SPATIAL ANALYSIS OF RELIEF CHARACTERISTICS IN KONDAGAON DISTRICT (CHATTISHGARH, INDIA) – A STUDY BASED ON REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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Abstract

A study is carried out to evaluate the terrain characteristics at micro level using high resolution satellite data. ASTER GDEM satellite data is used to extract the relief characteristics of the study area. Morphometric characteristics of the study area are extracted using $5km^2$ grid area. The highest slope in this region is recorded as 52.13degree. A 30 meters contour interval map was generated and high average relief is discernable in north-eastern and south-western part of the study sites (>676.81 meters). The relative relief in the study site is ranged from 52.75 – 374.95 meters. Very high dissection index (>0.27) is well marked northern and southern part of the study site. Higher drainage density was found in the north-eastern, central and southern part of the study site, while the lower drainage density (<0.20 per km^2) was delineated eastern and northwest part. The information obtained in the present research may aid in agricultural development in the study area.

Keywords: Terrain, Morphometry, Satellite data

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Introduction

Relief characteristics are one of the governing factors in the human environment as it influence on pattern and density of agriculture (Rasouli et al., 2009; Real et al., 2003). The natural geomorphological forms are created by different surface natural agencies and their impact on considering area. The topographic sheets are not always available with good horizontal and vertical resolution especially in remote areas such as Chattishgarh, India. Hence, studies related to variation of spatial variation of morphometric parameters are very few (Naithani and Rawat, 1990, Singh, 1972). The employ of space-borne satellite data and Geographical Information System (GIS) techniques in terrain analysis have appeared as dominant tools in current years predominantly for remote areas. Recently, Earth-Observation (EO) satellite data and GIS technology have been efficiently worn to figure terrain morphometric characteristics by considering the relief parameters at a larger spatial scale. With the free availability of Digital Elevation Model (DEM) from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM), the topographic inventory parameters can now be calculated (Nikolakopoulos et al., 2006). The information obtained from this study may aided in indulgent the hydrological, geological and topographical characteristics. However, in the previous research work, it is suggested that ASTER DEMs is the most appropriate for the calculation of topographic information (Bolch, 2004; Huggel et al., 2008; Colosimo et al., 2009).

Kondgaon district in Chattisgarh is economically very poor. Tribal agriculture in this region being still in a reluctant stage is a low productive endeavour. Furthermore, the region is more undulating and dissected. The region is drained by the tributaries of the river Indravati (a tributary of river Godavari). Most of the part in this region is covered by forest. Furthermore, the agricultural land is not only inadequate in area but its productivity is also stumpy. It may be due to undulating terrain and presence of gravels and pebbles in the soils (Mohammad, 1992). Hence, in the present study, we evaluated the terrain characteristics at micro level using high resolution satellite data and Geographical Information Technology to delineate the topographic characteristics. This information may aids to make the strategic plan for the land planners to improve the agricultural development in region.

Study area

Kondagaon District is lies between from 19º13’28.23” N to 20º10’ 23.65” N latitude and 81º17’ 11.92” E to 82º03’09.89” E longitude (Figure 1). The average elevation of the region is 593 metres. As per 2001Census of India, Kondagaon had a population of 26,772, out of which males constitute 50% and females 50% (Source: Census of India 2001: Data from the 2001 Census, including cities, villages and towns). The region is abundantly and richly endowed with forest resources. The region is characterized by the undulating topography, infertile soil, and low rainfall which restrict the scope of agricultural development. However, the origin of soil in Kanker is from Granite, Kneiss sand and Kheda. The climate of the study area is of predominantly a “Monsoon type”. May is the hottest month and December is the coolest month in the study site.

