DIGITAL ELEVATION MODELING USING ILWIS 2.1 IN PARTS OF PURULIA DISTRICT, WEST BENGAL, INDIA

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KEY WORDS: DEM, Slope, Aspect, Remote Sensing, Landuse, Hydrogeomorphology, GIS

ABSTRACT

The quest for the discovery of natural resources like groundwater, mineral resources, petroleum resources etc. have been going on since the dawn of civilization by using various available techniques. The recent technological development in the field of computer science has made the methods of discovery of natural resources and interpretation of data more interesting. Remote Sensing Technique and Geographic Information System (GIS) software provide a quick approach in the analysis and interpretation of data for an efficient management of earth's natural processes, like natural disaster management, coastal zone management (CZM), environmental impact analysis (EIA), etc.

The present study is an initialization of the above techniques for management of earth's natural resources. The study area is part of the Purulia District of West Bengal (Lat. 23° 05′ to 23° 10′ N and Long. 86° 00′ to 86° 10′ E; SOI toposheet no. 73 I/4) and is characterized by undulatory topography with rugged hilly terrain. The hilly terrain is mostly covered with forest while the plains are mainly barren or covered with grassland/ cropland and few villages. The area is mostly covered with Precambrian rocks (Granite Gneiss and Mica-Schist). Scattered occurrences of amphibolite and quartz veins are also noticed in the northern part of the study area.

Digital Elevation Model (DEM) forms an important component of any GIS analysis and interpretation. The interpolation of contour lines is the most popular technique as they are the most easily accessible geomorphic data of elevation. DEM has been prepared with help of ILWIS 2.1. Digital Elevation Model has a wide application and forms one of the main inputs in many GIS projects. It is also the basis for a large number of derivative informations.

Slope map forms an important component of a GIS related analysis and interpretation. Slope angle or slope percent in X and Y direction have been calculated using a DEM, gradient filters (DFDX, DFDY) and an equation of slope calculation. Similar to the slope map, the slope direction (aspect) map is also an important component in any GIS application. The aspect map has been calculated by combining the gradient maps, resulting from the application of the horizontal and vertical filters on a DEM. The slope map and slope aspect map prepared from the DEM by using gradient filters of ILWIS 2.1 can be utilized very effectively in any GIS application.

1. INTRODUCTION

Natural resources like groundwater, mineral deposits, petroleum resources are the essential commodity mankind has been hunting since the dawn of civilization using various available techniques. Protection from the fury of nature has also been a priority for the human race. The recent technological development in the field of aerial/ satellite photography (popularly known as Remote Sensing) and advancement in the field of computer science has made the methods of discovery of natural resources and interpretation of data more interesting. Remote Sensing technique using satellite imagery along with Geographic Information

System (GIS) software have proved to be an indispensable tool for the interpretation of geographic and geologic data for land and water resource management.

The first and foremost requirement for the study of land and water resources is the detailed study of the terrain which in turn requires the knowledge of overall elevation of the area. Thus an elevation model must be generated as the most important component of any GIS analysis. When computer plays a major role in the analysis we need to generate a Digital Elevation Model or DEM.

1.1 Objective

Digital Elevation Model is an important component of any computer based GIS analysis. The main objective of the present study is to prepare a DEM of Matha Protected Forest and adjoining areas in Purulia district West Bengal, India. A slope map and a slope aspect map are generated from the DEM using ILWIS 2.1 software. A landcover map and a hydrogeomorphological map has also been prepared using digital image data, ILWIS 2.1, hard copy image data and visual interpretation technique respectively. The ultimate aim is to integrate is to integrate the slope theme generated from the DEM with the landcover and hydrogeomorphology map and draw a conclusion about their inter-relationship and how they can successfully be used along with other geologic and geographic theme for groundwater exploration, natural hazard zonation.

1.2 Study Area

The study area, Purulia district is located on the eastern flank of Chhotanagpur plateau, forming southwestern part of West Bengal, India. The area is part of the Purulia district mapped on the Survey of India toposheet no. 73 I/4 and falls between latitude 23° 05′ to 23° 10′ N and longitude 86° 00′ to 86° 10′ E.

