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ORIGINAL ARTICLE

Runoff Estimation and Mapping within GIS Based Arc-CN-Runoff

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ABSTRACT
Due to the global water crisis, having the right information from that is essential in different parts for planning and optimization. Conventional methods of runoff measuring are very costly, time-consuming and difficult. Therefore, the purpose of this study was application of ArcCN-Runoff tools to create curve number and runoff maps in Haraz basin. For land use mapping Landsat image of 2011 was processed and analyzed. Hydrologic soil group map were prepared in GIS environment using the slope and soil texture map. Then, runoff and curve number maps were prepared by SCS method within ArcCN-Runoff tool in GIS environment. The results showed that the highest and lowest CNs respectively are related to bare lands (94) and dense forest (60). The average of CNs was 81.6. The average of runoff height was 0.42 inch. Runoff height in bare and residential uses was the highest value and in dense and low density forest was the lowest value. The total volume of runoff was 52.62 million cubic meters that the highest value was related to bare lands and the lowest value was related to forest areas.
Keywords: *Run-off, Curve Number, GIS, ArcCN-Runoff*

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INTRODUCTION

Land is the most important natural resource for human activities. Increasing in population and human activities cause an increasing demand for water and soil resources for agriculture, forest, rangeland and urban and industry uses. With increasing population, cultivated area cannot provide more population need, as a result, more areas must be cultivated to provide the surplus population need. The continuation and perpetuation of this situation reduce quality and quantity of water and soil resources [4]. With the increasing demand for water, the access to it will be critical and this issue complicates assessment and planning of water resources for sustainable use [16] Due to the global water crisis, planning for conservation and survival of water and efficient use of these resources are the most important development plans of each country. Without accurate information on water resources, planning would be meaningless [2]. With proper and principled planning, runoff can be very useful to solve the problem of shortage of water for drinking, agriculture and industry, particularly in drought conditions. On the other hand, measurements of runoff in Iran are a costly, time-consuming and difficult issue and moreover, in most basins of Iran, measuring stations of precipitation or runoff are absent or data are incomplete. Complete and reliable data in the researches related to hydrology are one of the serious issues. Thus, using of sensitive instrumentation to provide water resources and soil conservation data is an essential requirement in watershed management [3]. Also, in several studies, they pointed the simplicity and flexibility of decision-making with GIS and the possibility of reducing costs and improvement of planning quality [1]. A number of researchers have used GIS in different regions of the world. According to the mentioned studies, it is a powerful and effective tool in creating most input data in curve number methods for estimation of runoff. Thus, application of new tools such as RS and GIS for generating basic water resources data is also essential [8], [18]. The application of GIS and remote sensing for estimating

runoff in recent years has greatly increased [3], [5], [6], [7], [10], [12], [13], [18], [14], [15], Mallikarjuana, 2012). There are several internal and external studies in the field of estimating runoff using Arc-CN Runoff that were verified and emphasized the accuracy and efficiency of them. [3] provided the height runoff map using curve number method in GIS environment by ArcCN- Runoff tool in Azad river basin and they stated that this method is more accurate than traditional methods. The results of [8] showed that GIS and mentioned tools are highly accurate to predict basins runoff. Zhang and Huang [18] in a study, used ArcCN-Runoff tool to provide runoff and curve number map in Kansas state basin. They concluded that mentioned tools are useful for researchers to protect water resources in basins and It can be improved through considering more factors in determining runoff and curve number. Thus, with regard to all mentioned issues, in this study, ArcCN-Runoff tool in GIS environment was used to prepare runoff and curve number maps in order to water resources planning in line with the watershed management in Haraz basin.

STUDY AREA

The study area is part of Haraz basin with an area about 406000 ha, located in Mazandaran province in Iran. Fig. 1 shows the color composite of image (RGB432) in 2011. As the image shows, the main land uses are 1 and 2 grade range, hardwood forests, farming, horticulture and bare lands.

