A GIS Based Approach to Generate Feasible Digital Contour Map Using Different DEM Interpolation Methods; A Case Study of Aliganj, Lucknow

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Abstract: **This study was carried out to extract digital contour lines for observing and obtaining Digital Terrain Model (DTM) over existing methods. Recognition of the surface pattern of the earth on the basis of contour maps is extremely practical and useful for Remote Sensing and GIS applications in smart city solutions such as design of stormwater management system, for layout and design of sewerage infrastructure in the city, pipeline operations and integrity management etc. Here, in this study the Deterministic methods for spatial interpolation was applied which generates surfaces from measured geographic points, based on the extent of similarity (inverse distance weighted). Nowadays, open-source geo-spatial data is freely available on the internet in wide range & to take advantage of it the point data file: latitude and longitude was obtained from Google earth pro engine and the elevation data was collected for all geographical points by processing with GPS visualizer and TCX converter utility tool. Lastly, the obtained information was processed using ArcGIS 10.8 software by applying four different interpolation techniques to create contour lines which can be used for real-time multipurpose planning for smart cities.**

Key words: **DEM, interpolation, IDW, kriging, natural neighbour, spline, contour lines.**

INTRODUCTION

Information contained in contour maps is the measures taken at different spatial locations of the field, like elevation of the earth surface and depths of the lakes and seas. Contour lines or isolines are the lines representing an imaginary line on the earth surface where each contour has an associated contour value i.e., same elevation above a datum plane, generally above Mean Sea Level (MSL)(Usery and Hahmann 2015). In the past, contour maps were very useful for observing the character & shape of the Earth's surface in investigating, understanding & managing the environment. Today, topographic maps are of National importance because they contain & provide topographical information from large to small scales and give a spatial reference support for other data about the Earth & its resources(Kent and Hopfstock 2018).

Contour map works as a base map which is used to gather preliminary survey information from the topographical map before performing any other survey task in the execution and development of any civil engineering project such as layout and design of sewer infrastructure in city, smart city planning, geological mapping, irrigation, mining, construction, planning and management of building, design of gas pipeline, laying of railway track, construction of road maps and many more civil engineering applications(Marsudi 2017).There are various methods of spatial interpolation which are widely used in many areas of science and engineering such as geology, hydrology, botany, agriculture, climatology and civil engineering. Selection of the most convenient method of spatial interpolation for generation of contour maps depends upon many factors as different interpolation methods give different results. To acquire precise results all possible methods of interpolation are applied one by one and then results are compared(Al-Mamoori, Al-Maliki et al. 2021).

The purpose of this research study was to obtain contour maps using open-source spatial data freely available on internet today and by applying best appropriate spatial interpolation technique using ArcGIS 10.8 software for comparative study of different interpolation methods and generation of Digital Terrain Model (DTM).

STUDY AREA

The study area lies in between 26°53'13" to 26°54'50" N latitude and 80°56'15" to 80°57'27" E longitude covering urban area Aliganj of Lucknow District, Uttar Pradesh on Sitapur Road having total area of 3.82 sq km, perimeter of 8.27 km. The elevation ranges from 117 to 121 m (approx.) above MSL. The study area lies under UTM Zone 44 (Fig.1).