The district is characterized by rolling topography with rugged hilly terrain in western and southern part. Ground elevation of land surface ranges from 150 – 300 meters above M.S.L., though in the western part hills rise sharply above the plains. The elevation in the study area ranges from 200- 650 meters above M.S.L. with maximum elevation of 677 meters above M.S.L. The study area more specifically represents the intermediate and lowest levels of the "three stepped erosion surfaces" of Chotanagpur plateau (Niyogi, 1987). The drainage is uniform over the study area forming a dendritic pattern as seen in Figure: 1. Geologically, the area forms part of the Chhotanagpur Gneissic Complex (CGC) of Precambrian age. Granite gneisses dominate the northern part with scattered occurrence of amphibolite and quartz vein, while the southern part is characterized by mica-schist of the Singhbhum Group of rocks.

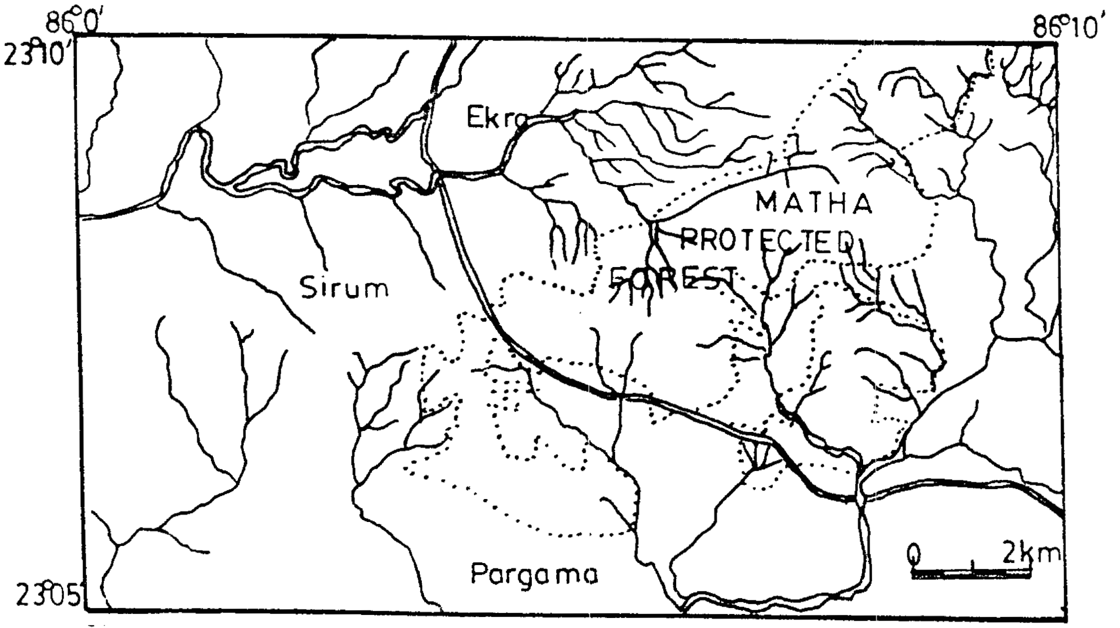


Figure 1. Map showing the Study Area.

2. METHODOLOGY

2.1 Digital Elevation Model (ILWIS 2.1USER'S GUIDE)

Digital Elevation Model forms an important component of any GIS analysis and interpretation. We know that contours are imaginary lines joining points of equal elevation / altitude. When this altitude is represented in digital form it is called a Digital Elevation Model· This altitude can be of soil layers, contact of soil rock, water-table etc. Digital Elevation Model can generally be prepared by 3 techniques:

- Photogrammetrical technique
- Point interpolation technique
- Interpolation of contour lines

The interpolation of contour lines is the most popular technique as they are easily accessible geographic data of elevation available from the toposheets. Digital Elevation Model can be stored both in vector and raster format.

The Digital Elevation Model shown in Figure 2. has been prepared with the help of ILWIS 2.1 using contour interpolation technique. It is in raster format with a value domain. The contour data available was first digitized manually. The accuracy parameters taken care of are

- Detail of the contour line used
- Scale of original toposheet; larger the scale of map, smaller the contour interval, more accurate the DEM.

