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Delineation of Torsa river basin from remotely sensed digital elevation data

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ABSTRACT : Identification, classification, and monitoring of the earth resources along with detailed topographic information for use in hydrological analysis and modelling can be easily done by using remote sensing. Present study was conducted for selection of watershed outlet, developing the watershed boundary, clipping the watershed from the entire basin and the streamline generation for Torsa river watersheds from SRTM data. Using the ERDAS IMAGINE 8.6 and ArcGIS 9.2 software the delineation was done. A total number of 163959 sinks were found to be present in the DEM data, after sink filling the numbers of sinks were reduced to 6225 that gave continuous stream network. The Torsa river watersheds boundaries were generated from the filled DEM data. Watershed catchment was delineated by superimposing this clipped stream network over watershed boundary image. Satellite imageries, soil data, land use, land cover map etc. can be generated to develop a detailed database for quick reference of the hydrologists working in the region.

KEY WORDS : SRTM Data, Geographical information system, Water-shed delineation

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Remote sensing is the science of obtaining information about an object, area, or phenomenon, through the analysis of data acquired by a sensor that is not in contact with the object. In this regard the significant areas of concern are accurate delineation of watershed and development of a hydrological database with the information like runoff, precipitation, soil, topography, stream network etc. In remote areas collection of spatial topographic data by ground surveying can be a cumbersome process. Even with the use of very accurate modern surveying techniques like total station, it remains a challenging task to capture and create database for a large river basin. The commonly used topographic data is known as Digital Elevation Model (DEM) where the elevations are recorded in digital format. Salient advantages of such DEM data are easy data acquisition over inaccessible area, data acquisition at different scales and resolutions, and analysis of the data in laboratory to reduce extensive field work.

The All India Soil and Land Survey Organization developed an interpretative data transfer technique for demarcation of priority sub-watersheds to aid selection of highly eroded and responsive watersheds for soil and water conservation programmes(Biswas, 1985).The layered approach of theme extraction and composite mapping is possible for prioritization of watersheds with respect to sediment yield (Karale, 1985). The relevance of soil reflectance, as affected by soil texture, structure, organic matter and soil moisture contents has importance in delineating eroded land directly from satellite borne images(FCC) with field survey for natural and precise delineation (Singh, 1985). Selection of imagery is important to obtain maximum possible information about stream network and watershed geometry e.g., in tropical regions Side Lokking Airborne Radar (SLAR) becomes handy to penetrate dense vegetation and produce an image that exhibits topographic features and drainage patterns (Chakraborti, 1994). Remote Sensing and GIS techniques along with natural resource survey of the watershed were used to delineate priority watersheds for soil and water conservation measures leading to sustainability of Guhiya basin, Rajasthan (Khan *et al.*,2001).

A major portion of the floodplains of North Bengal is frequently affected by floods. Therefore, the area has a vast scope for the researchers to conduct hydrological studies. But the non-availability of relevant hydrological data for the area is a major constraint for conducting such investigations. There is an urgent need to develop a hydrologic database for the major river basins of the area as till now no such database is available with the hydrologist working in North Bengal. Keeping this in view, the present project work was undertaken to carry out raster based analysis for delineating watershed areas of Torsa river basins using ArcGIS software and generate stream network and extract DEM data for Torsa river basins of North Bengal.

■ METHODOLOGY

Study area :

The Torsa river is a 'trans-Himalayan' river flowing through the entire state of Sikkim. This river forms the boundary between Sikkim and West Bengal before merging with Brahmaputra in Bangladesh as a tributary. The Torsa River originates from the Chumbi Valley in Tibet, China, where it is known as Machu. It flows into Bhutan, where it is known as the Amo Chu. It has a total length of 358 km, out of which 113 km in China and 145 km in Bhutan before flowing into the northern part of West Bengal in India.

SRTM data downloading and processing :

The Shuttle Radar Topography Mission (SRTM) data for the study area were downloaded from the website http://srtm.csi.cgiar.org/. To cover the entire region of interest four scenes of data were downloaded. The data were in the form of compressed image file (*.img* file extension). Systematic step by step approaches were followed for further processing and analysis of the SRTM data. The performance requirement for SRTM data products are (a) linear vertical absolute height error shall be less than 16 m for 90 per cent of the data (b) linear vertical relative height shall be less than 10 m for 90 per cent of the data (c) circular absolute geolocation error should be less than 20 m for 90 per cent of data.

Software used :

For the analysis and processing of the SRTM data ERDAS IMAGINE 8.6 and Arc-GIS 9.2 softwares were used. For initial operations like masaicing and sub-setting the image processing software ERDAS IMAGINE 8.6 was used. The grid based analyses were conducted using the GIS package Arc-GIS 9.2.

Moseying :

The extracted SRTM image files were joined together using the mosaic option available in ERDAS IMAGINE 8.6. The four image files to be joined were added to the list one by one and an output file name was specified.

