SLOPE ANALYSIS FROM SRTM DEM DATA: A CASE STUDY OF SOME PART OF UPPER VENA RIVER BASIN,MAHARASHTRA, INDIA

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Abstract :

Morphometric slope analysis in part of Upper Vena River sub basin was carried by Shuttle Radar Topography Mission (SRTM) 90m. resolution, toposheets of Survey of India and IRS LISS III satellite data of 23.5 mt. resolution as input data. The Slope categories in the study area were classified as in degree and the slope varies from 0° to 18°. Digital elevation models using integrated approach of Remote Sensing and GIS techniques. Digital elevation models (DEMs) by observing the elevation, aspect, slope and hillshade images. The present study area is the part of central India covering an area of about 825.69 km^2. in the Nagpur district of Maharashtra . DEM has been an excellent supplementary information database for interpretations in the present study area along with other data. However the SRTM DEM 90 m resolution is well utilized for the slope of any part of the earth surface. Moderately steep slope (9^0 to 18^0),Very gentle slope (1^0 to 3^0), Gentle slope (3^0 to 5^0), Moderately steep slope (5-9^0) and Level slope (0^0 to 1^0) have been extracted for the understanding the topography, geomorphology, soil types and their erodability, surface drainage.

***Key words* :** Slope, SRTM DEM, Classification,Satellite Image,Vena River

I. INTRODUCTION

Slope can be regarded as the outcome of active processes sloping passive materials with depending on the time during which the processes have operated. Slope can be identified in term of structure, processes and stage as outlined by Davis (1899). A more realistic approach is to view slope as numerous and complex linkage between factor, processes and forms. Digital elevation models suggest the most widely used methods for extracting important elevation and terrain information.DEMs are used for visual topographic analysis, landscapes and landforms other than modeling of surface processes (Welch 1990). Nowadays GIS is being used in various purposes such as evaluation of surface features for geological and geomorphological studies. The contemporary computer technologies may provide additional tools for geological mapping which may improve better agreement of determination of geomorphological, geological, topographical and slope analysis with the terrain topography (Jawadand, 2015).

Slope maps play a crucial role in addition to flow direction and flow accumulation in hydrological modeling. Slope is one of the important surface terrain parameter which is explained by horizontal spacing of the contours. In general, closely spaced contours represent steeper slopes and sparse contours exhibit gentle slope An understanding of slope distribution is essential as a slope map provides data for planning, settlement, mechanization of agriculture, deforestation, planning of engineering structures, morphoconservation practices etc. (Sreedevi et al. 2004) . DEM, Digital Elevation Data (DED), Digital Terrain Data (DTD) (Campbell, 2002) or Digital Terrain Model (DTM) all consists of different arrangements of individual points of x and y coordinates of horizontal geographic positions. Z is the vertical elevation value that is relative to a given datum for a set of x, y points (Bernhardsen, 1999; Bolstad and Stowe, 1994; Welch, 1990). Slope is a very important factor for watershed management. If the slope is higher degree there is a chance for more run off, infiltration is less, and automatically erosion is more. As the slope steepness increases, runoff velocity and volume increases, with it the kinetic energy and carrying capacity of the surface flow increase, infiltration decreases, soil slope stability decreases and the soil displacement down the slope increases. Integrated SRTM DEM , remote sensing and Geographic Information System (GIS) techniques especially Shuttle Radar Topographic Mission (SRTM)-Digital Elevation Model (DEM) of 90 m resolution used by analyzing the elevation, slope and image characteristics(Manjare,2014).

II. AREA OF STUDY

The Upper Vena Basin of Nagpur district is selected as a study area having 825.69 km^2area. It lies in the Survey Of India toposheet no. 55 K/12, 55K/16, 55 O/4, 55L/13 and 55P/1 bounded by the 20^0 50’ 00’’ N to 21^0 15’ 00’’ and 78^0 40’ 00’’ to 79^0 10’ 00’’E. The Upper Vena river basin situated South West to the Nagpur district of Maharashtra (Fig.1).