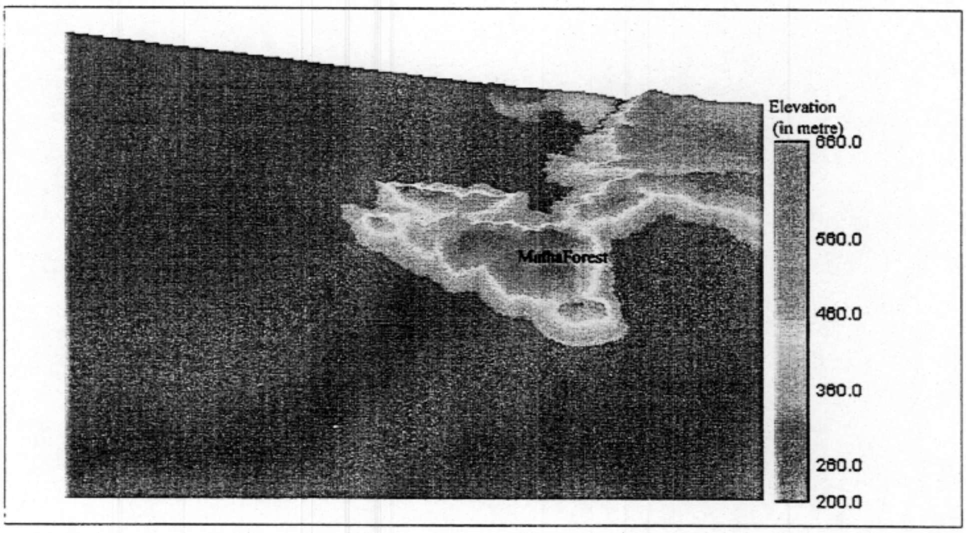


Figure 2. Digital Elevation Model of Matha Protected Forest and Adjoining Areas.

Creation of the DEM from segment map is done in two steps

- Segment to raster conversion. The segment map is converted to raster, using a geo-reference in which pixel size, number of lines and columns, maximum and minimum X, Y co-ordinates of map are defined. Pixel size should be so selected so that two contour lines do not fall in same pixel, resulting in interpolation problem.
- Contour interpolation. Linear interpolation is made between pixels with altitude values, to obtain elevation of undefined values in between rasterized contour lines.

The output map is a raster map with each pixel having a value at the center of the pixel.

DEM has a wide application and forms one of the main inputs of GIS projects. The main applications are:

- Slope map, showing steepness of slope
- Slope Aspect map, showing compass direction of slope (0° - 360°)
- Hill shade map, showing terrain under artificial illumination
- 3D view

DEM

SLOPE MAP **SLOPE ASPECT MAP**

The slope steepness and Slope Aspect are calculated from the DEM using a group of filters called gradient filters. The gradient filters DFDX and DFDY are used to calculate slope differences in X and Y direction respectively. The gradient maps produced by using these filters are then used to generate the slope steepness and slope direction maps.

The slope steepness value is calculated in percentage by the formula

$$\textbf{SLOPPER= ((HYP (DX, DY)/ pixsize (DEM)) * 100} \qquad (1)$$

where HYP (hypotenuse) is an internal map calculator of ILWIS 2.1, which calculates the square root of the sum of the squares of horizontal and vertical gradient, maps DX and DY respectively.

The slope value has been calculated in degrees by the formula

$$\textbf{SLOPDEG= RADDEG (ATAN (HYP (DX, DY)/ pixsize (DEM))} \qquad (2)$$

where ATAN and RADDEG are two internal map calculators of ILWIS 2.1. ATAN finds the slope in radian while RADDEG converts the value from radian to degrees.

The resulting Slope map is shown in Figure 3.

