

## Preparing the Runoff Curve Number, W Indicator and Surface Runoff Coefficient Map in the Basin of Iran

<sup>1</sup>Ali Gholami, <sup>2</sup>Ebrahim Panahpour, <sup>3</sup>Amir Hossein Davami

<sup>1,2</sup>Department of Soil Science, Science and Research Branch, Islamic Azad University, khouzestan, Iran.

<sup>3</sup>Department of Environmental Management, Science and Research Branch, Islamic Azad University, khouzestan, Iran.

Ali Gholami, Ebrahim Panahpour, Amir Hossein Davami: Preparing the Runoff Curve Number, W Indicator and Surface Runoff Coefficient Map in the Basin of Iran

### ABSTRACT

In this research, a part of Aghche basin in Isfahan province with an area about 2000 hectares, was chosen to be obtain curve number coefficient runoff and W indicator in second Cook method By using aerial photos 1968 and 1995, the satellite data of the IRS in 2008. Then the process of land use changes in the period of study and its effect on the changes of curve number (CN), W indicator and surface runoff coefficient (C) of the basin was investigated. These results showed that on the track of these land use changes the weight averages curve number (CN), surface runoff coefficient (C) and W indicator of the basin were increased to 0.92, 0.02 and 0.78 unit in the first period of study and 1.18, 0.03, 0.99 Unit in the second period of study respectively.

**Key words:** Surface Runoff Coefficient Map, Curve Number, W indicator, Land Use Changes, Watershed.

### Introduction

One of the most important factors in the exacerbation of erosion is land use change without considering the potential and capability of land which has had very negative and unacceptable compensatory effects such as changes in vegetation, increasing uncultivated and ploughed land, deforestation, land degradation and increase of desertification, water pollution and biological resources [1]. the important note is that the land use changes has direct effect on hydrological processes in the field, through its contact with evapotranspiration regime from one side and the degree, type and land cover from the other side and has a high tendency to reduce deep percolation and creating runoff and increasing water and wind erosion with the increasing of land changes [2]. For example, excessive livestock grazing in the pastures caused trampling and soil compaction and

reduced permeability and thus increase in the surface runoff. Also, deforestation caused the increased flow on land surface due to land cover ablation and increasing the speed of runoff [1]. Shrestha [3] in his study in Nepal, paid attention to land use changes during the years 1965 to 1981.

Then, by use of the SCS (Soil Conservation Service) method and average annual rainfall and weight CN determine of watershed concluded that land use change has been towards the increased runoff.

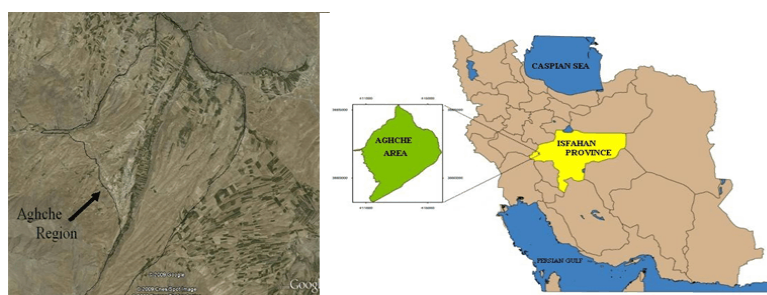
Kochenderfer *et al.* [4] with the study of the changes due to the forest management during the years 1979 to 1989 in watersheds 39 and 40 hectares of West Virginia, observed the significant changes in seasonal discharge and runoff volume and at the end offered suggestions for forest management activities, especially road construction to cause the minimum Surface runoff.