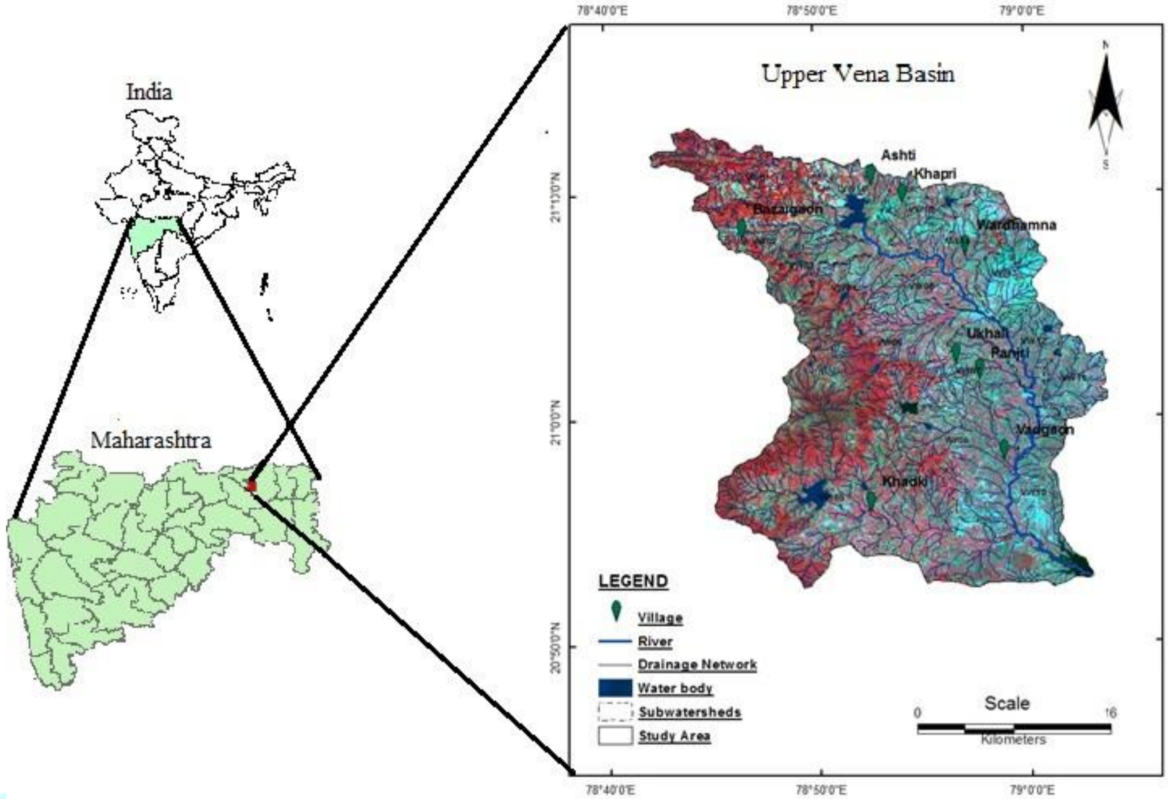

Figure1: Location map of the study area

III. METHODOLOGY AND DATA SOURCES

The slope map has been prepared by using 1: 50,000 scale SOI topographical maps with 20 m contour interval, IRS LISS III satellite image of 23.5 mt. spatial resolution (Fig.1) and support from the SRTM DEM of 90 m. resolution. The raster layer was georeferenced using Erdas Imagine software and slope extracted from the SRTM DEM from ARC GIS 10.1 version. **IRS LISS III satellite data and Toposheet**

False Color Composite (FCC) IRS-P6 LISS III satellite data generated from green, red and near infrared (NIR) spectral bands (2, 3, and 4) is rectified geometrically and registered with SOI topographical maps on 1:50000 scale using Arc GIS (Ver.10). Survey of India toposheet no. 55 K/12, 55K/16, 55 O/4, 55L/13 and 55P/1 covers the area of Nagpur district in Maharashtra state on Scale of 1:50,000.

