Studying the Impacts of Land Use Changes on Flood Flows by Using Remote Sensing(RS) and Geographical Information System (GIS) Techniques- a Case Study in Dough River Watershed, Northeast of Iran.

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Abstract

Floods are generally categorized as the most important hazard causing enormous social, economic and human loses .Land use changes caused by man's interference resulted to an increase of flood severity and frequency during recent decades. In this research Environmental impacts of land use changes on surface runoff and subsequently flood flows, have been studied in the Dough river watershed. Curve number (CN) method was employed to estimate maximum discharge in two different cases: present land use as well as the proposed land use based on land capability. The study revealed the significant role of land use changes in increasing flood flow as a result of increased surface run off in the basin, particularly in dry soil condition. Changing the present land use to a proper condition based on land capability, may decrease maximum discharge to 70 %, 50% and 20% respectively in moderate, sever and very sever wet soil conditions, also pick discharge will be decreased to 20% in the basin .Here, the important effects of land use policies in severity of heavy floods especially when the soil is dry are apparently clarified. In the case of wet soil condition with high amount of rainfall (with longer return periods), the effect of land cover decreases though still plays its moderating role in diminishing the severity of heavy floods. Obviously, climatic and physical elements like heavy rains, the extent and the size of the watershed are also responsible for causing floods in this region, but anthropocentric activities like degradation of forest and rangelands, incorrect animal husbandry, mismanagement of natural resource, irrational allocation of land to settlements and construction of unsuitable structures and facilities multiplies the impacts and severity of floods. Remote Sensing (RS) and Geographical Information System (GIS) techniques have been extensively used to provide necessary information and maps.

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INTRODUCTION

Floods are globally categorized as the most important natural hazards that cause enormous social, economic and human losss. Land use changes caused by man's interference resulted to an increase in flood severity and frequency during recent decades. After a destructive flood, it is often claimed that man-induced effects have increased its severity

(Rosso and Rulli, 2002).

From the ecological point of view, flood is a sudden event that occurs in a hydrological cycle. When water level of a river rises and surrounds lower grounds around a riverbed, causes economic and human losses which are called as "flood".

The hydrological system of a watershed is created by the average debit so by increasing of debit (compared to its ravage), water overflows into the floodplain. As most human activities are taken place in flood plains, when flood occurs, causes a lot of socio-economic and human losses.

When rainfall intensity is higher than soil infiltration capacity, excessive water runs over the surface along the slope and reaches to the river. Surface runoff is the amount of rainfall measured in the riverbed. There is a direct relationship between the amount of runoff and land cover degradation, therefore studying the land cover map is an essential factor for estimating runoff height in the watershed; For rainfall 64 mm^3/h, when a good rangeland turns to poor one, surface run off will increases from 2% to 71% and soil sedimentation will reaches from 12 ton/km^2 to 1349 ton/km^2. (Mahdavi, 1999)

The soil erodibility factor (K) represents the combined effects of susceptibility of soil to detachment and transportability of the sediment, and the amount and rate of runoff given particular rainfall erosivity. K value increased with slope for most land uses due to changing erodibility components such as SOM, texture, structure, and permeability. Shabani and colleagues (2010) indicated in their study that pasture land with slope of 8-18% had minimum value of erodibility. The

maximum K value was for irrigated farming with 8-18% of slope. In addition, forest has the second highest value; however dry farming has much more erosivity than forest. In Iran priorities are given to pastures, forests, dry framing, and irrigated farming respectively. The first and the most important issue for all land uses, is to try maximise pastures and forests to limit the erosion. The preferred, land type for each category of land use is the one with lower slope.(Shabani et al, 2010)

Land cover changes have major effect on hydrological process due to the relation of evapotranspiration regime and land cover type that causes the decrease of infiltration, producing runoff and increasing water and wind erosion.(Foher et al., 2001)

In Iran, 30 % of lands are prone to the flood and arid climate of the region intensifies the situation. Almost 98% of Iran's rangelands are classified as poor to medium that are being increasingly degraded, so watershed management studies become more important in the country. In this research environmental impacts of land use changes on surface runoff and subsequently flood flows, have been studied in the Dough river watershed. Curve number (CN) method was employed to estimate maximum discharge in two different cases: present land use as well as the proposed land use based on land capability. The study revealed the significant role of land use changes in increasing flood flow as a result of increased surface run off in the basin, particularly in dry soil condition.

MATERIALS AND METHODS:

The study area is **Dough river watershed**, which is located on the north part of Iran (Figure1). It is a sub-region of Gorgan basin. Golestan national park is located at the end of the watershed.

Total area of watershed is about 1863 km^2 and the administrative boundary of three provinces (Khorasan, Semnan and Golestan) crosses the basin (forest, range and watershed management organization, 1993). Dough river watershed was divided to 4 sub-basins and 27

parcels, according to the topography, hydrological network and objectives of the study (Figure2).
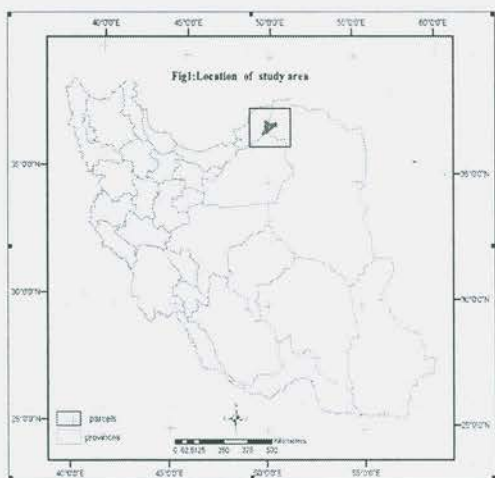
Reference :(Tehrani, 2002)

Fig1: Location of study area

Figure2: Sub- regions and parcels of Dough river watershed

Four major Dough river watershed's sub-basins are:

1. 1- Robat- e- gharebil: covers an area of 469 km2, extending to the eastern part of the watershed that includes 11 parcels.
2. 2- Golestan national park: with an area of 350 km2, in the western part of the watershed with 7 parcels.
3. 3- Dasht: with an area of 310 km2 in the central part of the watershed with 2 parcels.
4. 4- Nardain: that covers 734 km2 in the southern part and with 7 parcels.