### Corresponding Author

Ali Gholami, epartment of Soil Science, Science and Research Branch, Islamic Azad University, khouzestan, Iran.  
E-mail: a.gholami@khouzestan.srbiau.ac.ir

Melesse *et al.* [5] in order to estimate the three watersheds runoff in Florida in result of land use changes, the curve number method was used. Land-use information from the LANDSAT satellite images related to years 1984, 1990, 1995 and 2000, was obtained. The Result of this research to the vast use of curve number equation of direct runoff used in due to its simplicity and flexibility to obtain sub basin hydrological response emphasizes as a result of land use change. Study conducted in two parts of Florida and Chinese Taipei, the effects of changes in hydrological behavior watershed during years 1990 to 2000 by using the runoff coefficient and runoff volume estimate was studied. According to studies conducted in this research and comparing land use changes indicated that in both studied areas, severe increase in urban areas and the significant decrease in agricultural lands, forests and pastures

existed that caused weight runoff coefficient increase for both areas during 10 years, which increased the urban areas and afterwards to reduce the water permeability, which normally increases the volume of runoff and maximum discharge and the risk of flood [6]. By using this that the ultimate goal in watershed is using comprehensive, coordinated and integrated management on all the resources of the watershed so that in addition to reasonable and appropriate and optimal exploitation from natural, agricultural and human resources, the amount of water waste and soil erosion reduce to a minimum rate. The present research sought to determine the relationship between land use changes with hydrological behavior of the basin. The studied area due to various uses, change in the land uses by passing time, available aerial pictures, satellite images and data available for study was selected.



**Fig. 1:** Position of the study area to Isfahan province and Iran.

## Materials and methods

### 1. Study Area:

The region is a part of the Aghche basin a suburb of Feraydan city with an area of 1970 hectares located in Isfahan province located in 50°02'13" to 50°05'56" long-east and 33°03'34" to 33°07'25" northern latitude. Main ways to access Basin in via Isfahan road, Daran-Aznaveleh-then Aghche .The highest part of the basin with an altitude of 3788 meters is located near the Kolahgaz Mountains in the south of basin and its lowest altitude 2288 meters in main basin channel. General slope of the basin is from south to the north that all of the basin channels flowing on basin surface by scattered channel system in the basin surface are conducted to outside. Figure (1) shows the position of the sub basin to Isfahan province and Iran. The average annual precipitation in this region is 417.85 mm.

Climate zone based on Domarton method is semi-dry and Amberje method is semi-wet cold. The average annual temperature is 9.5°C. The average maximum temperature is 9.8°C and absolute maximum annual temperature is 41°C (highest in June and lowest in January).

Minimum temperature is 4.7°C, absolute

minimum annual temperature is -31° C (January). Frost period is 140 days and usually in the cold seasons (Sept to April). Moisture regime and thermal regime in the region are Xeric - Mesic, respectively. Soil of area based on classified comprehensive method of soil (soil taxonomy 2006) is in the categories of Inceptisols and Entisols. According to geology the region is located in zone of Sanandaj and Sirjan and in the margin of Zagros. Important villages of this region are: Aznaveleh, Zarneh, Aghche and Hezar Jarib.

### 2. Preparing Land Use Map by Using Aerialphotos in 1968 and 1995:

After determining the latitude and longitude of the study area, with a review of existing aerial photos in Iran, they were registered in 1995 and 1968. In order to interpret the images, first the study area was visited and by questioning from the residents of the area, five types of land use including, pasture, irrigation farming, dry farming, urban areas and gardens were selected for the region. So images were interpreted by software, and then after the geometric correction changed into land use maps of the area, five types of land use including, pasture, irrigation farming, dry farming, urban areas and gardens were selected for the region.

**Table 1:** Specification of the aerial photos of the region.

Year	Scale	Zone	Air Line	Photos No.			
1995	1: 40000	57	16	16	17	18	
			17	16	17	18	
1968	1: 20000	68220	16	23	24	25	26
			17	22	23	24	25

So images were interpreted by software, and then after the geometric correction changed into land use maps.

