drainage pattern to understand hydrological process of the basin. The drainage pattern is coarse texture and dendritic drainage pattern at watershed level. The annual average rainfall of the area is 758mm. The principal soil types are Shallow to very deep black soils, Red loamy soils, Lateritic soils. For the delineation of watershed for study area for hypsometric analysis, CARTODEM with 30m resolution (www.bhuvan.nrsc.gov.in) are delineated using ArcGIS Software.

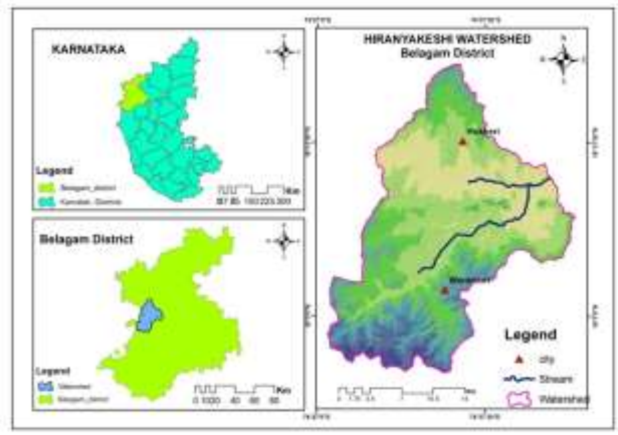
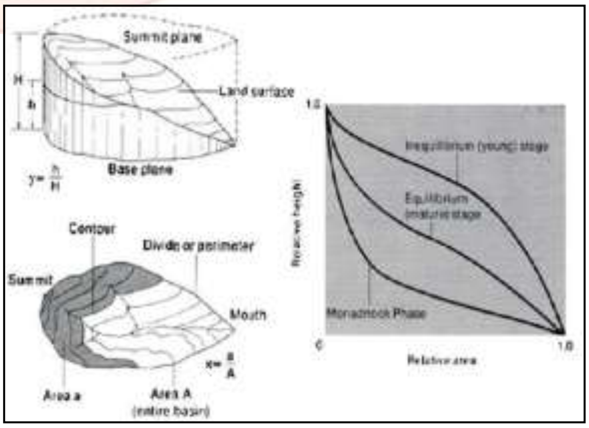


fig no 4: study area map of hiranyakeshi watershed

III. Methodology

GIS has used for data preparation, data manipulation and analysis of data. The Survey of India Topographical map has used as a base map. The contour line's elevation value used to create a Triangulated Irregular Network (TIN) model. Then the Digital Elevation Model (DEM) with 30m spatial resolution has created based on the TIN model. The drainage basin's boundaries have been identified through a tool set (fill, flow direction, flow accumulation and snap pour point) in ArcGIS software using DEM model as input. The elevation value of DEM has been used to find out the Hypsometric Integral for each drainage basin in the study area. Finally, Moran's spatial autocorrelation has been calculated to find out the relationship between the drainage basins in the study area.



hypsometric curves (hc) and estimation of hypsometric integrals (hsi)

Hypsometric curve is obtained by plotting the relative area (a/A) along the abscissa and relative elevation (h/H) along the ordinate. The relative area is obtained as a ratio of the area above a particular contour (a) to the total area of the sub watershed above the outlet (A). Considering the watershed area to be bounded by vertical sides and a horizontal base plane passing through the outlet, the relative elevation is calculated as the ratio of the height of a given contour (h) from the base plane to the maximum basin elevation (H), (up to the remote point of the sub watershed from the outlet) (Sarangi et al., 2001 and Ritter et al. 2002). The hypsometric integral is obtained from the hypsometric curve and is equivalent to the ratio of the area under the curve to the area of the entire square formed by covering it. It is expressed in percentage units and is obtained from the percentage hypsometric curve by measuring the area under the curve. This provides a measure of the distribution of landmass volume remaining beneath or above a basal reference plane.

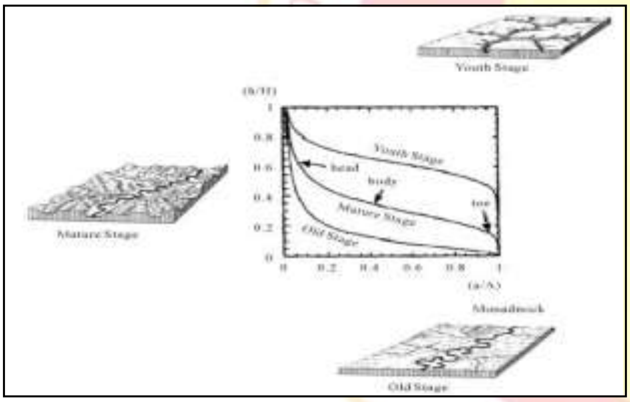


fig no 6: different stages of hypsometric curves

IV. Results and Discussion

Estimation of hypsometric integrals (Hsi)

The hypsometric integral (Hsi) was estimated using the elevation relief -ratio method as proposed by Pike and Wilson (1971). The relationship is expressed as,

$$E \approx H_i = \frac{Elevmean - Elevmin}{Elemax - Elevmin}$$

Where, E is the elevation-relief ratio equivalent to the hypsometric integral His, Elevation mean is the weighted mean elevation of the watershed estimated from the identifiable contours of the delineated watershed. Elevation maximum and Elevation minimum are the maximum and minimum elevations within the watershed. The hypsometric integral is expressed in percentage units. However, this method was observed to be less cumbersome and faster than the other methods in practice for Hsi Singh et.al. (2008). Fig no 8 shows the hypsometric curves for Hiranyakeshiwatershed.

Hypsometric analysis results with respect to stream order level (6 and 5) 6th Order result of hypsometry

fig no 7: stream order

Table No: 1 Values Of Hypsometric Integral Hiranyakeshi Waters

Elevation in m Reclassified in Arc GIS	Elevatio, ei (m)	Surface area, ai (sq.km)	cumulative (sq.km)	Elevation Difference(m)	a/A	e/E	Hypsometric integral
913	913	0	0	305	0	1	0.5
869-913	869	1.79	1.79	261	0.004	0.9	
825-869	825	9.92	11.71	217	0.02	0.7	
782-825	782	24.4	36.11	174	0.08	0.6	
738-782	738	38.71	74.82	130	0.16	0.4	
695-738	695	69.74	144.56	87	0.30	0.3	
651-695	651	166.97	311.53	43	0.65	0.1	

608-651	608	165.93	477.46	0	1	0	
	760.125						

V. Conclusions

In the present study, ranking of streams has been carried out based on the method proposed by Strahler (1964). Highest stream order obtained was 6th order and hence designated as 6th order catchment. Whereas the hypsometric curves results reveals that remarkably downward convex shapes (i, e. Monadnock Stage) Mature stage.as per (Strahler, 1964) hypsometric curve classification. The results of the 6th order & 5th orders of Hiranyakeshi watershed profile factor values less than 0.5 (I, e approaching monadnock stage) needs minimum mechanical and vegetative measures to arrest sediment loss but may require more water harvesting type structures to conserve water at appropriate locations in the watershed for conjunctive use of water.

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