SRTM-DEM(Shuttle Radar Topography Mission, Digital Elevation Models)

InSAR synthetic aperture radar interferometry (SRTM) campaign was carried out in a single pass in Feb. 2000. The Earth's area between 60° and 90° was covered for the first time by a worldwide high-quality DEM with a resolution of 1 arc sec. (30 m) and 3 arc sec. (90 m.) free availability(Van Zyl, 2001). The DEM's vertical errors are 16 m. and 6 m. plus or equal to in absolute and relative terms, respectively; at a 90 percent confidence level, the horizontal positional accuracy is 20 m. (Rabus et al., 2003).

The 90 m SRTM DEM and aerophoto grammetric DEMs were first assessed in high mountain terrain, and the results showed Root Mean Square Errors (RMSE) of 12-36 m in height and maximum vertical errors of more than 100 m in severely rugged topography (Kääb, 2005).In mountainous terrain, the SRTM DEM shows sections with data gaps, generally due to radar shadow, layover and insufficient interferometric coherence (Kääb, 2005). A 30 km x 40 km SRTM DEM was utilised for the investigation and resampled at a grid resolution of 90 m. There were just a few data gaps in this DEM subset, and they were barely relevant for the goals of this investigation. Comparing the positional precision to 1:50,000 topographic maps, it is within the sub-pixel range (Fig.2). SRTM data for this study was downloaded from the website of the Consultative Group on International Agricultural Research Consortium for Spatial Information.

