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PRIORITIZING THE MOST EFFECTIVE FACTORS OF PRODUCING RUNOFF IN THE WATERSHED OF *RAZAVAR* RURAL DISTRICT IN THE CENTRAL DISTRICT OF KERMANSHAH COUNTY, KERMANSHAH PROVINCE (WITH AN EMPHASIS ON FLOOD PLAINS OF THE NORTH BASIN)

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ABSTRACT

Razavar watershed is one of the basins large and flood-prone in the north of Kermanshah. Geological parameters of vegetative cover, land use, infiltration of intercept time and time of concentration and intensity of precipitation in the basin were studied along with the separation of the basin into hydrological and smaller homogeneous units, moreover the statistical analysis of depth of runoff and peak discharge were calculated for each sub-basins and the major basin using SCS method, in the end the CN map was provided by collimating the map of units of soil hydrological, land use and vegetative cover. Thus the condition of lands was surveyed and evaluated in terms of the capacity of production of runoff, classification, weighting of geology factors, vegetative cover and S and CN coefficients. The findings of study indicate that geology factors, vegetative cover and CN coefficient have respectively been the most influential factors among effective factors in producing the runoffs of basin.

Keywords: Flood Plain, Homogenous Units, Soil Conservation Service (SCS) Model, Curve Number (CN) Coefficient, Weighting

INTRODUCTION

The amount of runoff coefficient in floodplains of river basins is due to the efficacy of several factors. The role and efficacy of each of these factors depending on climatic, natural and geographical conditions in each region is different from

other regions and of a constantly variable operation. Hence the relationship between rainfall and runoff varies considerably from a basin to the other one. There is this difference not only among basins with one another but also within each sub-basin of one basin, furthermore each sub-basin should be evaluated independently. (*Umīdvār* 2010, 73)

Different approaches are used to evaluate the state of the runoff coefficient in river basins the most important of these studies can be noted globally and domestically are as follows:

Hawkins (1979) made an effort to create a relationship between the surfaces of basin saturation and curve number (CN) in the State of Utah, but he did not obtain good results in runoff prediction by using the equation S2% for the preliminary reduction of basin. By studying several different flooding of watersheds, Bales et al (1981) concluded that the runoff from rainfall is way sensitive to changes of CN; therefore, by studying the physical properties of soil, they got to the point that the land use and physical properties of soil are the most important factors in determining the curve number.

Singh (1997) believes that the production of runoff in a watershed depends on several factors such as the characteristics of watersheds, dynamic precipitation,

infiltration and the preceding conditions of the basin. In another study done by *Legesse* et al (2003), they forecasted 30% reduction in the amount of runoff is due to the 10% reduction in the portion of rainfall, whereas the 1.5% increase of temperature has made the runoff reduce to lower rate and 15 %.

Pruski and Nearing (2005) studied the impact of change of the precipitation regime on the runoff in eight regions of the United States by using the outputs of monthly rainfall Hadcm3 Model. They reported that changes are variable from -9.6% to 10.6% in annual rainfall and from -24.5% to 41% in the runoff. Chang et al (2006) examined the GIS model to predict the runoff volume of river in areas without measuring station, and they have assumed in the model that the runoff relates to the portion of rainfall and the basin drain is the variance of rainfall and the amount of runoff can be modeled as a structure of rainfall.

Jenicek (2007) has dealt with the impact of vegetation on runoff process using CN&SCS methods and proven the effect of destruction of vegetation on flood increasing.

Huashi et al (2009) has examined the SCS method to estimate the amount of S-plane water detention and stated that the amount of surface runoff leads to soil erosion at first and turns into flood at the downstream.

In the present study the most effective factors of the production of runoff and the amount of runoff coefficient of CN have been identified and their prioritizing has been done as well by investigating factors affecting the runoff coefficient of CN and real data analysis using the SCS model, classification and weighting.

