Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 4, No.5, 2014

Preparation of Geomorphological Map and Their Characterisation with the help of Remote Sensing and GIS: a case study of Sankha Nadi Drainage Basin

Sadhan Malik

Guest Lecturer, Memari College, University of Brdwan

E-mail: sadhanmalik06@gmail.com

Abstract
One of the most advanced and rapidly growing tools and techniques for geospatial analysis is Remote Sensing and GIS. Dhanjori Basin is a structurally complex tectonic belt with high abundance of important mineralization patterns. It also has a varied geomorphological setting encompassing its areas, which make it an interesting area of study. In this paper we study Sankha Nadi basin areas through recognition of satellite imagery and visualization of geomorphological characteristics. Geomorphological features are identified using Remote Sensing and image processing techniques and converted to a vector form in GIS platform.
Keywords: Geomorphological Map, Sankha Nadi, Remote Sensing, GIS, Dhanjori Basin & geospatial analysis.

1.0 Introduction

Geomorphology is the study of rational description and measurement of earth's surface features, their surrounding environment and the processes responsible for present shape. Before set up of any kinds of activity related to ground earth surfaces it is very important to understand the nature and its properties of the particular ground, so, in this way geomorphological mapping of any region provides good assessment of that area. Landforms in this region evolve in response to a mixture of natural and anthropogenic processes like tectonic uplift and volcanism, denudation, mass wasting etc. Until the space age, scientists conducted most geomorphic analysis by mapping– generally topographic (for shape) and geologic (for structure and underlying rock types) – and by field observations and measurements. Eventually, aerial photographs and further satellite remote sensing became a leading tool for mapping and interpretation (Singh B. and Dowerah J., 2010).In this study we are attempting to geomorphological mapping of the region with the help of Remote Sensing and GIS of Sankha Nadi drainage basin or geologically Dhanjori basin. The Sankha Nadi, a right bank sub-tributary of Subarnarekha River is a museum of geology and geomorphology. Administratively belongs to the East Singhbhum district of Jharkhand. It possess a rich panorama of geological history from Precambrian to present with distinctive geological events as well as rich topographical features characterized by structural hills, scarps zones, multiple erosional surfaces, high rise cliffs and residual hills (dungri) etc. The basin has been tectonically active over a long period of time.

2.0 Objective

Our main objective of this study is to evaluate the region geomorphologically as well as mapping of this region which will provide a very good asset to the people and to the developers who are engaged in this region for planning and developmental purpose.

3.0 Database and methodology

The Geomorphology of the area is relatively less understood since the terrain is inaccessible and environment is hostile for free movement. An attempt to prepare geomorphological map morphometric analysis of the drainage basin, satellite imagery IRS LISS III has been undertaken to visualize the geomorphological characteristics of the area. Remote Sensing and image processing techniques have been employed and converted on a GIS platform to identify the patterns and spatial distribution of different geomorphic units.

Table- 1: Types of maps used for this study

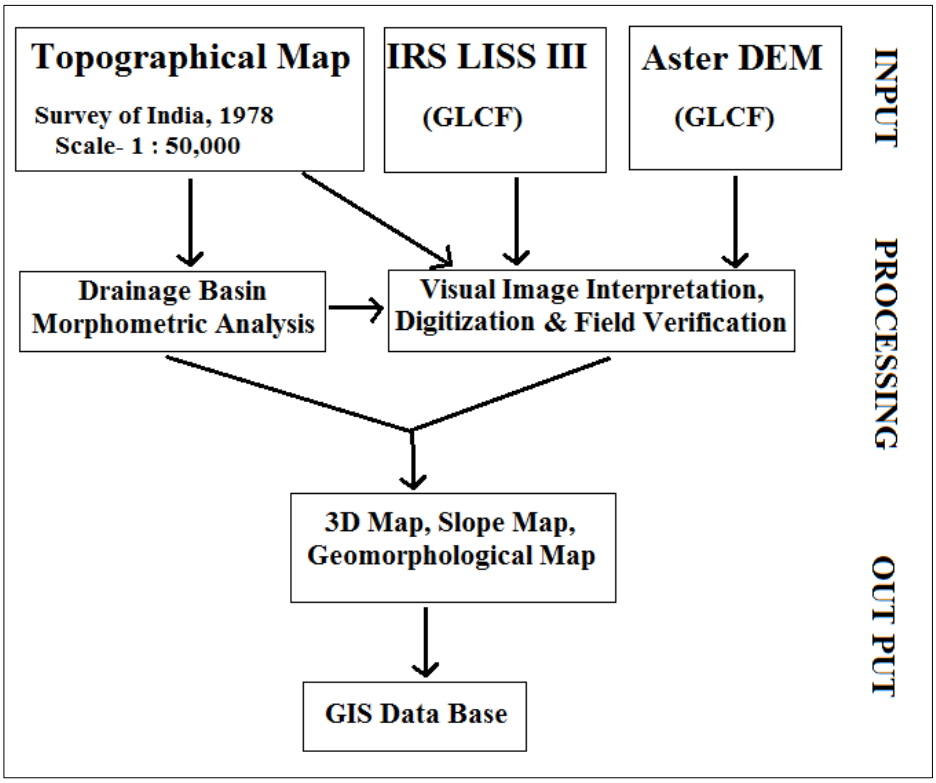
Type of Maps	Name of the Map	Published By	Year	Scale
Topographical Maps	73 J/6, 73 J/7 & 73 J/11	Survey of India	1978	1:50,000
Geological Maps	Geology of East Singhbhum	Modified after Saha, 1994; Sarkar and Saha, 1962	2010	1:1,000,000