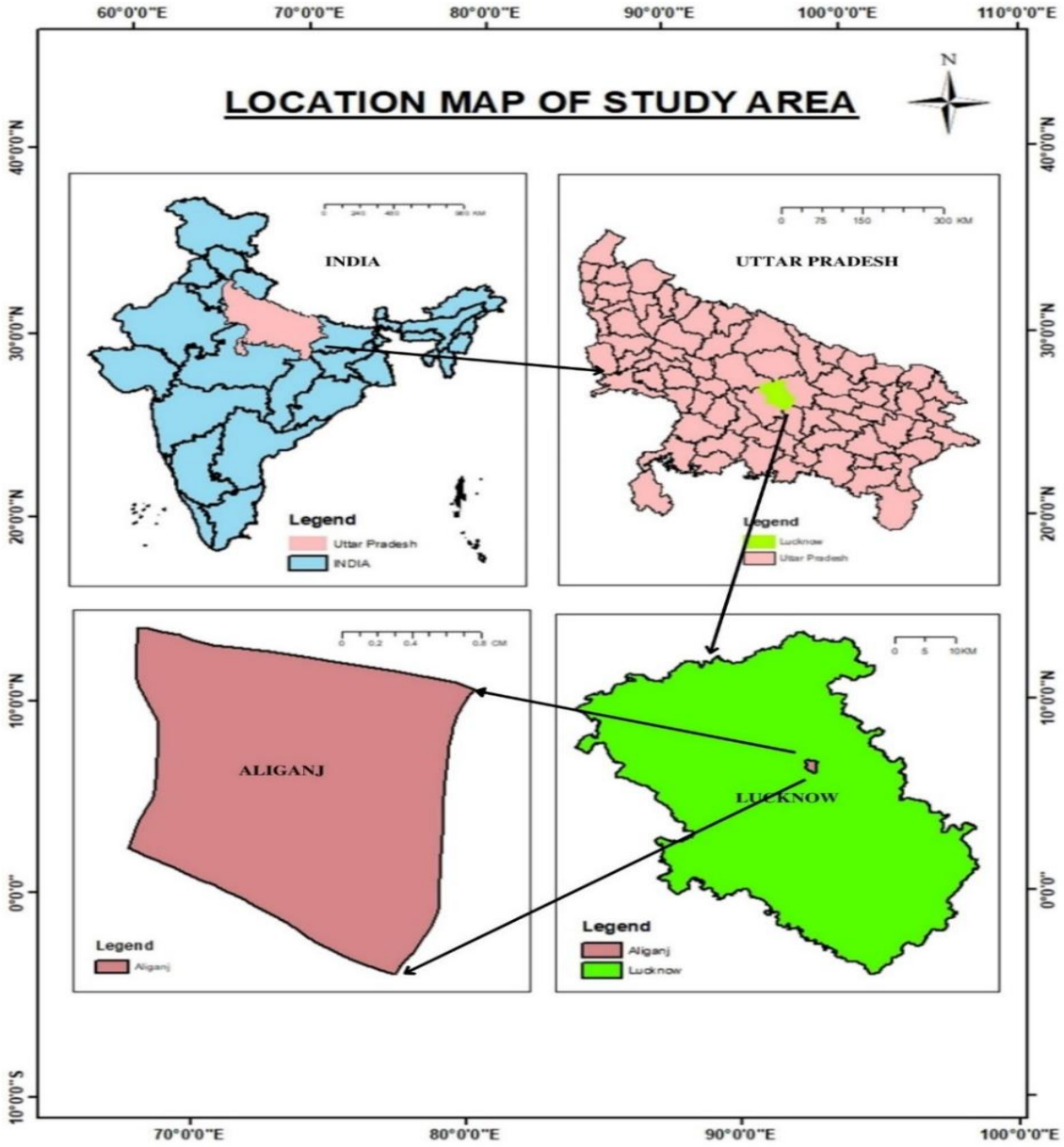

Fig. 1. Location map of the study area (Aliganj, Lucknow, Uttar Pradesh, India)

DATA & SOFTWARE USED

Survey of India topographic maps of Lucknow district on 1:50,000 scale was used for the identification and delineation of study area boundary i.e., Open Series Map No. OSM_G44I13_63B13. Google earth pro engine was used to generate multiple point data file of the study area containing latitude and longitude of each point. Digital contour map of study area was generated using the coordinates obtained from Google Earth Pro Engine & processing with GPS Visualizer utility tool, TCX Converter 2.0 & Spatial analyst tool installed in ArcGIS 10.8 software.

METHODOLOGY

The following methodology was adopted to generatedigital contour maps based on different DEM interpolation methods using spatial analyst tool installed in ArcGIS 10.8 software (Fig. 2).