This study was conducted with the following objectives:

1. Computing the runoff coefficient in sub-basins and *Razavar* major basin runoff through the SCS Model;

2. Identifying effective factors on the amount of the production of runoff and comparing the quality and quantity of their performance in different areas;

3. Prioritizing the effective factors on the production of runoff basin.

Basin location:

Razavar watershed is located in the North and North West of Kermanshah between the longitude of 46°43′ 31″ to 34° 25′ 26″ and latitude of 34° 25′ 26″ to 34° 54′ 36″ and is considered as sub-basins of *Qarehsū* and Karkheh Rivers. The main channel of the river basin of *Razavar* is approximately 72 km long that the name, *Razavar* basin, was adopted from this river. The basin is within two provinces of Kermanshah and Kurdistan from the point of political divisions, and from constructional aspect it has been developed within two structural and major zones of Iran, namely, Zagros and *Sanandaj-Sirjan*.

Figure 1 shows the location of *Razavar* watershed in terms of provincial, administrative and regional divisions.
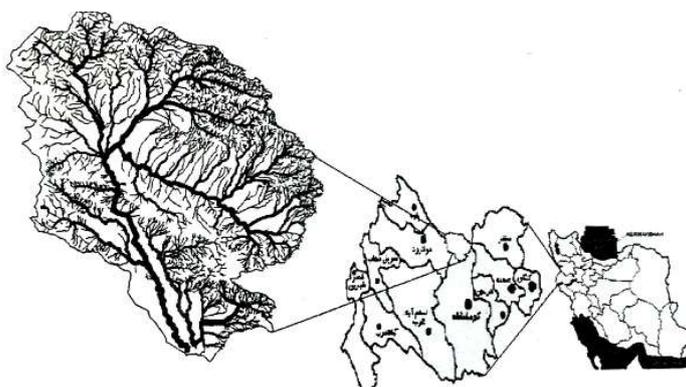

Figure1: *Razavar* **watershed Location (Source:** *Malikī* **2014, 112)**

MATERIALS AND METHODS

The depth of runoff has been computed using the United States Soil Conservation Service (SCS) which is working on basins with no or incomplete statistical data. Time of concentration and intercept time of each of sub-basins and the major basin have been obtained via the SCS method. The method of classifying the geological, vegetation cover and weighting map is used to

determine the most effective factor in producing the runoff.

Computing the runoff by Curve Number (CN) Method

In this method, the following formula is used to estimate the runoff.

$$R = \frac{(p - \%25^2)}{2(p = \%85)}$$

Where

R = the depth of runoff

p = the portion of rainfall (mm)

S = the index of water retention on the surface which is obtained by the following equation.

$$S = \frac{(25400)}{CN} - 254(\ mm\ )$$

Where

CN = Runoff coefficient

The rate of CN are obtained from the registration of maps of hydrological units of the region soil and the map of vegetation and land use of the basin with each other and current-specific coefficients proved. Runoff from rainfall can be described in terms of depth or volume. (*'Alīzādih* 369, 1998)

Computing the concentration time and the intercept in the basin by SCS:

Equation used to compute the time of concentration is as follows:

$$tc = \frac{ti}{\%6}$$

Where

tc = the time of concentration of basin (hour)

ti = The following equation calculates the intercept time of basin.

$$ti = \frac{(L)^{0/8}[2540 - 22.86 \times cn^{0/7}]}{14104 \times cn^{0/7} \times y^m}$$

ti = the intercept time of basin.

cn = Runoff coefficient

y^m = Gravitational gradient

L = the main drainage length

Isoheytal Method and gradient

The statistic regarding to the average annual rainfall of basin is computed by the method of isoheytal mapping and the portion of 6-hour and 24-hour rainfalls with different return periods, the method of rainfall gradient and recorded statistics in *Varmahang* site which has enough recorded rates and is higher than the other sites; the results of meteorology studies have been used herein.