Table- 2: Types of Satellite images used for the study

Type Image	Name of the Satellite	Sensor	Date of Pass	Resolution	Path-Row Number
Multispectral Image	Resourcesat-1	LISS III Band 2,3 &4	20th Oct 2009	23.5 metre spatial resolution and a swath of 141 km	P-106 R- 056
Elevation Data	SRTM	ASTER DEM		30 m	

Software used: ERDAS IMAGINE 9.1 and Arc GIS 9.3

Fig-1: Methodology of the study



4.0 Study Area

The Sankha Nadi, a right bank sub-tributary of Subarnarekha River is a museum of geology and geomorphology. Administratively belongs to the East Singhbhum district of Jharkhand. It possess a rich panorama of geological history from Precambrian to present with distinctive geological events as well as rich topographical features characterized by structural hills, scarps zones, multiple erosional surfaces, high rise cliffs and residual hills (dungri) etc. The basin has been tectonically active over a long period of time. Rejuvenation of the topography in late Tertiary times and tilting of the Singhbhum plateau south east consistent with uplift resulted in the development of relatively shorter and smaller tributaries, among which Sankha Nadi is one of them. The extensive level surfaces in many parts of the basins are related to complex geomorphological history involving several cycle of erosion. The general shape of the basin area is more or less circular and its general slope as well as elevation gradually comes down in the direction from south-west towards north-east following the main trunk stream. An extensive area lies between 100 to 300 meters.

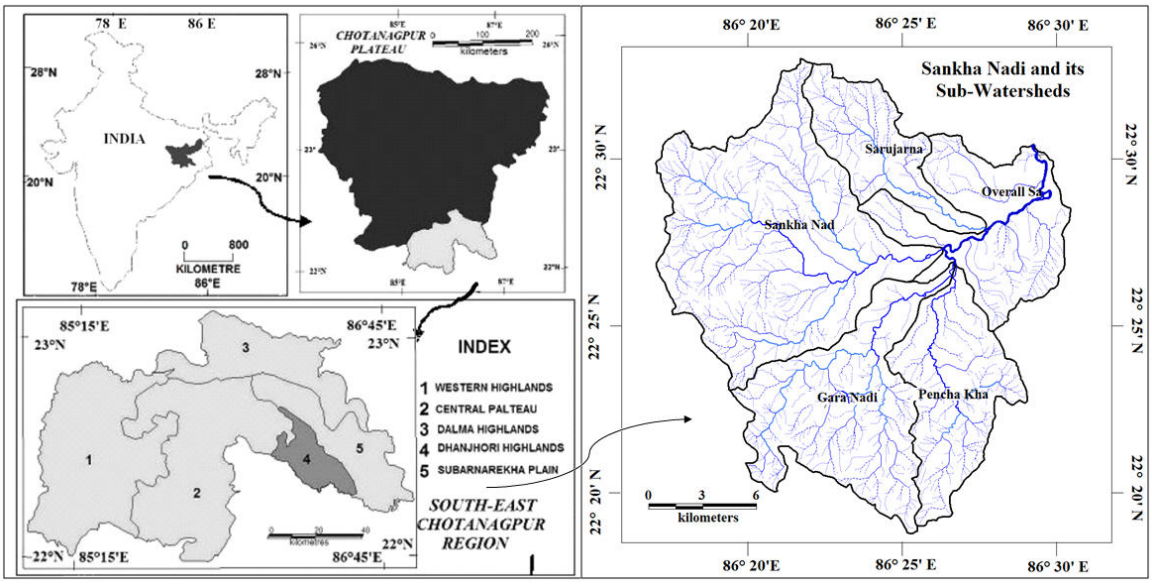


Fig-2: Location of the Study Area

5.0 Geology of the Basin

The study area, Sankha Nadi Basin, lies between $86^0$17'E to $86^0$31'E longitude and $22^0$19'N to $22^0$32'N latitude, of southern part of East Singbhum District, Jharkhand consists of mainly Dumaria Block and some parts of Musabani, Potak, Dhalbhumghar and a very small part of Mayurbhanj district of Orissa. This region belongs to the Dhanjhori highlands of south-east Chotonagpur Plateau, composed of basaltic lava. The Basin has glimpses of ancient Dharwar formation (Mica Schists and Phyltite), Dhanjhori stage (Sandstone and Conglomerate), Iron-ore Stage, Dhanjori Basalt, Singhbhum Granite etc. this region belongs to Red-loamy to lateritic soil with the presence of thick morum bed. Four possible erosion surfaces (i.e. 600, 450, 300 and 150 meters) are identified by D.P.P. Satpathi in 1971.