(Forest, range and watershed management organization, 1999)

METHODOLOGY

The following steps have been taken to study land use changes effects on flood flows in the study area:

1. Choosing the suitable method (Curve Number method) for estimating runoff based on land use changes.
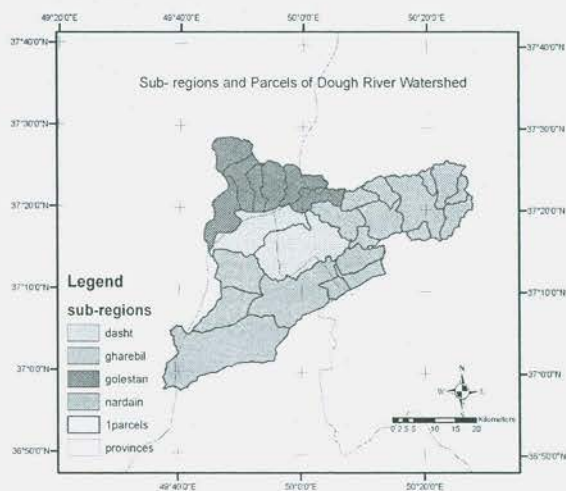2. Produce necessary maps and information with using Geographical information system (GIS) and remote sensing (RS) techniques.
3. Processing related Landsat satellite images and Choosing and processing suitable Landsat images: TM 1998) for producing land use map.
4. Gathering 30 years' statistical data of rainfall for 13 stations and Calculating 24 hours rainfall and different return periods of rainfalls (2-5-10-25-50-100-200-500 years).
5. Preparing CN and Run off Maps in 3 different soil moisture condition (I, II, III) and with different return periods in two cases: current land use and land capability.
6. Comparing land cover, soil, CN and runoff of watershed, sub-regions and sub-regions in two conditions. Current land use and land capability.
7. Studying the maximum debit produced in parcels, sub regions and the whole watershed. Figure 3 shows the flow chart of the study.
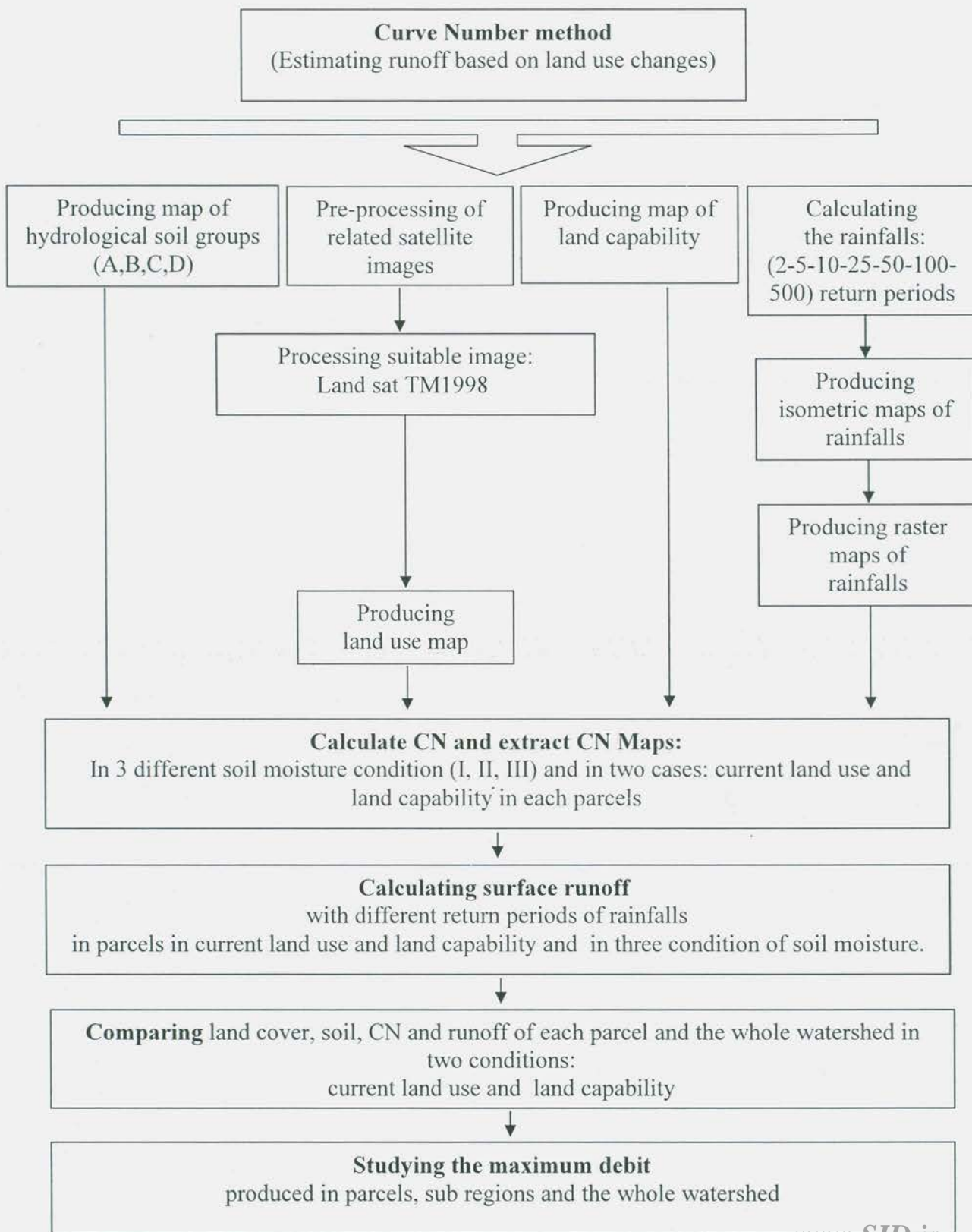