Lands condition surveying in point of CN & S coefficients

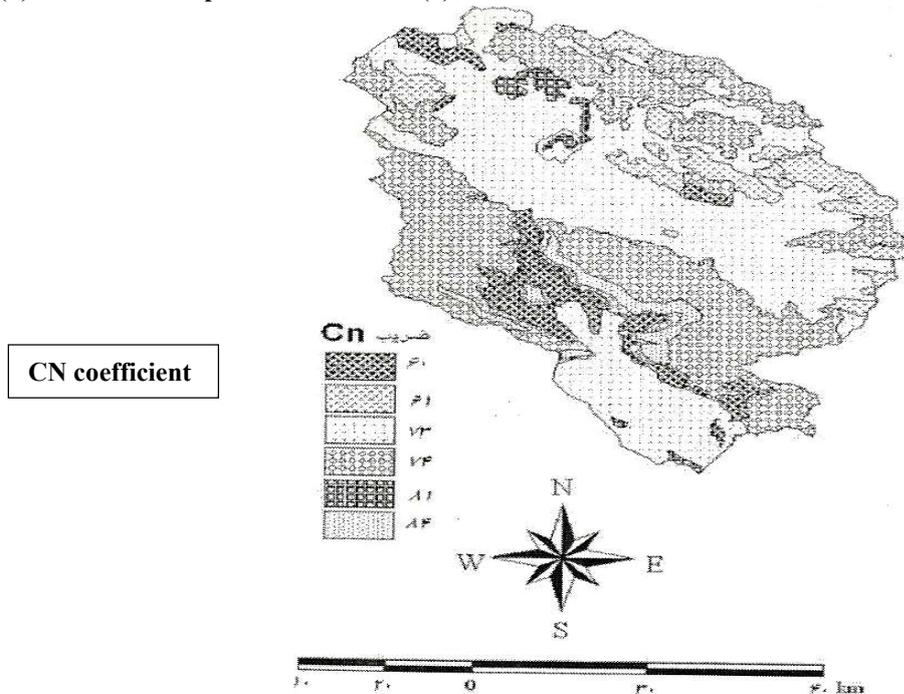Given the CN mapped of *Razavar* basin, lands with soil hydrological groups are of low CN coefficient and located in very low category in terms of runoff production; moreover, lands with D hydrologic groups are of high CN coefficient and are in very high category of the ability to produce runoff. At that according to the S map of lands drawn which of very low CN coefficient are of in the low rank of S

coefficient or the profile of absorption, and the lands of low CN coefficient are of high-level of absorption potential and in terms of S coefficient and are of high category in point of S coefficient. The classification of CN & S values are presented in the following **Tables 1-3**.

Class	
Low infiltration	
Average infiltration	
High-level infiltration	
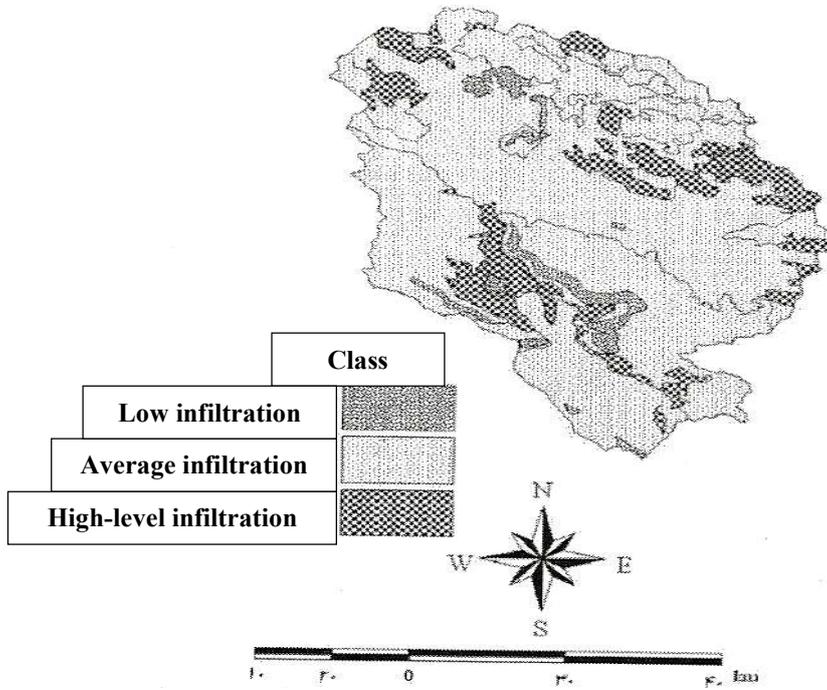
(S) Coefficient map of *Razavar* basin (1)

CN coefficient

(CN) permeability map of *Razavar* basin (2)

Determining the most effective factors of runoff production

Classification and weighted geological factor down

For this purpose, lithofacies and sedimentary facies of basin fall into five categories from the potential of runoff production aspect that consists of: with high-level permeability, permeable, semi-permeable, low permeable and non-permeable. Hence each rock unit in each sub-basin is weighted considering its area; in that facies with high-level permeability have assigned the maximum weight to themselves, meanwhile impermeable facies are assigned to the lowest weight.