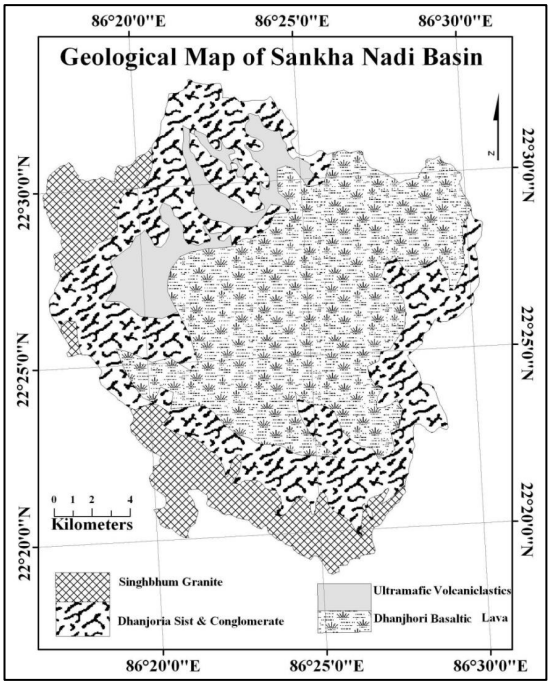


Fig-3: Geological map of the Sankha Nadi drainage basin (modified after Saha, 1994; Sarkar and Saha, 1962).Abbreviations: Gp., Group; Fm., Formation.

6.0 Discussion and Analysis

6.1 Relief: Relief of the Sankha Nadi prepared with the help of Arc GIS 9.2 from SRTM data, it is clear that Sakha Nadi drainage basin express elevation ranges 77m to 765m. Maximum elevation mainly located along the drainage divider of the basin in a continuous manner and it rapidly comes down to 200m, from this contour gradual declination of elevation noticed. This indicates presence of structural hills. Maximum area of the basin belongs to 100m to 300m contour indicate presence of vast plain land surfaces, which suggest this drainage basin belongs to mature stag of landscape evolution. So from this discussion we can conclude that the Sankha Nadi basin has experienced epeirogenetic uplift, and is characterized by intrusive bodies with vast planation surface, i.e. this basin belongs to mature stage with presence of intrusive structural hills.