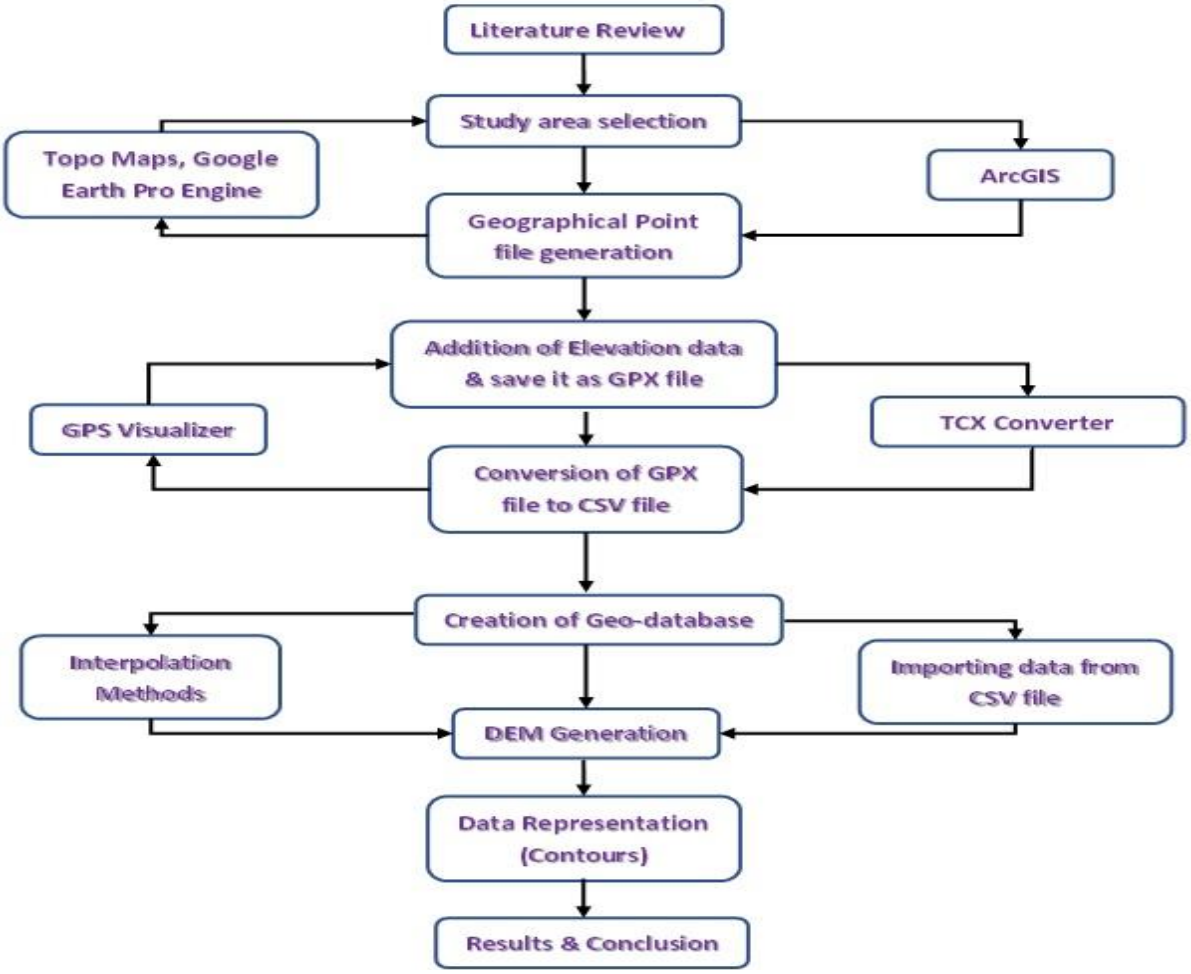

Fig. 2. Flow chart for adopted methodology

RESULT AND DISCUSSION

Different interpolation methods give different results when applied over the same geographic data points. The basic principle of interpolation is that it predicts cell values in a raster from a limited number of sample data points. Unknown values for any geographic point data, such as elevation, rainfall, chemical concentrations, noise levels etc can be predicted using the different interpolation methods according to the need(Childs 2004).

Table 1: Comparison of contours.