Sub-basins in this category with the lowest weight have the least effect on the runoff production. Classification and weighting of geological formations are in the following **Tables 4-5**.

The evaluation of the digits given to the weight of each of sub-basins in the above tables showed that sub-basins 11-12-13-14-15 which belong to the northern basins are of the lowest weight of geological factor that shows the sensitivity of geological formations to the CN runoff coefficient. Being located the aforesaid sub-basins on the top of the basin of the spread of structural zone of *Sanandaj-Sirjan* and the reason of matter abovementioned would be well stated by the review of geological

map, for the northern districts of the basin is located on the geological-volcanic-metamorphic formations of *Sanandaj-Sirjan* that these geological formations in these regions are of low permeability, moreover they barricade the rapid penetration of water into the soil and create runoff in the sub-basins; furthermore the floodplains of this area are of higher depth of runoff and flood discharge than other parts of the basin. Then the lands located in these areas have been classified in very high altitude at the classification of the depth of runoff.

Classification and weighting of the factor of vegetation

Vegetation

Weighting the map of vegetation condition was taken to evaluate the efficacy of this factor on the production of runoff, additionally good vegetation cover is evaluated with high weight while the poor one with low; besides, in terms of vegetation, the basin to 4 classes very poor, poor, average and good divided by the weight of 1 to 4 has considered respectively as the factor of weighted vegetation cover. Afterwards the weight of each factor is multiplied by the area of each sub-basin and in the end divided by the total area of sub-basin, then the weight of any type of vegetation in each sub-basin has been determined and a weight was assigned to

each sub-basin from the vegetation point of view. Sub-basins with the lowest weight have the most effective role on the amount of runoff production, and those with the highest weight have the least role.

Weighting vegetation cover and the weight of each sub-basin is presented in the following tables in terms of vegetation.

The above tables show that almost the entire *Razavar* watershed is poor from the point of vegetation and indicative of the fact that vegetation is an important factor in the production of runoff.

Weighting the factor of CN runoff coefficient

The review of CN map prepared of the basin show that basins with high-level runoff coefficient are of the most efficacy on the amount of runoff production. Therefore the measure of weighting the CN map was taken and weighted CN obtained for each of sub-basins. The depth of runoff coefficient of each sub-basin is then presented as follows.

The above **Tables 7, 8** show that the basins 14 & 15 with the ranking 5 and the basin 5-6 as well with the rank 5 were of the high-level of CN coefficient and in terms of the depth of runoff in classification fell into the far way class.

Table 1: Classification of CN and S values for basins with rank 5

Classification for the CN of basins with rank 5			S classification for basins with rank 5		
Classification	The rank of each class	The name of sub-basins	Classification	The rank of each class	The name of sub-basins
Low	42 / 70-80 / 67	1-2-4-9-10-11-15	Low	68 / 94-71 / 81	3-5-6-14-16-17-18
Average	04 / 73-42 / 70	7-8-12-13-18	Average	65 / 107-68 / 94	2-7-8-12-13
High	66 / 75-04 / 73	3-5-6-14-16-17	High	62 / 120-65 / 107	1-4-9-10-11-15

Table 2: Classification of CN and S values for basins with rank 6

classification for the CN of basins with rank 6			S classification for basins with rank 6		
Classification	The rank of each class	The name of sub-basins	Classification	The rank of each class	The name of sub-basins
Low	58 / 72-51 / 71	1-6, 3-6, 6int	Low	95 / 90-84 / 85	4-5,6-6
Average	65 / 73-5872	2-6,6-6	Average	06 / 96-95 / 90	2-6,6-6
High	42 / 74-65 / 73	4-5,6-6	High	19 / 101-06 / 96	3-6,1-6, 6int

Table 3: Classification of CN and S values for basins with rank 7

Classification for the CN of basins with rank 7			S classification for basins with rank 7		
Classification	The rank of each class	The name of sub-basins	Classification	The rank of each class	The name of sub-basins
Low	40 / 72-53 / 71	7int	Low	72 / 92-54 / 88	3-7
Average	27 / 73-40 / 72	1-2,7-7	Average	90 / 96-72 / 92	1-7,2-7
High	14 / 74-27 / 73	3-7	High	08 / 101-90 / 96	7int