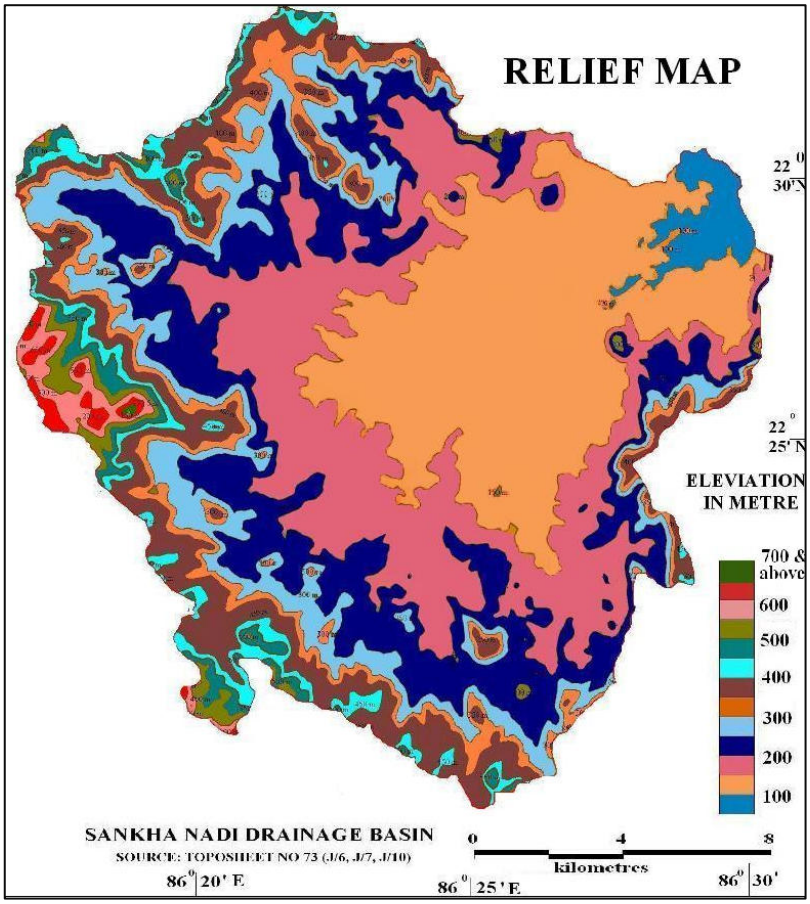


Fig-5: Relief map of the SakhaNadi drainage basin

6.2 Slope: Slope defined as angular inclinations of terrain between hill-tops and valley bottoms, resulting from the combination of many causative factors like geological structure, absolute and relative reliefs, climate, vegetation cover, drainage texture and frequency, dissection index etc. (Singh S. and Srivastava R., 1975). In case of slope analysis of Sankha Nadi slope map was prepared with the help of Erdas Imagie 9.1. Maximum average slope of this region has been found to be 26^{o} degrees and minimum of 0.04^{o}, very high average slope mainly concentrated in the outer boundary characterized by hilly range and towards from it average slope gradually decline and the slope analysis of Sankha Nadi by following the Wentworth (1930) method it has found that maximum average slope of this region has been found to be 26^{o} degrees and minimum of 0.04^{o}, very high average slope mainly concentrated in the outer boundary characterized by hilly range, deep cut river valley, high rise scarps it indirectly indicate these are intrusive bodies and towards from it average slope of the basin gradually decline. If we notice the distribution of average slope then we will find out that increasing area with decline slope. Greater percentage of area (733%) is under very low ($<5^{o}$) to medium (10^{o} -15^{o}).

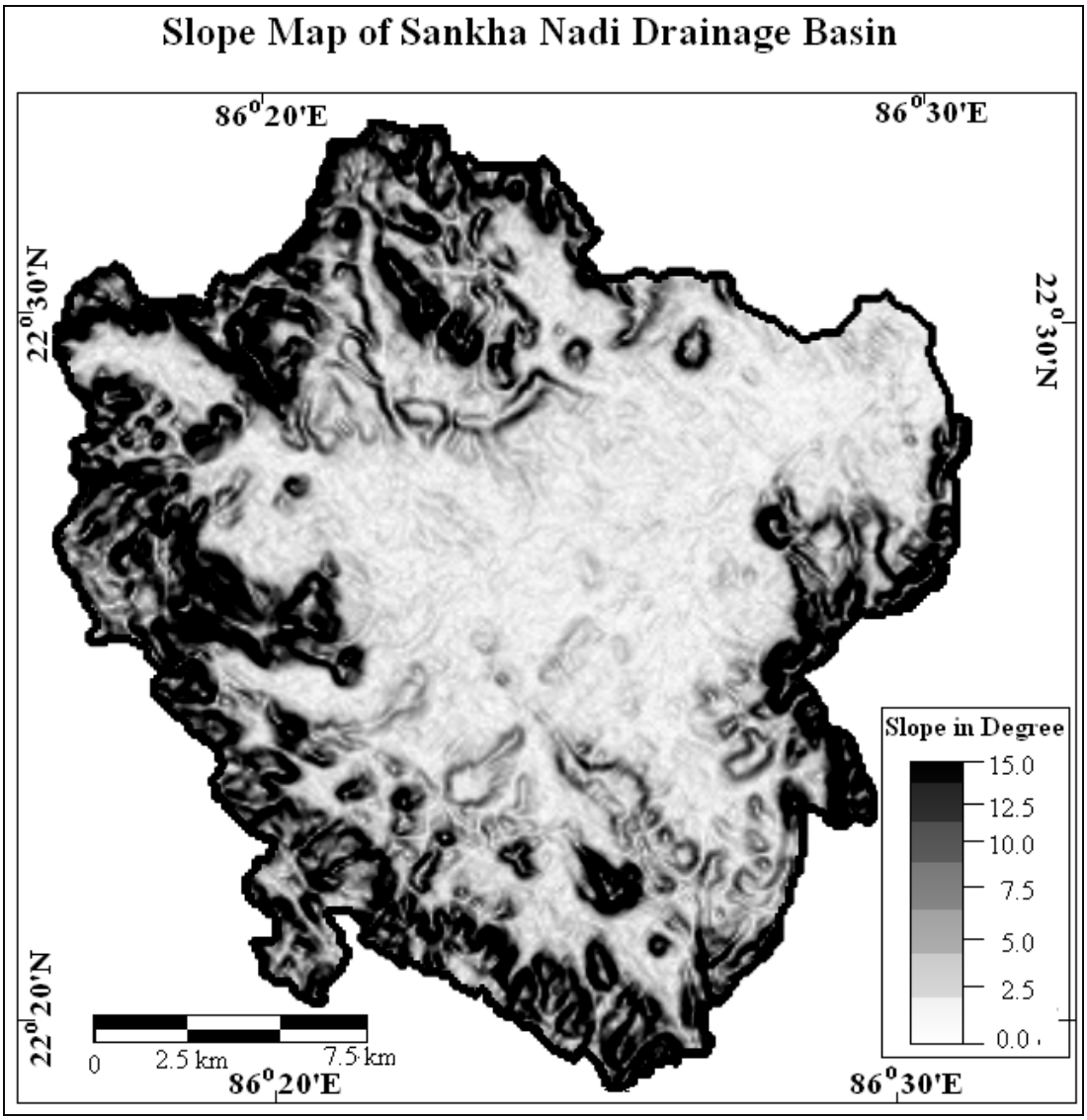


Fig-5: Slope map of the Sakha Nadi drainage basin

6.3 Drainage Network: In studying Sankha Nadi drainage basin ranking of streams has been carried out based on the method proposed by Strahler (1964) and we have found 6thorder hierarchical stream order in total, these are arranged in a systematic manner. From the drainage network map it is found that this Dhanjori Basin possesses mainly radial drainage pattern radiation from structural hills and coagulating each other and meets with Subarnarekha River. The morphometric characteristics of the Sankha Nadi drainage basin is as follows-