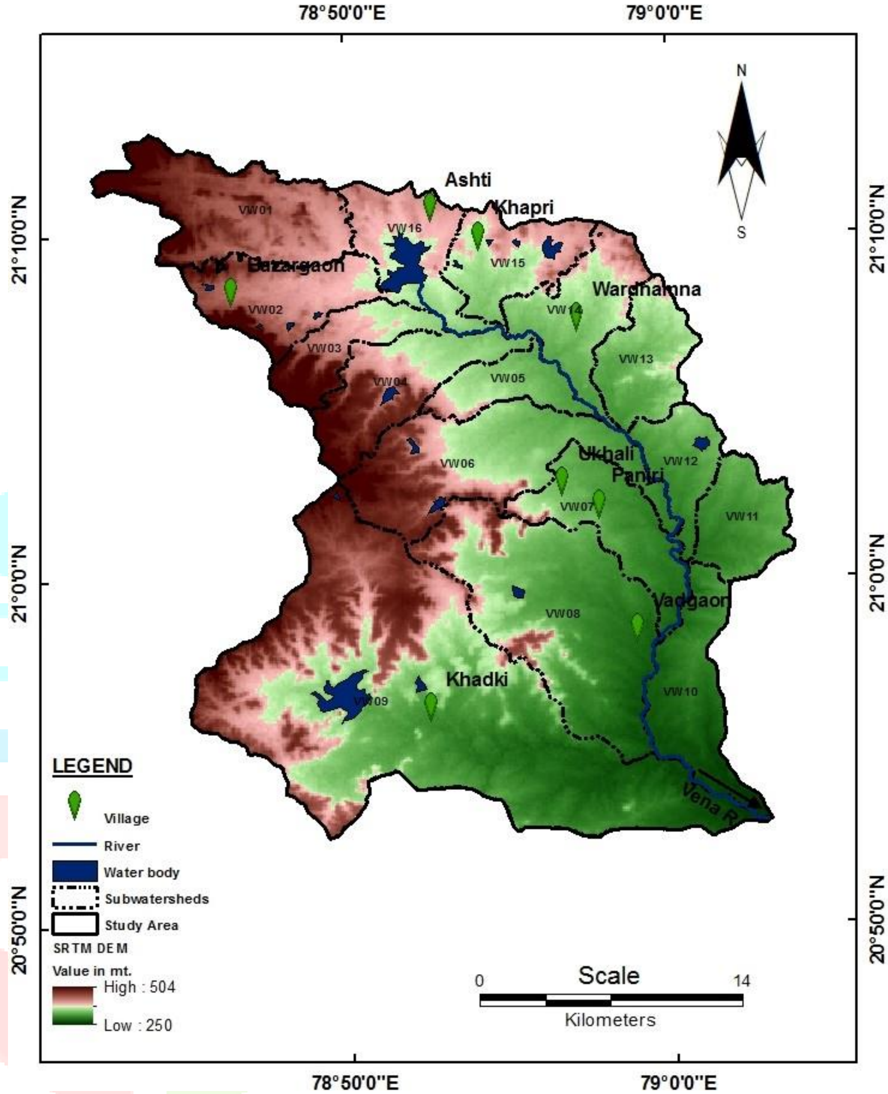

Figure2: DEM map of the study area

IV. SLOPE ANALYSIS

An attempt has been made to prioritize and evaluate conservation strategies of the upper Vena river basin of Nagpur district, Maharashtra based on integrated analysis in GIS environment. The river basin has been further delineated into 16 subwatersheds for detailed morphometric analysis. Digital Elevation Model (DEM) was generated in GIS for slope analysis. The slope of a surface refers to the maximum rate of change in height across a region of the surface. Slope of terrain is one attribute of topography that can have very adverse effect on both soil and water resources as well as on land use development in a watershed. Slope is the measure of steepness or the degree of inclination of a feature relative to the horizontal plane. It is one of the major factors controlling the time of over land flow and concentration of rainfall in stream channels and is of direct importance in relation to the flood magnitude. The slope elements, in turn are controlled by the climatomorphogenic processes in the area having the rock of varying resistance. The Earth's landscape can be thought of as being composed of a mosaic of slope types, ranging from steep mountains and cliffs to almost flat plains.

Slope and elevation are the two basic but separate concepts in the study of landforms. The slope or inclination of the terrain is the resultant of many factors, such as the relative relief, dissection index, drainage texture, drainage frequency, climate, geology and tectonics operating in the area It is one of the attribute of topography that can have very adverse effect on both soil and water resources as well as on land use development in a basin. The slope of the drainage basin has an important relation to infiltration, surface runoff, soil moisture and ground water contribution to stream. Slope influences the drainage pattern of a basin. Very steep slopes make it difficult for rainwater to seep into the ground. This causes water to runoff and increases erosion.

V. SLOPE CLASSIFICATION

Slope study classified on the basis of the guidelines mentioned in Integrated Mission for Sustainable Development (IMSD) document. Finally, slope coverage has been readied as one of the coverage in the integrated analysis. The various degree of slope leads to severe runoff,infiltration land and soil. The effect of slope on drainage,topography,landuse, and soil was studied and a direct relationship was observed. The slope for the upper Vena basin varies from 0° to 18° (Table 1).

Table 1: Slope Classification for the study area

Value of slope	Slope class
$0\text{-}1^0$	Level to nearly level
$1\text{-}3^0$	Very Gentle sloping
$3\text{-}5^0$	Gently sloping
$5\text{-}9^0$	Moderately sloping
$9\text{-}18^0$	Moderate to Steep sloping

It is evident from the slope map which has been extracted from the SRTM DEM (90 m) resolution in which five slope category have observed in the given study area. The slope map has been prepared for the study area using 1: 50,000 scale SOI topographical maps with 20m contour interval and support from the SRTM (DEM). The raster layer was georeferenced using ARC Map GIS software. The isotangent lines were digitized and final isopleth map (a map displaying the distribution of an attribute in terms of lines connecting points of equal value) was prepared.

a) **Level slope (0^0 to 1^0):** This is the lowest category of slope in this region and is associated with extremely flat part of the area. This class provides ideal condition for any type of farming, provided other agronomic condition favourable. Almost all erodible lands fall in this category which is drained by the river and streams and represents an erosional surface of the current cycle. Some flat tops of the hills also show the same slope (Fig.3).

b) **Very gentle slope (1^0 to 3^0):** This category of slope class covers an area having gently sloping terrain and do not have irregularities in the form of small mounds or some undulation, which can be removed by leveling process (Fig.3).

c) Gentle slope (3^0 to 5^0): This type of slope does not have any serious problem for cultivation unless there are irregularities on the surface. The problem of drainage does not arise (Fig.3).

d) **Moderately steep slope ($5-9^0$):** It covers the area in patches mostly in northwest and southwest part of the basin. It is observed along bazargaon, maunda and mohgaon area (Fig.3).

e) **Moderately steep slope (9^0 to 18^0):** It covers the area in patches in different parts. This slope zone is prominent along the contacts of hill ridges and flat grounds. Pediments are included in this category. The strongly sloping areas, the land use utilized for specific purpose (Fig.3).