Materials and Methods

ASTER GDEM satellite data (ASTGTM – N20E081, ASTGTM2 – N19E082, ASTGTM2 – N19E081) is downloaded from the USGS Earth Explorer Community, which is in GeoTIFF format with 30 meters ground resolution. All these data were mosiced to cover the entire study area. The study area is extracted using the administrative boundary layer through area of interest (AOI) tools. To understand the relief characteristics, terrain analysis and morphometric characteristics has been performed. The average relief, slope and aspect analysis has also been performed in ArcGIS software. The Slope calculates the maximum rate of change between each cell and its neighbours. Every cell in the output raster has a slope value. The lower the slope value represents the flatter the terrain; the higher the slope value, the steeper the terrain (http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?-TopicName=Calculating_slope). Out if the various important morphometric characteristics, some important ones are selected for the present study, such as absolute relief, relative relief, dissection index, drainage density (Singh, 1974). Alternatively, to delineate the morphometric characteristics, the surface area has been categorized into 2 km^2 grid area. Clipping and subsetting method was used to extract the information of morphometric characteristics of each grid the study sites. Finally, second order polynomial interpolation technique is used to delineate the surface characteristics of the region. Drainage layer of the study area is obtained through heads-up digitizing method. Descriptive statistics is calculated for each morphometric characteristics in Microsoft Excel Spread sheet.

Result and Discussion

Absolute relief characteristics

Digital Elevation Model (DEM) was generated of the Kondagaon district to represent the relief characteristics of the study site (Figure 2). The lowest relief is recorded as 386 meters, represented in cyan colour on the map; while the highest relief (870 meters) is shown in white colour. The brown colour area on the map showed the medium elevation region. However, the highest elevation is recorded from the north-eastern part of the study site, while the lowest elevation was found in the small pockets of northern and southern corner of the study site. The green areas of the study sites represent the river valley region, with an elevation of approximately 400 – 500 meters. Most of this region is represented the undulating topography. The information delineated from the ASTER DEM is very much useful in delineating the terrain morphology, including the existence of erosion surface.

Slope

Slope plays a significant role in the configuration of landscape, demonstrating the steepness of the land surface. However, slope of land persuades agriculture in diverse manners, like terracing, influences field pattern and indicates ground moisture. A slope map was generated of Kondagaon district in ArcGIS software to represent the steepness of land surface. On the basis of slope ranging from 0 – 52.13degree, the surface area is divided into 5 categories, like (i) gentle slope: < 2 degree; (ii) low slope: 2 – 5 degree, (iii) medium slope 5 – 10 degree, (iv) steep slope: 10 – 20 degree, and (v) very steep slope: >20 degree (Figure 3). The very steep to steep slope is portrayed in the northern and southern part of the study site. Most of the area is extended through less to medium slope. The less slope land can simply be utilized for agricultural activities if other necessary resources for it are presented.

Relief representation by Contours

Contouring, provides a two-dimension view of relief, is one of the best suited methods to characterize the relief features of an area. A 30 meters contour interval map was generated of the study area (Figure 4). The green line contour showed the lowest elevation of the study site; whereas, the red colour contours portrayed the highest elevation within the study site. However, the highest elevation was observed in the north-west corner and some small pockets of northeast and southeast corner of the study site. On the other hand, the lowest elevation was found in the northern and southern corner of the study area. Eastern and western side of the study sites represents medium to highest elevation. The results of our analysis also showed wherever the contours are closely spaced, the slope is steep, wherever they are far apart, and the slope is gentle.

Average relief characteristics

The average relief of each grid area is calculated separately and interpolated through second order polynomial interpolation across the entire study site. Based on the average relief characteristics of the study site, the entire district is categorized into seven regions using geometric interval (Figure 5). High average relief is discernable in north-eastern and south-western part of the study sites, with an elevation of more than 676.81 meters. Subsequently, the region with higher average relief is characterized by poorly irrigation, and lower degree of agricultural development. The average relief within the grid area is varied from 466.75 – 756.99 meters (mean±standard deviation – 620.24±41.32). On the other hand, low average relief is discernable (less than 548 meters) in southern part and small pockets of northern part of the study area.