Subsetting :

After mosaicing the final image becomes a large file and grid based operations to be carried out with such large files may be time consuming. Therefore, wherever possible a smaller frame containing the area of interest can be clipped out for analysis. ERDAS IMAGINE 8.6 software was used to do the subsetting. The area of interest was defined by a rectangular selection and the selected area was subsetted using the subset option. The subset file created is also in *.img* format.

Preprocessing :

The grid based operations of DEM were done with ARC-GIS 9.2 software. For this the DEM data is to be converted from image format to grid format.

Water-shed delineation :

With the help of flow accumulation grid a suitable outlet can be specified from the viewer or by its co-ordinates. To specify outlet from flow accumulation grid the following grid command was used.

wshed = watershed (flowdirection (elevation), selectpoint (elevation,*))

where, *wshed* is the output grid file of watershed boundary. The command for clipping streamlines for watershed is

CLIP strmcov wshedcov wshedstrm LINE

where, *strmcov* is the generated stream network, *wshedcov* is the polygon coverage of watershed boundary, *wshedstrm* is the clipped stream coverage for the watershed.

Sink filling :

Sink filling is the process of filling the uneven depression in the streamlines and making the streamlines continuous. For the subset DEM file used in this study it was detected that there were total 163959 sinks. Now the filling of sinks is done interactively slowly increasing the fill depth till we get continuous streamlines. The grid command used for filling is

FILL elevation filled SINK 5

where, *filled* is the DEM file after doing 5 units of sink filling of the DEM file *elevation*.

■ RESULTS AND DISCUSSION

The selection of watershed outlet, developing the watershed boundary, clipping the watershed from the entire basin and the streamline generation were done for the Torsa watershed from SRTM data.

Creation of mosaiced image :

Using the ERDAS IMAGINE 8.6 mosaicing and subsetting of the data were done. The output image is displayed in Fig. 1 in greyscale composition.

Conversion from image to grid :

The subset image was converted from image to grid format using ArcGIS 9.2. The grid format DEM data is shown in pseudo colour composition in Fig.2.

Generation of continuous stream lines :

The stream lines visible in Fig. 2 are not continuous. This is because of the presence of sinks. A total number of 163959 sinks were found to be present in the DEM data. Using the process of sink filling the numbers of sinks were reduced to 6225. At this stage with the filled DEM the generated flow accumulation showed continuous stream network as seen in Fig. 3. This grid file was converted to arc coverage to get the stream network coverage.

Watershed delineation and data layer generation :

The Torsa watershed boundary was generated from the filled DEM data. Fig. 4 shows the Torsa river basins. Now using the watershed boundary polygon coverage the stream network for Torsa (Fig. 5 and 6) watersheds was clipped out. Similarly, different layers of data can be generated for these