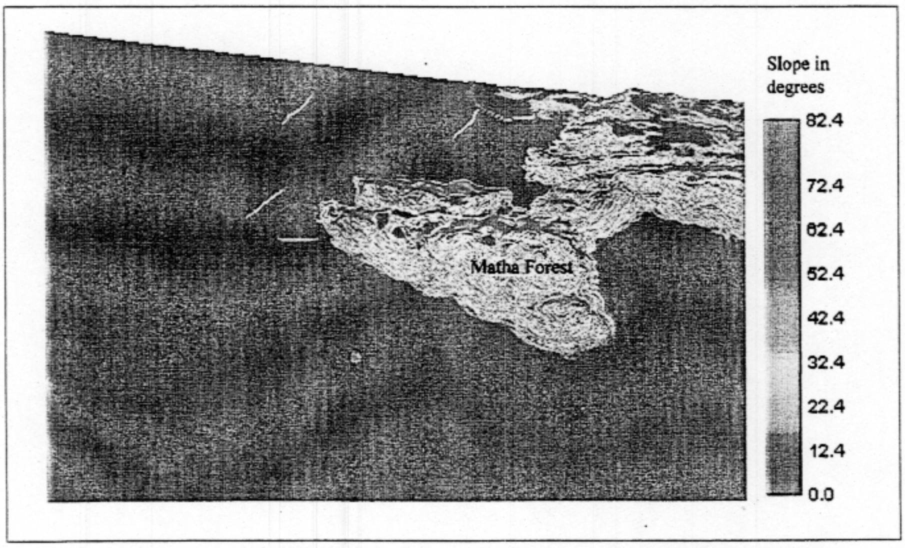


Figure 3. Slope Map of Matha Protected Forest and Adjoining Areas

Similarly slope direction is calculated by combining the gradient maps, resulting from application of horizontal and vertical filters on DEM. The aspect is then found out by using the formula

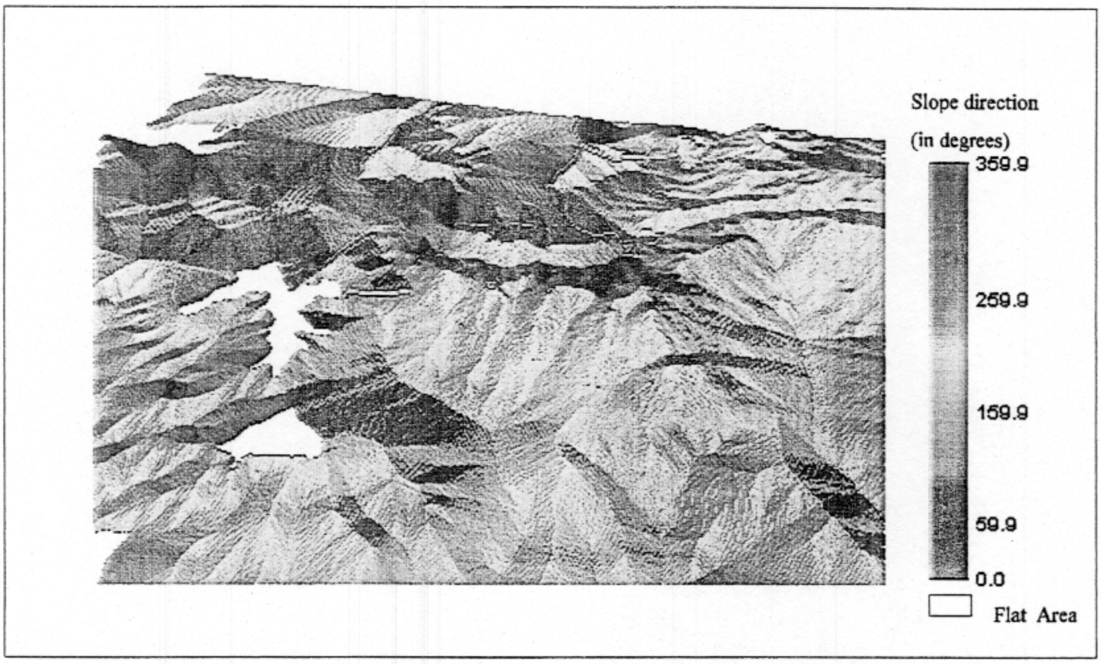


Figure 4. Slope Aspect map of Matha Protected Forest and Adjoining Areas.

