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DEM Development using Geographic Information System for Topographic Assessment

Vivek Verma[1], Ishtiyaq Ahmad[2]*
[1]Department of Civil Engineering, SSIPMT Raipur, Raipur (C.G.), India
[2]Department of Civil Engineering, NIT Raipur, Raipur (C.G.), India

Abstract

Topography of the earth surface plays a vital role in the distribution of water within the natural land surfaces. This includes various hydrological processes like surface runoff, infiltration and evaporation. The quantitative assessment of these processes mainly depends upon the topography of the surfaces. Many topographic features can be computed directly from Digital Elevation Model (DEM). Assessment of topography manually is generally tedious, time consuming and often subject to error. In the present paper, author has demonstrated the methodology of creating the DEM using two data set contour lines and elevation data.

Keywords: *topography, digital elevation model, GIS, interpolation, toposheet*

**Author for Correspondence* E-mail: iahmad.ce@nitrr.ac.in

INTRODUCTION

Digital Elevation Model (DEM) is a digital file containing the elevation and co-ordinate data of a particular terrain. Generally, it is a file containing co-ordinates data "x", "y" and "z". In actual conditions, "x" and "y" data represents the latitude and longitude and "z" data represents the altitude. Researches over the last few decades established the use of automatic extraction of topographic information from DEM [1].

Various techniques are available to extract hydrological parameter like slope, catchment areas, drainage divides, channel networks, and other data [2]. These automated techniques provide more accurate measurements than traditional techniques applied to topographic maps and has the advantage that they can be easily imported and analyzed in GIS.

METHODOLOGY

Before proceeding to methodology we should be familiar with following important terms related to DEM:

Topography

The term topography originates from the greek word "topos-graphia" means writing about a place. Thus, topography is the study of earth surface shape and features especially in terms of latitude, longitude, and altitude [3].

The main use of topography is to determine the position of any features and its detailed and accurate graphical representation.

Scanning

The process of converting paper based item for e.g., a topographic map, into a digital format which is usually integrated with GIS [4].

Geo-referencing

Initially the scanned item in digital format is without any reference. The process of describing the correct location and shape of features – typically by assigning co-ordinates from a known reference system such as latitude/longitude.

Digitizing

The process of converting spatial features (point, line & polygon) from a paper based source into a digital format by tracing. This can be done by on-screen digitization.

Interpolation

The process of assigning values to unknown points by using values from usually scattered set of known points [4].

DEM DEVELOPMENT

A typical layout of the process involved in the preparation of DEM is shown in Figure 1. Prior to on-screen digitizing, paper maps have to be integrated into the GIS database by converting them into digital format. The process of such conversion is known as scanning. Initially, one of the topographic sheets 64 G-12 having 1:50,000, shown in Figure 2, procured from Survey of India scanned in the scale 1:1, this topographic sheets acts as the basic data for DEM preparation. The scanned topographic sheet is then added to the ArcGIS software. The topographic sheet added is without any spatial reference. Sheet is geo-referenced by adding control points and giving a spatial reference. The Survey of India Toposheets is made with the co-ordinate system WGS-1984. One-forth portion (i.e., right hand bottom corner) of the area of interest has been selected to demonstrate the process for creating DEM.

Digitization and Interpolation (using Contour Lines)

On screen digitization was started and the contour lines available in the topographic sheets were digitized. The contour lines digitized are 290 m, 300 m, 310 m and 320 m as shown in Figure 3. Digitization of contour lines was done using ArcGIS.

The "Topo to Raster" interpolation method can be accessed from the "Spatial Analyst Tools" of ArcGIS under "Interpolation". The digitized contour lines shown in Figure 3 were used as input. This method allows interpolating the digitized contour lines to generate the DEM. The generated DEM is shown in Figure 4.

