A GIS based Automated Extraction Tool for the Analysis of Basin Morphometry

N.S. Magesh, N. Chandrasekar and S. Kaliraj

Abstract--- An automated extraction tool was developed through the model builder technique in ArcGIS environment to delineate the basin morphometry. The basic requirements to run this tool are a SRTM data, and a pour point shapefile. The developed model will create necessary data required for morphometric analysis after the processing of the input data. The output from this model will create a number of parameters such as, stream network (Strahler’s), aspect, slope, DEM, drainage density, hill shade, and basin boundary in meter square. Before proceeding with the model, there is an option to the user to select the minimum upstream area to which a stream should be counted. This option helps the users to select the range of stream delineation. The slope generated will be in degrees and the drainage density in Sq.km. This technique is very useful for those who work in the field of terrain analysis, hydrology, and watershed analysis as it is easy to use with a single click for the generation of a reliable database for morphometric analysis.

Keywords--- ArcGIS, Model Builder, Morphometric Analysis, SRTM, Stream Delineation

I. INTRODUCTION

Drainage basin analysis is one of the important criteria for any hydrological investigations. It provides valuable information regarding the quantitative description of the drainage system, which is an important aspect of the characterization of a basin [1]. Morphometric analysis requires measurements of linear features, areal aspects, gradient of channel network and contributing ground slopes of the drainage basin [2]. Drainage characteristics of Many River basins and sub-basins around the globe have been studied using conventional methods [3] [4] [5] [6] [7]. Identification of drainage networks in a basin can be achieved using traditional methods such as field observation and topographic maps alternatively by advanced methods like remote sensing and extracting features from digital elevation models [8] [9] [10]. Analysis of all drainage networks from field observation is a tedious task because of the extent of vast areas and rough terrain. In this respect, DEMs can be used to extract the drainage networks with the help of GIS techniques.

Extracting the drainage networks from DEMs is based upon the gravity, which means the water will flow from higher to lower elevation using the steepest descent, and it is assumed that there is no interception. However, to perform the analysis it requires step by step process without any flaw. To overcome this task, an automated extraction model is developed in this study that can be used to extract the drainage networks with the help of SRTM data and a pour point. The developed tool requires the above-mentioned data as input parameters for basin delineation and other supporting data for morphometric analysis. The developed tool was applied to Tamiraparani sub basin for data validation, and it was found that the generated data are reliable for further morphometric analysis.

II. METHODOLOGY

The SRTM (Shuttle Radar Topographic Mission) data used for this study was provided by the Consultative Group for International Agriculture Research Consortium for Spatial Information (CGIAR –CSI) Geoportal with a spatial resolution of 90 m. The area selected for this study is Tamiraparani basin within which a sub-basin was delineated using the automated extraction tool in ArcGIS (Figure. 1). The detailed schema of this tool is shown in figure 2. The resolution of the digital elevation model affects the accuracy of the extracted parameters. Therefore, it depends on the user, whether they go for high resolution or marginal resolution. High resolution gives better results as compared with low resolution.

A. Automated Extraction Tool

The extraction tool comprises of different Elements and Connectors. The elements are the data or a tool which is used as a building block to construct a model and the connectors which connect the elements for further geoprocessing. The element comprises of tool and variable. A Tool is represented by rectangle and is created when a tool was added or dragged from Arc Toolbox to the model builder window. Variables are represented with oval shape and are considered as containers that can hold values and can be changed as per user needs.

The model input parameters are highlighted in blue. These are Input DEM, output coordinate system, pour point data and minimum upstream areas in hectares. The yellow rectangles are the tools, and the green ovals are the variables. The ‘P’ marked near to the variables are the model parameters which will be shown in the tool before executing. The user has to give the location path for the input and the output parameters.

The model starts with a raw DEM then it is projected to user defined projected coordinate system. The output will be a projected DEM, and then it is processed by a Fill tool which removes the errors such as sinks and eliminates discontinuities. The output of the filled DEM is fed to flow direction tool. This tool calculates the direction in which water

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will flow out of the pixel to one of the eight surrounding pixels. This concept is called as the eight direction (D8) pour point model [11]. With the help of a pour point field and the flow direction raster data, a watershed raster is created. This raster is converted to a polygon using raster to polygon tool. Further the watershed polygon is subjected to a calculate area script tool. This will calculate the area of the extracted watershed in Sq.m. The watershed polygon and the projected DEM are fed to the Extract by Mask tool. This will clip the DEM with respect to the extracted watershed. From the clipped DEM various surface parameters are extracted using different surface tools like Aspect, Slope, and Hill shade rasters. Again, the clipped DEM is further processed for flow direction analysis, and the output is fed to flow accumulation tool.

The output from the flow accumulation tool is subjected to a conditional analysis using the Con tool. Here, the user has to give a condition that how much upstream area in hectares that a stream should develop. This conditional output raster is fed to stream order tool (Strahler's), the raster produced by this tool is subjected to stream to feature tool, and this will generate the stream network polylines. These lines are smoothened by smooth line tool using Bezier algorithm. The resultant stream network shapefile is further subjected to line density tool to create drainage density raster. The unit of this raster is in sq.km. The drainage network created by this model will have a Grid Code (i.e.) stream order number, a From Node, and a To Node. These nodes may be further analysed in Network analyst module to perform network-based analysis. The stream length of each stream order can be calculated using the field geometry option on the attribute table and analysed for further morphometric parameters.

Figure 1: Location Map of the Study Area

Figure 2: Geoprocessing Model for the Extraction of Basin and Supportive Morphometric Parameters
III. **RESULTS AND DISCUSSION**

This method effectively explores various spatial parameters and describes the process of geospatial model building for the extraction of basin morphometry. The screenshot of the developed model is shown in figure 3 and 4.

![Screen Shot of the Developed Model](image1)

Figure 3: Screen Shot of the Developed Model

The rasters created by this model are shown in figure 5. The results reveal that the Tamiraparani sub-basin is a seventh order basin with a dendritic drainage pattern. The slope varies from 0° to 61°, and most of the slope area is seen in the western part within the study area.

![Screen Shot of the Developed Tool](image2)

Figure 4: Screen Shot of the Developed Tool

The aspect reveals that there is a dominance of east-facing slope in the study area. High drainage density is seen in patches throughout the study area and ranges from 0.33 to 5.13 sq.km, and the elevation ranges from 29 to 1805 meters.

For data validation, the sub-basin polygon is overlaid with Survey of India toposheet of the respective area and found that the boundary line of the polygon is almost matching with the toposheet basin boundary. Hence, it proves that the data generated by this model is reliable for morphometric analysis.

IV. **CONCLUSION**

Automated model based extraction of stream network and other supportive morphometric parameters derived from remote sensing and GIS techniques have proven to be an efficient tool for basin analysis. This tool has reduced the work load for generating thematic maps and digitizing stream network from published topographic maps in GIS environment. The accuracy from the data produced by this tool is reliable for any basin analysis in a single click. Hence, this model may be considered as a time-saving tool for basin analysis in the future.
Figure 5: Supportive Rasters Created by the Extraction Model (DEM, Aspect, Slope, Drainage Density)

REFERENCES


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