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ISSN 0974-5904, Volume 08, No. 02

International Journal of Earth Sciences and Engineering

April 2015, P.P.222-225

Effect of Lineaments on Hydroelectric Project on the Chenab River near Raoli, Lahul Spiti, District, Himachal Pradesh, India using Geoinformatics- A case Study

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Abstract: It is known fact that geology and structural features i.e fold, fault, joints and lineament pattern of an area affect a great deal in selecting a site for hydroelectric project. In addition to conventional methods, remotely sensed data and topographic sheets provide detailed requisite information about these aspects. The paper deals with deriving geological and information about structural linear features. The basic objective was to find out the possible impact of lineaments on the upcoming hydroelectric power project on the Chenab river site in the vicinity of the upper Himalayas characterized by mountainous topography. The study area falls in toposheet number 52 D/5 at 1:50,000. The project involves construction of a diversion structure across the Chenab river about 2.5 km downstream of the confluence of the Gharal nala and the proposed powerhouse is located just upstream of the confluence of Raoli nala with the river Chenab near Raoli village, Lahul Spiti district of Himachal Pradesh, India. The lineaments studies were carried out using LADSAT 7 ETM+ satellite data of September 2000. The general trend of the rocks is NNE-SSW & NE SW. The common geomorphic features are deep steep rising hills with intervening dissected valleys. The rock type reported are Quartzite, phyllite, slate, schist and limestone of BATAL and MAZRI formations. The Chenab River flowing from south to north direction with dendritic to trellis type of drainage pattern. It is observed that one set of lineaments controlled the major river in the study area and general trend is towards NS. Another set of lineaments identified in structural hills, pediments and valley fill zones in the study areas are controlling the river channel and nallah. Lower order streams viz. first order and second order streams are controlled by lithology and shows typical sub parallel, parallel and dendritic pattern and interestingly meet river Chenab almost perpendicular in the study area. It is evident that major drainage is structurally controlled and could be in tune with Himalayan major deformation i.e trending NW and SE direction. ASTER data were used to create a DEM, which clearly brings out the elevation details of the study area. DEM was further used to prepare slope of the area to understand slopping pattern of the terrain for the proposed site. From the study it is concluded that existing geology and lineaments will pose no threat to the upcoming dam site.

Keywords: *Lineaments, Hydroelectric project, Chenab River, geoinformatics, LANDSAT ETM+ and ASTER*

1. Introduction

A case study was undertaken for upcoming Hydropower Project near Raoli village, Lahul Spiti for Larson and Toubro Ltd. It was desired to carry out lineament studies and prepare lineament map so as to understand their affect on hydropower project in the vicinity of the area. The map was to be prepared at 1:50,000 scale from remotely sensed data. For preparing base map SOI toposheet was used. Since Hobbs (1904) introduced the term lineament, it was used in different fields (e.g. petrology, geology and hydrogeology) as indicator for remote detection of the respective objects of interest. Lineaments can be identified using remotely sensed imagery based Tone, color, texture, pattern. The definition of lineament as given by O'Leary et al (1976) "is a mappable, simple or composite linear feature of a surface, whose parts are aligned in a rectilinear or slightly curvilinear relationship which differs distinctly from the patters of adjacent features and presumably a subsurface phenomenon". Phtotolineaments generally represent the surface traces of features in bedrocks, projected more or less vertically upwards.. Several studies have been reported in the literature about use of satellite data for lineament studies. Chirashree et al (2004), used satellite data for tectonic interpretation, NW Himalaya in conjunction with preexisting geological knowledge studies was also taken as an input. K. Ganesha Raj et al. (2001) carried out a- remote sensing based analysis of lineament and seismicity of Kerala. Kshitij Mohan et al (2007) studied pattern and genesis of lineaments in and Across Son-narmada lineament. Singh, L. G., Nathani, A. K et al (2013) carried out Geological, lineament and landslide studies

of the reservoir and its vicinity of Bunakha project, Bhutan Himalaya. The following procedures were followed to achieve the above objectives. The LADSAT 7 ETM+ satellite data of September 2000 were used for lineaments studies. Satellite data are Low-cost and have non-invasive approach. In addition Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data have been used for generating Digital Elevation Model (DEM) of the site for terrain analysis. DEM was further used to prepare slope map of the area to understand slopping pattern of the proposed dam site. Based on the study it final conclusions were drawn.

