Ain Shams University
Faculty of Engineering
Irrigation and Hydraulics Department

A New GIS Technique for Runoff Modeling and Depression Storage Assessment

A Thesis
Submitted in Partial Fulfillment of the Requirement for the Degree of
DOCTOR OF PHILOSOPHY IN CIVIL ENGINEERING

Submitted By

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Statement

This thesis is submitted to Ain Shams University for the degree of Ph.D. in Civil Engineering (Irrigation and Hydraulics).

The work included in this thesis was carried out by the author at the Department of Irrigation and Hydraulics, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

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Abstract

Digital elevation model (DEM) is usually used for hydrological applications and have been broadly applied to analyze hydro-morphological characteristics of watersheds such as flow direction, flow accumulation, stream channel network.

Rectification of depressions and flat areas within DEM is needed before determination of flow direction of each grid in DEM. This is a problem in hydrological modeling, as mostly all DEMs have sink and flat grids, both can be actual or artificial and if they are kept unprocessed, flow paths will not be correctly simulated. Hence, a set of algorithms are available for correcting sink and flat grids in DEM in order to solve the problem of flat areas and depressions.

In this research, a semi-distributed grid-based GIS model has been developed for watershed delineation on a pixel scale. The model purpose is to develop a more accurately estimate of the initial abstractions due to the presence of depressions in a watershed over the duration of the adopted storm event. The developed model has been used to evaluate the effect of depressions on the total surface runoff volumes and peak discharges. This could be significantly used to reduce the sizing of the protection hydraulic structures. The model simulates hydrological processes of precipitation, surface runoff, and depression storage while water balance is maintained for each pixel. The total surface runoff is produced using (SCS – CN) method that accounts for land use, soil cover and soil type.

Additionally, the impact of the presence of depressions on runoff has been assessed from three points of view; outlet location, runoff volume, and peak

discharge downstream the depression. This has been carried out through three approaches; the first approach neglects the presence of depression, the second approach considers the depression in study but assuming one outlet with width equal to one cell size and the third approach is the same as the second approach but with multi-outlets with different widths and levels according to the nature of depression perimeter. The third approach gives more realistic values for runoff volume and peak discharge as it accounts for the volume of water stored in depression and represents the outflow from depression in more accurate way.

Keywords: DEM, GIS, Pixel, Peak Discharge, Runoff Volume and Depression

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