Relative relief characteristics

Relative relief portrays the difference between the highest and lowest elevation of any region. The higher the relative relief represent the highest slope while lower relative relief illustrate erosion. The relative relief in the study site is ranged from 52.75 – 374.95 meters (mean±standard deviation - 131.23±58.86). The whole area is divided into seven categories based on the geometric interval of relative relief values, like (i) extremely low relative relief (<75.69 meters), (ii) moderate low relative relief (75.70 – 83.45 meters), (iii) low relative relief (83.46 – 97.16 meters), (iv) moderate relative relief (97.17 – 121.39 meters), (v) high relative relief (121.40 – 164.23 meters), (vi) very high relative relief (164.24 – 239.95 meters) and (vii) extremely very high relative relief (>239.96 meters). The absolute and relative relief correlated statistically, illustrated that the coefficient of correlation value of +0.58. This low relative relief designates that the region is almost flat land and appearing mature stage of geomorphic evolution. It might be accredited to the bang of various upheavals particularly, and the upliftment of this area causing it rejuvenation. However, the maximum relative relief value is calculated northern and southern part of the district. Conversely, the lowest relative relief is found in the central and eastern corner of the district (Figure 6). Furthermore, the region with high relative relief is noticeably undulated in nature, whereas physical constraints hinder the agricultural development in various ways and different stages of variation (e.g. small size of agricultural plots, high soil erosion etc). Thus, the area extended with lower relative relief proposes that if accessibility of water is made, the region can be rehabilitated to a very good agricultural region.

Dissection Index

Relative relief is not satisfactory as a criterion of natural relief, on the basis of the fact dissection index is calculate of the study area which is the ration between relative relief and absolute relief. The value of dissection index is varied from 0 (complete absence of dissection) to 1 (vertical cliff). The dissection index value of the study area is varied from 0.08 – 0.49 (mean±standard deviation – 0.19±0.08). The entire study area is separated into seven categories based on the geometric interval of dissection index values, like (i) extremely low dissection index (<0.10), (ii) moderate low dissection index (0.10 – 0.12), (iii) low dissection index (0.12 – 0.14), (iv) moderate dissection index (0.14 – 0.16), (v) high dissection index (0.16 – 0.19), (vi) very high dissection index (0.19 – 0.27) and (vii) extremely very high dissection index (>0.27). The areas of low dissection index category are mainly confined in the central part of the study area, while very high category is well marked northern and southern part of the study site (Figure 7). However, this minimum value of dissection index recommends that the erosion of river is very less and the total area is mounting towards the mature stage of development in the cycle of erosion.

Drainage density

Another aspect of dismantling the relief characteristics goes with the study of drainage density, demonstrated the channel length per unit area. The density of drainage of the study area is divided into nine categories (Figure 8). Higher drainage density (>0.85 per km^2) was found in the north-eastern, central and southern part of the study site, while the lower drainage density (<0.20 per km^2) was delineated eastern and northwest part of the study area. The low density of drainage is due to structural control and poor supplies of rain water have restricted the branching of the rivers and their tributaries (Singh, 1980).

Conclusion

Based on the automatic morphometric analysis using ASTER DEM, results showed that high absolute relief area comprises on the north western part of the district. Spatial distribution of relative relief in the study sites indicates asymmetrical distribution. However, the low relative relief area may be attributed to the agricultural land by developing the irrigation system to improve the agricultural productivity. Low value of dissection index is observed in almost whole river valley apart from few places at downstream and at intersection of the tributaries with main stream. The dissection index value shows the erosion of river is very less and the entire study area is budding towards the old stage of development in the cycle of erosion. The slope of the study area ranges from a steep slope in the northern and southern part with a very limited area to gentle slope in the central and eastern part of the district. The drainage density of the study area shows that maximum portion of the block is having significantly moderate to good amount of available surface water resources. But maximum time of a year the water body remains dry, it may be due to the less amount of rainfall and higher elevation that influences the local slope of the topography.