Verification of maps produced by aerial photos in 1968 and 1995: Regarding to this fact, in years 1968 and 1995, there were not any maps about land uses according to comments of Barati *et al.* [7] only contented with a general evaluation of the local people through questions and the numerical map was finally interpreted based on local people.

### 3. Preparation the Curve Number Map and Calculating the W Indicator in Second Cook's Method:

The first step in this stage is preparing the map of hydrological soil groups. To prepare this map, the map of resources evaluation and land ability in Golpayegan sheet with scale of 1:100000 were used in which some of soil properties including permeability, soil texture, soil depth and gravel in each unit have been determined. By using these characteristics, and mainly relying on soil texture and depth, the map of hydrological soil group of basin according to standard definitions of SCS(soil conservation services) [8], soil groups were prepared. In the tables pertaining to curve number for various land use and hydrological soil groups, the amount of CN (Curve Number) was determined and presented [9,10,11]. Then regarding to the land uses of the basin and hydrological soil groups which are in three groups B, C and D, the amount of CN for conditions of primary moisture average (mode II) was calculated. For preparing the map of basin CN, in ERDAS, land use map and hydrological soil groups were combined together and the final map of curve number in years 1968, 1995 and 2008 was obtained. Finally, to evaluate the trend of CN changes, the weight average of the sub basin cure number in each period was calculated. The calculation of W indicator in second cook's method use of Soil Conservation Services method was performed in which the height of runoff with land cover, soil depth, permeability, drainage and slope conditions were linked, and all these factors were mixed together in one factor as . In this way W value for each factor was calculated by a table, and the total of them determines the amount of . By mixing and basin area, maximum discharge of flood with a return period of 50 years will be obtained. This calculated maximum discharge will be corrected by two R and F coefficient. R coefficient is the geographical factor of rainfall and

F the factor of conversion of probable happening which determines the maximum discharge for the return period of other than 50 years [8]. Considering that the aim of this study is to evaluate the trend of changes in a sub basin by passing time, area and the geographical factor of rainfall (which is calculated by average annual rainfall) are almost fixed, for studied periods only was calculated and the resulting numbers were compared together. So with the studies that performed in the region and help of previous studies, for the reviewed periods, maps of land cover, soil depth, permeability, drainage and slope conditions were prepared and according to the tables, this method was rated and finally to calculate, these maps were addition together [10].

### 4. Preparing the Surface Runoff Coefficient Map of the Basin (C):

Runoff coefficient is a ratio of the height of precipitation which flows on the surface of land depends on factors such as intensity of soil permeability, pothole storage, condensation of land cover, rainfall intensity and land slope [11]. In this research runoff coefficient by use of the tables in hydrology books, (considering the amount of slope and type of land use and soil permeability rate) was determined for various land uses [12]. Finally it was prepared as runoff coefficient map for the three periods 1968, 1995 and 2008.

## Result and discosion

### 1. Map of Basin Runoff Coefficient:

By using the runoff coefficient values determined for the various land use maps of basin runoff coefficient in years 1968, 1995 and 2008 were prepared. According to these maps weighted average basin runoff coefficient in 1968 equals 0.37, in 1995, 0.39, and in 2008, 0.42, were obtained. Table 3 shows changes of the curve number, and runoff coefficient in the courses of the review.

### 2. Map of the Basin Curve Number in Different Period of Study:

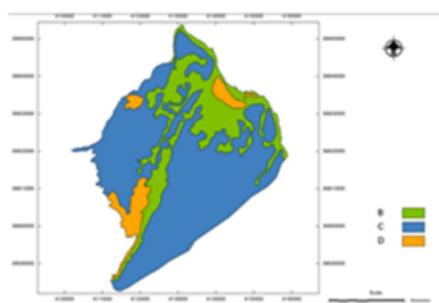
The map of the hydrological soil group of the basin is presented in figure (2) and their specifications in table (2). Regarding to the presented steps in the procedure, basin CN maps in the years 1968, 1995 and 2008 were prepared.

