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Hydrological and surface analysis using remote sensing & GIS techniques in parts of Nalgonda district, Telangana, India

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Abstract

In the processes of Hydrological and surface analysis, Digital Elevation Model (DEM) data have been applied to obtain hydrological features, which provide as inputs to several models. Hence altitudes data are accessible from different sources with various spatial resolutions. The current research paper represents the precision and excellence of drainage network study resulted from DEM. The concurrence degree connecting two layers is very low down for spatial model, drainage density and river rate of recurrence in plain regions. The D8 model procedure used to get the flow direction. Our method uses the D8 model to get the flow directions for each and every one pixel in the DEM. Many geographic information systems are being updated that store topographic information as the primary data for analyzing water resource problems. ArcGIS 10.3 version was used to derive drainage networks, flow direction and flow accumulation from DEM for the study area of Suryapet region. Finally the prepared flow accumulation data superimposed with drainage data for valid verification.

Keywords: Surface analysis, DEM, flow accumulation, flow direction, remote sensing & GIS

1. Introduction

Surfaces correspond to phenomena that have values at each point across their area. The values at the infinite number of points across the surface are derived from a limited set of sample values. These may be depend on straight measurement, like altitude principles for a height surface, or temperature principles meant for a temperature surface; among these computed places values are tagged to the surface by interpolation. Surfaces can moreover be scientifically resulted from another data, like slope and aspect surfaces resulted from an elevation surface, a surface of length from bus stops in an urban habitation.

2. Study Area

It forms a part of Nalgonda District which is bounded on the north by Ranga Reddy & Warangal districts and south by Krishna & Guntur districts respectively, on the east by Khammam and on the west by Mahabubnagar district Figure 1. The area under study lies between 16°56'-17°18' degrees latitude and 79°25'-79°48' degrees longitude and falls in SOI toposheet number 56O/12 and partially in its neighboring toposheets, covering entire area of approximately- 1253 sq. km and from the mean sea level, the height is 571m.

3. Data Used and Methodology

NRSC (National Remote Sensing Centre, Hyderabad) collected the IRS-1D LISS-III data (24th January, 2009) in digital form and topographic maps 56O/12 and partially in its adjacent toposheet at scale 1:50,000 published by Survey of India (SOI) have been utilized. Digital data registered with SOI toposheet and identified different hydro logical units, mapping with image interpretation techniques, digital image processing, contour map, DEM, Flow direction map, Flow accumulation map using Erdas Imagine 8.6 and ArcGIS 10.3 software.

4. Results and Discussion

In this section Surface analysis & Hydrological analysis results are discussed as below.

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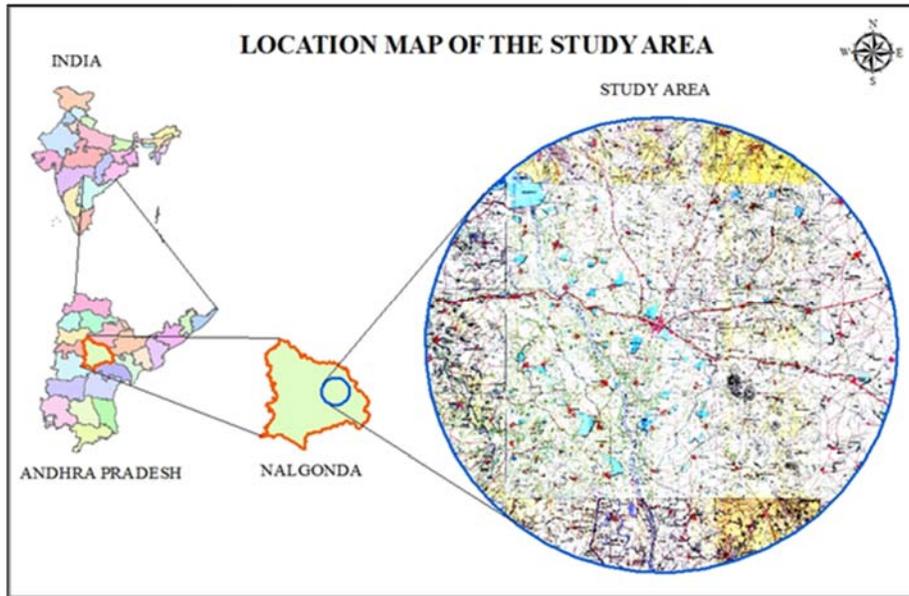