Curve Number method
(Estimating runoff based on land use changes)

| Producing map of hydrological soil groups (A,B,C,D) | Pre-processing of related satellite images | Producing map of land capability | Calculating the rainfalls: (2-5-10-25-50-100-500) return periods |

Processing suitable image: Land sat TM1998

Producing isometric maps of rainfalls

Producing raster maps of rainfalls

Producing land use map

Calculate CN and extract CN Maps:
In 3 different soil moisture condition (I, II, III) and in two cases: current land use and land capability in each parcels

Calculating surface runoff
with different return periods of rainfalls
in parcels in current land use and land capability and in three condition of soil moisture.

Comparing land cover, soil, CN and runoff of each parcel and the whole watershed in two conditions:
current land use and land capability

Studying the maximum debit
produced in parcels, sub regions and the whole watershed

Figure 3: The flow chart of the study.

1- SCS Curve Number Method:

Curve Number (CN) is one of the basic methods for estimating run off and has been developed by American Soil Conservation Service (SCS) and is used in watersheds with inadequate or inaccurate statistical data. (NEH, 1985).

Curve Number is widely used in applied hydrology to estimate surface run off. It is an efficient method to determine the approximate amount of direct runoff in a particular area which accounts explicitly for land use in the parameterization of potential soil retention. The runoff curve number depends on the area's hydrologic soil group, land use, treatment and hydrologic condition. References, such as from USDA, indicate the runoff curve numbers for characteristic land cover descriptions and a hydrologic soil group. (Rosso and & Rulli, 2002)

Hydrologic soil group number, land use type, vegetation cover, soil conservation measures, antecedent soil moisture conditions are the basic catchment's characteristics used for curve number Calculations. (Tekeli et al, 2004)

The basic assumption of the SCS curve number method is that, for a single storm, after runoff begins the ratio of actual soil retention to potential maximum retention is equal to the ratio of direct runoff to available rainfall.

This relationship, after algebraic manipulation and inclusion of simplifying assumptions, results in the following equation found in Section 4 of the National Engineering Handbook (NEH-4) (USDA-SCS, 1985), where curve number (CN) represents a convenient representation of the potential maximum soil retention, S (Ponce and Hawkins, 1996):

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

(a)

Where   Q is runoff (mm)

P is rainfall (mm)

S is the potential maximum soil moisture retention after runoff begins (mm)

and the runoff curve number, CN, is then related:

$$S = \frac{1000}{CN} - 10$$

(b)

CN may vary from 30 to 100; lower numbers indicate low runoff potential while larger numbers are for increasing runoff potential. The curve number {CN) is estimated from a classification in one of four hydrological soil groups together with a classification of land use. Applying the curve number and a selected amount of storm rainfall, equation (a) yields the corresponding amount of excess rainfall. (Mkhandi, 1994)

2- Calculating the Curve Number (CN):

The following parameters are needed to calculate the CN value in a basin:

A-hydrological soil groups:

The CN value is different for three antecedent soil moisture condition (I ,II,III).

In order to determine the runoff curve number of the catchment, soils of the study area were classified and hydrological soil group maps were extracted by using GIS and Remote sensing soft wares. Figure 4 shows the hydrological soil groups of Dough river watershed.
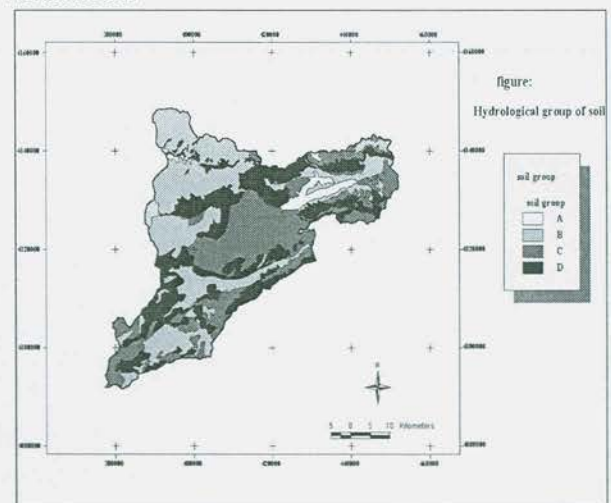
Reference: (Tehrani, 2002)

Fig 4 :hydrological soil groups of Dough river watershed

(Group A= high   B= moderate C=low and   .
       D= very slow infiltration Rate)

B -Land use type:

Land use classification maps were produced using satellite images .

C-Degree of land usage :

Degree of land Usage, refers to the treatment and hydrologic condition of the catchment. Land use, soil hydrological groups and land capability maps as well as other information were prepared to estimate CN for every parcel in the region.