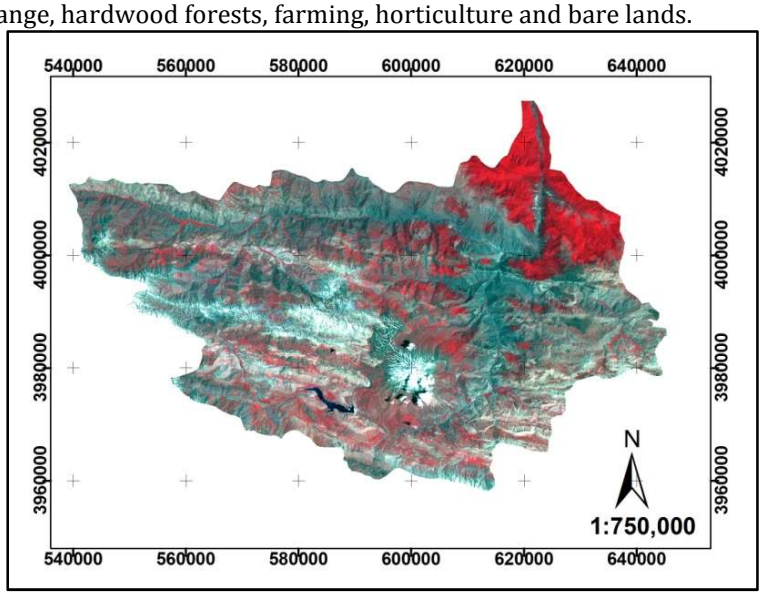

Fig. 1. Image color composite of study area (2011)

Land use mapping

In this study, the supervised classification method and maximum likelihood algorithm were used to land use mapping from the image of 2011. Then, the obtained map was processed and analyzed in GIS environment and different uses information were extracted. The classes were 1. Residential, 2. Irrigated farming, 3. Water, 4. Low-dense forest and orchard, 5. Dense forest, 6. First grade rangeland, 7. Second grade rangeland, 8. Rangeland and dry farming, 9. bare lands.

CN determination of land uses

The CN of different land uses in different hydrological groups in average moisture conditions were set and saved by literature review [9], [17] within a index table with DBF format.

Mapping Curve number

This step was performed within ArcCN tool in ArcGIS environment. To provide curve number map, land use and hydrological map were overlaid using Intersect function. Then, CN value per unit (Polygon) was identified by extracting relevant CNs of index table.

Mapping the runoff height and volume

This stage was performed by average rainfall in 2011 and resulted map of overlaying land use and soil hydrologic group with SCS method within ArcCN-Runoff tool in GIS environment and runoff height and volume map was calculated for each unit or Polygon.

RESULTS AND DISCUSSION

Land use map

Land use map and its different classes have shown in Fig. 2. This map indicate that residential, irrigated farming, water, low-dense forest and orchard, dense forest, 1 and 2 grade range, rangeland and dry

farming and bare lands included respectively 1, 0.15, 0.22, 2.46, 6.04, 4.65, 7.31, 62.74and 15.43% of the study area (Table 1).