S No.	Type of Interpolation Used	Number of contours generated		
		0.2 m Interval	0.5 m Interval	1 m Interval
1.	Inverse Distance Weighted	1027	397	179
2.	Kriging	651	260	132
3.	Natural Neighbor	2897	1174	585
4.	Spline	1619	644	311

Comparative analysis of different interpolation methods

The investigations have shown that different interpolation methods give different numbers of contour lines when used over the same data points (Table. 1). The four interpolation methods used in the study were IDW (Inverse Distance Weighted), kriging, natural neighbour and spline. The IDW (Inverse Distance Weighted) tool uses the method of interpolation that estimates cell values by averaging the values of sample data points in the neighbourhood of each processing cell and 1027, 397, 179 contour lines were generated from contour interval of 0.2m, 05m, 1m respectively (Fig. 3). Kriging is an advanced geostatistical procedure that generates an estimated surface from a scattered set

of points with z-values and 651, 260, 132 contour lines were generated from contour interval of 0.2m, 05m, 1m respectively (Fig. 4) (Degen and Scholz 1998). The Natural neighbour interpolation finds the closest subset of input samples to a query point and applies weights to them based on proportionate areas to interpolate a value and results showed 2897, 1174, 585 number of contour lines were generated from contour interval of 0.2m, 05m, 1m respectively (Fig. 5). The Spline tool uses an interpolation method that estimates values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points and results showed 1619, 644, 311 contour lines were generated from contour interval of 0.2m, 05m, 1m respectively (Fig. 6) (Childs 2004). All the above contour results were generated using the same geographic data point file containing 4339 numbers of geographical point elevation data over the whole study area.