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3- Calculation of S (potential maximum soil moisture retention after runoff begins):

As mentioned in previous section, there is a relation between S and CN. S may be obtained by applying CN in the equation *(b)*.

$$S = \frac{1000}{CN} - 10$$
(b)

4- Calculating the rainfall:

30 years rain fall's statistical data from 13 stations within or around the study area were collected and in some cases renovated to produce necessary information. 24 hours rainfall data and different return periods (2- 5, 10, 25, 50- 100, 200- 500 years) were calculated.

Smada software programme was used to prepare Isometric rainfall curves and they were converted to the polygons with the use of ArcView software, then average rainfall for every parcel was calculated. Fig 5 shows the conversion of rainfall **isometric curve**s for 25 years return period to rainfall polygons by using Arc View software.

The weighted average rainfall was calculated in each parcel to estimate the peak debit, Tensity- Duration curves of the study area was used to obtain 12 hours rainfall from 24 hours rain fall. Figure 6 shows the weighted average rainfall in each parcel of the region.
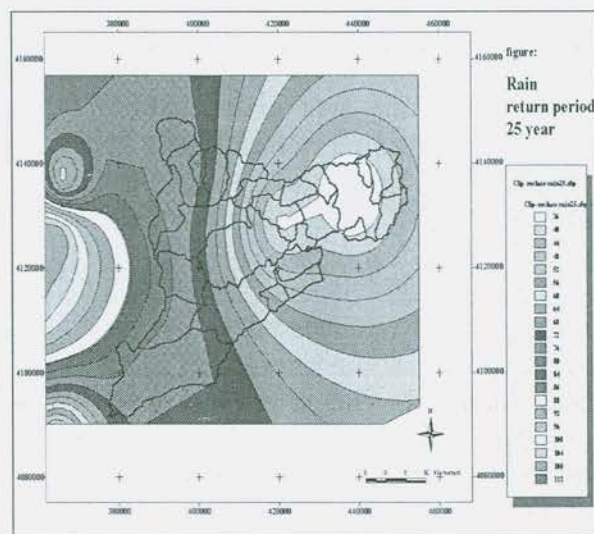
Reference:(Tehrani,2002)
Fig 5: conversion of rainfall isometric curves to polygons
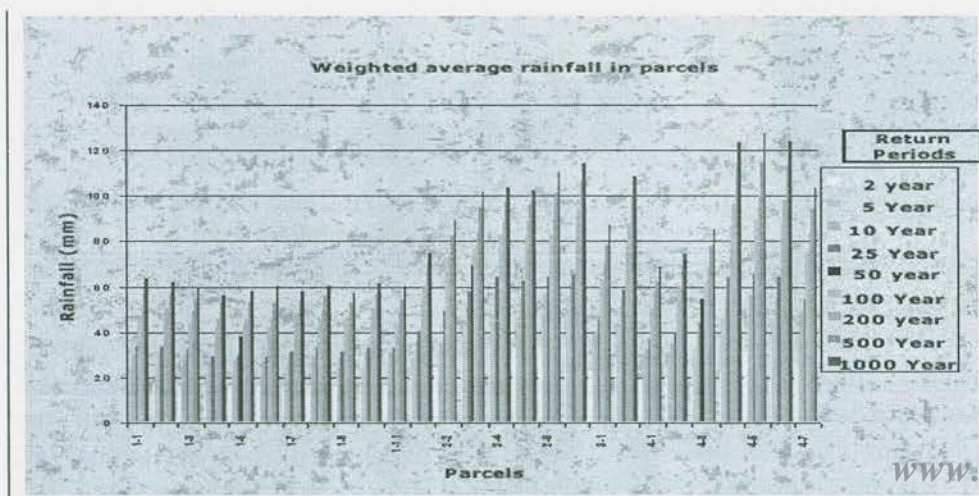
Reference:(Tehrani,2002)

Fig 6 Weighted average rainfall in parcels of the region

5- Land use map preparation by using satellite images:

Landsat images MSS (1976), TM (1988) and TM (2001) were used in order to study land use changes during past 25 years. Finally the Landsat TM (1998) was chosen and 4, 3, 2 false-color composite was generated in order to update the basic land use map- which were prepared by the ministry of Jihad- and to produce final land use map.

Figure 7 shows false-color composite 4- 3- 2 of Landsat TM image of Dough river watershed (1998). With using the ER Mapper software, unsupervised classification was performed for the whole area of watershed. Then about 120 training area were selected for specified classes from known areas to preform supervised classification. Visual interpretation was also performed and finally 11 classes of land use were generated with integrating data from basic land use map, satellite images classifications and visual interpretation.Table1 shows Land use classes and Figure 8 demonstrates Land use map that was produced from Landsat TM image (1998) from Dough river watershed .

use in hydrology and water resources studies. (Sharma et al., 2001; Misgna et al., 2004; Zhang& Huang, 2004; Tsou & Zhang, 2004)

Table 1: land use classification generated in Dough river watershed

F1	Dense forest
F2	Semi- Dense forest
F3	Poor Forest
FO	Forest & Orchard
R1	Dense Rangeland
R2	Medium Dense Rangeland
R3	Poor Rangeland
R4	Very Poor Rangeland-Wasteland
I	Irrigated Farming
DF	Dry Farming
RD	Dry Farming-Rangeland

Source: Tehrani(2002)

Reference:(Tehrani,2002)
Figure 8: Land use map of Dough river watershed extracted from Land sat -TM (1998) image.