Table 4: *Razavar* basin lithofacies classification

Lithofacies classification	Name of each formation	Weight of each facies
Facies with high permeability	QV	5
Permeable facies	QTBL	4
Semi-permeable facies	DB-JK-ELV-TRJK	3
Low permeable facies	MQ-MM-ELF-KM-ELV-UB-GB	2
Non permeable facies	SR-EF-EL	1

Table 5: weighting the geological factor for each sub-basin

Basin name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Basin weight	4	4	4	4	4	3.38	2.39	2.29	2.33	4.11	3.21	2.70	2.57	1.81	2.15

Continued - Table 5: weighting the geological factor for each sub-basin

Basin name	16	17	18	1-6	2-6	3-6	4-6	5-6	6-6	6	1-7	2-7	3-7	7	R
Basin weight	2.60	4	4	3.85	4	3.36	3.15	2.64	3.21	4	3.92	3.25	2.92	4	3.33

Table 6: Vegetation classification

Vegetation cover condition	weight assigned
Good	4
Fair	3
Poor	2
Very poor	1

Table 7: the weighting of each sub-basin from the point of vegetation

Basin name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Vegetation weight	2.61	2.22	2.57	1.99	3.04	2.90	2.12	2.19	2.28	2.09	3.50	2.45	2.31	2.36	2.14

Continued -Table 7: the weighting of each sub-basin from the point of vegetation

Basin name	16	17	18	1-6	2-6	3-6	4-6	5-6	6-6	6int	1-7	2-7	3-7	7int	R
Vegetation weight	2	2	2	2.21	2.43	2.13	2.40	2.09	2	2	2.32	2.26	2.04	2	2.20

Table 8: Depth of runoff coefficient (CN)

Basin name	1	2	3	4	5	6	7	8	9
CN coefficient	69.53	70.91	75.51	70.04	74.78	73.90	71.41	70.44	68.39

Continued - Table 8: Depth of runoff coefficient (CN)

Basin name	10	11	12	13	14	15	16	17	18
CN coefficient	69.64	69.42	71.97	71.88	75.66	67.80	73.58	73.59	72.90

Continued - Table 8: Depth of runoff coefficient (CN)

Basin name	1-6	2-6	3-6	4-6	5-6	6-6	6int	1-7	2-7	3-7	7int	R
CN coefficient	71.89	73.30	71.51	74.01	74.74	73.56	71.53	72.59	72.67	74.15	71.53	72.73

RESULTS

Reviewing isohyetal map of basin shows that the maximum portion of precipitation over the eastern districts of basin is the average annual of 475-505 millimeters and over the central districts of *Varmahang* is 570 millimeters. Despite the higher rainfall, the less depth of runoff they have in comparison with other parts of the basin, and it suggests that the reason of production of runoffs of the basin is not the rainfall intensity but the role of other factors is more conspicuous. The development of limy Facies and intrusive masses despite of making the high-level and dipping formation feature has lower coefficient of runoffs that is due to vast development of systems of fracture and diaclase on these rocks and their high-level permeability. The chance of the production of runoffs on geological formations is only when the rainfall is like the severe showers in these parts of the basin. Although the development of Flysch Facies with the rotation of marl strata, sandstone, clastic lime, metamorphic rocks of serpentinites

and Chile marls affected by the characteristics of petrology and low resistance to erosion in districts of the North and East and North-West of basin have formed inferior morphological features and mild slopes, they have low permeability and higher runoff coefficient than other parts of the basin. If the hydrographic basin map was looked through carefully, the broad density of drainages in these zones would be showed well that it would confirm the low permeability and high runoff coefficient of these parts of the basin.

At that in some areas of the basin which has had better vegetative cover and so in this respect had a high weight and in the meantime been very low in classification from the point of the production of runoff, whereas some areas have come to very high-level in classification with low vegetative cover and low weight from the production of runoff aspect.

Generally speaking the results obtained from the study of factors affecting runoff production suggest the fact that geology factors geology, vegetative cover and runoff coefficient, respectively, are the most effective factors and sub-basins with good conditions in terms of geology, vegetative cover and infiltration have lower runoff coefficient as well.

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