Hydrological Analysis of Sooriyawewa Area using Remote Sensing and GIS Techniques

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Abstract: Sri Lanka is traditionally divided into three main zones namely Wet Zone, Intermediate Zone and Dry Zone according to the average annual rainfall. The dry zone of Sri Lanka is very often faced with severe drought conditions and the situation is becoming worse as time moves on. On the basis of surface water availability, Hambantota area, which falls with in the dry zone, appears to be a heavily affected area. Proper water management systems as well as preservation of existing surface and ground water resources and recycling are essential measures to overcome this problem. Hydrological analysis of the area is needed for a proper water management system. Integration of Remote Sensing and Geographical Information System (GIS) techniques provides a reliable, accurate and updated database on land and water resources, which is a pre-requisite for a proper water management system. Sooriyawewa was selected as the project area considering the average rainfall variations in Hambantota District. The spatial data based hydrological conditions such as, flow direction, catchments, drainage lines, drainage points, etc. were interpreted in the area. The hydrological condition in Sooriyawewa area is adequately delineated using these techniques, as pre-requisite to a proper water management system.

Key words: Catchments, Drainage, Dry zone, Hambantota, Water management

1. Introduction

The average annual rainfall in Sri Lanka ranges from 800 mm to 5000 mm. With respect to regional distribution of average rainfall, the country is traditionally divided in to 3 main zones named as, Wet Zone (receiving over 2500 mm rainfall annually), Intermediate Zone (receiving 1750-2500 mm rainfall annually) and Dry Zone (receiving less than 1750 mm rainfall annually).

Approximately 65% of the island falls under the Dry Zone. The Comprehensive Assessment of the Fresh Water Resources of the World (1997) predicts that two-thirds of the world's population will experience water stress conditions by year 2025. According to the studies conducted by United Nations, countries which withdraw their

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available water resources at a rate higher than 40 percent will face higher water scarcity conditions, thus forcing them to adopt urgently a proper management system of water supply and demand.

In the South Asian region, withdrawal rate of available water resources is 48 percent; thus severe water scarcity conditions can be predicted in the near future, if there is no proper management of available water resources.

Considering the availability of surface and ground water, as well as seasonal rainfall variations and drought conditions in the last few decades in Hambantota area, there is a high possibility for the area to face severe water scarcity problems in the future. Hence, a proper water management system is essential for the District to overcome these problems.
Integration of Remote Sensing and Geographical Information Systems (GIS) techniques provides an accurate and reliable data base. The objective of the study is to prepare a GIS database to interpret hydrological conditions of the area using RS and GIS data and other available data.

Sooriyawewa, located in the Hambantota district was selected as the project area. The methodology developed can be generalized to the whole District; and as the second stage, the method can be extended to other Districts in the Dry Zone to predict the possible water scarcity conditions in the future.

2. Methodology

1:10,000 Digital data of Sooriyawewa Area was purchased from the Survey Department of Sri Lanka.

The Triangulated Irregular Network (TIN) for the Sooriyawewa area was created by using the 5 meter interval contour map. It was converted in to a Raster layer and the Digital Elevation Model (DEM) by using ArcGIS software. Agree DEM was developed from DEM and the stream layer of the area using ArcHydro software. The Agree DEM was hydrologically corrected by fill sinks function (explained later) and Hydro DEM was created. If a cell is surrounded by cells with higher elevation, water is trapped in that cell and cannot flow. Fill sinks function eliminates this problem.

The Flow Direction Grid (Figure 1) was developed using Hydro DEM. This gives the direction of flow of the area and the values of cells indicate the direction of steepest descent from that cell.

Using the Flow Direction Grid, the Flow Accumulation Grid was created. Flow Accumulation Grid indicates the number of cells accumulated in the upstream to each cell.

Then the Stream Grid was created using Flow Accumulation Grid. The default River Threshold value (1410.48), which represents one percent of the maximum flow accumulation, was adopted for the area in Stream Definition.

Using the Flow Direction Grid and the Stream Grid, the Link Grid was created by using Stream Segmentation function, which assigns a unique identifier to each segment along a stream, separated at each junction.

Then the Catchment Grid (Figure 2) was created using the Flow Direction Grid and the Link Grid. Catchment Grid indicates to which catchment the cell belongs to. Then by using Catchment Polygon Processing, Drainage Line Processing and Adjoint Catchment Processing, the raster data developed was converted into vector data, which yield the Catchment Map, the Drainage

Line Map (Figure 3) and the Adjoint Catchment, respectively.

The drainage points related to each catchment were achieved by Drainage Point Processing Function, and the Drainage Point Layer (Figure 4) was developed by using the Flow Accumulation Grid and the Catchment Grid.

3. Results

The Flow Direction Grid (Figure 1), the Catchment Grid (Figure 2), the Drainage Line Map (Figure3) and the Drainage Point Map (Figure 4) provides information about the hydrological condition of the area.

The value of each cell in the Catchment Grid identifies to which catchment it belongs (Figure 2). The value corresponds to the value carried by the stream segment in that area, defined in the stream segment link grid.

