International Journal of Geography, Geology and Environment

P-ISSN: 2706-7483
E-ISSN: 2706-7491
IJGGE 2021; 3(2): 117-120
Received: 18-04-2021
Accepted: 20-06-2021

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Study of morphotectonics in relation to Neotectonic Activity in parts of Tapi River Valley: A review

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Abstract
Morphotectonics refers to the study of short- and long-term superficial evidence of tectonic activity. The most sensitive parameters are the lineament, drainage, and relationship with structures those control its courses. Morphological analysis of topographic features, lineaments, has long been applied in structural and tectonic studies because the manifestation of the subsurface geology and structures are many times, well documented in the landform features of a region. In recent years, remote-sensing data have increasingly been used for the interpretation of objects and mapping in various applications of geology. Digital elevation model (DEM) is very useful for detection, delineation, and interpretation of geological and structural features. Use of DEM data by enhancing objects using digital-image-processing filtering techniques and extraction procedures of the linear objects performing in a semi-automated way. Study of Carto DEM of the area identified many linear structures across which large changes in elevation are seen. Such structures have dismembered the entire terrain in crustal blocks showing differential uplift. Moderate to Low seismicity of the area is manifestation of active tectonic status of the area. The study area (i.e. Some part of Tapti Lineament Zone) located within the Topo-sheets 55C/3, 55 C /4, 55 C /7, 55 C /8, 55 C /10, 55 C /11, 55 C /14 & 55 C /15 bounded by latitude $21^{O}00'00"$ to $21^{O}31'00"$ N, longitude $76^{O}00'00"$ to $76^{O}30'00"$ E and latitude $21^{O}15'00"$ to $21^{O}45'00"$ N, longitude $76^{O}30'00"$ to $77^{O}00'00"$ E. Covering the parts of Khandwa, Khargone & Burhanpur Districts in Madhya Pradesh and some parts of Amravati, Buldhna & Jalgaon in Maharashtra.

Keywords: Remote Sensing, digital image processing, digital elevation model (DEM), Carto DEM, lineaments

Introduction
Morphotectonics refers to the study of short- and long-term superficial evidence of tectonic activity. The surface expression of endogenous mechanism driving the tectonic activity is always represented by relative movements such as uplifting, subsidence and translation of the crust. The most sensitive parameters are the lineament, drainage, and relationship with structures those control its courses. Surface methods such as remote sensing and morphological analysis provide fast and relatively cheap information, complementary to classical field geology to study subsurface geology. Morphological analysis of topographic features, in particular lineaments, has long been applied in structural and tectonic studies because the manifestation of the subsurface geology and structures are many times, well documented in the landform features of a region. Numerous terms have been used to describe lineaments, e.g., geologic lineaments, tectonic lineaments, photo lineaments, fracture traces and photo linear or geophysical lineaments, based on the assumed origin of the feature or sometimes the data source from which it has been derived. The term lineament for significant lines of landscape caused by joints and faults, revealing the architecture of the rock basement also described as a mappable, linear feature of a surface whose parts are aligned in a rectilinear or slightly curvilinear relationship and which differ from the pattern of adjacent features and presumably reflect some subsurface phenomenon. In recent years, remote-sensing data have increasingly been used for the interpretation of objects and mapping in various applications of engineering geology. Digital elevation model (DEM) is very useful for detection, delineation, and interpretation of geological and structural features. The use of image elements for interpretation is a common method to extract structural features. The extraction procedures of the linear objects are performed in a semi-automated way. Photographic elements and geotechnical elements are used as main keys to extract the information from the satellite image data. The application of DEM and usage of various filtering techniques with different convolution kernel size applied on the DEM.

Usefulness of DEM and satellite digital data for extraction of structural features like Faults, folds, and lineaments interpreted from remotely sensed data are often used as indicator of major fractures in near surface. Many researchers have mapped and interpreted the structure of a region based on the information extracted from aerial photographs and satellite images. Remote sensing provides plenty of information about the morphotectonic and active tectonic processes operating in a region. GIS technique provides analytical tool for study and analysis. The systematic digital terrain analysis procedure was designed to use various tools in combination to extract morphotectonic features and parameters from DEM. Study of CartoDEM of the area, where the presence of many linear structures across which large changes in elevation are seen. Such structures have dismembered the entire terrain in crustal blocks showing differential uplift. High seismicity of the area is manifestation of active tectonic status of the area.

The objective of this study is to understand the morphotectonic characteristics of Tapi Valley based on available seismic data by using Remote Sensing and GIS technology. This study is helpful to understand how seismic characters are related to the active tectonics in the study area, which is inferred based on remote sensing data with the aid of GIS technology.