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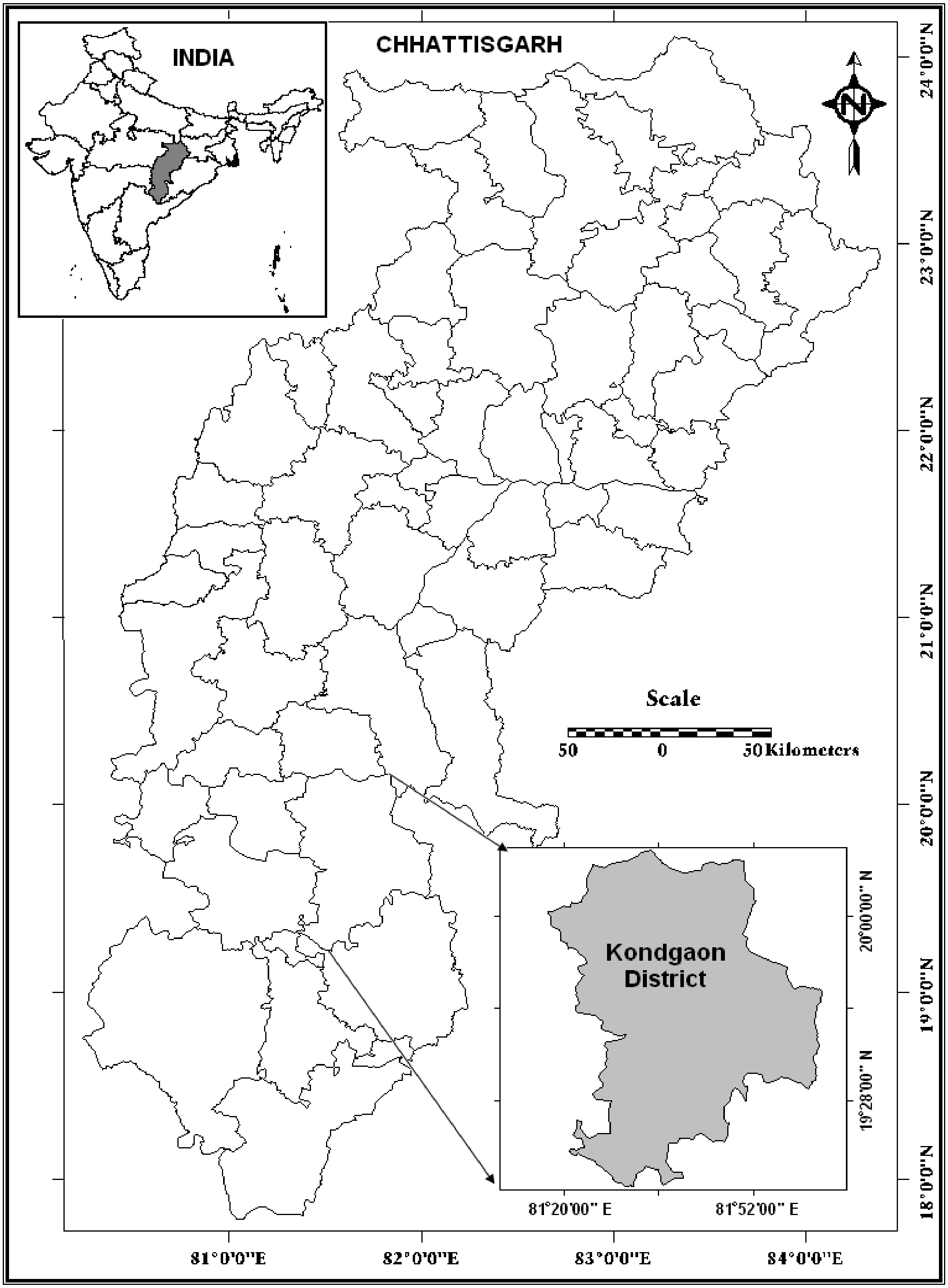