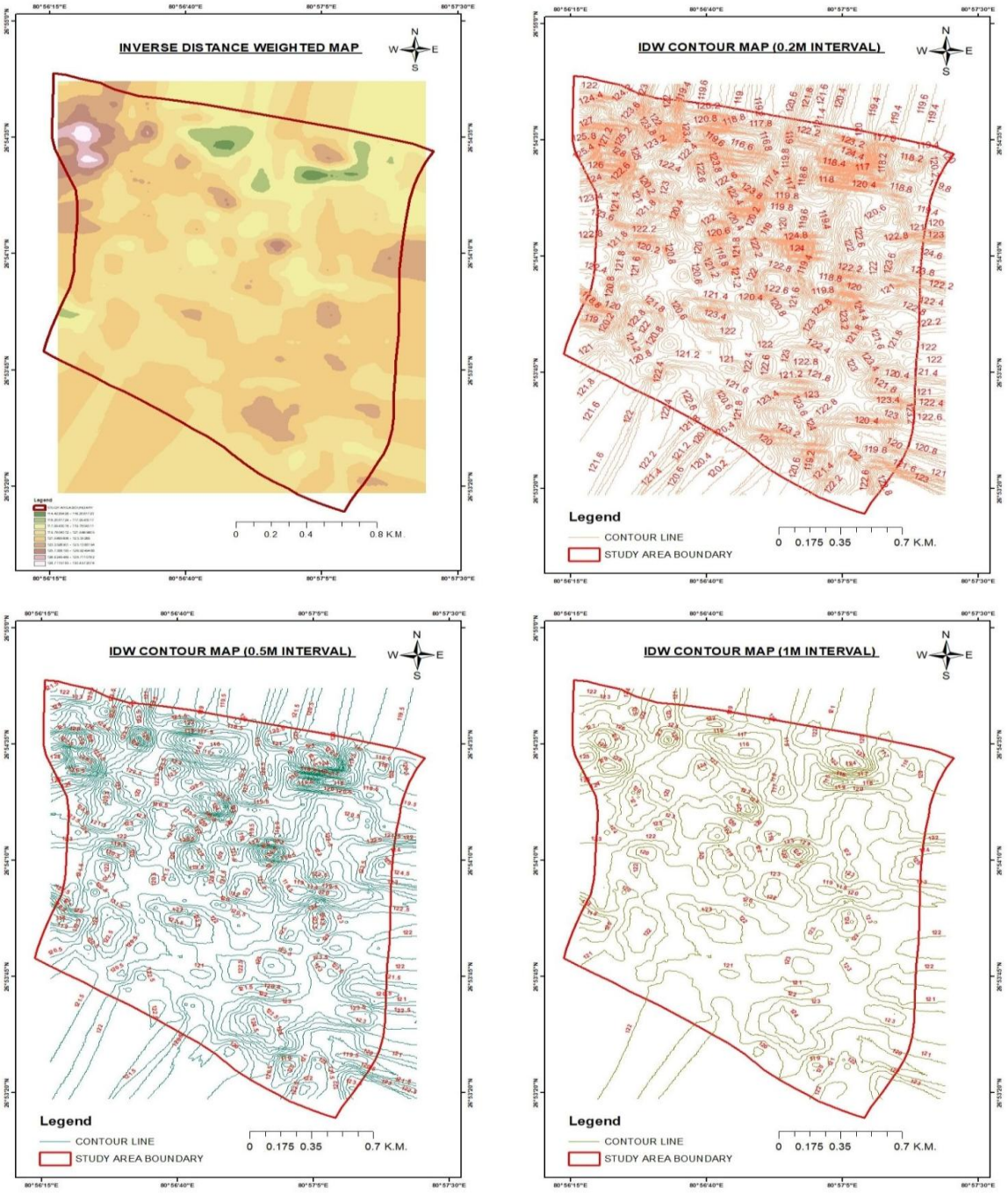

Fig. 3. DEM and contour maps generated using Inverse Distance Weighted Interpolation Method