Literature review

Jain *et al*. (1995) [2] had done a detailed study of SONATA for the project CRUMANSONATA. The study comprises various aspects (i.e., Geochemical, Geophysical, Structural etc.) in detailed for this project. Major portion of the Son-Narmada-Tapti (SONATA) lineament zone falls in the states of Maharashtra and Madhya Pradesh between Lat. 20º and 25º N and long. 73º and 84º E. The area comprises a wide variety of rock types ranging in age from Archaean to Recent. In the southern part of the area, a major curvilinear suture zone (Central Indian Suture Zone: CIS) with a general ENE-WSW trend has been identified during the investigation. It separates two distinct Precambrian crustal blocks to its north and south with distinctive litho-tectonic features Raju *et al*. (2004) [7] suggested by their study that Morphotectonic features delineated in the Andaman backarc basin suggest a complex western and relatively smooth eastern part. Three segments characterize the backarc spreading ridge with distinct topographic and magnetic signatures in the southwestern and northeastern parts. The kinematics of the backarc basin evolution, derived from the identification of the sea floor spreading magnetic anomalies, suggest very slow opening rates of about 1.6 cm/yr. The study shows that the true sea floor spreading has commenced prior to about 4 Ma. The sea floor spreading phase involved westward propagation of the spreading rift. Pradhan *et al*. (2006) [6] have analyzed that Lineament of the Himalayan region has been carried out with the aid of IRS LISS-1 satellite image and by the application of various image processing techniques. The adaptation of this approach is straightforward without any major limitations. Although improvement in accuracy can be achieved by using higher resolution remote sensing data. Based on the present investigation the authors conclude that due to neotectonic activities the stress orientation of the study area follows a north-eastern trend. Singh and Srivastava (2010) have analyzed that the landforms and major structures of the terrains reveals that the tectonic histories of the two morphometric units are different at least up to certain stages even though the units are lying together. The whole pattern of study of the landforms across the SNSF which is southern boundary limit of the Son-Narmada Tapti Lineament Zone suggests that the Son Narmada Lineament zone is not just a simple rift valley as it is generally referred in the literature. It has got a prominent strike slip component that has caused sinistral shearing of the rocks in the Lineament Zone. The most likely bounding domain of the shearing with coupler forces seems to be the south bounding SNSF and north bounding Son Narmada North Fault (SNNF). This shearing movement is difficult to identify by conventional geological mapping because the rock types on either side of the SNSF or SNNF are entirely different. Hence no marker bed or horizon is available for identification or measurements of strike slip movement of the fault. However, present study using remote sensing techniques is clearly able to recognize the sinistral type of shearing in the study area based on landforms characters and underlying structures. The study also explains the contrasting difference in the landform characteristics in the study area is due to underlying structures between the morphotectonic units. Pirasteh *et al*. (2011) [4] compared the filtering techniques on DEM and suggests that the high pass filtering with 9×9 convolution kernel size is reliable to be used for the detection of geo structural features. Furthermore, the comparison between high-pass filtered DEM and ETM+ Landsat with band-4 infrared indicates that the combination of both raster data makes it powerful and strengthens the ability to have a semi automated interpretation. The information extracted from the ETM+, DEM, and field observations have been merged in GIS environment and produced a structural map for future geo engineering application purposes. As a conclusion, study shows the advantages of the remotely sensed data and GIS techniques for detecting the linear features by using semiautomatic filtering techniques. It also reveals that the DEM can be a very useful tool for the study of geomorphology within the GIS environment. Similar studies can be adopted for different study areas with mountainous topography. Masoud and Koike (2011) [4] suggested that the methods employed in the study provided a complete framework for characterizing the tectonics and geodynamics of the Sinai Peninsula. Spatial and statistical analyses of lineaments extracted from SRTM 90-m data successfully identified the prominent tectonic trends and the relative strength of dominant tectonic regimes. Prominent trends and faulting styles provided important clues for the timing of their development as well as a structural inheritance model. The pattern of the lineaments on the surface represents not only the overprints of the deep tectonic structures, but also the results of the interaction between inter- and intra-plate forces dominant throughout its geodynamic evolution. The accurate mapping, therefore, integrating modern digital technologies combined with the reference geological and structural data can improve the exploration process, in terms of cost, accuracy, and time. Ramu *et al*. (2013) [8] studied of morphometric analysis of Tungabhadra using GIS retrieved that, Geographical Information System helps the researchers to analysis the drainage basin easily and accurately. The study of linear aspects of drainage basin result shows that, the basin has been formed in dendritic pattern with fourth order stream, plotting the logarithm of number of streams against stream's order shows a straight line which states the number of