The Drainage Point Map (Figure 4) indicates the most down-stream point of each catchment.

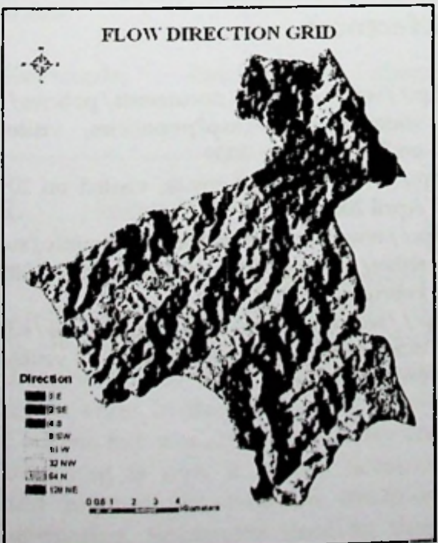

Figure 1. Flow Direction Grid of Sooriyawewa

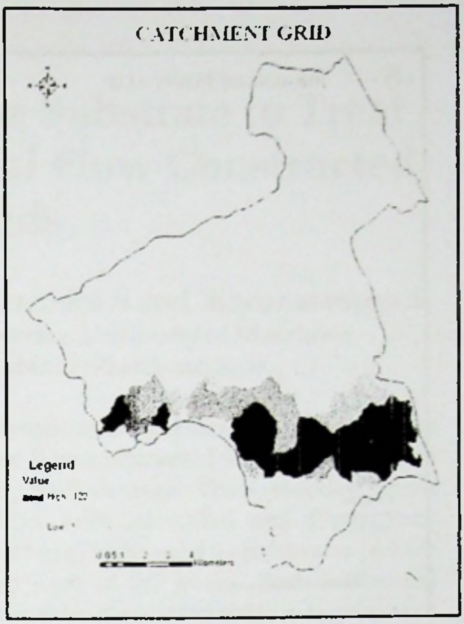

Figure 2. Catchment Grid of Sooriyawewa

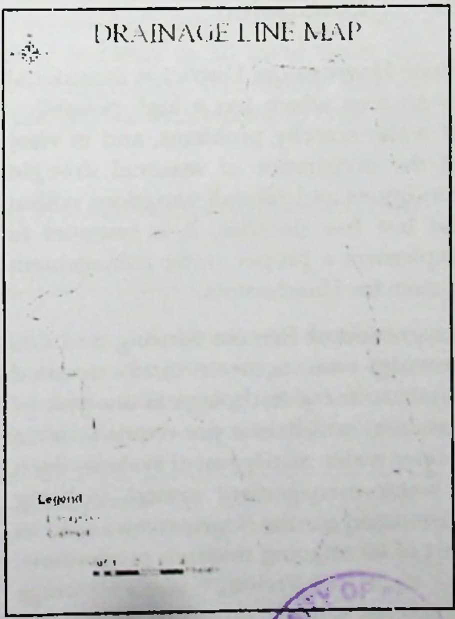

Figure 3. Drainage Line Map of Sooriyawewa

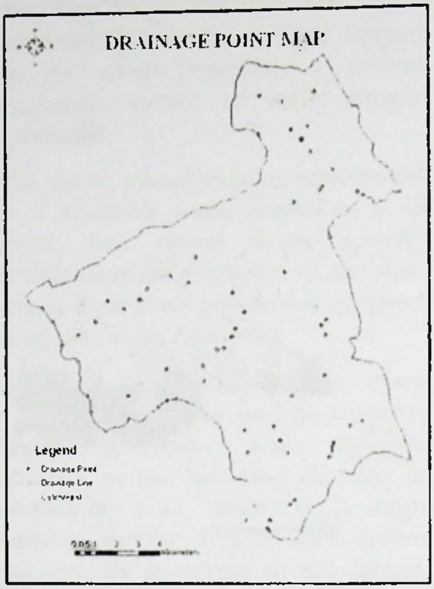

Figure 4. Drainage Point Map of Sooriyawewa

4. Discussion

Since Hambantota District is considered as an area which has a high possibility of water scarcity problems, and in view of the occurrence of seasonal drought conditions and rainfall variations within the last few decades, it is essential to implement a proper water management system for Hambantota.

Integration of Remote Sensing and GIS provides an accurate and updated database for a hydrological analysis of the area, which is a pre-requisite for a proper water management system. Such a water management system is being formulated for the Sooriyawewa area as part of an ongoing research programme. In such a system, water storage structures will be proposed at suitable locations, depending on the maps and the model developed using RS and GIS techniques.

5. Conclusion

Considering Sooriyawewa as the project area, and by using the contour map of the area, Triangulated Irregular Network (TIN), Digital Elevation Model (DEM), Agree DEM, Hydro DEM, Flow Direction Grid, Flow Accumulation Grid, Stream Grid, Stream Link Grid, Catchment Layer, Drainage Line Layer, Adjoint Catchment and Drainage Point Layer was developed, which can be then used to develop a water management system for the area.

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