The results of curve number maps, the average weight curve number of the basin were obtained. 78.532 in 1968, in 1995, 79.454 and 80.636 in 2008.

### 3. W Indicator in Second Cook's Method:

By rating the maps of land cover, soil depth, permeability, drainage and slope conditions and collecting the maps with each in other, for each period the weighted average was obtained that this rate in 1968 equal to 48.085, in 1995 equal to 48.862, and in 2008 was equal to 49.852.

Significant part of the pastures is changed into farmlands. In the second period (1995 to 2008) the greatest decrease was about pastures and about 12 percent of their area is been decreased. But the highest increase in this period belongs to dry farming so that about 8 percent was added to the area.



**Fig. 2:** The map of soil hydrological groups.

**Table 2:** The areas of soil hydrological groups.

Hydrological Group	Area(hectare)	Area (%)
B	476.1275	24.17
C	1360.67	69.07
D	133.0925	6.76

**Table 3:** Changes of three reviewed factors in studied courses.

Factor	1968	1995	2008
Curve Number (CN)	78.532	79.454	80.636
$\Sigma^w$	48.085	48.862	49.852
Runoff Coefficient	0.37	0.39	0.42

### Conclusions:

#### 1. Land Use Changes During the Years 1968 to 2008:

Decrease in the pastures area in review of the entire the course is clearly visible, so that from the beginning of 1968 to 2008 a total of about 24 percent of the land use area has reduced. Due to the permanent plant coverage of these pastures which often consist of different species of *Astragalus* and by paying attention to this point that these pastures have often changed into farmlands and so in some periods of year they are in lack of required coverage to protect soil and water storage which is expected that the maximum discharge during this period will increase.

Regardless of changes in CN, and the coefficient of runoff, development of water erosion, especially surface erosion, rill erosion, gully erosion and piping erosion were visible in the visit of the area, which can attribute their recent development to their increase amount of surface runoff and discharge, although this may be arise from climate changes, natural factors and other factors.

### 2. CN Changes in the Region:

Comparing maps of CN during two periods 1968 to 1995 and 1995 to 2008 and amount of weight CN value estimated for the basin, increasing in the amount of curve number is seen in the basin. In the study period 1968 to 1995 because of the increasing, about 9 percent in the surface of irrigation farming and pastures decrease about 12 percent the value of CN, 0.92 has been increased which is showing the interference of human in the natural lands in this period of study in the region. During the years 1995 to 2008 level of pastures has decreased about 12 percent again about in this period because the major part of the change was the conversion of pasture land to dry farming (approximately 8 percent was added to the lands) the added to its amount. During the period 1968 to 2008 in total 2.10 rate curve number was added.

### 3. Changes W Indicator in Second Cook Method:

With the curve number, the amount of both periods 1968 to 1995 and 1995 to 2008 show increscent. It is interesting that the same as the curve number increased, the rate of increase in the second period (1995 to 2008) shows more than the first period (1968 to 1995). This increase rate for the second period has been 0.99 and for the first term 0.78.

Increased in both periods can be referred to the same reasons than the curve number. But the similarity in curve number and in the studied period can be interpreted like this: in order to calculate the curve number have been used hydrological groups and land use maps and to calculate , maps of land cover, soil depth, permeability status of drainage and slope have been used.

If the map of hydrological group has been prepared correctly it includes three maps of the soil depth, permeability and drainage situation, therefore if we assume that the slope in two studied periods is almost without change, regarding to correlation and relationship of land cover map to land use map, This similarity in the process referred to both factors is justified.