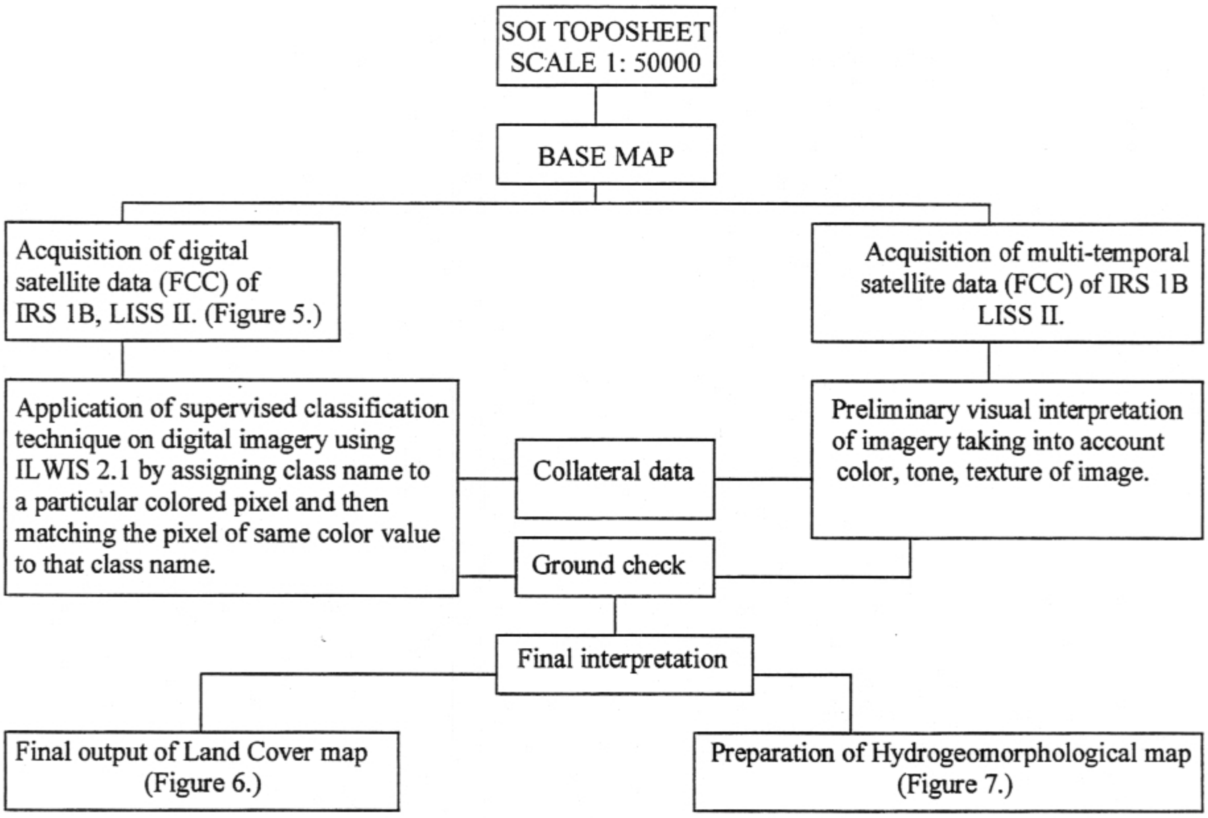
$$\mathbf{ASPECT = RADDEG\ (ATAN2\ (DX, DY) + \pi)} \qquad (3)$$

where RADDEG and ATAN2 are two internal map calculators of ILWIS 2.1 giving the aspect values between 0° and 360° as seen in Figure 4.

The Slope map and Aspect map generated from the DEM can be used very effectively in any GIS application.

2.1 Land Cover And Hydrogeomorphology Map

A land cover map and a hydrogeomorphology map has also been prepared using digital image data and ILWIS 2.1 by supervised classification technique and by visual interpretation technique using hard copy of satellite imagery along with ground checks respectively. The process is shown with the help of a flow chart, which is given on the following page. The resulting Land Cover and Hydrogeomorphology map follows the flowchart.