Fig 1: Location map of the study area

4.1 Surface Analysis

The topography of a land surface is represented by digital elevation data. This data set consists of the elevation in the form of grid points in a raster based GIS. In vector based systems, the elevation is represented in the form of Triangulated Irregular Network (TIN). The most commonly used terrain functions are calculation of slope and aspect. The slope given the rate of change of elevation and the aspect is the direction that a slope faces. The maximum slope is called as the gradient.

Surface analysis process involves creation of Triangulated Irregular Network (TIN) and Digital Elevation Model (DEM) from elevation data either in the form of spot heights or isoheights. In the present study contour data in the vector form the Survey of India toposheets on 1:50,000 scales have been used.

4.1.1 Digitization Contours from Raster image for the study area

Survey of India toposheet on 1: 50,000 scales have been scanned using A0 size flat bedded scanner and converted to uncompressed tiff raster format. These maps have been projected to real world coordinate system. Contours (polylines of equal elevation) have been digitized using Arc GIS (Version.10.3) software. After digitization, editing has been done to remove pseudo nodes, overshoots and undershoots. Arc topology has been created by 'clean' command. The coverage has been projected to polyconic projection after establishing tics to generate TIN, which is an essential part in surface modeling to generate Digital Elevation Model (DEM). For this contour data thus generated in the vector format (Fig.2) has been used to generate TIN (Triangulated Irregular Network) using Arc Map 3D analyst functions, later this TIN has been converted to DEM (Digital Elevation Model) (Fig.3) raster form by spatial analyst functions.