Table-3: Stream Hierarchy of Total Sankha Nadi Drainage Basin

Order (u)	No. of Segments (N_u)	Bifurcation Ratio (R_b)	Total Length (Km.)	Mean Length in km. (*Lsm*)	Cumulative Mean Length km. (L_u)	Length Ratio ($R_L=L_u/L_{u-1}$)
1st order	780	-	442.44	0.57	0.57	
2nd	182	4.286	176.1	0.97	1.54	2.702
3rd	48	3.792	106.87	2.23	3.2	2.078
4th	11	4.364	53.547	4.87	7.10	2.219
5th	3	3.667	37.04	12.3	17.17	2.418
6th	1	3.000	14.75	14.8	27.1	1.578
Mean		(Rbm)=3.822		5.96		2.199

Source: Computed from Topographical Maps

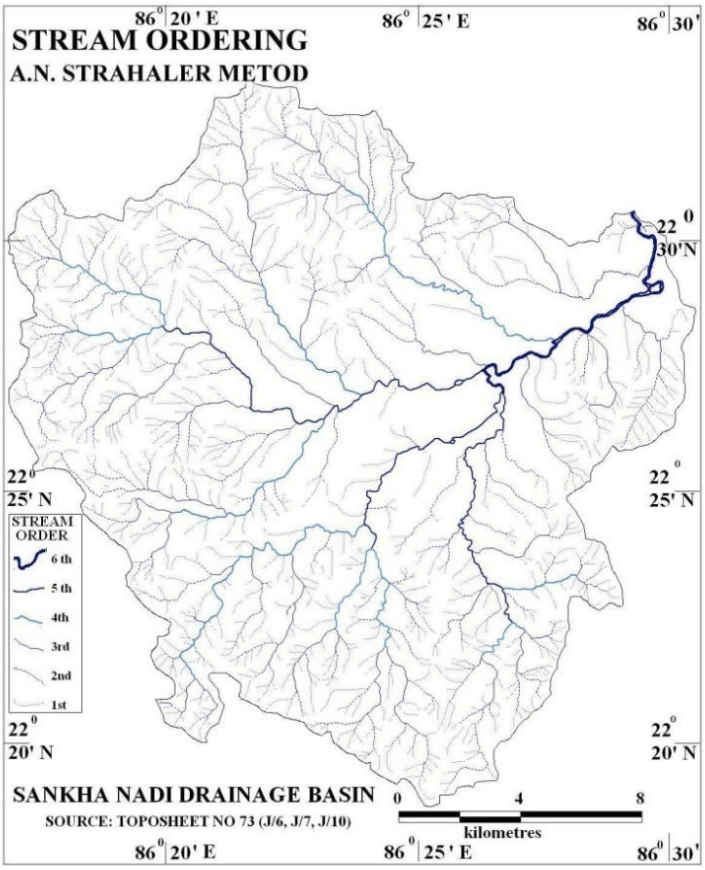


Figure-3: Drainage Map of the Study Area

7.0 Result & Geomorphological Mapping:

Dhanjhori Basin is an important geological formation in this region. Its origin is related to tectonic processes. The geological formations, from which it is composed, as well as the geomorphological characteristics, indicate the clear influence of tectonic activity in the study area. The collected data are finally stored into a Geographic Information System, and a corresponding database is created. The geomorphological and physical-geographical characteristics are used for the development of a geomorphological map. The Geomorphological units are interpreted from the LISS III imagery with the help of the image interpretation keys like tone, texture, pattern, association after processing the imagery in Erdas Imagine. The contour lines at 20 m intervals are extracted from the ASTER DEM (30m) and the slope map of the area is generated from it.