2. Study Area

The study area falls in the Lahaul & Spiti district of Himachal Pradesh on the river Chenab. The site of hydroelectric project is planned on Chenab River between the confluence of Gharal nala and Raoli nala. The project involves construction of a diversion structure across the Chenab river about 2.5 km downstream of the confluence of the Gharal Nala with the river Chenab and the proposed powerhouse is located just upstream of the confluence of Raoli nala with the river Chenab near Raoli village. The site is located at 76°26'30" E, 32°47' 20" N to 76°24', 32°50'N as shown in Figure1.

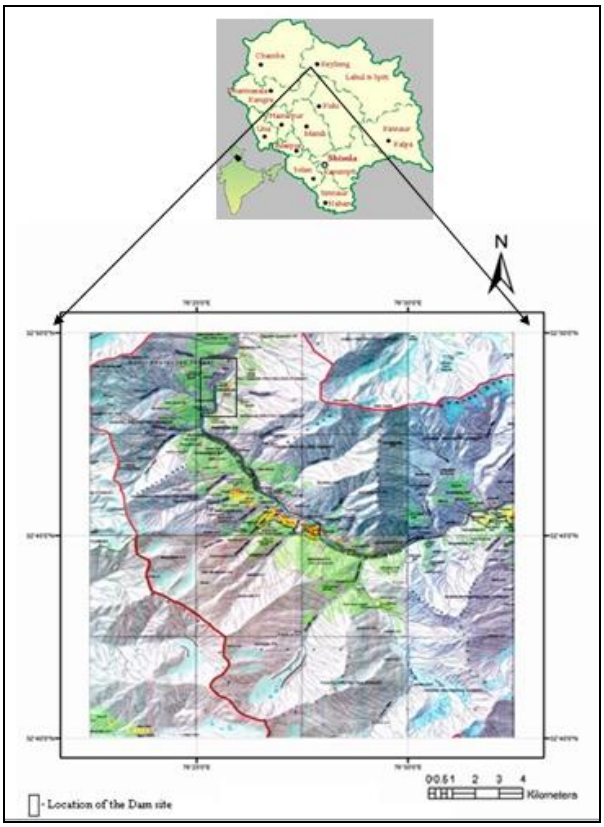

Figure 1 *Location map of the study area*

3. Methodology and Data Used

Area of interest was cut from the Survey of India toposheet 52 D/5 at 1: 50,000 to be used for preparing base map of the study area. Information on general topographic details i.e drainage, its direction, geomorphic units etc were derived from the SOI maps and satellite data. Digital scene of the study area of LANDSAT 7 ETM+ of September 2000 was used to demarcate lineaments for the study areas. Sensor employed in this study and its spectral and spatial resolutions of bands, quantization of the imagery are shown table 1.

Table 1: *Sensor attributes*

Sensor	Band	Spectral resolution (mm)	Spatial Resolution (m)	Quantization (bits)
LANDSAT 7 ETM+	1	0.450-0.515	30	8
	2	0.525-0.605		
	3	0.630-0.690		
	4	0.750-0.900		
	5	1.55-1.75	30	
	6	10.40-12.50	60	
	7	2.08-2.35	30	
	8 (Pancromatic)	0.53-0.90	15	

The first version of the ASTER GDEM, released in June 2009, were generated using stereo-pair images collected by the ASTER instrument onboard Terra. ASTER GDEM coverage spans from 83 degrees north latitude to 83 degrees south, encompassing 99 percent of Earth's landmass. The ASTER GDEM maintains the GeoTIFF format and with 30-meter postings and 1 x 1 degree tiles.ASTER data were used for creating DEM and slope map of the dam site. Pre-existing geological maps were referred for understanding lithological and other information on the geology for area (GSI, 1994).

4. Results and Discussions

4.1. Lineament Studies

The lineaments are the most obvious structural features that are pathways for water and responsible for infiltration of water into subsurface. They destabilize the area apart from developing into major structural deformities. The lineaments are the linear or curvilinear feature pattern and are critical in geomorphic and structural analysis studies. The lineaments like joints and fractures etc, developing generally due to tectonic stress and strain provide clue on surface features. The remote sensing data, which offer synoptic view of large area, helps in understanding and mapping the lineaments both regional and local scale. Lineament analysis of the area from remotely sensed data provide

important information on subsurface fractures. In the context of this study, a lineament is considered a surface expression of fracturing in the form of topographic alignments (i.e., valleys and cliffs), alignments of streams, rivers, and other drainages, linear trends in vegetation and truncation of rock outcrops.