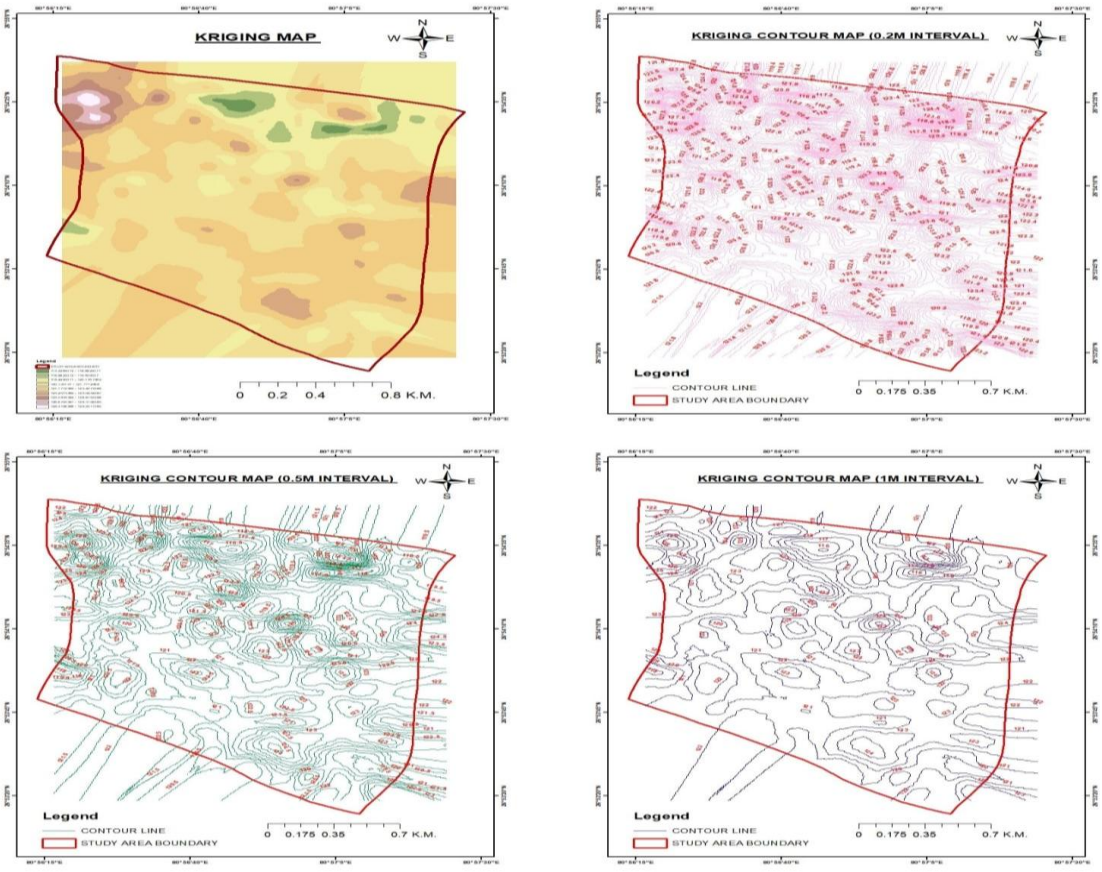

Fig. 4. DEM and contour maps generated using Kriging Interpolation Method

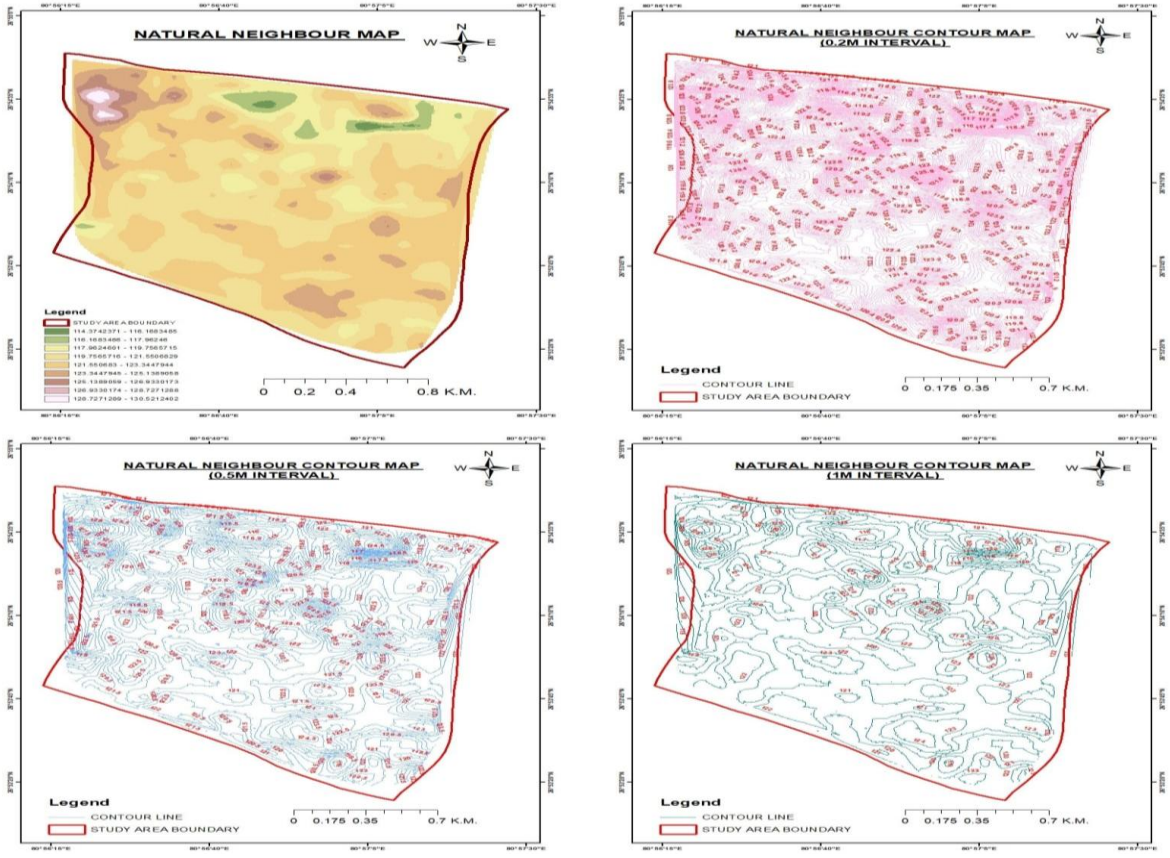

Fig. 5. DEM and contour maps generated using Natural NeighbourInterpolation Method