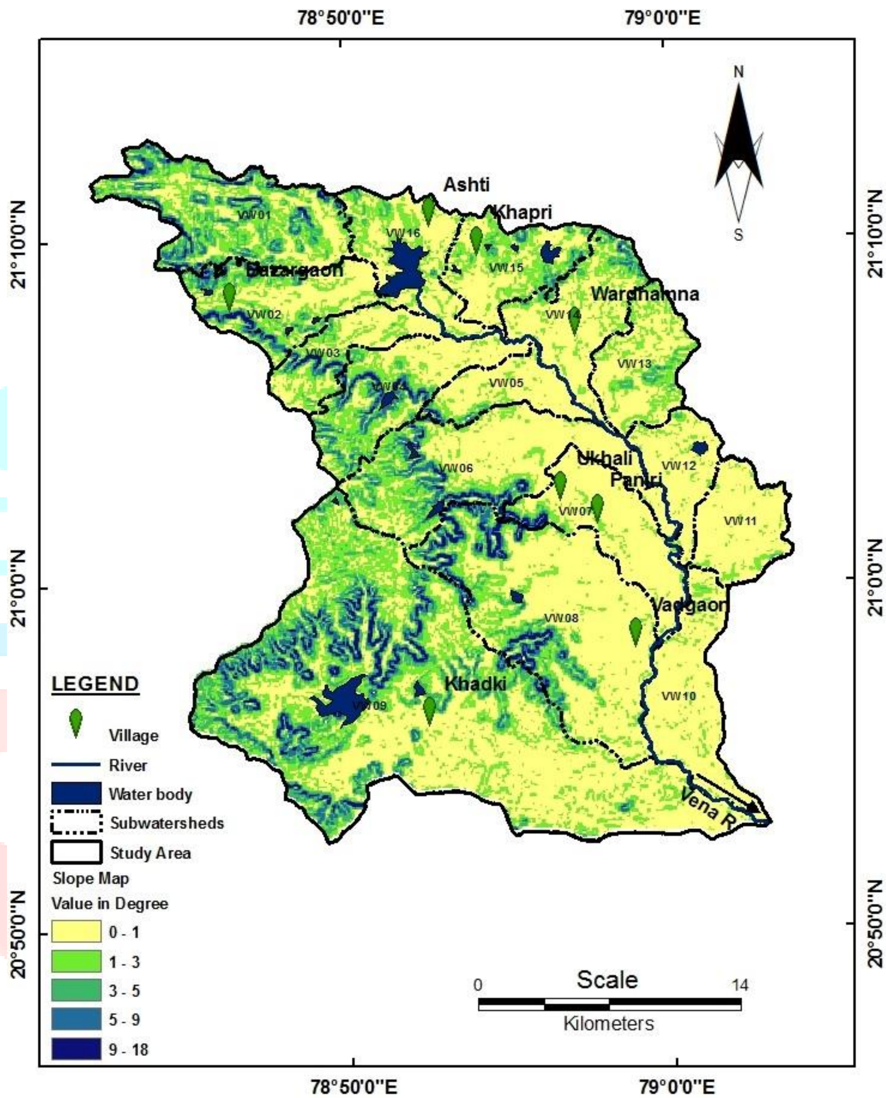

Figure3: Slope map of the study area

VI. DISCUSSION

The common nature of the slope in the study area is observed convex to concave form on the ground. The convex slope and found mostly in the area of moderate to high altitude while the concave slope occupies the lower parts. The upper convexity is due to soil creep while lower concavity due to concentration hill action, escarpment face which separates these two slope. As the hills of region are thickly covered with vegetation, the creeps takes place through network of the roots. The length of overland flow, the runoff intensity, infiltration capacity, initial resistance of surface and base level control are some of the important factor which determine the slope forms in the study area. The hill slope forms in the region may be due to polyphase action as described by Savigear (1956), it is subjected to the tectonic movements, climate and base level changes since the inception of the surface.