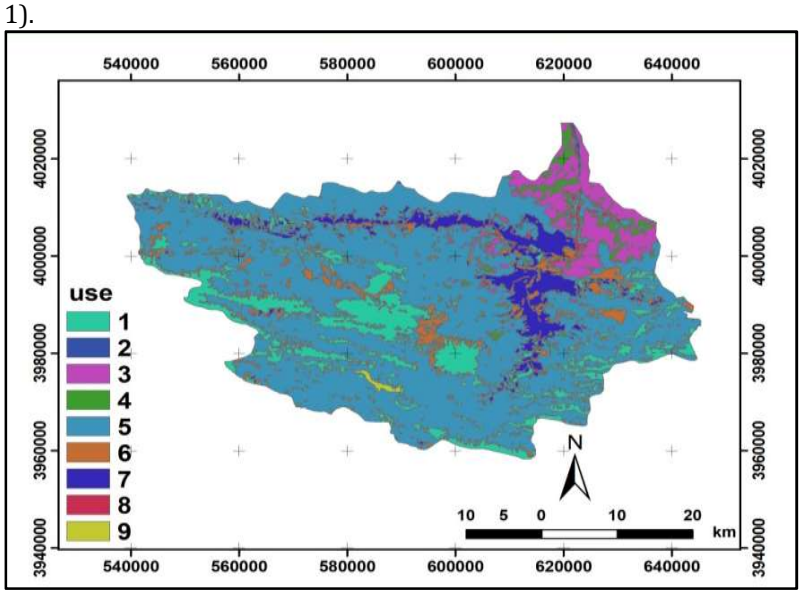

Fig. 2. Land use map of 2011

Table 1. Area of land use classes

Use code	Land use	Area (%)
1	Bare	15.43
2	Irrigated farming	0.15
3	Dense forest	6.04
4	Low dense forest and orchards	2.46
5	Range and dry farming	62.74
6	1 grade range	4.65
7	2 grade range	7.31
8	residential	1
9	Water	0.22

The map of curve number

Curve number map and corresponding uses has shown in Fig. 3. About 47% of the area had curve number 50-80 (Including all land uses except water, bare and residential lands) and 53% had CN more than 80 (Including all land uses except water, dense forest and first grade rangeland).

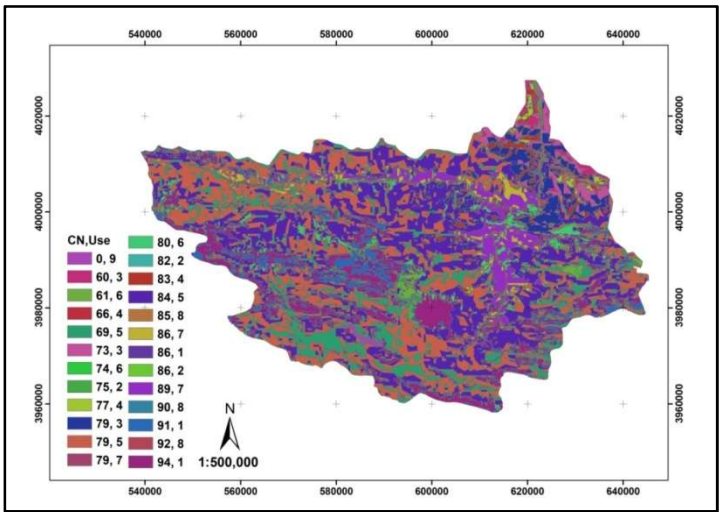

Fig. 3. Map of curve number and corresponding land uses

Runoff height map

Runoff height map and corresponding land uses has shown in Fig. 4. Results of this map, as is obvious from Table 2, show runoff height in different land uses, average and total of runoff height (0.42 and

11.38) in 2011. Runoff height in bare and residential uses had the highest value and in dense and low dense forest had the lowest value. This indicates the high impact of vegetated covered lands such as forests and rangeland in runoff control. Results of this study about runoff height (minimum 0.01 and maximum 1.2 inch) are relatively consistent with research results of zhan and Huang [18] (Minimum 0.01 and maximum 2.57 inch) according to differences of the rainfall amount and type and area of land uses.