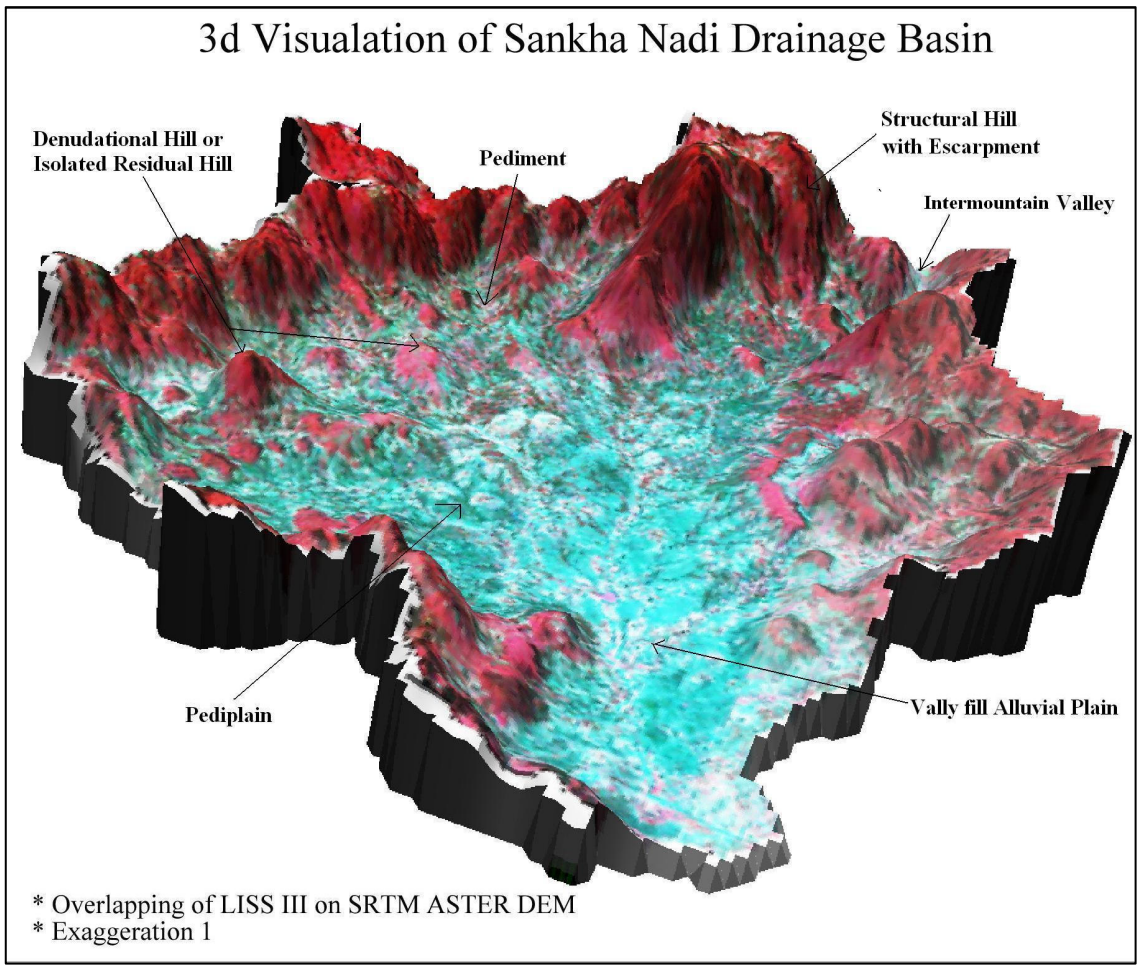


Fig-4: Overlapping of LISS III on SRTM ASTER DEM

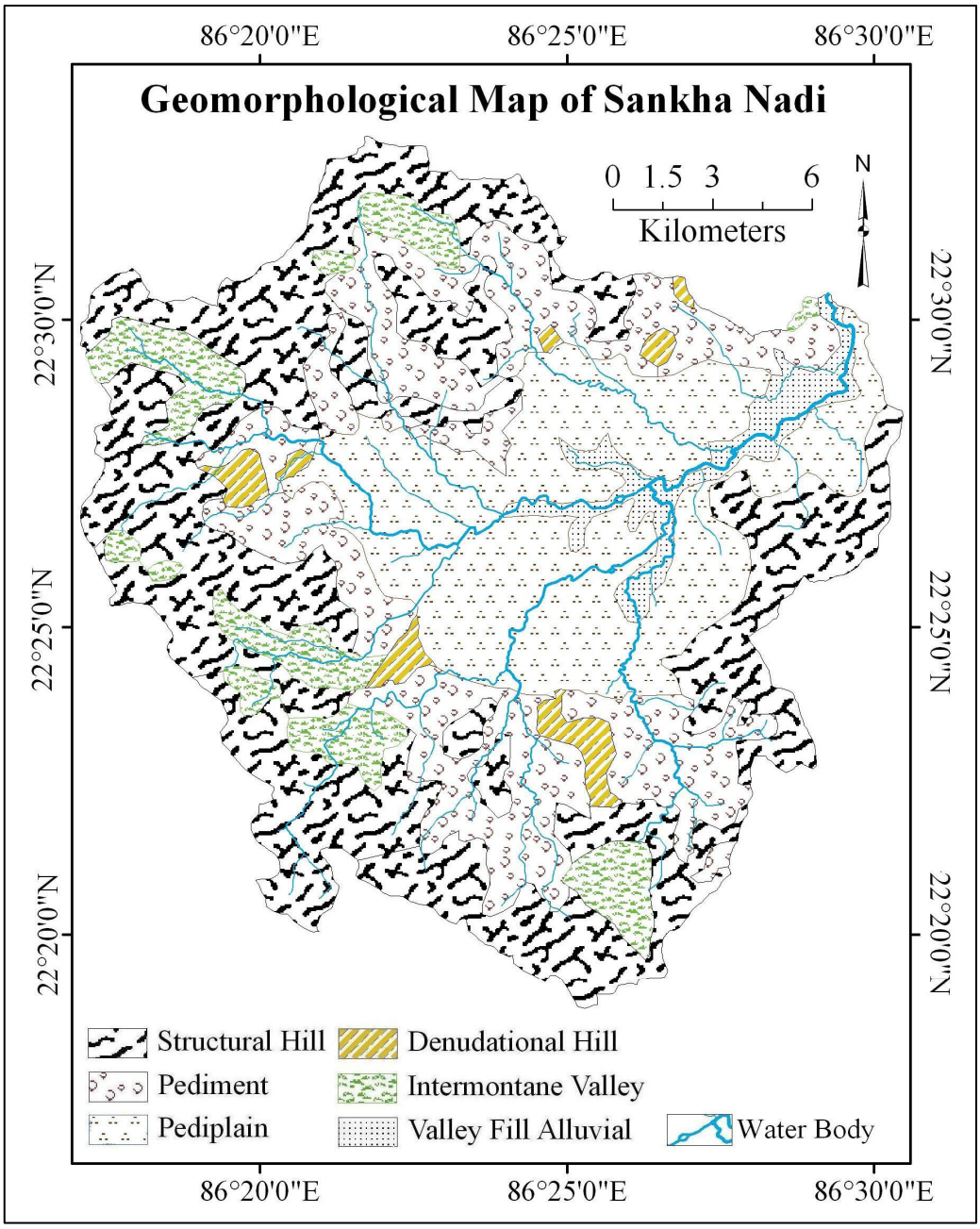


Fig-5: Geomorphological map of Sankha Nadi

The geomorphological units that are mapped are structural hill associated with scarp zone, denudational hill, intermountain valley, pediment-inselberg complex, pediplain, pediment, undissected plateau, residual hill, alluvial plain, valley fill, river and valley terrace, water body and river. Now these features are discussed below

Table-4: Measurement of geomorphological units of Sankha Nadi

Geomorphological Unit	**Area (sq. km.)**	**Percentage of Area**
Structural Hill	144.46	38.38
Denudational Hill	08.91	02.37
Intermountain Valley	30.24	08.03
Pediment	86.20	22.90
Pediplain	89.50	23.78
Valley Fill Alluvial	14.68	03.90
Water Body	03.42	00.64

7.1 Structural Hill: Structural hills or escarpment (Ghats) are mainly found in water divided of the drainage basin mainly composed of Sighbhum granite and Dhanjori shist and conglomerate, characterised by high relative relief, high dissection index, high slope and covered with dense mixed jungle mainly Sal. These features are occupied most of the area about 144.46 km^2 (38.38% of area) and they are mainly formed due to tectonic forces (Mukhopadhaya, S. 1980). Edge of the features is mostly associated with scarp slope and in some places these areas itself suggesting the former structural hills.

