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Rainfall Runoff Modeling Using GIS–A Review

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Abstract—*Water is one of the vital natural resource of any country. Water becomes scarce to meet the industrial and urbanization demands. Extensive care should be given to the operation and management of reservoirs and watersheds to overcome the water related problems. Hydrological modeling is a commonly used tool to estimate the basin's hydrological response to precipitation. It allows to predict the hydrologic response to various watershed management practices and to have a better understanding of the impacts of these practices. Urbanization has led to increase in surface runoff. This decreases infiltration and results in the increase in surface runoff and contributes more to the natural streams directly. Eventually the discharge and the surface area of the river are increased. The changes lead to water management issues.*

1. INTRODUCTION

Urbanization leads to change in land use. It decreases vegetation and increases concretization. Rain water runoff increases due to concretization. This changes the water-drainage patterns and rainfall-runoff pattern. This eventually results in rise of water management issues in a long period of time.

GIS is a computer based system used to capture, store, analyse, update and display data. GIS handle mainly two classes of data which are spatial data, identifying the location and topography of map and attribute data, identifying the characteristics of these feature.

2. REVIEW OF PREVIOUS WORK DONE

2.1 GIS

GIS is a system which provides a flexible environment for entering, storing, capturing and displaying digital data from various sources which are necessary for urban future identification, change detection and data based development. GIS allows forming multiple layers of information which is displayed on a single map.

GIS technology provides a flexible environment for entering, analysing, and displaying digital data from various sources necessary for urban feature identification, change detection, and database development. (Q.Weng, 2001).

Reddy (1997) described that satellite data provides integrated information on rock types, land forms, geological structures, weathering, soil types, erosion, land use/land cover, surface water bodies, distribution of ground water, slope details, soil type, rainfall, irrigated areas and their acreage etc., All this data if it is incorporated into the GIS package, it will form an excellent data base and becomes useful for judicious planning, proper development and effective management of water resources.

GIS plays an essential role to help people for collecting, analysing spatial data and displayed data in different format.

2.2 HEC-HMS

The HEC-HMS model is capable of representing accurately the different hydrological processes taking place in the watershed. The HEC-HMS replicates the entire shape of the observed stream flow hydrographs.

Baltas E. A. (2015) found that the HEC-HMS model is capable of representing accurately the different hydrological processes taking place in the watershed and replicating the entire shape of the observed streamflow hydrographs. The simulation of both the value and timing of the peak discharge volumes was generally very satisfactory, but in two cases there was notable overestimation. Overall they concluded that HEC-HMS model developed for the studied catchment is the robust tool for the prediction of runoff from rainfall data. Moreover, the low complexity of the model structures proves it a user-friendly, effective and efficient tool for hydrologic modeling.

HEC-HMS (Feldman, 2000) was used for rainfall runoff modeling. Separate sub models available in HEC-HMS were used, based on their suitability for event modeling as well as data availability and limitations. The purpose of the sub models combination was to enable estimation of all required parameters values from the available data. Unknown values of ungauged sub catchments were estimated from the local regionalization of the optimum parameters obtained from the calibration of the gauged sub catchment models.

Kotsifakis K. G. (2015) used three major tasks that were performed: (i) simulating the geomorphological features in ArcGIS environment, mainly by using the HEC-GeoHMS toolbar. (ii) importing the processed data to HMS and combining the historical data with the processed DEM. (iii) model processing.

It was found that the HEC-HMS model is capable of representing accurately the different hydrological processes taking place in the watershed and replicating the entire shape of the observed streamflow hydrographs. The simulation of both the value and timing of the peak discharge was remarkable. The simulation of the discharge volumes was generally very satisfactory, but in two cases there was notable overestimation. Overall, we may conclude that the HEC-HMS model developed for the studied catchment is a robust tool for the prediction of runoff from rainfall data. Moreover, the low complexity of the model structure proves it a user-friendly, effective and efficient tool for hydrologic modeling.

2.3 SWAT

Soil and Water Assessment Tool-SWAT model was used (Arnold et al 1995) to predict the effect of management decisions on water, sediment, nutrient and pesticide yields with reasonable accuracy on large, ungaged river basins on a daily time step. The components of the model are weather, surface runoff, return flow, percolation evapotranspiration, transmission losses, pond and reservoir storage, crop growth and irrigation, groundwater flow, reach routing, nutrient and pesticide loading water transfer.

Winchell et al. Spatial data (DEM, soil and land use) are used in the preprocessing phase and fed into the SWAT model through the interface. The soil and land cover make important responding units and the same is accomplished by SWAT model by subdividing the watershed into areas having unique land use and soil combination which are called Hydrological Response Units (HRU) during the process of runoff generation. SWAT requires an assortment of input data layers for model setup and watershed simulations. The topography of watershed is defined by a Digital Elevation Model (DEM). It is used to calculate sub-basin parameters such as slope and to define the stream network. The soil data are required to define soil characteristics and attributes. The land-cover data provide vegetation information on ground and their ecological processes in lands and soils. Climate, precipitation and stream flow data are sourced and prepared according to SWAT input requirements. (07)

2.4 SCS-CN

Beven and Krikby (1979) estimated the distribution of runoff yield by the technique called Variable Source Area (VSA) is a modified version of physically based modeling system and it is first developed by them with incorporating topographic index for identifying the fractional areas contributing runoff. By this technique the saturated and unsaturated zones of watershed can be delineated with the effects of land surface parameters.

Steenhuis et al. (1995) and Lyon et al. (2004),emphasized that it is more accurate to identify saturation areas and their locations in the river catchment with the use of Geographical Information System (GIS) and geo statistical tools of grid-based approach of land surface. Therefore the modified SCS-CN approach is appropriate runoff model for well vegetated humid areas since the saturation of soil based on the topographic parameters and effective rainfall depth.

M. K. Ghose (2010) used modified Soil Conservation System (SCS) – CN model for rainfall runoff estimation that considers parameters likeslope, vegetation cover, area of watershed. In order to study land cover type they have used Hybrid Classifier and soil map given by National Atlas and Thematic Mapping Organization (NATMO) as input to Soil Conservation System (SCS) model for rainfall runoff estimation.

3. CONCLUSION

Hydrological model of the region will show the changes in rainfall-runoff relationships and water drainage patterns as compared to that of previous years. Change in the Land Use Land Cover will have an impact on the rainfall-runoff relationship and eventually on the water body's discharge, storage capacity and related losses to water storage.

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