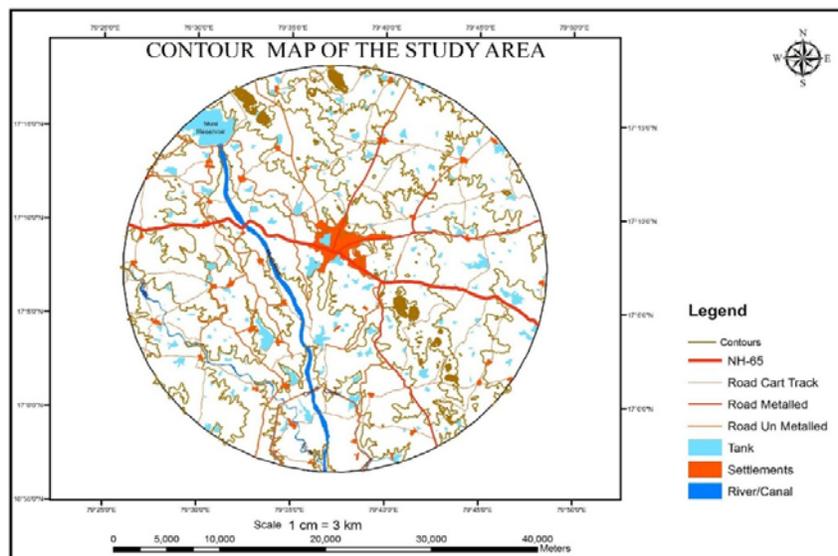


Fig 2: Contour map of the study area

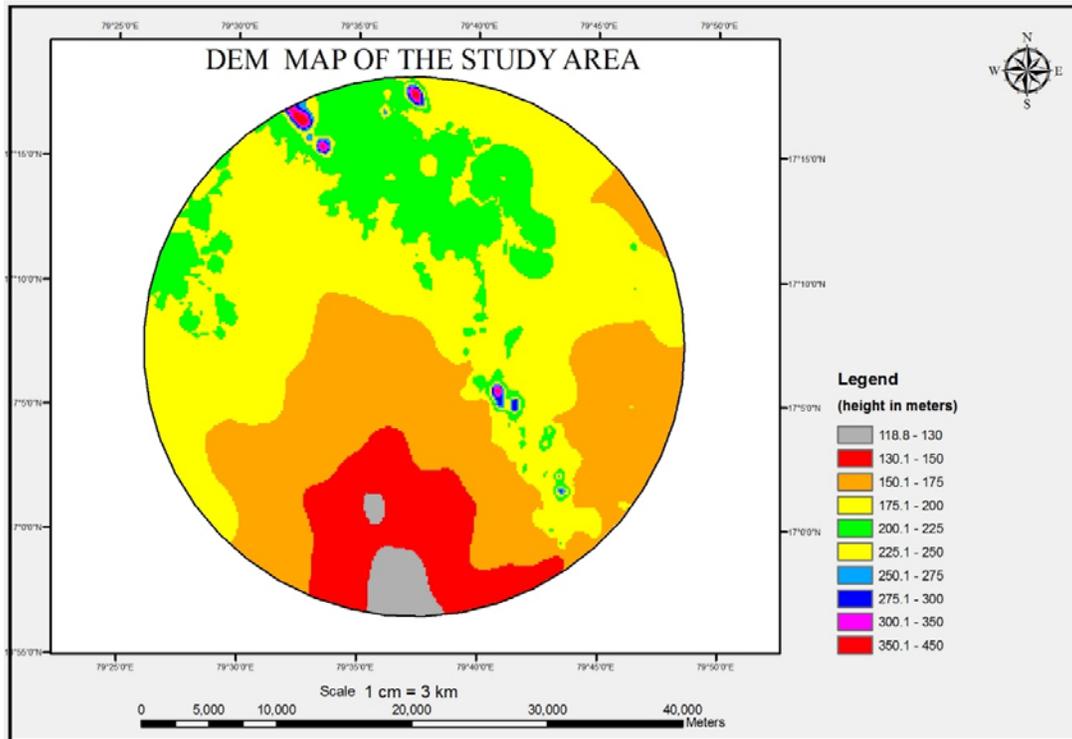


Fig 3: DEM map of the study area

As discussed above the utility of Remote Sensing and GIS, in this work first and foremost was the creation of digital elevation model (DEM) for the study area, which helped in understanding the terrain of the area for sampling.

4.2 Hydrological Analysis

The process includes filling of sinks, identifying maximum flow directions, possible accumulation points, creating a stream network, basin demarcation based on flow direction, by locating pour points (lowest point along the boundary of the watershed) at the edges, sinks and by identifying the contributing area above each point. An elevation raster is required to process hydrological modeling.

4.2.1 Sinks

Sinks are the junction features which pull flow from the ends of the network as per the definition in hydrology, but the sinks that appear in the elevation raster data are due to errors like sampling effects and rounding of elevations to integer numbers. Sinks in this model have undefined directions of one of the eight valid values in a flow direction raster (i.e. 1 to 136). Sinks generally occur in elevation raster due to neighboring cells are higher than the processing cells the elevation raster data should be free from sinks to create an accurate representation of flow direction and accumulated flow. ‘Fill sinks’ option has been used under hydrology function to remove sinks from the elevation raster data (DEM).

4.2.2 Flow Direction

Flow direction indicates the direction of surface flow which is an integer raster value ranges from 1 to 255. In an elevation raster if a cell is lower than its neighboring cells,

the direction of the flow will be towards that cell. In some elevation raster’s when multiple neighbors have the lowest values then the flow will be defined by filtering out one cell sinks. In some cases if a cell has the same change in ‘Z’ value in multiple directions the resulted flow direction will be sum of those directions. The flow direction can be determined (Fig.4 &5) by finding steepest descent from each cell which can be calculated from this equation. (i.e. Change in Z value/Distance *100).

