Cloud Publications
International Journal of Advanced Earth Science and Engineering
2017, Volume 6, Issue 1, pp. 492–499
ISSN: 2320–3609, Crossref: 10.23953/cloud.ijaese.236

Case Study **Open Access**

A Case Study: Morphometric Characteristics of Sub-Watershed (P-17) in Paras Region, Akola District, Maharashtra, India – using Remote Sensing & GIS

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Publication Date: 21 April 2017

DOI: https://doi.org/10.23953/cloud.ijaese.236

Abstract In this study, an attempt has been made to understand the morphometric characteristics of surrounding of Paras thermal power plant, using remote sensing and GIS techniques. The main objective of this study is to give priority for river sub-watershed (P-17) development by determining the morphometric parameters. This study involves drainage network delineation and morphometric parameters determination, using onscreen digitization on 1:50,000 topographic maps through GIS environs.

Keywords *Geographical Information System & Remote Sensing; Stream Order Map; GPS; Morphometric Analysis*

1. Introduction

Land is not easy to get resource in the earth planet and hence it requires intensive conservation, preservation and management actions. The prioritization of sub-watershed (P-17) is practical application for conservation and management of soil. The channel receives supply from the drainage basin. The two purposes are fulfilling by morphometric analysis of drainage basins. It provides a classic description of the landscape. It also helps in comparing the form and process of drainage basins that may be widely apart in space and time (Easthernbrook, 1993). A great step forward was made by Horton (1932), moved further, previous works and added new measures and proposed general methods for the description of drainage basins characteristic. The drainage basin has shown temporal and spatial variation in morphometric characteristics. Therefore, it seems necessary to investigate in detail of basin characteristics, form area to area and time to time. The reason is, the shape of a basin depending upon morphometric characteristics determine the processes operating in such a basin. The elevation varies from 270m to 290m above mean sea level. There are mainly two types of soil found in the study area, namely-Medium Black and Deep Black soil. The crops grown are Cotton, Pulses, Jowar, Oil seeds. Due to heavy rainfall, the eroded parts and also the grit act as erosive tool. These scrape the gullies in its course downstream. In the upstream, the management practices like grassing, plantation and a forestation are largely followed. Water management, both in its conservation and control aspects, has significantly benefited from satellite remote sensing inputs that has become an effective tool for a number of applications related to water resources development and management. Remotely sensed data enable us to inventorying of surface water resources through mapping of water bodies and study various hydrological processes and there by water balance with reasonable accuracy. Sub-watershed (P-17) assessment needs an approach that can handle complex problems but is easy, that is flexible consistent, can be applied at different spatial scales, and that can readily be translated into easily communicated descriptions related to management decisions (Khadrri, 2013).

2. Study Area

The area of study surrounds Paras Thermal Power Plant. It is bounded by latitudes 20^{0}47`N and longitudes 76$^{0}$45`E. It forms part of Survey of India Toposheet 55 D/13 and 55 D/14 with scale 1:50,000. It covers an area of 1283 sq/km. It falls in Akola district of Maharashtra State (Figure 1). According to the 2001 Census, there was 546 Gram Panchayat for the purpose of Management. The main crops grown in the district are Jowar, Wheat, Cotton, Tur, and Mung. The two main rivers of the district are the Purna and the Penganga, the other less important rivers being the tributaries of these two rivers. Purna River is the main river passing through the study area. Others are tributary to this river, such as Mun River, Man River and Bhikund River. The Bhikund is closest river to the study area. The Bhikund river confluence to the Man River. It is flowing SE zone. The NH-6 national highway is closest to the study area. After its confluence with the Bhuikund, the Man is crossed by the Bombay-Nagpur railway line over a bridge which is south-east of Nagjhari railway station.