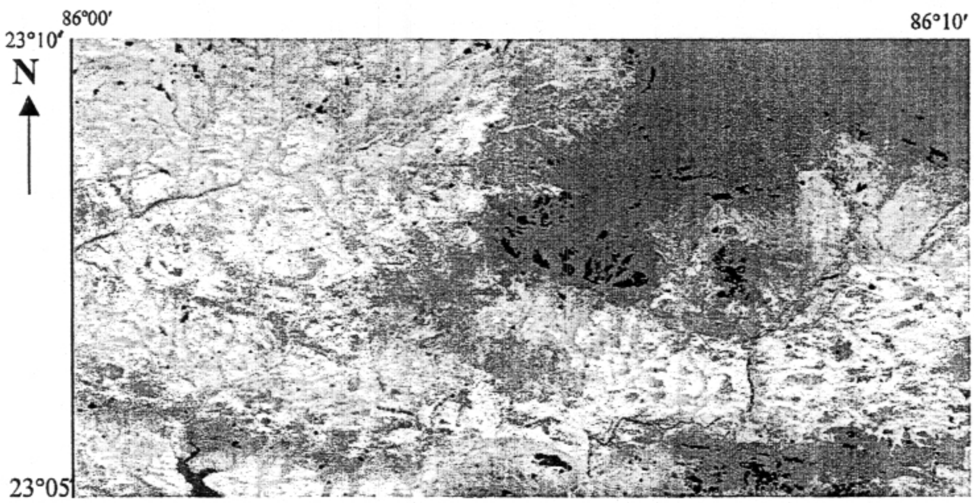


Figure 5. False Color Composite (FCC) of Matha Protected Forest of IRS 1B, LISS II

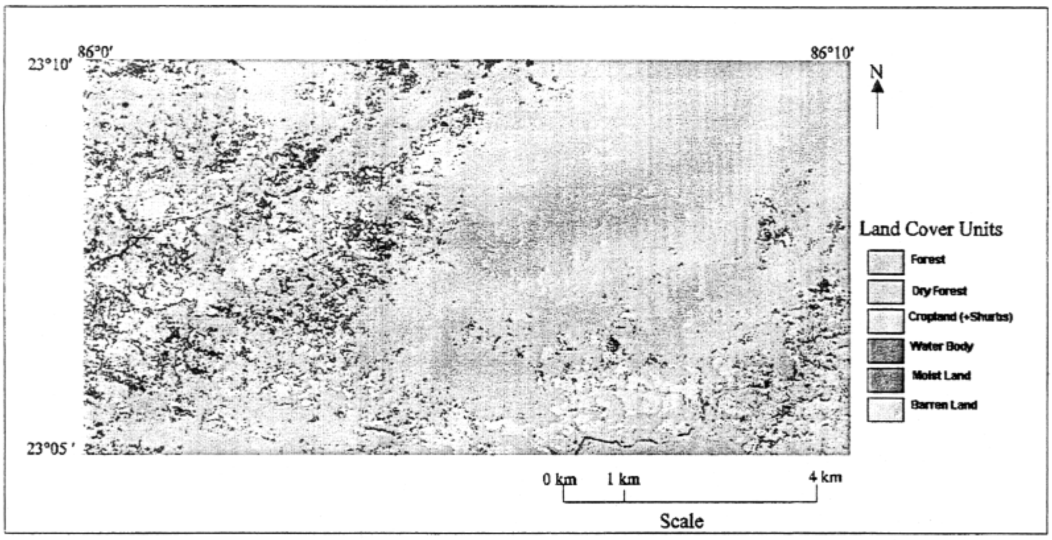


Figure 6. Supervised Classification showing Land Cover Units Of Matha Protected Forest and Adjoining Areas.