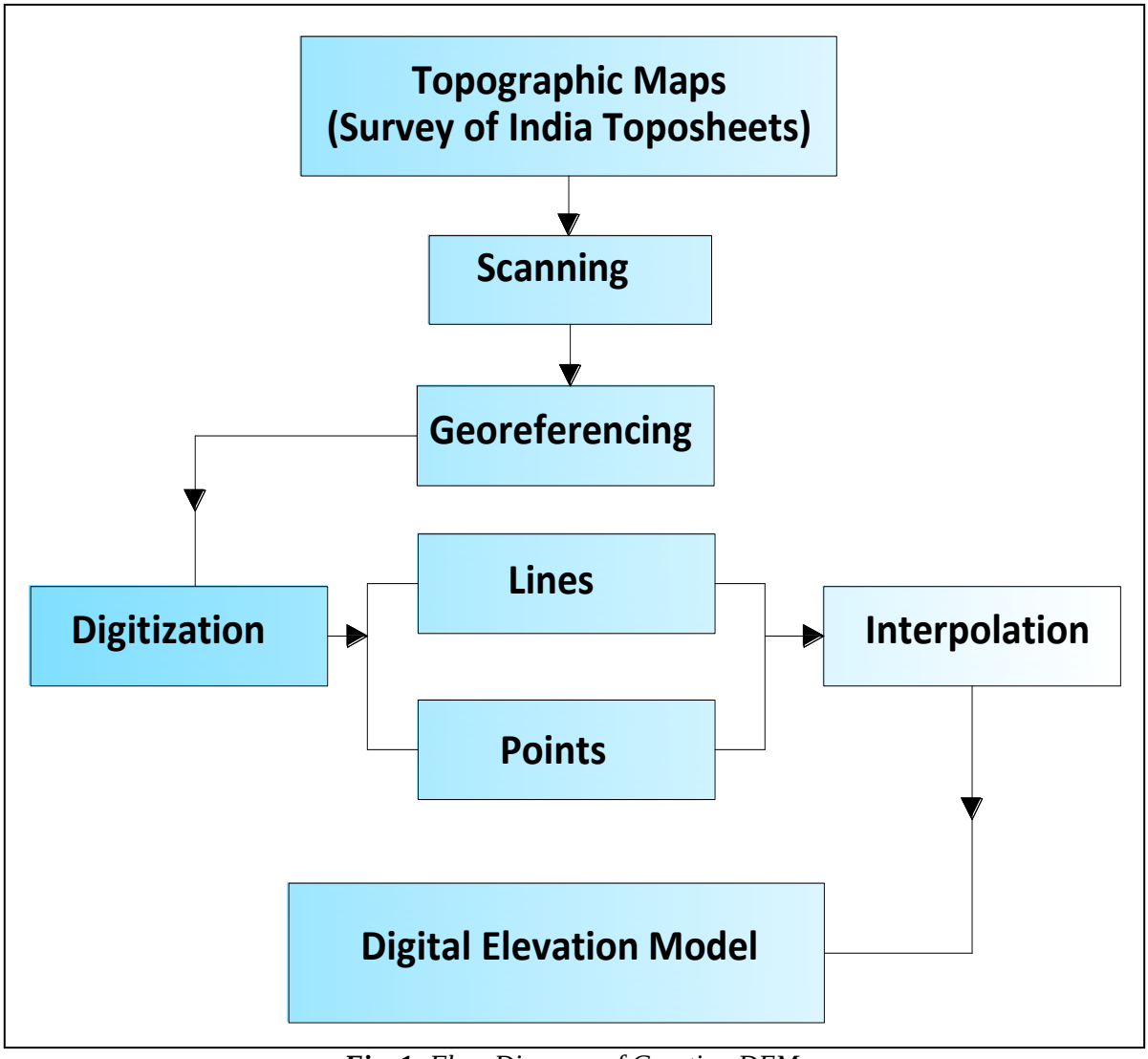

Fig. 1: *Flow Diagram of Creating DEM.*

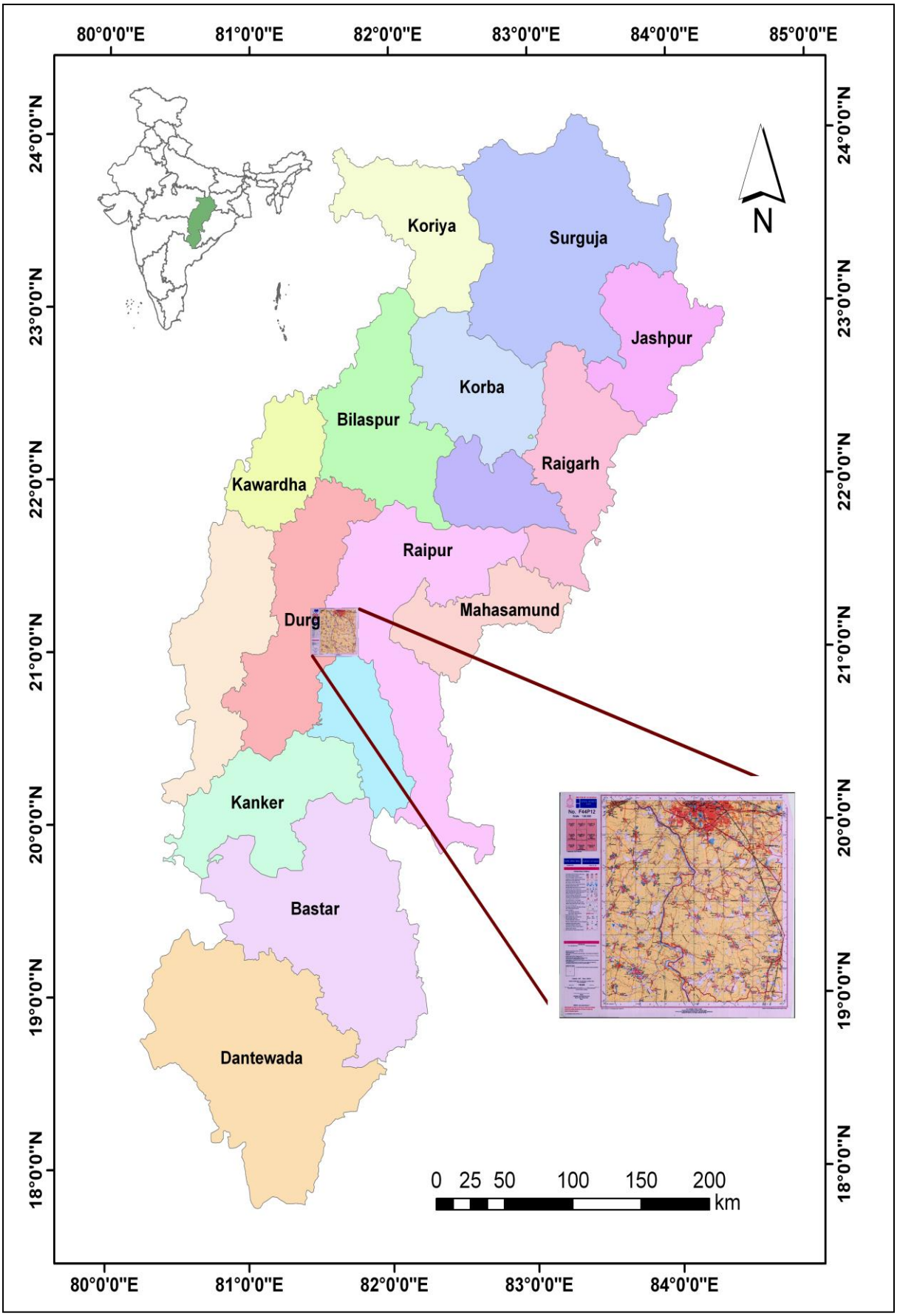

Fig. 2: *Area of Interest Showing SOI Toposheet No. 64-G12.*

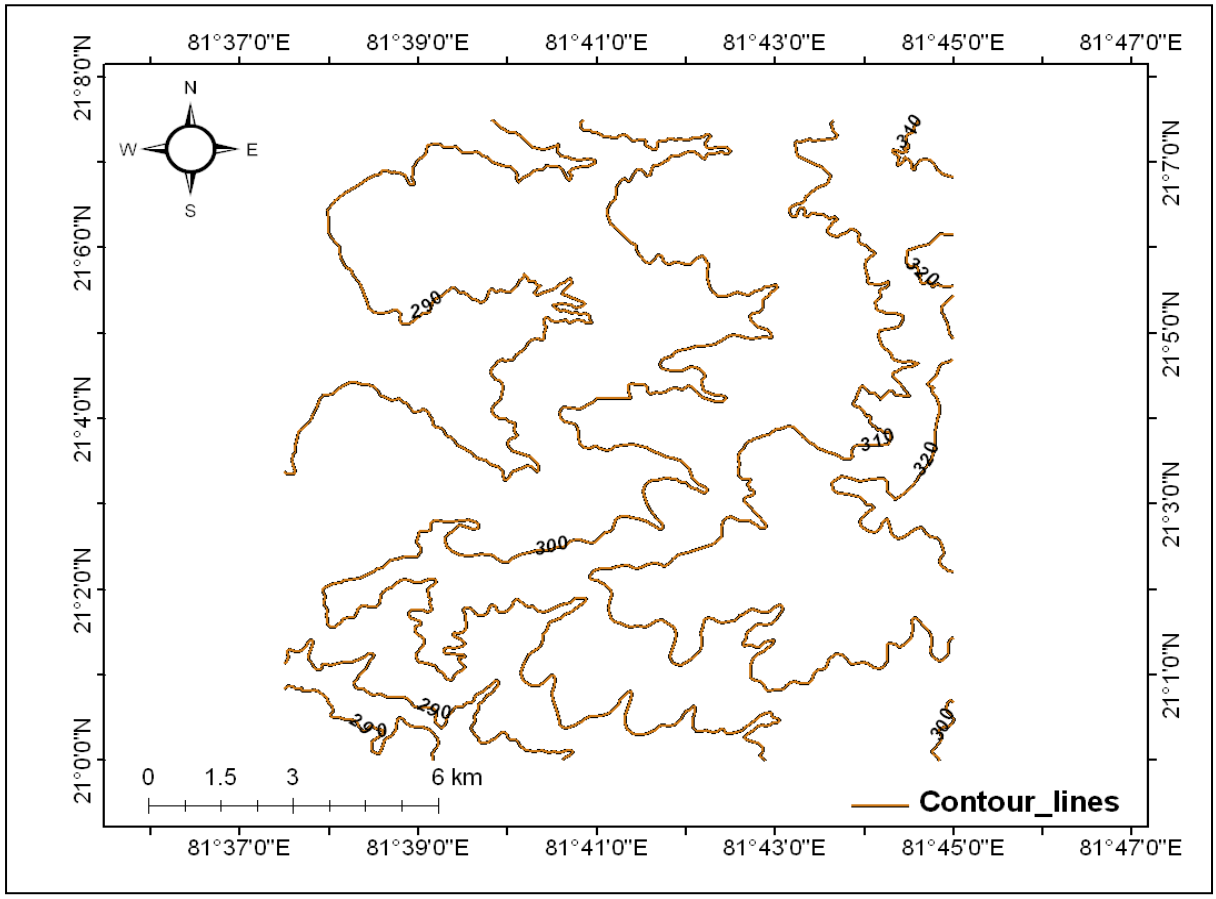

Fig. 3: *Contour Map of Area of Interest.*

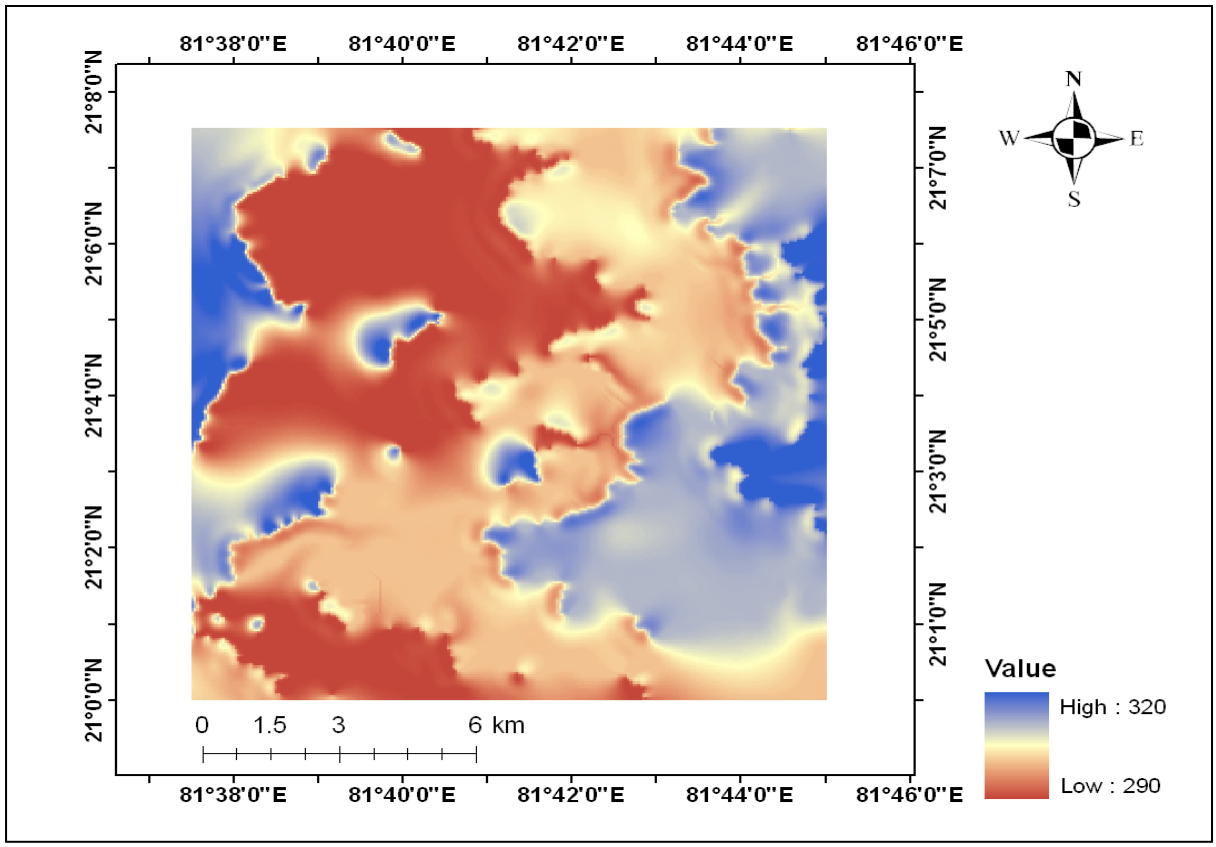

Fig. 4: *DEM of Area of Interest using Contour Lines.*

Digitization and Interpolation (using Elevation Lines)

On screen digitization was started similarly as in previous step but the difference is that in place of "lines," "points" were using the base topographic sheet as the elevation points. The elevation points are shown in Figure 5.

Some of the most common interpolation methods include Inverse Distance Weighted (IDW) interpolation, Spline and Kriging. These are all available in ArcGIS software [4].

IDW: This method is used when the set of points is dense. It estimates the cell value by averaging the values of elevation points in the neighborhood of each cell [5].

Spline: This method estimates the values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the elevation points [5].

Kriging: This is an advanced procedure that generates an estimated surface from a scattered set of points with elevations points and involves investigation of the spatial behavior of the phenomenon represented by the elevation points [6].

In the present paper, spline method of interpolation has been used and DEM generated is shown in Figure 6.