VII. CONCLUSION

The study area geologically consists of mostly Deccan trap and the resultant soil is black cotton soil. The crests are uneven surface on which plenty of rocks outcrop, weathered boulders and regolith are seen. The crests are border by moderate escarpment of almost moderate slope elements. These are indented by number of stream valley, with result of convexity of slope till merge in to the debris slope. These debris slopes have a slope angle of 10^0 to 18^0 and are usually terraced in nature. The slope element from the study area is dependent on variables such as stratigraphy, structure, inherited form, climate and basal erosive activity of river. Moderately steep slope (9^0 to 18^0) covers the area in patches in different parts. This slope zone is prominent along the contacts of hill ridges and flat grounds while moderately steep slope ($5\text{-}9^0$) covers the area in patches mostly in northwest and southwest part of the basin. Very gentle slope (1^0 to 3^0) class covers an area having gently sloping terrain. The slope information is useful in understanding the topography, geomorphology, soil types and their erodability, surface drainage etc.

REFERENCES

[1] Bernhardsen T. and Stove M. (1999). Geographic Information Systems: An Introduction, 2nd ed,; John Wiley and Sons, Inc: New York.

[2] Bolstad, P.V. et al. (1994). An Evaluation of DEM Accuracy: Elevation, Slope, and Aspects,*Photogrammetric Engineering and Remote Sensing*, Vol.60 (11) pp., 1327-1332.

[3] Davis, W.M (1899) The Geomorphic cycle Geroge. J. V. pp. 481-504.

[4] Kääb, A., (2002). Monitoring high-mountain terrain deformation from air and spaceborne optical data: Examples using digital aerial imagery and ASTER data. ISPRS J. Photogramm. and Remote Sens. 57 (1-2), pp.,39–52.

[5] Jawadand Sanjiwani, (2015) “Watershed Morphometry For Sustainable Development And Ground Water Potential Zone Identification: An Integrated Approach Using Remote Sensing, And Gis Techniques” Unpublished Dissertation Thesis Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur, P. 55.

[6] Kääb, A., (2005). Combination of SRTM3 and repeat ASTER data for deriving alpine glacier flow velocities in the Bhutan Himalaya. Remote Sens.Environ. 94 (4), pp.,463–474.

[7] Manjare, B. S. (2014). Identification of Groundwater Prospecting Zones Using Remote Sensing and GIS Techniques in Upper Vena River Watersheds Nagpur District, Maharashtra, India, 15th Esri India User Conference,pp.1-14.

[8] Raaflaub, L.D., Collins, M.J. (2006), The effect of error in gridded digital elevation models on the estimation of topographic parameters. Environmental Modelling and Software 21, pp.,710-732.

[9] Rabus, B., Eineder, M., Roth, A., Bamler, R., (2003). The shuttle radar topography mission a new class of digital elevation models acquired by spaceborne radar. ISPRS J. Photogramm. and Remote Sens. 57 (4), pp.,241–262.

[10] Savigear R. A. G., (1956) techniques in the investigation of the slope farms. Slope comm., Rep.pp.,166-75.

[11] Sreedevi, P. D., Subrahmanyam, K. and Ahmed, S. (2004). The Significance of Morphometric Analysis for Obtaining Groundwater Potential Zones in a Structurally Controlled Terrain, Env. Geol., Vol. 47, No. 3, pp. 412-420.

[12] Van Zyl, J.J., (2001). The Shuttle Radar TopographyMission (SRTM): A Breakthrough In Remote Sensing of Topography, Act Astrona. 48 (5-12), pp.,559–565.

[13] Welch R. 3-D Terrain Modeling for GIS Applications. GIS World. 1990. 3 (5) pp.,26-30