Figure7:False-color composite4-3-2of Landsat TM image of Dough river watershed (1998)

6- Application of Geographical Information Systems (GIS) and Remote Sensing (RS):

Advances in Geographical Information Systems (GIS) and Remote Sensing (RS) technologies have lead to their wide speared

Nowadays different land use types and vegetation cover can be determined with the help of satellite images and the data derived can easily be used in hydrological studies focusing on runoff calculations. Remote sensing and GIS techniques are widely used in

the determination of spatial distribution of the catchment ecosystem characteristics and their impact on catchment's hydrology. (sharma et al, 2001)

In this study, GIS and Remote Sensing techniques were vastly used for producing, processing, analyzing and storing the data and information, also figures, tables and DEM (Digital Elevation Model) of the study area and isometric rainfall maps were prepared by using RS/GIS techniques.

7-Preparing CN and Run off Maps:

Land use and vegetation cover of the basin were prepared using satellite images and according to the data and information obtained, run off curve number of the basin was calculated by using SCS method for antecedent soil moisture condition (I, II, III).

The amount of CN in three antecedent soil moisture condition (I, II, III) and in two cases: current land use condition and land capability condition were calculated, analyzed and compared with each other.

Figure 9 and 10 show the CN calculated based on current Land Use and Land capability of the Dough river watershed.
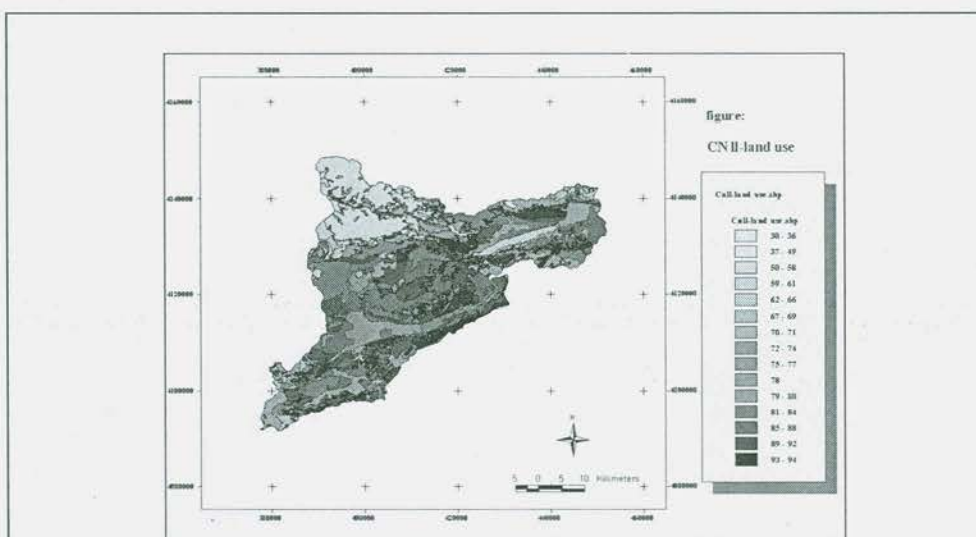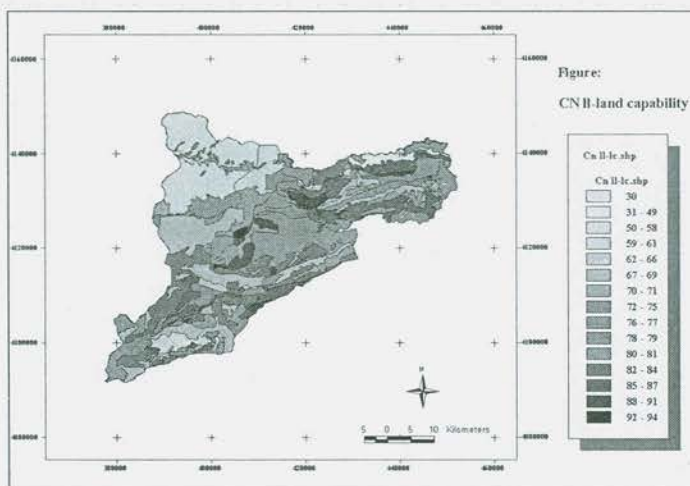

Figure 9: CN calculated based on current land use.

Reference :(Tehrani, 2002)
Figure 10: CN calculated based on land capability

The comparison between two CN maps indicates current land use causes higher CN in the most parts of the watershed, while CN map extracted from land capability is lower in most parts of the area.

Surface runoff from different return periods of rainfalls in each parcel, sub regions and regions in two cases of current land use and Land capability were calculated and compared. Table 2 shows the surface runoff of rain falls in parcels with different return periods in current land use and in three condition of soil moisture

Table 2: surface runoff of rain falls in parcels with different return periods in current land use and in three condition of soil moisture