Figure 1: Location map of the study area

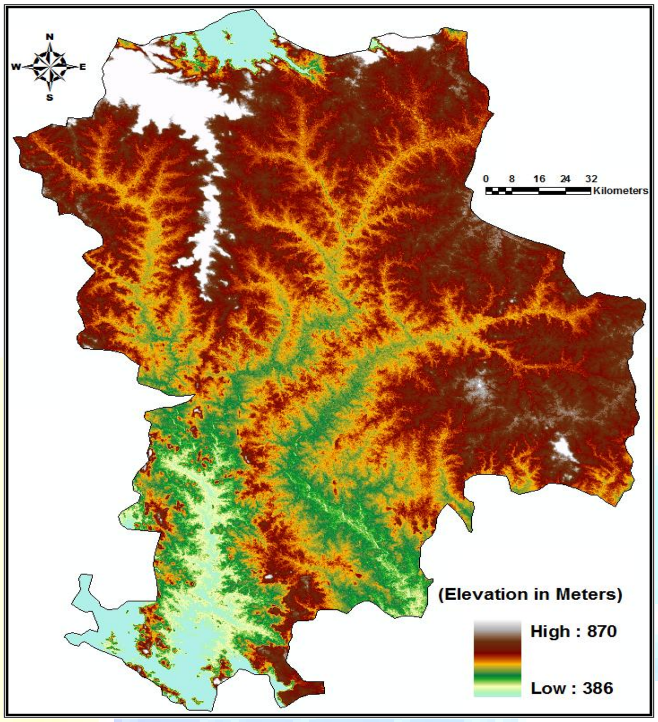

Figure 2: Absolute relief characteristics Kondagaon district using ASTER GDEM data.

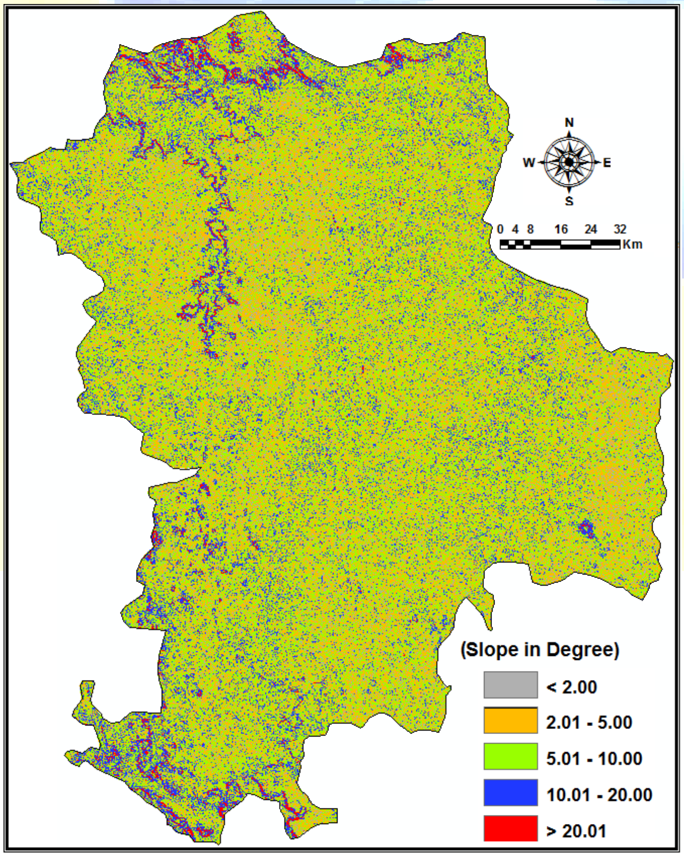

Figure 3: Slope of Kondagaon district using ASTER GDEM data.