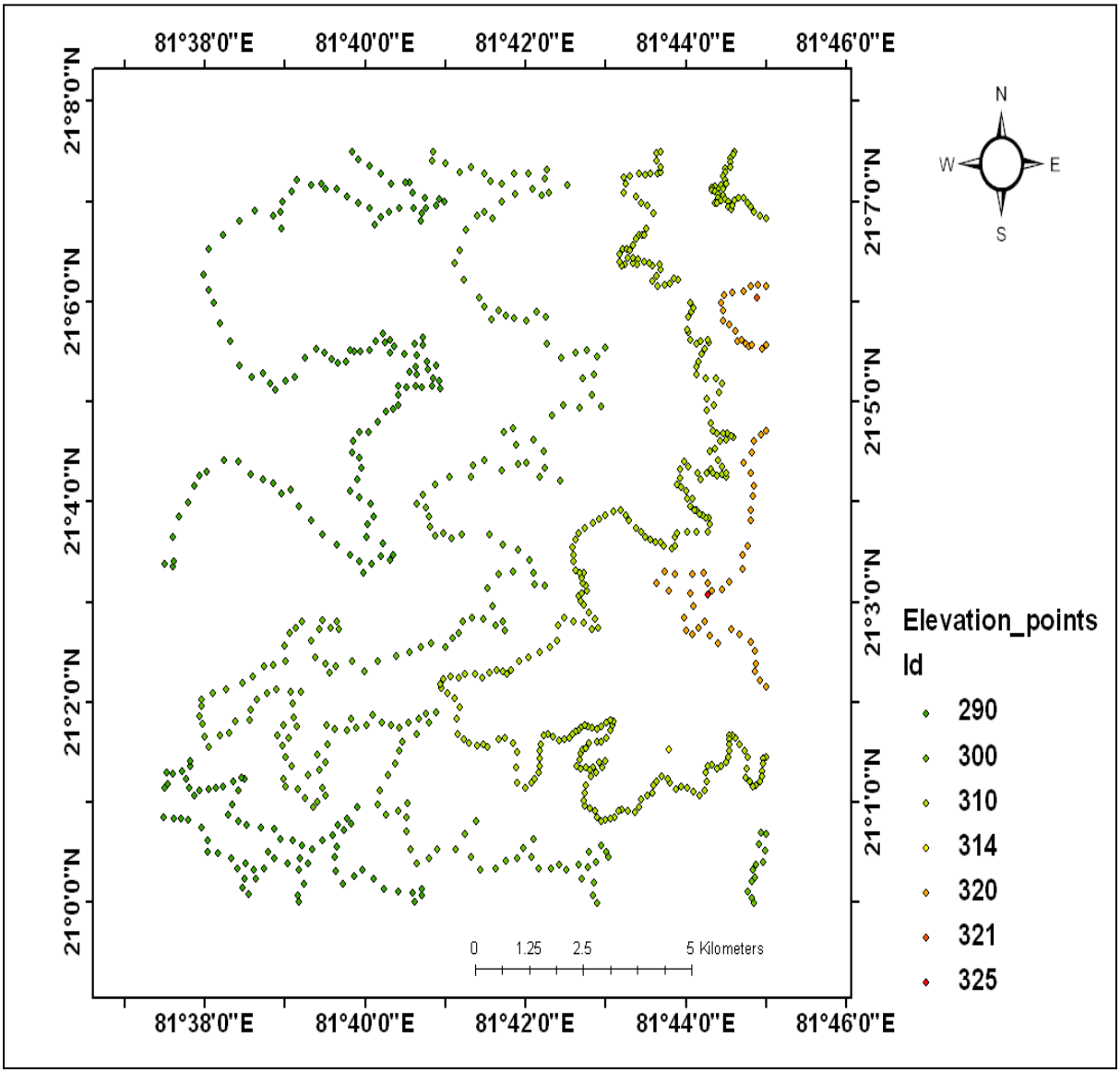

Fig. 5: *Elevation Points of Area of Interest.*

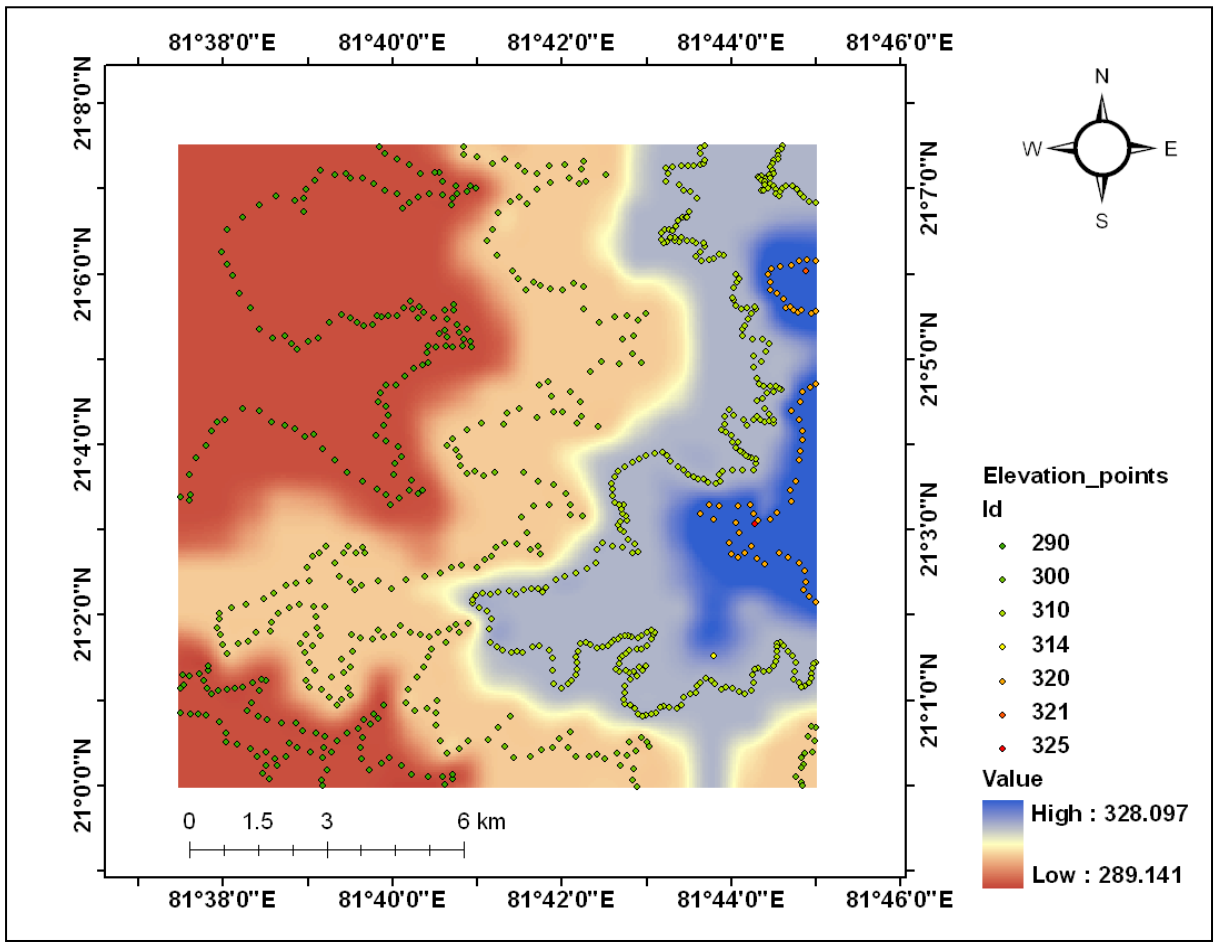

Fig. 6: *DEM of Area of Interest using Elevation Points.*

RESULT AND CONCLUSION

The DEM generated by two methods i.e., DEM by contour lines and DEM by elevation points have been shown in Figures 4 and 6 respectively. The standard deviation has been compared for these two DEM in Table 1.

Table 1: *Statistical Comparison Between DEM's.*

Statistics	DEM	
	By Contour Lines	By Elevation points
Min	290.00	289.14
Max	320.00	328.10
Mean	301.43	300.63
Std. Deviation	8.59	9.01

From the table, it is clear that there is not much difference in the standard deviation of DEM generated by two set of data i.e., contour lines and elevation point of the area of interest. Thus, any set of data, as per the availability, can be used to create DEM. The DEM generated can be used in number of ways in hydrological analysis. Several topographic features like slope and aspect can also be derived from the DEM. In this paper, methods in creating a DEM using contour lines and elevations points digitized from a paper based topographic sheet were illustrated.

There are number of interpolation methods, thus one should carefully select the appropriate method based on the available data and underlying purpose.

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