Return Periods

Parcels	2			6			25			60			100		
	CN I	CN II	CN III	CN I	CN II	CN III	CN I	CN II	CN III	CN I	CN II	CN III	CN I	CN II	CN III
1-1	0.0	1.2	5.9	0.0	3.6	11.0	0.3	6.1	15.3	1.2	8.0	18.2	2.3	12.8	26.2	3.5	16.7	29.2
1-2	0.0	1.4	6.9	0.1	4.2	12.4	0.6	6.8	16.8	1.7	8.8	19.9	3.1	13.8	27.1	4.5	16.9	31.2
1-3	0.0	0.1	3.2	0.0	1.1	7.2	0.0	2.3	10.2	0.0	3.5	12.7	0.2	6.8	18.8	0.6	8.9	22.4
1-4	0.0	0.7	5.3	0.0	2.2	9.0	0.0	4.2	13.1	0.4	5.1	14.6	1.3	9.7	22.1	2.2	12.3	26.0
1-5	0.0	0.9	5.3	0.0	2.9	9.7	0.1	4.8	13.1	0.6	6.1	15.3	1.5	10.6	22.1	2.5	13.3	26.0
1-6	0.0	0.7	4.5	0.0	2.2	7.9	0.0	4.2	11.8	0.4	5.1	13.2	1.3	9.7	20.4	2.2	12.3	24.2
1-7	0.0	0.3	3.8	0.0	1.6	7.6	0.0	3.1	11.3	0.1	4.1	13.3	0.5	7.7	19.6	1.1	10.1	23.3
1-8	0.0	0.4	3.8	0.0	2.3	8.8	0.0	4.3	12.6	0.2	5.4	14.6	0.8	9.5	21.1	1.6	12.5	25.6
1-9	0.0	0.3	3.8	0.0	1.5	7.6	0.0	3.1	11.3	0.1	4.1	13.3	0.4	7.3	18.9	1.1	10.1	23.3
1-10	0.0	0.5	4.5	0.0	2.7	9.8	0.2	5.2	14.6	0.6	6.1	16.0	1.7	10.9	23.4	2.7	13.5	27.3
1-11	0.0	1.2	6.2	0.0	3.8	11.5	0.7	7.3	17.6	1.5	8.3	19.1	2.6	12.7	25.5	3.9	15.6	29.5
2-1	0.0	0.1	3.2	0.0	1.3	7.9	0.0	2.9	11.8	0.0	4.7	15.4	0.3	8.4	22.2	0.9	10.9	26.4
2-2	0.0	0.0	2.3	0.0	0.3	6.7	0.0	0.3	6.7	0.0	2.7	14.5	0.0	5.5	21.1	0.0	8.0	26.2
2-3	0.0	0.0	2.9	0.0	0.6	8.0	0.0	2.0	12.7	0.0	3.5	16.7	0.0	6.8	23.8	0.0	9.7	29.4
2-4	0.0	0.0	3.5	0.0	0.8	9.1	0.0	2.3	13.8	0.0	4.1	18.1	0.0	6.9	24.1	0.0	10.0	30.2
2-5	0.0	0.0	3.3	0.0	0.8	9.0	0.0	2.4	13.7	0.0	4.2	18.2	0.0	7.6	25.5	0.1	10.5	31.1
2-6	0.0	0.0	3.2	0.0	0.6	9.1	0.0	2.0	13.8	0.0	3.6	18.1	0.0	7.0	25.9	0.0	9.1	30.2
2-7	0.0	0.3	5.9	0.0	2.7	13.6	0.0	5.5	19.9	0.1	8.2	26.2	0.8	13.8	34.9	1.7	17.7	41.2
3-1	0.0	3.4	10.9	1.2	8.8	19.9	2.8	13.3	26.3	5.4	16.7	31.0	8.2	24.0	40.3	11.3	29.6	47.1
3-2	0.0	3.0	11.9	0.8	8.8	22.6	2.4	13.7	30.2	5.2	18.4	36.9	8.1	26.5	47.8	11.3	32.3	55.3
4-1	0.0	1.7	7.5	0.2	5.0	13.8	0.9	7.8	18.4	2.4	10.4	22.2	3.9	15.6	29.5	6.0	20.1	35.3
4-2	0.0	3.2	10.1	1.1	7.9	17.7	2.3	11.3	22.6	4.8	14.8	27.3	7.3	21.5	35.8	10.1	26.4	41.7
4-3	0.4	5.1	12.3	2.3	10.5	20.1	4.6	15.5	26.6	8.3	20.0	32.2	11.8	28.0	41.7	15.7	33.9	48.6
4-4	0.0	2.6	9.0	3.2	15.1	28.4	6.4	22.0	37.3	11.6	29.0	46.0	16.9	40.1	59.1	21.8	47.6	67.7
4-5	0.7	7.3	16.0	4.2	16.3	28.4	8.2	24.0	38.1	14.0	31.3	46.8	19.7	42.7	60.0	26.1	51.9	70.2
4-6	0.4	6.6	15.0	3.2	15.1	28.4	6.4	22.0	37.3	11.6	29.0	46.0	16.9	40.1	59.1	22.3	48.3	68.5
4-7	0.4	5.7	13.8	2.9	12.6	23.9	5.9	18.6	32.0	10.5	24.6	39.1	14.6	33.4	49.6	19.6	40.9	58.1

Table 2 : Surface runoff of different rain return periods in 3 conditions of Soil moisture

Reference: (Tehrani, 2002)

8-Calculating maximum debit:

According to the equation I, the maximum output debit was obtained.

$$Q\ max = 2.083 * Q * A / Tp \qquad \text{I}$$

A = watershed area (Km^2)

Q = Height of calculated runoff (cm)

Tp = time to peak (hour)

Tp = Tl + Te/2

Tl = Lag time   Te = effective time

In this research, output flood peak debit for every parcel and then every sub-region and finally for the whole watershed was calculated considering their antecedent soil moisture condition (I, II, III) and in two cases: current land use and land capability conditions and then were compared with each other. Table 3 Shows the decrease in maximum debit if current land use changes to land capability in different antecedent soil moisture condition (I, II, III).

The Tp (time to peak) of parcels are different as a results of their different Tc (concentration time). In order to precisely calculati watershed output debit hydrograph was calculated by the use of the rain pattern of the region. Combined hydrographs of parcels were produced by applying the SMADA software and the results were compared.