4.2. Geomorphology and Geological Setting

The study area forms the part of the Great Himalayan Range and is characterized by rugged mountainous topography with high hills, deep valleys, escarpments, valley fills and cliffs. The rocks are generally trending NNE-SSW & NE SW direction with steep slopes. Deep steep rising hills with intervening dissected valleys are common feature. As per Devraj et al (1994) area include Quartzites, phyllites, slates, schists and limestones of BATAL and MAZRI formations.

4.3. Drainage

The Chenab River is the main river in the study area flowing from south to north direction across the strike of the various formations. The drainage pattern of the study area in general was found to be dendritic to trellis type.

4.4. Satellite Data Interpretation

In the present study lineament studies were carried out by integrating satellite interpreted details with topographic sheets at 1:50,000 scale. This included identification of lineaments from the satellite data in conjunction with basic information derived from topographic sheets. Satellite remote sensing provides an opportunity for better observation and more systematic analysis of lineaments following synoptic, multispectral repetitive coverage of the terrain. However, in the present study digital scene covering the study area was used for detailed studies. The sub sets covering study areas was cut from the main digital geo-referenced satellite data of LADSAT 7 ETM+ as shown in Figure 2. This file was then brought in the ARC / GIS platform for further analysis. First, satellite digital sub set of the areas was exactly overlaid on topographic sheets to ensure compatibility using swipe module. Having base information from the topographic sheet digital satellite data of study areas was visually interpreted. The lineament map was prepared by digitizing linear features on screen from digital data having categories of drainage or topographic driven lineaments. Each category of lineament was stored as separate layer. On the basis of tonal, textural, topographic and drainage linearities, curvilinearities and rectilinearities lineaments of the study area were delineated. It is observed that one set of lineaments controlled the major river in the study areas and general trend is towards NS. Another set of lineaments identified in structural hills, pediments and valley fill zones in the study areas are controlling the river channel and nallah as shown in figure 3.

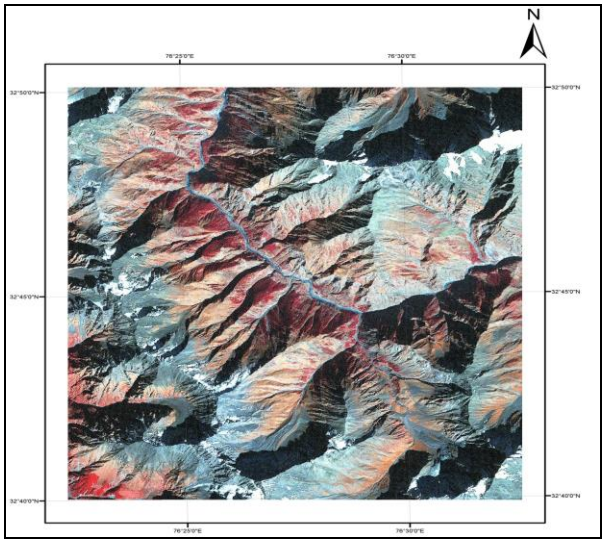

Figure 2 *Showing LADSAT 7 ETM+ data of the study area*

Lower order streams viz. first order and second order streams are controlled by lithology and shows typical sub parallel, parallel and dendritic pattern and interestingly meet river Chenab almost perpendicular in the study area. It is evident that major drainage is structurally controlled and could be in tune with Himalayan major deformation i.e trending NW and SE direction. In Raoli study area apart from river Chenab Gharel nala and Channed nala control the drainage and has major influence on lithology.