7.2 Denudational Hill: Denudational hills are mainly result of down wasting of land surfaces due to intense sub-areal erosional activity from its early origin. These features covered an area of 8.91 km^2 (2.37%). Davis in 1909 says that these features are characteristics of later stage of the cycle of landscape evolution. Denudational hills are characterised by centripetal drainage pattern and covered with mainly open mixed jungle, mainly Sal.

7.3 Intermountain Valley: Intermountain valley is an interesting geomorphic features found in this drainage basin. Development of these kinds of features is mainly responsible for nature and development of stream network of this region, due to mainly headward stream lengthening, relative response of subarea denudation and its antecedent nature of the streams may be responsible for such kinds of geomorphic unit or region. Total area covered by this region is about 30.24 km^2 (8.03%) and geologically composed of ultramafic volcaniclastic, Dhanjori shist and conglomerate and in some places with singhbhum granite.

7.4 Pediment: Extensive erosion surface characterised by concave slope surrounded by mountains is called pediments. Pediments are slopes of transportation cut on bedrock (Bryan K., 1922). A few geomorphologist (e.g. W. penck) argued that pediments are structurally and tectonically rather than climatically controlled and L. C. King has opened that the processes of pediplanation and pedimentation is universal and it occurs in all environmental conditions (Singh, 2002). These surfaces extend for 0.5 to 3 km and characterised by 1^0 to 7^0 in slope. Geologically these areas are mainly Dhanjori shist and Conglomerate in nature. This feature also occupied 86.2 km2 area (22.9%) and the 3rd largest geomorphic unit of this drainage basin.