Table 3: decrease in maximum debit if current land use changes to land capability in different antecedent soil moisture condition (I,II,III) and rain return periods:

|	RETURN PERIOD								
	2	5	10	25	50	100	200	500	1000
	Q MAX(M3/S)								
CNI	4.85	64	135	251	373	504	649	885	1092
	0.09	8.0	33	69	154	233	326	486	634
CHANGES %	98.16	87.50	75.66	72.39	58.68	53.76	49.75	45.10	41.94
CN II	119	367	565	746	1080	1326	1576	1959	2276
	39	184	323	459	721	923	1133	1461	1738
CHANGES %	66.79	49.76	42.85	38.51	33.27	30.42	28.14	25.44	23.64
CN III	409	851	1153	1412	1865	2181	2491	2954	3327
	264	632	898	1133	1549	1845	2138	2579	2937
CHANGES %	35.31	25.77	22.11	19.78	16.92	15.39	14.16	12.70	11.73

Reference: (Tehrani, 2002)
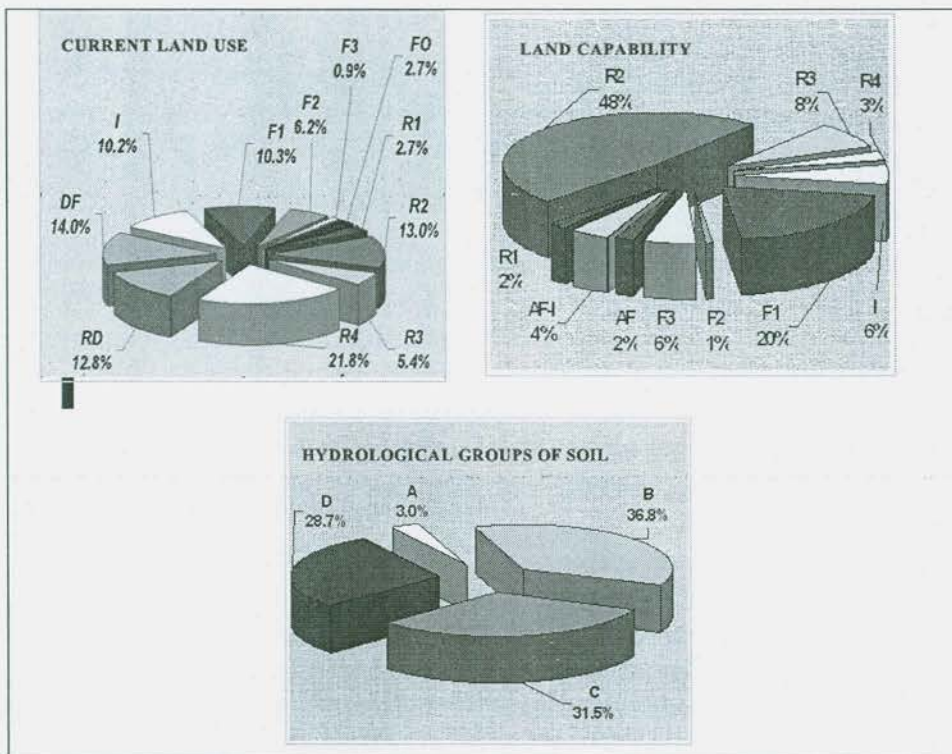
Figure 11: Percentage of current land use, land capability and hydrological soil groups of Dough river watershed.

RESULTS AND DISCUSSIONS:
1- Comparing land cover, soil, CN and runoff of watershed in two conditions: current land use and land capability:

According to the produced maps, 36% of watershed's soils are categorized in B hydrological group with medium permeability, 31.5% in group C with low permeability, 28.7% in group D with very low permeability and only 3% of the soils are categorized in group A with high permeability.

Current land use includs 16.3% of forest area that could be increased to 27% and Current area of good and fair rangelands are

15.7% that could be increased to 50% considering the land capability. Farmlands (irrigated and dry farming) and poor rangelands are 58.6% of the study area that should be decreased to 15% considering the land capability of the area. Figure 11 shows the percentage of current land use, land capability and hydrological soil groups of Dough river watershed.

2-Comparing surface runoff height of sub-regions in two conditions: current land use and land use based on land capability:

The antecedent soil moisture conditions (I, II, III) play an important role in the amounts of produced runoff. Rainfalls occurring in wet seasons (spring and winter) produce higher surface runoff. As mentioned before, Table 2 shows the runoff height produced from rains with different return period in three soil moisture conditions (I, II, III) for current land use. Sub-regions studies revealed that despite of the higher precipitation in sub region 2, because of higher permeability, the produced surface runoff is lower than other three sub regions.

Sub regions 1 and 3 play a major role in producing higher runoffs that cause severe flooding in the study area.

3-Studying the maximum debit produced in parcels, sub regions and the whole watershed:

Instant Maximum debit of the flood is the maximum runoff that passes from a point of watershed per time unit. In this research, instant maximum debit produced from rainfalls with different return periods were calculated at outlets of parcels, sub regions and the whole watershed. Figure 12 shows the difference between hydrograph of Maximum debit in current land use and land capability of the Dough river watershed. If current land use changes to land capability, the amounts of maximum debit after 12 hours (concentration time of the watershed) will decrease about 600 m³/s.

In order to draw watershed's hydrograph in

its outlet (Tangrah) especial conditions of soil and rainfall as well as land cover, were considered. Figure13 demonstrates Dough river watershed hydrograph in its outlet for 24 hour rainfall with 100 year return period and soil moisture condition II and current land use. Studying the hydrograph of Tangrah demonstrates that maximum debit will occur after 10 hours in the outlet of the watershed that is about 1600 m3/s .(with specified conditions: 24 hour rainfall,100 year return period , soil moisture condition II and current land use)
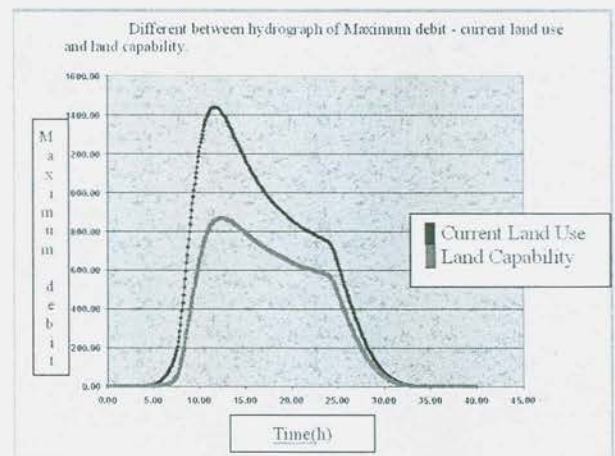
Reference: (Tehrani, 2002)