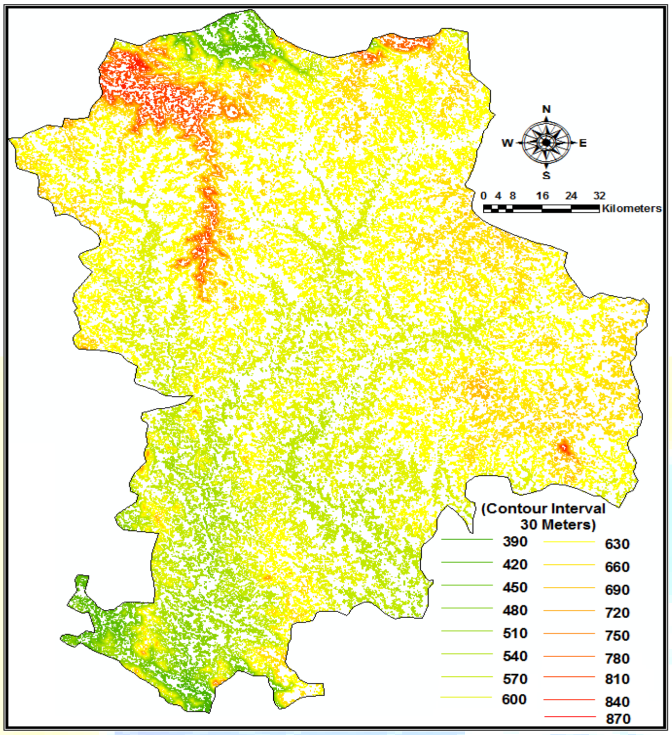

Figure 4: Contours of Kondagaon district using ASTER GDEM data.

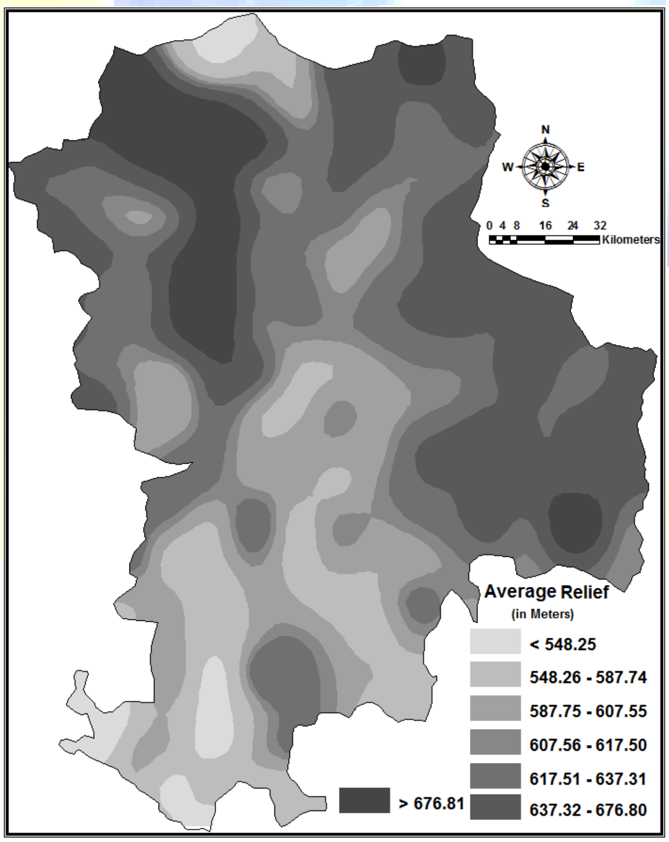

Figure 5: Contours of Kondagaon district using ASTER GDEM data.

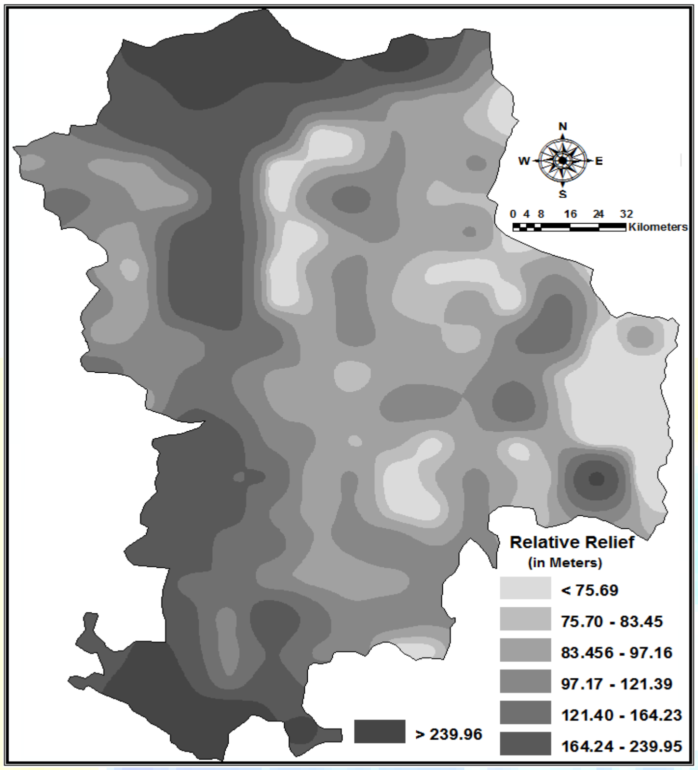

Figure 6: Relative relief of Kondagaon district using ASTER GDEM data.

