Determination the Curve Number Catchment by Using GIS and Remote Sensing

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Abstract—In recent years, geographic information systems (GIS) and remote sensing using has increased to estimate runoff catchment. In this research, runoff curve number maps for captive catchment of Tehran by helping GIS and also remote sensing which based on factors such as vegetation, lands using, group of soil hydrology and hydrological conditions were obtained. Runoff curve numbers map was obtained by combining these maps in ARC GIS and SCS table. To evaluate the accuracy of the results, the maximum flow rate of flood which was obtained from curve numbers, was compared with the measured maximum flood rate at the watershed outlet and correctness of curve numbers were approved.

Keywords—Curve number, GIS, Remote sensing, Runoff.

I. INTRODUCTION

ONE of empirical methods that is widely and global used by hydrologists, water project planners and water Engineering, is the curve numbers method that has been suggested and supported by the department of agriculture natural resources conservation service of USA [1]. Some applications of GIS are mapping curve number (CN) of catchment by using the digital data analysis, vegetation cover, land using and hydrologic soil groups; in this field, few studies had been done about the shortcomings and advantages of this approach and technology. Malekian et al (2004) used standard tables depending on factors such as vegetation cover, land using and soil hydrologic groups for mapping the curve numbers of the famous basin of Lighvan [4].

Khosroshahi and Saghafian (2004) made vegetation cover map Damavand watershed basin by using satellite images and then map of land using and soil hydrologic groups have integrated with GIS by using ILWIS software and curve numbers (CN) were calculated for the entire basin and sub-basins [2]. Molaei (2002) used SCS method to calculate the runoff volume in the watershed of Zanjan [3]. He combined the map of vegetation, soil hydrologic groups and using the field studies and applied some changes in the way of determination of CN, by using GIS and ILWIS software. This study focuses on the faster and more accurate ability of GIS in determining the CN.

Poundi et al (1999) prepared catchment land using maps in Remi by using satellite imagery IRS-1B, then with a combination of land using maps and determined land cover, soil maps and soil hydrologic group; and finally basin area

weighted curve number was determined according to the given surface by considering the available data and standard CN table in India [7].

The results of this study showed that no requirement exists for monitoring runoff basin Remy. Therefore the SCS curve number method can be used to predict runoff. In 2006 (InciTekeli), the curve number for the basin of Guvence in India was identified by using GIS and RS tools. In determining land using maps were used Landsat TM and for the density of the vegetation was applied the index NDVI [8].

Measured amounts of rainfall and catchment from 1987 to 2005 have been used for various return periods to calculate the flood discharge.

The purpose of this study is preparing the map of curve number in catchment runoff Darband in Tehran by using land maps, the soil hydrology group and vegetation area with SCS table, and also is combining these maps in ARC GIS environment to estimate catchment runoff.

II. METHODOLOGY

A. The Studied Area

The studied area is a part of the southern slopes of the Alborz Mountains, in which the cities of Tehran and Ray have been involved. Peaks of Tochal with a height of 3950 meters above sea level in the north part of this area and Shahr Rey with a height of 1,050 meters above sea level in the south of area are located. Flows resulting from rainfalls in the area are directed towards salt lakes through the above-mentioned rivers and along the north-south drainage. Catchment study is the part of the catchment area in north of Tehran which is located in the central basin in terms of overall watershed division in Iran. Catchment area is approximately 30 square kilometers and located in Tehran province. It is one of the important watersheds because its situation overlooks the political center of the country. The rivers of Glabdarreh and Darband are the main rivers within the project area. Glabdarreh catchment area is located in north of Tajrish and along the north-south flow. The river cross the street Darband after crossing near the village Glabdarreh and joins to the Draband river in bridge of Tajrish. Darband river catchment is located in the north of Shemiran and Darband square also at the west of Glabdarerh river. It is composed of the two main branches Jafarabad and Osun. Both branches have originated from the Tochal peak and are joined in Pas Qalee village and make up Darband River and enter to Tajrish and then Tehran. Then they cross the Sorkhe Hesarriver and flow to Shahre Rey. They tend to the southeast side after passing through the city. They enter to Jajrud near the Takhte Changi village. The studied area is