#### 4. Changes in Runoff Coefficient in Region:

In this study with comparison runoff coefficient maps prepared from the basin during two periods 1968 to 1995 and 1995 to 2008 and the estimated weight value of C is seen from the basin that the runoff coefficient value has increased, so that from 1968 to 1995 increase runoff coefficient has been 0.02 and during the years 1995 to 2008, 0.03, the process of the increase is similar to two other factor (CN and  $\sum W$ ) in the second period shows more than the first period. Of course it seems that changes in runoff coefficient in study periods were less than the actual rate, the reason can be considered to the approximate tables related to determine the runoff coefficient. The main cause of the increase is severe changes in land use without considering the potential and capability of land which has had very negative and irreparable effects such as changing land cover of pastures to irrigation and dry farming Tan *et al.* [6], Increasing uncultivated and ploughed land Fohrer *et al.* [2], trampling and pressing the soil of pastures due to excessive livestock grazing Symeonakis *et al.* [1], reducing permeability and maintenance of soil surface and consequently increase in the coefficient of runoff and afterwards increase in surface runoff. It is necessary to explain that irrigation and dry farming in studied area were not selected mostly based on land suitability and capability and if this attribute is considered to determine CN of farmlands in the area, certainly the increase in CN and the runoff coefficient will be more than determined value. With regard to this issue, if we could calibrate CN and C determined tables for regional conditions, better results can be obtained. Unfortunately, in the study region, there was no hydrometric information to help you calculate the correct values for three curve numbers, and runoff coefficients, but regarding to the aligned of three factors and the process of their same change during the course study and also regarding to the process of increasing water erosion and expanding types of water erosions in the region, can be somewhat sure of increasing process in surface runoff. So can be cited that increased incorrect human interference into their pastures and changed into inappropriate user in the region, has caused visible effects upon the soil and erosion, that a part of this effect has been due to the increased surface runoff which these three factors correctly show this increment.

#### References

1. Symeonakis, E., S. Koukoulas, A. Calvo and E. Arnau, 2004. A land use change and land degradation study in Spain and Greece using Remote Sensing and GIS, proceeding of XXth International Society for Photogrammetric and Remote Sensing Congress, Istanbul, Turkey, 12-23.
2. Fohrer, N., S. Haverkamp, K. Eckhardt, and H. Frede, 2001. Hydrologic response to land use changes on the catchment scale. *Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere*, 26: 577-582.
3. Shrestha, M.N., 2003. Spatially distributed hydrological modeling considering land-use change using remote sensing and GIS In The proceeding of Asia Map Conference, Nepal.
4. Kochenderfer, J., N. Edwards, J. Pamela and F. Wood, 1997. Hydrologic impacts of logging an Appalachian Watershed Using West Virginia's Best Management Practices, *North Journal of applied forestry*, 14(4): 207-218.
5. Melesse, A.M., W.D. Graham and J.D. Jordan, 2003. Spatially distributed watershed mapping and modeling: GIS based storm runoff response and hydrograph analysis: Part 2, *Journal of Spatial Hydrology*, 3(2): 2-28.
6. Tan, C.H., A.M. Melesse and S.S. Yeh, 2002. Remote sensing and Geographic Information System in runoff coefficient estimation in China Taipei. *Proceeding of Asian Association on Remote Sensing (AARS)*.
7. Barati, S., S. Soltani Kupaei, S.J. Khajeh aldin, and B. Rayegani, 2010. The review of land use changes in Qalleh Shahrokh sub basin by using remote measuring techniques (period 1976-2003), *Journal of Science and Agricultural Techniques and Natural Resources*, 47: 349-365.
8. Soil Conservation Service (SCS). 1985. *National Engineering Handbook, Section 4 Hydrology*. (US Department of Agriculture, Washington DC),.
9. McCuen, R.H., 1998. *Hydrologic Analysis and Design*. Prentice-Hall press. New Jersey.
10. United States Department of Agriculture (USDA), 1972. *National Engineering Handbook, Section 4, hydrology*. Soil Conservation Service, US Government Printing Office, (Washington, D.C).
11. Mahdavi, M., 2003. *Applied Hydrology*. Tehran University Press.
12. Ziaei, H.A., 2002. *Principles of Watershed Management Engineering*. Imam Reza University press.