The elevation raster thus generated without sinks has been used to generate the flow direction in the study area using ‘Flow direction’ option in hydrology analysis function. The output flow direction raster shows eight (8) possible directions of surface.

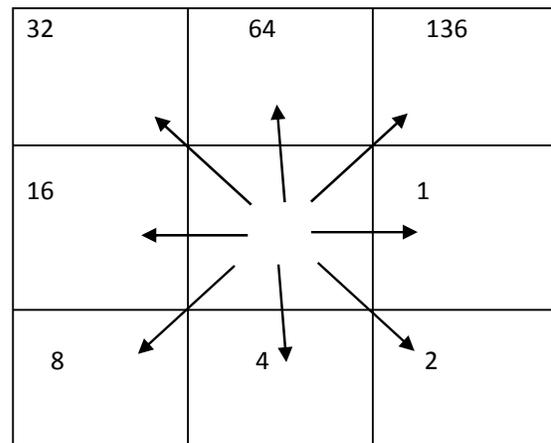


Fig 4: Flow Direction

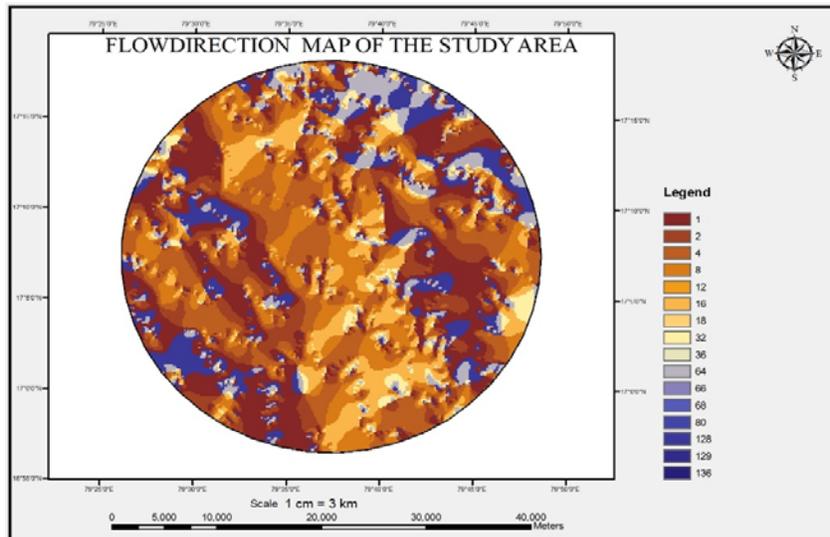


Fig 5: Flow direction map of the study area

4.2.3 Flow Accumulation

Flow accumulation is generated from the error free elevation raster data. The cells of undefined flow directions other than (1 to 8) will only receive flow accumulation. The accumulated flow (Fig 6 & 7) in the output raster will be calculated based upon the number of cells flowing towards each cell. The high flow areas in the output raster are the areas of concentrated flow which are important to identify possible stream channels similarly, those areas with flow accumulation value zero (low) are the areas of topographically high like ridges. A stream Network can be created by using the results of the high accumulated flow. Similarly, this stream network can be used as input to generate stream order, stream line and stream link.

the identification pour points (outlet of the drainage) all along the edges and sinks and by identifying the contributing area above each pour point in the source raster. Pour points are the lowest points along the boundary of the watershed. This analysis is helpful for generating the water resource expansion plan.