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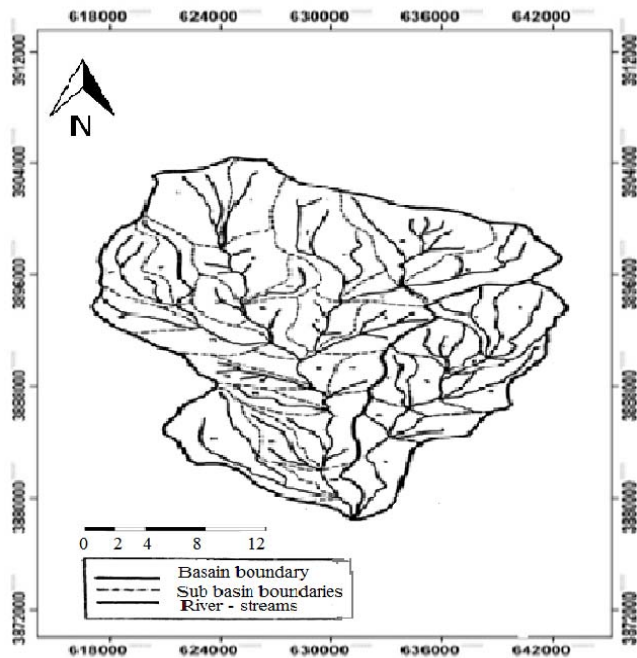Vol:8, No:5, 2014

shown in the Fig. 1.

Fig. 1 General location and hydrographic network Basin Darband

B. Making Topographical Map of the Catchment

To make a ArcCN-Runoff map for investigated catchment, information which was taken from lands at +ETM sensor have been used and in addition:

- Topographical maps (with the scale of 1:25000) in numerical and paper form taken from cartographic center
- geological maps
- SCS(US Soil Conservation Service) standard tables and other existing numerical and printed information in this zone also have been used.

In the recent decades, development of the hydrological models based on Geographical Information System (GIS) has captured the attention of the researchers and specialists. ArcCN-Runoff is one of the methods, ArcCN-Runoff determines the elevation and volume of the surface Runoffs based on SCS method.

The main characteristic of this method is calculation of Arc Number and Runoff number for each polygon separately.

This method has following inputs:

1) Land soil layer: this layer is created to do intersect operations on two layers of land use with Sub ClASS column and a soil layer with HYDGRP column.
2) Index table: in this table, ArcCN number for each hydrological groups of soil is extracted considering the type of land use and is saved in dbf format in the Excel then will be added to GIS working space.
3) Precipitation amount (P): precipitation amount with the dimension inch.

C. Making Land Use Map for the Catchment

Land use is an important characteristic of the Runoff process which affects the erosion and infiltration.

Land sat satellite images have been used to make a Land use map. Before using satellite images, radiometric and geometric correction have been done on +ETM bands and then correction have been done on +ETM bands and using merging method, spectral bands have been merged.

Topographical maps (scale 1:2500) and 6 control points on earth with proper distribution have been used to execute geometrical matching. All of the bands except $6t^h$ band have been used for assortment.

The image which is obtained from merging Land sat satellite bands has low resolution 30m; therefore resolution of the image has been increased by PAN satellite to 14m.

D. Soil Layer

The zone's soil map was taken from "Range land & watershed management organization of Tehran" and different types of soil have been digitalized in GIS working space. Then, hydrological groups of soil developed by US Soil Conservation Service (SCS) allocated to each type of soil. In this method, all of the soil based on their capacity to establish Runoff are divided to 4 groups A,B,C and D. Hydrological group of A has low capacity of Runoff creation and subsequently Hydrological group of B has high capacity.

E. The Map Representing Range Land Condition of the Catchment

It is required to be determined the condition of rangelands in terms of Vegetation density. Therefore NDVI (Normalized Difference Vegetation Index) is used on the +ETM data.

NDVI is efficiently applied to distinguish good Vegetation condition and bad Vegetation condition and bared soils and also to determine relative Vegetation condition.

There is NDVI values between -0,32 to 0,48 on the processed map.

SCS standard tables is used to determine the levels and considering rangelands condition ,the catchment is divided to three following levels, good, almost good ,average.

Determining levels have been executed by maximum possibility algorithm in "Erdas" software with regular checkout.