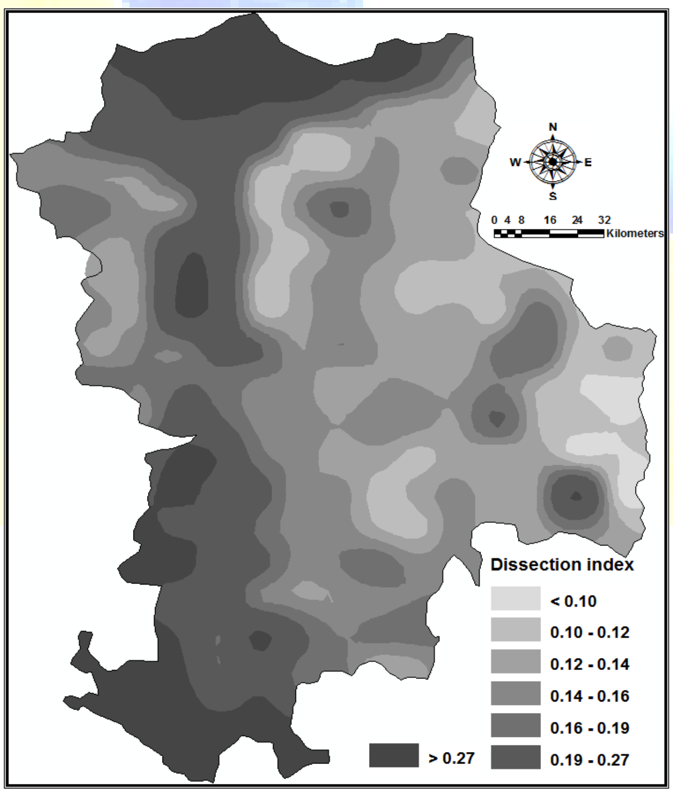

Figure 7: Dissection index of Kondagaon district using ASTER GDEM data.

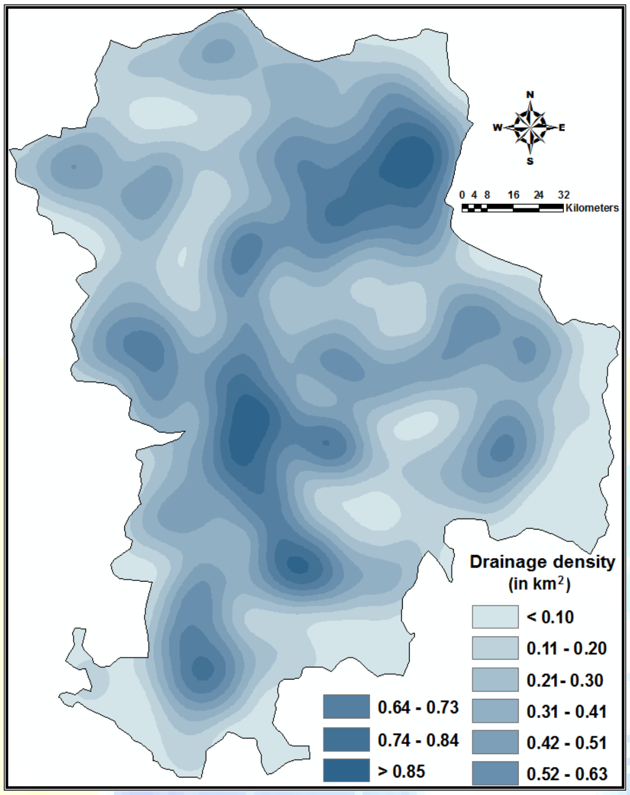

Figure 8: Drainage density of Kondagaon district using ASTER GDEM data.