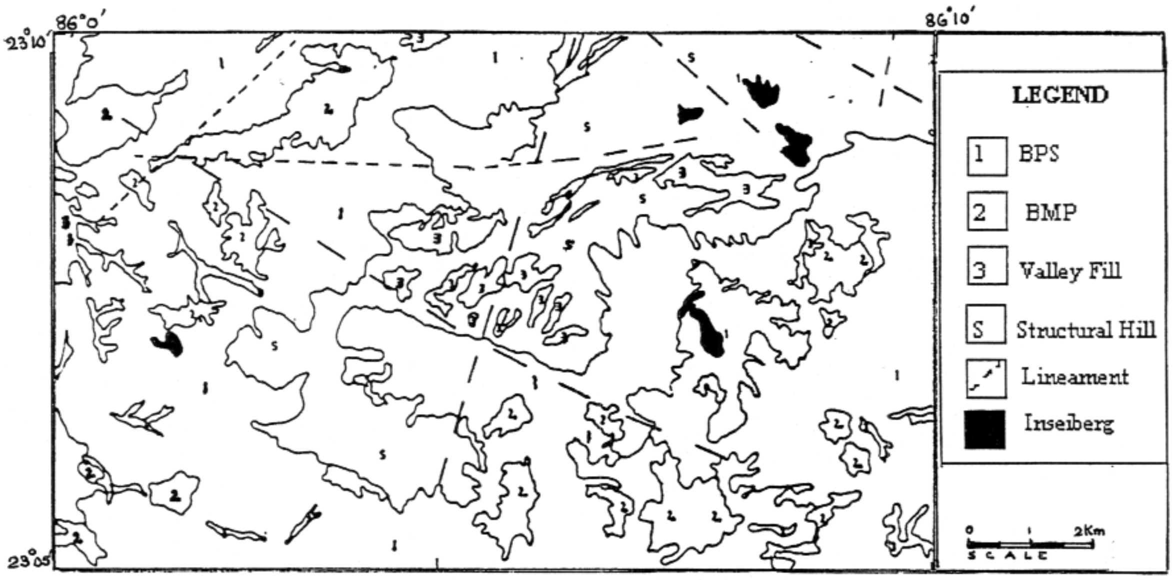


Figure 7. Hydrogeomorphology Map of Matha Protected Forest and Adjoining Areas.

3. RESULT AND DISCUSSIONS

The resulting themes can be integrated for further study. The DEM gives a clear picture about the lowest and intermediate level of the "three stepped erosional surface" of the Chhotanagpur plateau (Niyogi, 1987). The elevation range of 500 – 660 meters above M.S.L. represents the intermediate level while the elevation of 200 – 300 meters above M.S.L. represents the lower level. A relation can also be drawn between the slope map and the land cover map. It is seen that areas with very high slopes (>65°) generally show exposed rocky scarp sections within the forest. The areas where the slope values ranges from 35°– 65°are covered with open mixed jungle and forms part of the major structural hill and inselbergs present in the area. At the slope break portion the land use varies from barren land along with scrub forest and cropland at places. In the plains agriculture is the dominating land cover type with scattered pockets of barren land and settlements. The moist lands seen in the land cover map coincides with the major drainage of the area and the water bodies present in the area. As the False Color Composite (FCC) used for the classification was of the month of May, and Purulia being a dry area comes under the moist land category. Field data supports the relation drawn from the two theme maps and shows that settlement locations are mainly on the plains where availability of ground water are higher after it flows down the slope.

Similarly a relations can be drawn between the hydrogeomorphology map and the land cover maps. It is seen that the areas marked as structural hills and inselbergs are dominated by forest with rocky exposure at places. Besides the structural hill, BPS (pedimental area with thin soil cover) is one of the major geomorphic units. It is mainly covered with sparse agriculture though barren land occurs at places in the area depending on the availability of water. BPM (pedimental area with a moderate soil cover) are also present as small pockets constituting of only agriculture. The other important geomorphic unit present is the valley fills, which constitutes agriculture as the main land cover type. The settlements though not marked/ classified are strewn all over the area. Some lineaments have also been identified by visual interpretation technique.

The aspect map can be correlated with the drainage of the area to find if the drainage pattern matches the slope directions of the area. The hydrogeomorphological map can also be used to predict a qualitative availability of ground water depending on the geomorphic unit e.g. availability of ground water is good to moderate in BPM and Valley Fills where as poor in BPS, Structural Hills and Inselbergs. A quantitative study requires ground data of dug wells.

Thus the DEM, the slope map and the aspect map generated from it can be used very effectively integrated with the land cover and hydrogeomorphology map and other themes like drainage, soil, geology for further GIS analysis in the field of ground water exploration, landslide hazard zonation etc.

The accuracy of the analysis can also be enhanced through detailed study, which was beyond the scope of this work.

ACKNOWLEDGEMENT

The work is not an individual enterprise; contribution from every corner has made this work possible. One of the author (SKN) is grateful to the Jadavpur University for providing financial assistance through UGC Minor Research Project. The authors would like to convey their sincere regards to Dr. P.S.Roy, Dean, Indian Institute of Remote Sensing, (IIRS) Dehradun, India for permitting to work at the institute and use their facilities. We would also like to thank Dr. V.N.Jha and Dr. S.S. Chatterjee of IIRS for their kind guidance during the preparation of the maps and for their suggestions. Our special thanks to Dr. P. Chakrabarti and Mr. S. Nag of the State Remote Sensing Center, West Bengal, India for their suggestions and co-operation during the preparation of the paper.

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