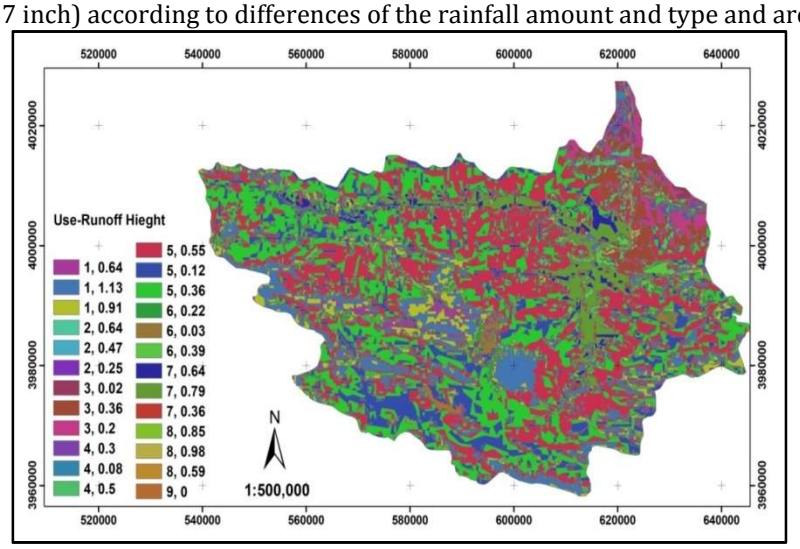

Fig. 4. Map of height runoff and corresponding land uses

Table 2. Runoff height and volume in different land uses

Land use	Runoff height (inch)	Runoff volume (mm3)
Bare	2.63	15.96
Irrigated farming	1.36	0.05
Dense forest	0.58	1.69
Low dense forest and orchards	0.88	0.88
Range and dry farming	1.03	26.4
1 grade range	0.64	1.36
2 grade range	1.79	5.39
residential	2.42	0.89
Water	0	0

Runoff volume map

Runoff volume map and corresponding land uses have showed in Fig. 5 and Table 2. As is obvious from the mentioned table, the highest runoff volume, respectively are related to range and dry farming, second grade range, bare land and the lowest are related to water, irrigated farming, residential, dense and low dense forest and first grade range. The total runoff volume in 2011 was 52.62 million cubic meters.Range of runoff volume according to the rainfall amount, area and current land uses are relatively consistent with the results of previous studies [18].

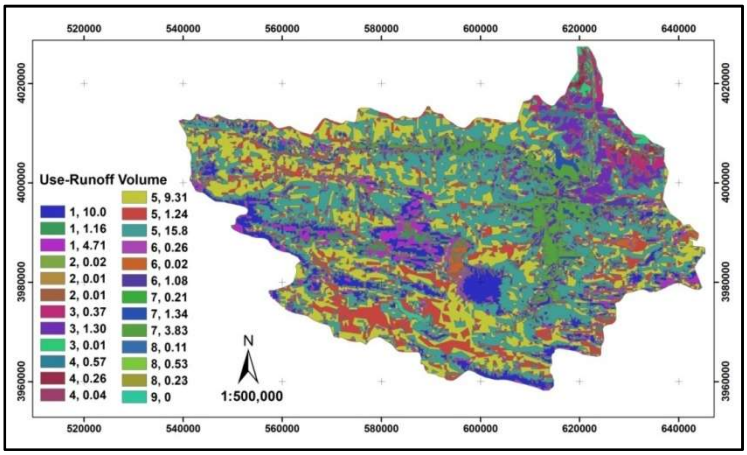

Fig. 5. Map of runoff volume and corresponding land uses

CONCLUSION

Approximately 86% of the study area has medium and heavy soil texture with capability to produce moderate to high runoff. Hydrologic groups B and C allocated about 85% of the study area. The highest CNs were bare lands (94) and residential (92) and the lowest except water were dense forest (60) and first grade rangeland (61). According to the total volume of runoff and total rainfall in 2011, percentage of runoff was high (about 30%) while it causes flood and erosion and subsequently many other environmental problems. Results of this study, like similar studies [18], [3] showed that ArcCN-Runoff tool creates many polygons by integration of land use and soil hydrologic group layers. Thus, curve number, volume and height of each of these polygons are determined with high speed and precision. Therefore, mentioned tools can be effective in water resources research. Also in this study, like previous research [1], the application and manner of new technologies such as remote sensing and GIS was showed to provide basic data in natural resources and applying them in watershed management plans.

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