streams usually decreases as the stream order increases. The result of relief aspect shows the study area is high relief and high stream density, the result of arial aspect shows the texture of drainage is moderate and the result of elongation ratio indicates the drainage is high relief and steep ground slope. Dikshit and Patil (2013) [1] found DEM analysis to be useful to recognize and demarcate three distinct trends of lineaments and three geomorphic subzones in the Lanja region from southern KCB. Three subzones from west to east are Dissected Tableland (DTL), adjacent to coast, Low Relief Lowland (LRL), at middle and Escarpment Foothill (EFH). TPI and terrain generalization image analysis also supports in demarcation of geomorphic subzones. The demarcated subzones are fault bounded blocks related to the uplift, subsidence, and tilting. The variation in elevation, relief, slope, gradient, drainage and landform patterns, degree of dissection etc. in these three subzones are as a result of tectonic activity responsible for the development of half graben structure**.** Parseeda *et al*. (2015) [5] discussed in their study that the southern Peninsular India is crisscrossed with several lineaments and crustal scale structures. There are also incidences of sporadic low-level seismicity in the region. ASZ is one of the structures in Peninsular India. This 15-20 km wide zone has a number of parallel lineaments extending over 120 km strike length. Even though the signature of Achankovil shear zone system is identified area east of Western Ghats till the coastal region were not identified earlier. The observations from this study suggest that the geomorphic expressions of Thenmala lineaments represent the youngest deformation (brittle) of the region and highlights that a detailed field investigation can identify tectonic features that were reactivated, which will help in evaluating neotectonics. Sharma and Sarma (2017) [9] analyzed the drainage basin morphotectonic indices and applied in assessment of the influence of tectonic activity on thirteen selected drainage basins of the streams having linear courses and flowing over two very prominent regional structure of northeast India, *viz*. the Belt of Schuppen and Dauki fault. Such analysis has been made to assess the influence of tectonic activity of these structures on the morphology of the drainage basin of those streams. Results of the analysis of the morphotectonic indices of the drainage basins infer that morphology of the both the streams and drainage basins have been influenced by the regional structures and the present tectonic status of these two structures varies from active to slightly active phase. The study also revelled that presently the state of tectonic activity is not uniform within the same regional structure and the Belt of Schuppen is relatively more active as compared to the Dauki fault. Kumar *et al*. (2018) [3] mapped and delineated the drainage basin of the Kalyani river, a tributary of Gomati river using Survey of India toposheets (1:50,000 scale) and remote sensing satellite data. The digitization, slope map preparation and statistical calculations have been carried out with the help of geographical information system (Arc GIS 10). The analysis of riverbank height 'r' (escarpment) and longitudinal profile of the river closely revels neotectonic activity at some locations in the basin. Srivastava and Kale (2018) [10] have been studied Purna River and its basin area using advanced techniques of remote sensing and geographical information system. Various quantitative measurements belonging to linear, aerial and relief aspects of the watersheds have been calculated and interpreted. The lineament study reveals that the main channel has a strong control of a major lineament, whereas certain tributaries bear minor reflections. In general, the density of lineaments is low in alluvial area as compared to basaltic terrain. Attempts have also been made for delineation of land use/land cover categories, paleochannels and soil types of the basin area. Comments have also been made on the inland groundwater salinity prevailing in the central alluvial part of the basin covering an area of 2900 km^2. Both shallow and deep aquifers experience low to high levels of salinity creating major socio-economic problem in the area.

Discussion and Conclusion

The literature review has several important purposes that make it well worth the time and effort. The major purpose of reviewing the literature is to determine what has already been done that relates to the topic. Previous studies provide the rationale for research hypothesis, and indications of what to be done can justify the significance of study. Another important purpose of reviewing the literature is to discover research strategies and specific data collection approaches that have or have not been productive in investigations of similar topics. Intensive Geochemical, Geophysical, Structural studies have been carried out in this area under the project CRUMANSONATA by Jain *et al*. (1995) [2]. As for the morphotectonic study using remote sensing techniques done so far for many of the areas but there is slight gap for the Tapi valley. So, in this study we are trying to fill up these gaps. In this study, Attempts have made to study morphotectonics in the context of neotectonic activity of tapi river valley area by considering the Indian remote sensing satellite data by using remote sensing and GIS approach. The satellite remote sensing has added new dimensions of this study. The main advantages of the remotely sensed data and GIS techniques are for detecting the linear features by using semiautomatic filtering techniques of the study area and provides improvement in accuracy straightforward without any major limitations.

Acknowledgment

We have collated a set of scientific papers where, for the sake of accessibility for the reader, we have largely restricted ourselves to the journal papers. Inevitably we had to select and hence some papers have been omitted as this is the nature of any review. We apologize to those authors whose papers have not been included. Discussions with various researchers in geologic remote sensing helped in shaping the discussion and conclusion section. We gratefully acknowledge the review of the anonymous referees.

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