4.2.4 Basin/Watershed/ Catchment / Contributing area

Basin can be defined as the total area flowing to a given outlet or pour point. Basin role in hydrology delineates all drainage basins by identifying ridgelines among adjacent basins. Here the basin analyzes flow direction raster to find all sets of connected cells which belong to the same drainage basin. The drainage basin will be created based on

0	0	0	0	0	0
0	1	1	2	2	0
0	3	7	5	4	0
0	0	0	20	0	1
0	0	0	1	24	0
0	2	4	7	35	1

Fig 6: Flow Accumulation Grid

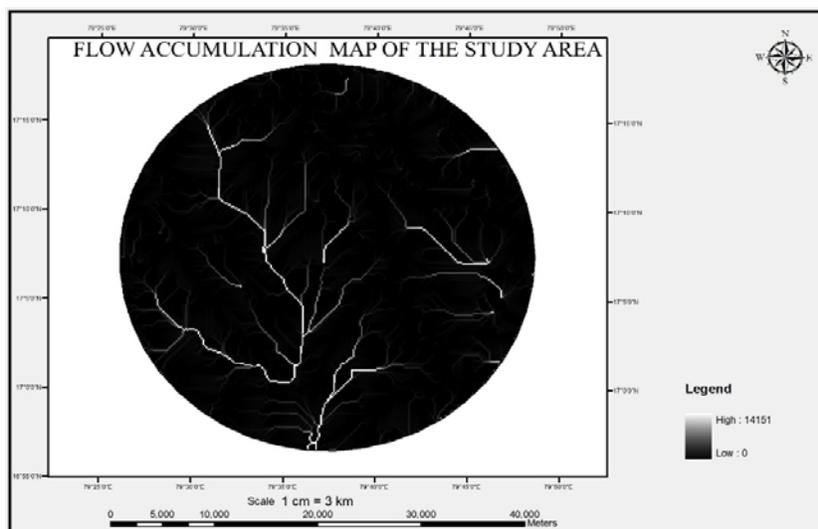


Fig 7: Flow accumulation map of the study area

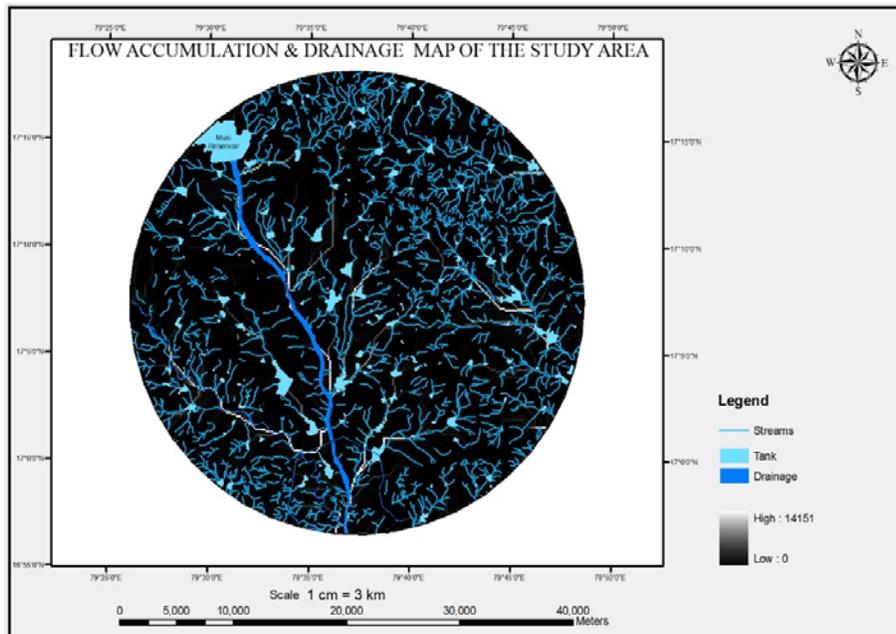


Fig 8: Flow accumulation and drainage map of the study area

5. Conclusion

The present study concludes that part of surface analysis DEM is generated from TIN by using contours and DEM is helpful to understand the terrain of the study area or any region for sampling purpose. Hence the results of hydrological analysis, Pour points are the lowest points along the boundary of the watershed and this analysis is helpful for generating the water resource expansion plan. Prepared flow direction map useful to indicate direction of surface flow and the results of the high accumulated flow useful to extract stream network, stream order, and stream line & stream link.

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