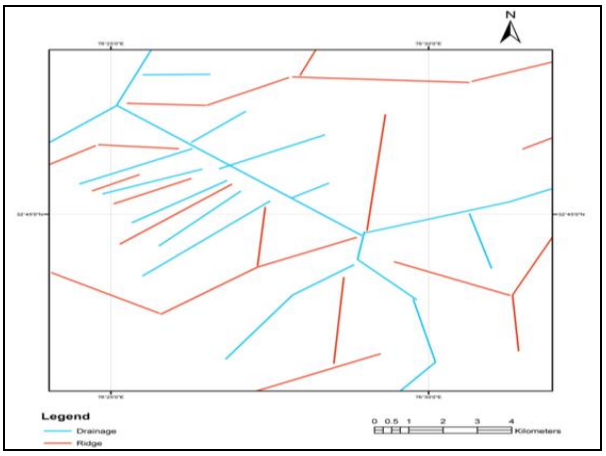

Figure 3 *Lineaments interpreted from LADSAT 7 ETM+ satellite data*

As shown in figure 4 DEM has brought out clearly information about general elevation of the study area ranging from 2327 m to 5138 m. In addition to this slopping pattern prevalent in the vicinity of the project site is well understood.

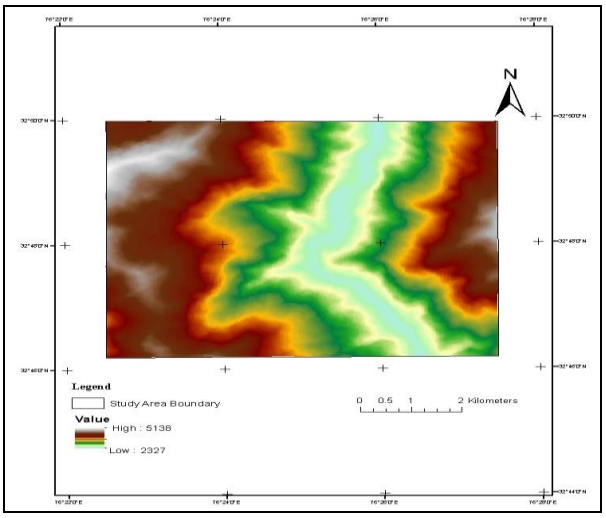

Figure 4 *DEM of the study area prepared from ASTER satellite data*

A slope map was prepared from DEM and 5 classes were generated for slope analysis of the study area. It is revealed from the slope map that highest slope in the site is 74 degree and right bank of the river is steeper than the left bank of the river near diversion, thus will require extra care.

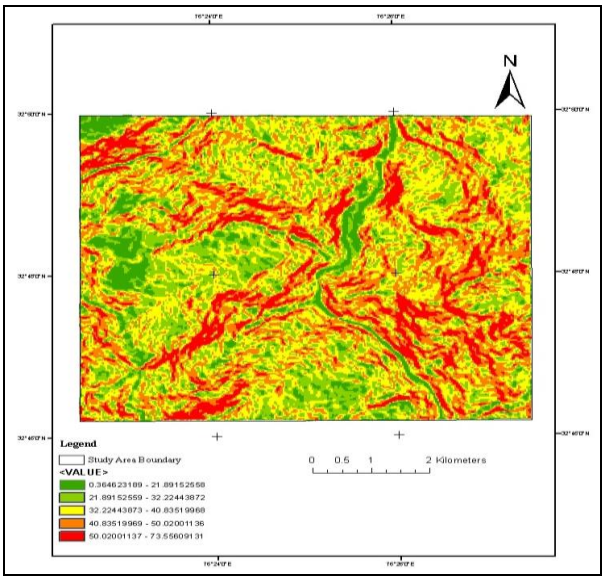

Figure 5 *Slope map of the study area (in degree)*

5. Conclusion

Integration of topographic maps, LADSAT 7 ETM+ and ASTER data produced very useful information about terrain features i. e elevation differences through DEM, slope, drainage, lineaments and geomorphology. For a hydroelectric project presence of lineaments will adversely affect stability of the structure. The study demonstrates effect of lineaments on upcoming hydroelectric project on the river Chenab in the vicinity of upper Himalayas derived from satellite imagery. Potential of ASTER derived DEM brings out accurate assessment of topographic differences. Slopes in general are steep. The lineaments due to drainage runs parallel to the Chenab River and meeting perpendicular to the main river course are stream joining it. The major lineaments due to topographic relief are at the higher locations in the vicinity of the study area and minor lineaments are meeting perpendicularly the river main course. From the above study it is concluded that there are no major structural lineaments in the study area. However, lineaments present in the study area shall pose no threat to the proposed diversion site and powerhouse in the vicinity of Raoli village across river Chenab.

6. Acknowledgement

Author expresses his sincere thanks to Larson & Toubro Hydro Electric, Delhi to referring this problem to PEC University of Technology.

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