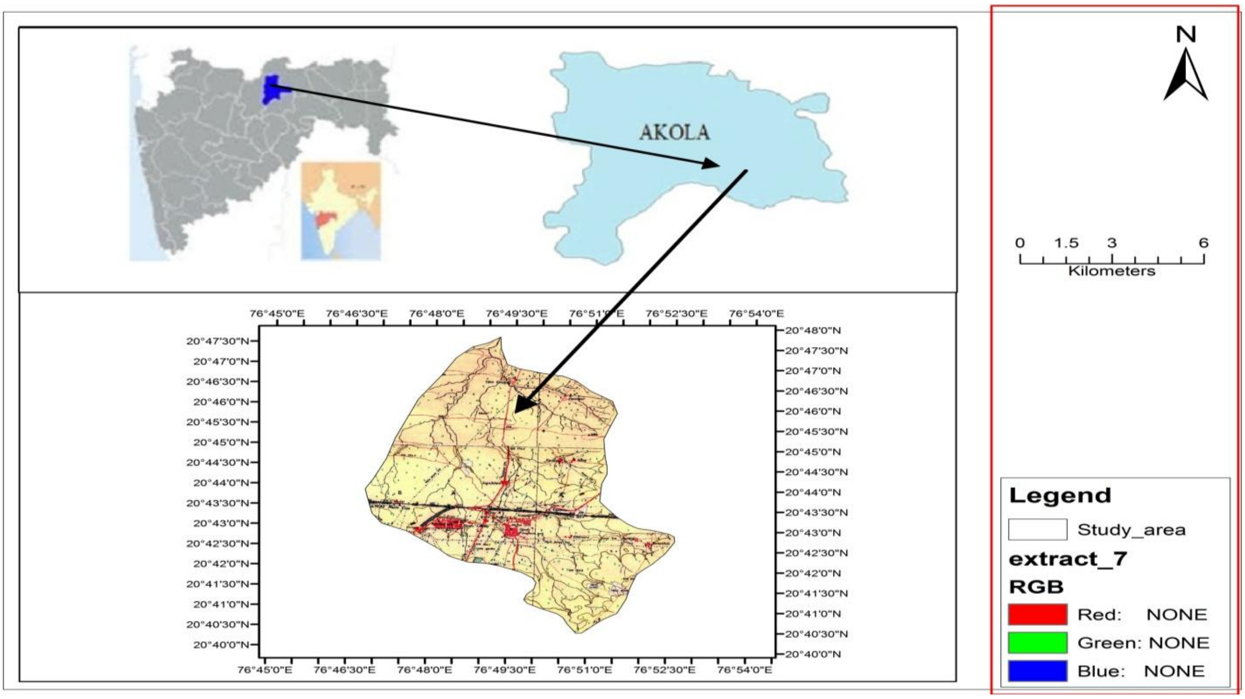

Figure 1: *Location map of the study area*

2.1. Climate

The climate of the district is characterized by a hot summer. General dryness prevail throughout the year except during the south-west monsoon season. The period from about the middle of November to the end of February constitutes the winter season. The summer season extends from March to June. This is followed by the south-west monsoon season which extends up to the end of October. (Khadrri, 2013).

2.2. Rainfall

The average annual rainfall of the district is 846.5 mm (33.33"). The rainfall during the monsoon months constitutes about 85 per cent of the annual rainfall.

2.3. Temperature

Temperature rises rapidly after half of January till May which is the hottest month of the year. In May, the mean daily maximum temperature at Akola is 42°C and the mean daily minimum temperature is 27°C. Days are hot in the summer season and the nights are comparatively tolerable. During the period from April to June the maximum temperature, may be about 46°C or 47°C. The weather becomes pleasant with the arrival of the south-west monsoon in the district by about mid-June. The day temperature increases gradually after the withdrawal of the monsoon. On the other hand, night temperature decreases progressively after September. From October till December, day and night temperature decreases rapidly.

2.4. Humidity

The air is generally dry over the district, except during the southwest monsoon season. During this season the humidity is between 60 to 80 percent. The relative humidity is even less than 20 percent in the afternoons on summer days.