7.5 Pediplain: Many pediments coalesce to form flat surface termed by King as pediplain which is characterised by uneven surface with low reliefs and subdued intersecting concave surfaces (Singh, 2002). According to Davis these features are mainly formed during mature stage. This area possesses the 2nd largest area coverage with 89.5 km^2 (23.78%). Geologically this area belongs to Dhanjori basaltic lava characterised with extensive flat plain surface, very low relative relief, low drainage density and scanty slope.

7.6 Valley Fill Alluvial Plain: Valley fill alluvial plain is mainly associated with rivers of this drainage basin. They are characterised with small flat plain surface, very very low relative relief, scanty slope with valley fill alluvium. These features mainly formed due to riverine activity. Geographically this area contain very small portion of the drainage basin and it is about 14.68 km^2 (3.9%) but for agriculturally this region is the most important unit of all.

7.7 Water Bodies: Water bodies in this region are mainly by the drainage network. Number of surface water tank in this region is very little. Geographically this region contains about 3.42 km^2 (0.64%) and they are very much important for irrigational purpose.

8.0 Conclusion

The Geomorphology of the Sankha Nadi area is relatively less understood since the terrain is inaccessible and environment is hostile for free movement. Geomorphological studies are useful in identifying the pattern and spatial distribution of various landforms and deriving information on the natural resource potential. An attempt to prepare geomorphological mapping of Sankha Nadi Drainage Basin morphometric analysis, satellite imagery IRS LISS III and ASTER DEM has been undertaken to visualize the geomorphological characteristics of the area. The area represents various geomorphological units like alluvial plain, denudational hill, structural hill, intermountain valley, water bodies etc. The Dhanjori is mainly covered by structural hills and intermountain valleys in between. Geomorphological mapping of the study area shows that spatial expression of the topography is more relied on structure underneath resulted from tectonic activity. Further detailed studies are suggested in order to locate the vast potential of mineral resources in this locality which can be undertaken based on the geomorphological information's.

References

Chorley R. J., (1969), The drainage basin as the fundamental geomorphic unit. In Chorley R. J. (ed.), *Introduction to Physical Hydrology* (London: Methuen), 37-59.

Chorley, R. J., Schumm, S. A. and Sugden, D. E., (1985), *Geomorphology*, Methuen and Co. Ltd., Lodon.

Das, N. G., (2001), *Statistical Methods*, M. Das and Co., Kolkata.

Fairbridge, R. W. (1968). 'Hypsometric Analysis, '*The Encyclopedia of Geomorphology'* (Ed.) Reinhold Book Corporation, New York.

Ghosh S., (2011), Determination of Significant Variables in the Evolution of Sarujharna Basin of East Singhbhum, Jharkhand, Practicing Geographer Vol-15.

Jones, J.A.A. (1999), *Global Hydrology: Processes, Resources and Environmental Management*, Longman, 399pp.

Lakshmammaet.al, (2011), Morphometric analysis of Gundal watershed, Gundlupettaluk, Chamarajanagar district, Karnataka, India, International Journal of Geomatics and Geosciences, Volume 1, No 4

Lillesand, T. M., Kiefer, R. W., and Chipman, J. W., *"Remote Sensing and Image Interpretation"* (5th edition), Wiley, USA.

Miller V. C. (1953), A Quantitative geomorphic study of drainage basin characteristics in the Clinch Mountain area Virginia and Tennessee.Proj NR 389-402 Tech Rep3, Columbia University.Department of Geology, ONR. New York.

Mukhopadhyay S. C. et. al, (2010), *Advance River Geomorphology* (acb publication, New Deli), 185-186.

Mukhopadhyay S. C., (1980). Geomorphology of the Subarnarekha Basin, The University of Burdwan, Burdwan.

Nautiyal M. D. (1994) Quantitative analysis of a drainage basin using arial photographs: A case study of Khairkuli Basin, District Dehradun, U.P.

Pankaj A. & Kuman P., (March 2009), GIS-based Morphometric Analysis of Five Major Sub-watershed of Song River, Dehradun District, Uttatakhand with Special Reference to Landslide Incidences, J. Indian Soc. Remote Sens.

Satpathi , D. P. P. (1965), *An Outline in Indian Geomorphology*, Rajesh publicat i on, Allahabad

Sen P. K., (1993), *Geomorphological Analysis of Drainage Basin*, Pub. The University of Burdwan.

Singh, B., ad Dowerah, J., (2010), Terrain Mapping of Singhbhum Shear Zone (SSZ) and its Surrounding Areas using Remote Sensing and GIS, Vol. 03, No. 03, pp. 371-375

Singh, S., (2002), '*Geomorphology'*, Prayag Pustak Bhawan pub.

Strahler A. N. (1957), Quantative Analysis of Watershed Geomorphology, Transaction, American Geophysical Union.

Strahler A. N. (1957), Quantative Analysis of Watershed Geomorphology, Transaction, American Geophysical Union.

Rao, D.P., (2000), Remote sensing application in geomorphology, Tropical Ecology, International Society for Tropical Ecology.