III. PREPARATION OF CURVE NUMBER MAP (CN) OF BASIN

At first, land use and hydrologic soil group maps in GIS program were combined. Then, with the help of curve number table [5], CN in the condition of average former moisture (class II) was defined. After that, with integration of homogeneous units, curve number map (CN) of basin was prepared according to (1) [5]:

$$CN = \frac{\sum CN_i A_i}{A} \qquad (1)$$

where, *CN*- weighted mean of curve number, *CNi* - curves number in per unit, *Ai* - Area in per unit and *A*- the total area of the basin.

According to Table I Sub-basin curve number is expressed as follows:

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- Below the confluence with the River Basin Avsvn Shirpala: 87
- Below the confluence with the River Basin Shirpala Avsvn: 88
- Central Basin River between the confluence of the rivers captive Avsvn and Shirpala to Bridge Rehabilitation: 80
- The following Glabdrh river basin to basin precipitation: 86
- Central basin River basin precipitation Glabdrh between the bridge and Rehabilitation: 81

TABLE I
NUMBER OF CURVES AND HYDROLOGIC GROUP DIFFERENT APPLICATIONS IN THE STUDY AREA

Percent of area	CN	Hydrologic group	Land use
0.21	67	A	
0.062	78	B	Irrigated
0.5	85	C	
0.476	30	A	
31.66	55	B	Forest
29.12	70	C	
1.6	76	C	Supplies
0.007	49	A	
7.3	67	B	Dry farming
23.5	81	C	
0.96	79	C	Pasturage
4.52	79	C	Terraces
0.005	68	B	Residential
0.58	79	C	
100			Total

IV. CALCULATION OF DIRECT RUNOFF BY USING THE SCS

SCS method is one of the partly simple ways to make synthetic unit hydrograph. In this method, time to reach to peak and amount of peak flow should be computed. In this method, input data included of lag time that is time difference between center of rainfall excess and peak of unit hydrograph. Maximum discharge and time to reach to peak are computed as follows (2), (3) [6].

$$U_p = c \frac{A}{T_p} \qquad (2)$$

where
A is the space of basin or sub-basin (km^2 or Iker)
C is the constant factor(0.208) for SI system and 484 for English system.
Up is the peak hydrograph discharge (M^3/S or F^3/S)
Tp is the time to reach to peak in hydrograph unit(h)

$$T_p = \frac{\Delta t}{2} + t_{lag} \qquad (3)$$

where
Δt is the time period or duration of the rain face excess(h)
t_{tag} is the time difference between center of the rain face excess and peak point of hydrograph unit(h)

In basin that data are it exist, for computing t_{tag} Scs suggest that (4):

$$t_{lag} = 0.6t_c \qquad (4)$$

where Tc is the time of concentration of basin for controlling number of the obtained curve, using combination of hydrological models HES-HMS, precipitation processes and runoff in basin, analyses of extension flood in river Darband simulated.

For modelling mentioned basin, at first, the physical basin modelling shows be added which, in Fig. 2 different Sub-basin by copy of corresponding river shown.

Fig. 2 Local Watershed DARBAND in HEC-HMS software

Unit hydrograph for mentioned basin can be seen in Fig. 3. After finishing HEC-HMS models, models of precipitation of extended runoff have ability to convert any kind of rainfall Floodwater in area. Comparisons show there is a good comparative between obtained hydrograph and observed hydrograph.

Fig. 3 Derived unit hydrograph of area by SCS method

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V. CONCLUSION

The results of this study showed that GIS and ArcCN-Runoff tools have high accuracy for estimating of runoff from watersheds, because GIS calculates hydrological groups, former moisture, land using and hydrologic conditions for each poly-gon curve number method. And also there is a power of combining layers of soil and land use in the GIS environment, which is the input of curve number method. All of them provide the raising of the accuracy of the model to estimate runoff. Storm runoff from the estimated independently in each period is the other advantage of this approach by GIS. Since the conversion of rainfall to runoff is the most applications curve number map, so many studies of basin hydrologic can be used for from the map of the prepared curve number. The results of this study suggest that the use of GIS, to provide a variety of maps, including maps of land using and watershed curve number map, is suitable and quickly and accurately guides the user information. Defining map of the watershed curve number shows is a significant difference between the weighted average numbers of curves in some sub-basins. Sub-basin curve numbers which have values larger than the other sub-basins, contain the prone to runoff and flood and the possibility of flooding in the basins are more in relative to other sub-basins.

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