3. Research Method

This work is based on map analysis carried out by onscreen digitization. Toposheet number 55 D/13 and 55 D/14 with the scale of 1:50,000. (Survey of India) were mosaic to subset the study region. The subset image is geometrically corrected through the process of georeferencing.

4. Results and Analysis

The result of the work has been presented in the following section and discussion of each item of result has been done simultaneously. Morphometric analysis of Paras region sub-watershed (P-17) tributary has been carried out quantitatively including linear, aerial and relief aspects. In the linear aspects are calculated in various morphometric parameters, such as stream order (μ), stream number (Nμ), stream length (Lμ), and bifurcation ratio (Rb); presented in Table 1. Figure 2 shows the drainage network as well as stream numbers. The areal aspects of the drainage basin are perimeter, geometric shape of basin, drainage density (Dd), Stream Frequency (Fs) and drainage texture (Dt). The relief aspect is altitude determine by TIN networks creation and ground slope as presented in (Figure 4 & 5). Strahler's, Horton's and Schumm's methods have been employed to assess the fluvial characteristics of the study region (Horton, 1945; Strahler, 1964). The maps were georeferenced and digitized using the Arc GIS 9.3 and ERDAS Imagine 9.1 GIS software's and attributes were assigned to create the digital database.

4.1. Drainage density (Dd)

According to Deju A., Raul (1971) Drainage density is the ratio of total length of all the streams in the sub-watershed (P-17) to the area of sub-watershed. It helps in determining the permeability and porosity of the sub-watershed and an indicator of landform elements in stream eroded topography. Thus, it concludes that the drainage density increase with the decrease in areal coverage and the soil moisture in the region remains more. Similarly, as the drainage density decrease the area of the intra basin increase and soil moisture decreases.

The drainage density of the Paras sub-watershed basin is 3.37. High drainage density is the result of weak or impermeable surface materials, sparse vegetation, and mountainous relief. Low drainage density leads to coarse drainage texture (Strahler, 1964). As per Drainage map the area shows low drainage density and drainage texture is coarse. The simplest way to calculate drainage density on a regional scale is to divide the basin into grid squares of one square mile or one square kilometer each and to measure the total stream lengths in each grid square.

4.2. Stream Frequency (Fs)

Stream frequency or drainage frequency (Fs) is the total number of stream segments of all orders per unit area (Horton, 1932). The stream frequency value of the basin is 0.40.