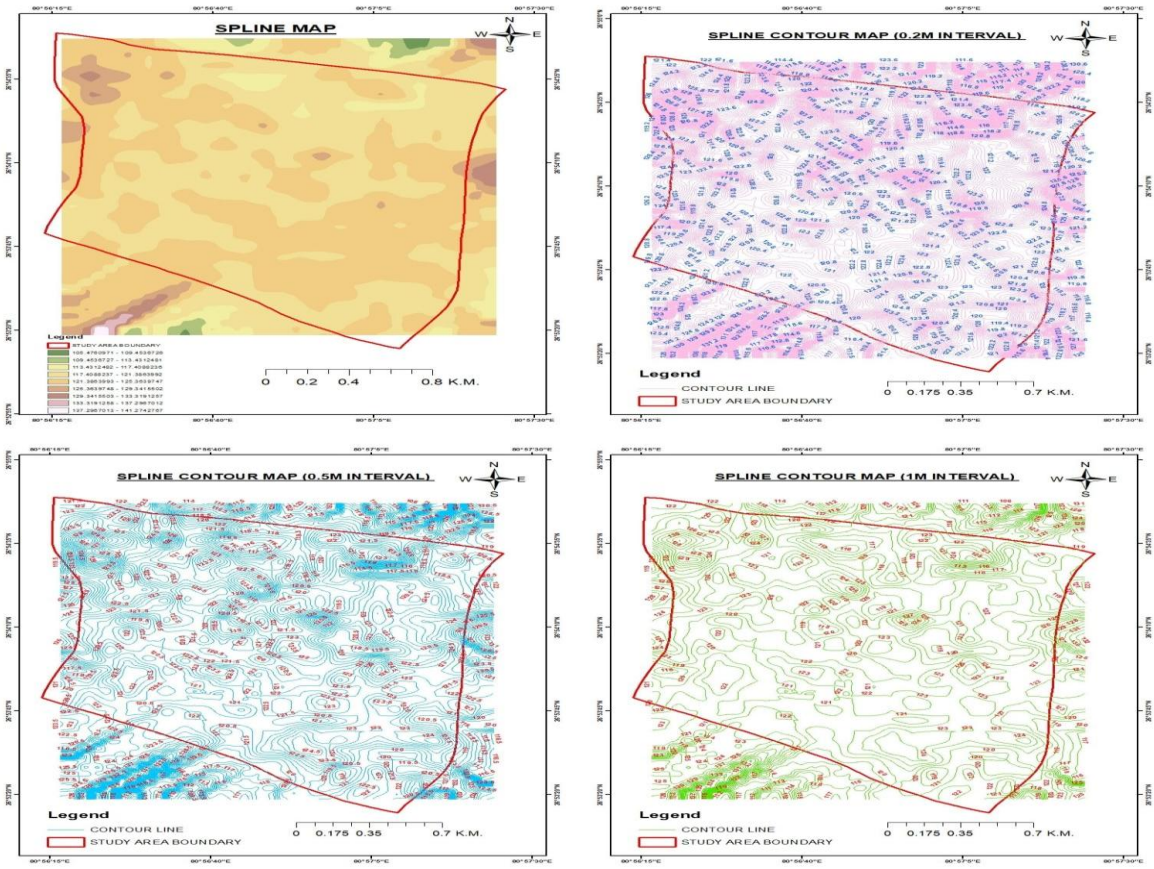

Fig. 6. DEM and contour maps generated using Spline Interpolation Method

CONCLUSION

Visual interpretation reveals that IDW (Inverse Distance Weighted) method gives better results as compared to other three interpolation methods for generation of DEM and digital contour maps as kriging, natural neighbour and spline methods result in irregular shape, size and pattern of contour lines. DEM and digital contour maps generated using different interpolation methods for same geographic point data file gives practical idea about the elevation profile of the surface of earth which can be useful for Urban Planning, Civil Engineering and Remote Sensing and GISapplications for expeditious analysis instead of taking account of time consuming existing old instrumental DGPS or total station survey methods.

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