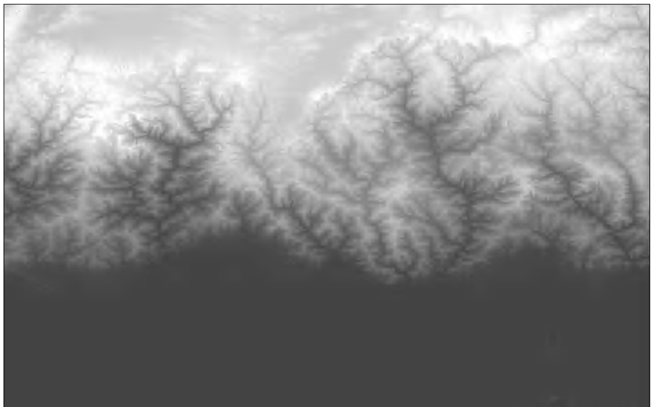

Fig. 1: Mosaiced and subsetted image in grey colour composition

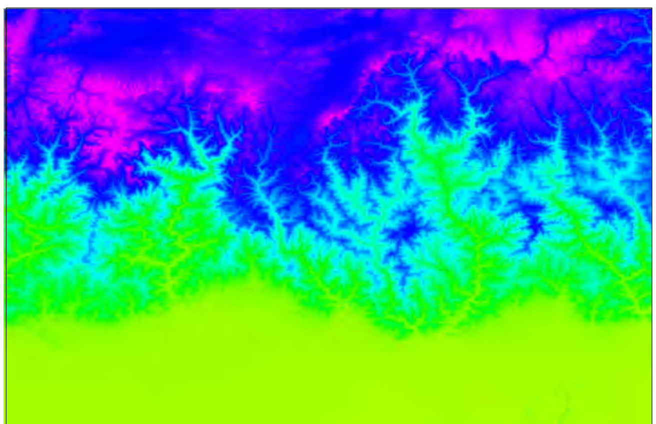

Fig. 2: Grid format DEM image in pseudo colour composition

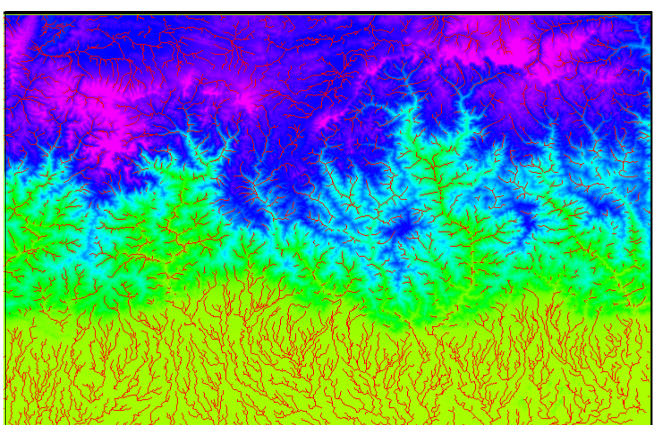

Fig. 3: Continuous streamlines superimposed over DEM

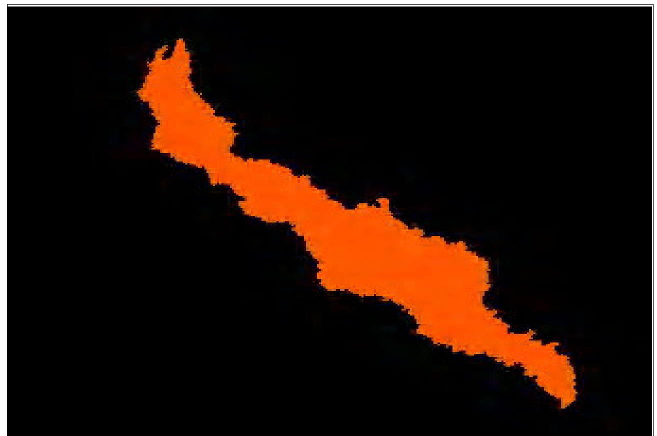

Fig. 4: Watershed boundary of the Torsa river

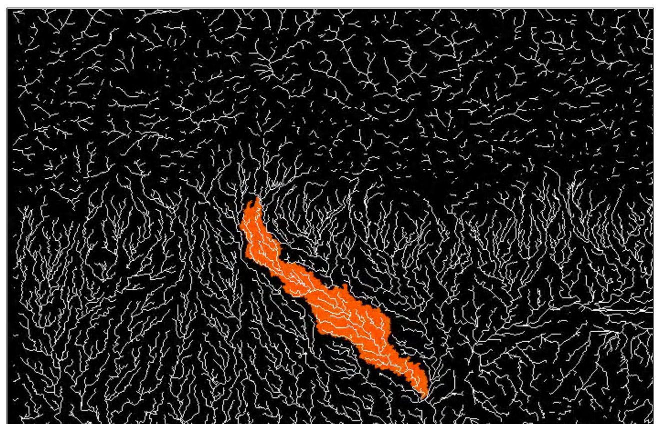

Fig. 5: Clipping of stream network for the Torsa watershed

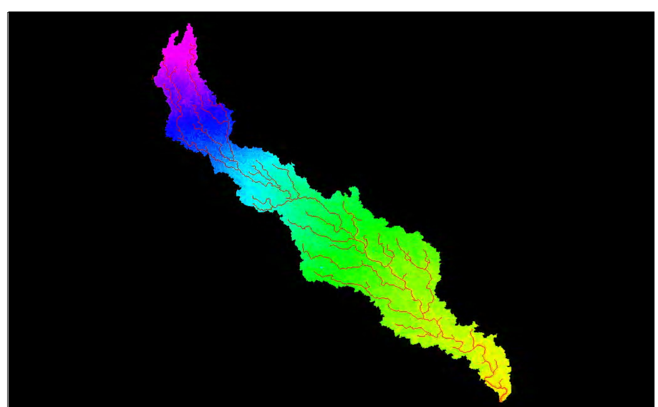

Fig. 6: Stream network layer over the DEM data of the Torsa watershed

watersheds. Similarly, satellite imageries, soil data, land use, land cover map etc. can be generated to develop a detailed database for quick reference of the hydrologists working in the region.

Conclusion :

The Torsa river basins were delineated successfully from the freely available 90 m resolution SRTM data. The stream network of the major river of North Bengal was also generated. In future the satellite data of land use and land cover (ETM, TM, LISS etc.), soil map etc. can easily be generated for the watersheds. Therefore, the use of remotely sensed digital elevation data can serve the purpose of GIS database generation for the remote but important river basin. The created database can be efficiently implemented for any hydrological analysis. The database can provide .

– Any necessary information to the hydrologist for their research
– Land use classification, soil map, runoff estimation etc.
– Slope map generation of the watersheds
– Valuable information as input to physical based hydrological models

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