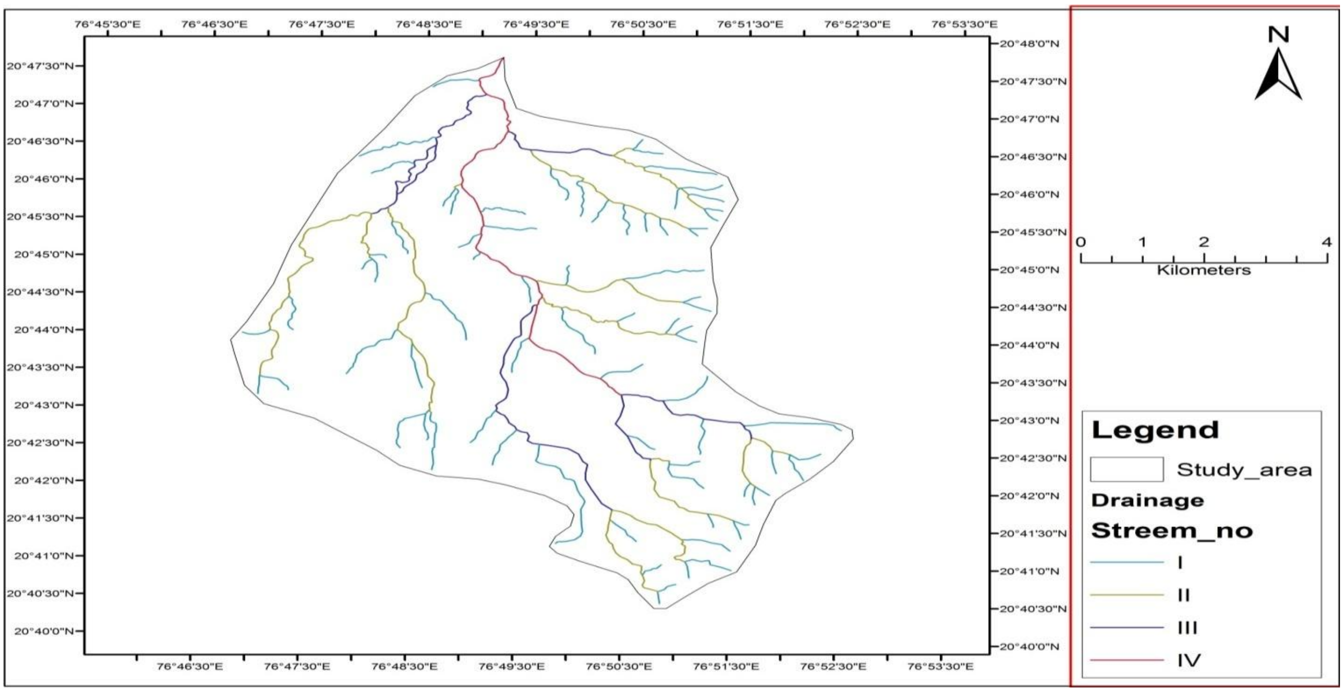

Figure 2: *Drainage Map of the study area*

4.3. Drainage texture (Dt)

Drainage texture is defined as the total number of stream segments of all orders per perimeter of that area (Horton, 1945). Drainage texture in the area is coarse.

4.4. Bifurcation Ratio (Rb)

The bifurcation ratio is the ratio of the number of the stream segments of given order 'Nu' to the number of streams in the next higher order (Nu+1), Table 1. Horton (1945) considered the "bifurcation ratio as index of relief and dissections and demonstrated that bifurcation shows a small range of variation for different regions or for different environment except where the powerful geological control dominates". It is observed that the Rb is not same for one order to its next order (Schumm, 1956). These irregularities dependent upon the geological as well as lithological development of the drainage basin (Strahler, 1964). The bifurcation ratio is dimension less property and generally ranges from 3.0 to 5.0. The lower values of Rb are characteristics of the sub-watershed, which have suffered less structural disturbances (Strahler, 1964) and the drainage pattern has not been distorted because of the structural disturbances (Nag, 1998). In the present study, the higher values of Rb indicate strong structural control on the drainage pattern.

4.5. Stream Length (Lu)

A stream length supports the theory that geometrical similarity is preserved generally in sub-watershed of increasing order (Horton, 1945). Author has computed the stream length based on the law proposed by (Horton, R.E. 1945), Table 1. It is observed that stream length is maximum that is 163.12 for second order streams.

Stream Order	Number of Stream	Bifurcation Ratio	Length of Stream (km)
1	76	5.07	54.07
2	15	03	163.12
3	05	05	12.89
4	01		10.45
Total	97	13.07	240.53

Table 1: *Stream order and number of streams*

4.6. Generation of contour map

Contours are imagery lines of joining points of equal elevation. The elevation points were prepared from SRTM data. All individual projected values in maps were finally merged as a single layer. The contours were with an interval of 10m. The contour attribute table contains an elevation attribute for each contour line (Table 2). The contour map was prepared using Arc Map of ArcGIS 9.3. Contour map is a useful surface representation to enable, simultaneously visualize flat and steep areas, ridges, valleys in study area (Anji Reddy, M 2001).

4.7. Contour Map

A contour map is a map illustrated with contour lines. Area shows three contours with 10 meter interval having value 270 meter, 280 meter, 290 meter. The gradient between 280 and 290 contour is steep while that between 270 and 280 is gentle (Figure 3*).*

4.8. Slope Map

In Figure 4 shows*,* a shaded relief map of the study region prepared using 3D analyst extension of Arc GIS 9.3 software. It works as a model and simulates how the terrain looks with the interaction between sunlight and surface features. A mountain slope directly facing towards sunlight will be very bright as well as a slope opposite to the light will be changed. The analysis reveals that the south eastern part of the study region is hilly and undulating as compare to north part.

4.9. Triangular Irregular Network (TIN)

A Triangular Irregular Network (TIN) is a raster representation of a continuous surface, usually referring to the surface of the earth. The TIN map is used to refer specifically to a regular grid of spot heights (Anji Reddy, 2001). It is the simplest and most common form of digital representation of topography (Figure 5).

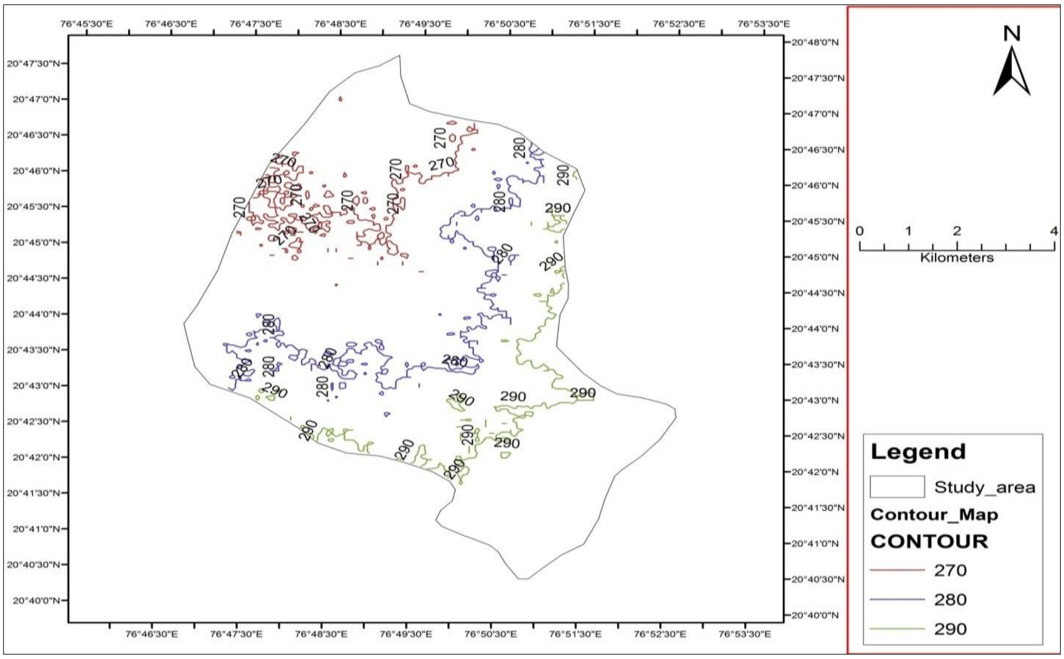

Figure 3: *Contour map of the study area*

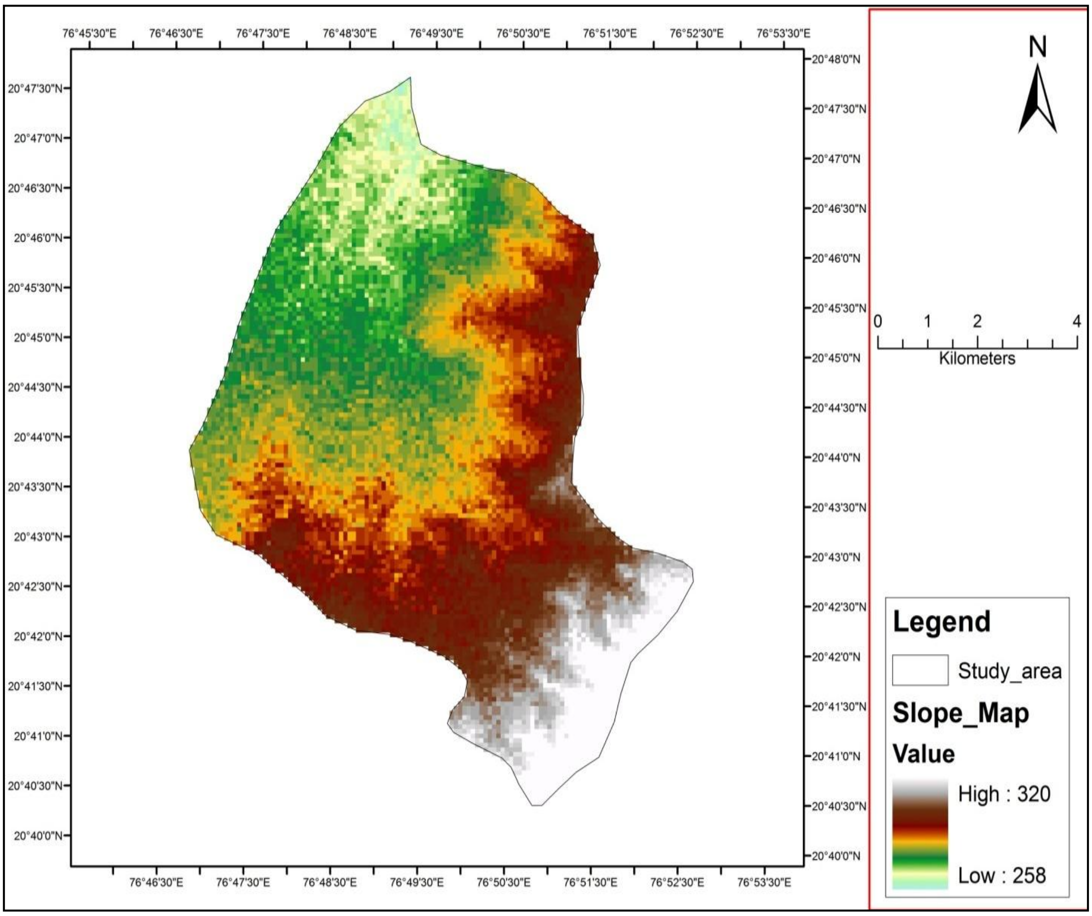

Figure 4: *Slope map of the study area*

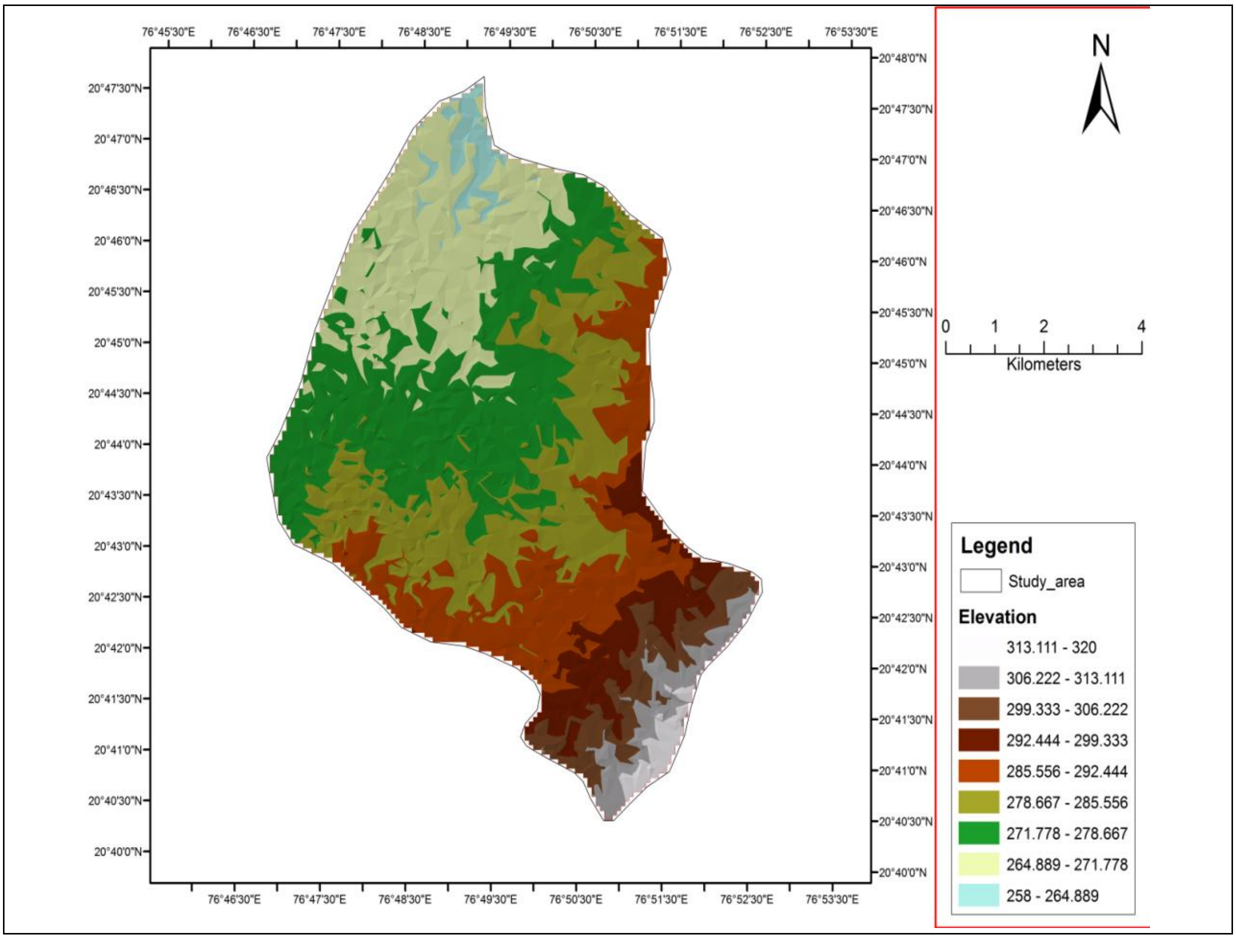

Figure 5: *TIN map of the study area*

5. Conclusion

This study, attempts to understand morphometric characteristics of area surrounding Paras thermal power plant, using remote sensing and GIS techniques. The drainage network delineation and morphometric study were done using on screen digitization on 1:50,000 topographic map through GIS environment such as ArcGIS 9.3 software. Stream frequency value of the basin is 0.40 in the present study. The higher value of Rb indicates strong structural control on the drainage pattern. It is observed that stream Length is maximum i.e. 163.12 km for second order streams. Area shows three contours with 10 meter interval having value 270 meter, 280 meter, 290 meter. The gradient between 280 and 290 contour is steep while that between 270 and 280 is gentle. The underlying exposed rock is predominantly basaltic. A little hilly structure is seen in the South-East Region. As per Drainage map the area shows low drainage density and drainage texture is coarse this indicate permeable surface material dense vegetation and gentle relief. The drainage is flowing from SW to North. Drainage density is slightly higher on NE side of the basin while it is low on NW side. TIN Map is the 3-D presentation of the surface derived by the interpolation of contour map. It represents x, y and z-axes in pixel size of the order 23.5 meters. The altitude or z axis ranges from 258 meters to 320 meters above sea level. Most of these criteria suggest good ground water resource.

Acknowledgment

We are very grateful to Principal of Shri Shivaji College of Arts, Commerce and Science, Akola (MS) for constant motivation and support. We are thankful to Dr. N.R. Kokate, Shri. G.L. Taker and Ms. Sonal Thorat for their time to time help and suggestions. We are also thankful to Shri J.R. Thokal, for his help in typing work.

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