Figure 12: difference between hydrograph of Maximum debit (m³/s) in case of current land use and also land capability of the Dough river watershed
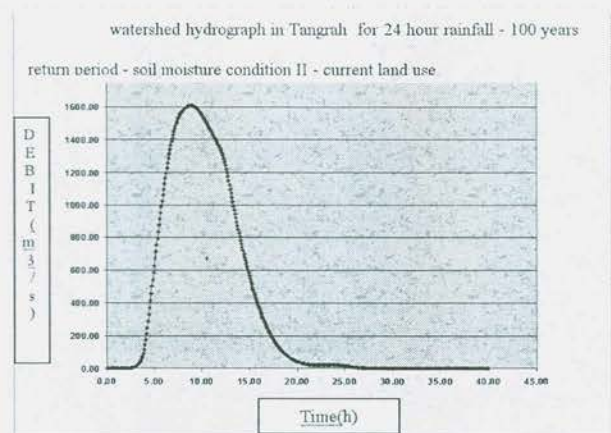
Reference: (Tehrani,2002)

Figure13: Dough river watershed hydrograph in its outlet (Tangrah) for 24 hour rainfall with 100 year return period , soil moisture condition II and current land use.

4- Studying tables related to instant maximum peak with current land use condition:

Studying peak debits in parcels shows that if the soil moisture condition is I or the soil is dry and has higher permeability (almost in summer) maximum debits is much less than the other soil moisture conditions (II , III) .

If current land use activities change according to the land capability of the watershed, maximum debits of parcels with soil moisture conditions (I , II) will decreased to (30-50%) % and it will be balanced in parcels with higher potentials to produce runoff. In higher rain return periods and with soil moisture condition III, the effects of land cover and land use will decrease. In case of using land based on its capability, instant maximum debit of parcels decrease (20-30) %.

Figure 14 demonstrates percent of flood debit decreases if current land use is changed to its capability with different rain return periods and hydrological groups of soil in Dough river watershed
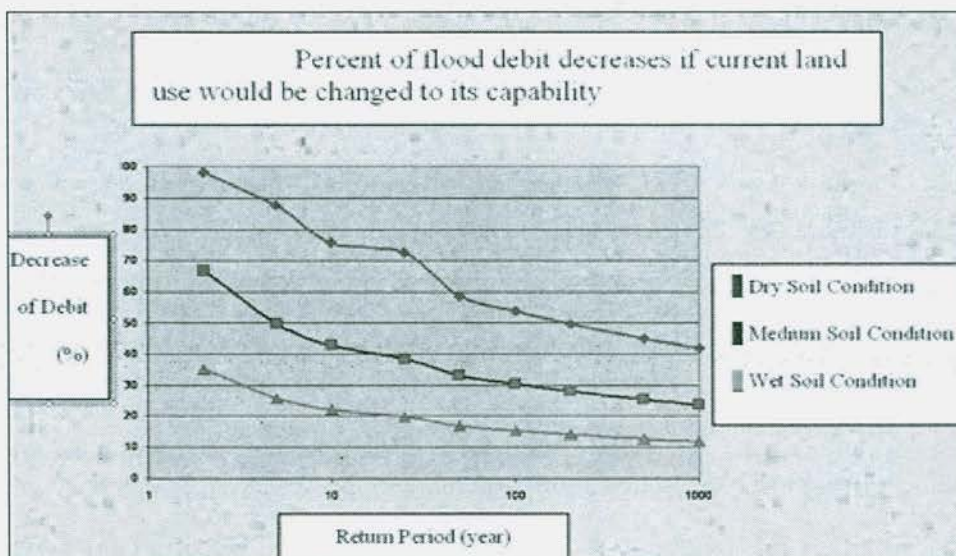
Reference:(Tehrani,2002)

Figure 14: Percent of flood debit decreases if current land use would be changed to its capability with different rain return periods

CONCLUSION

A comparison of maximum peak debit in current land use with land capability condition, reveals that in case of floods with shorter return periods between (5- 50) years, if current land use would be changed to its capability, there will be a decrease in maximum peak debit, that in dry soil condition in average is 70%, in medium 40% and in wet soil condition 20%.

In case of floods with medium return periods (100-200 years), maximum peak debit will decrease 50%, 30% and 20% respectively in dry, medium and wet soil condition.

In case of longer return periods (200-1000 years), the effect of land cover decreases (30% to10%) by increasing of soil humidity and rainfall intensity, though it plays its moderating role in diminishing the severity of heavy floods.

Since the most part of the region have dry soil condition and apparantly rainfalls with short return periods cause floods with degraded land cover, here the important role of land use policies in controlling the severity of heavy floods especially, when the soil is dry in the study area are apparently clarified.

Obviously, climatic and physical elements like high probability of heavy rains, the extent

and the size of the watershed are also responsible for causing floods in this region, but anthropocentric activities like degradation of forest and rangelands, incorrect animal husbandry, mismanagement of natural resource, irrational allocation of land to settlements and construction of unsuitable structures and facilities multiplies the impacts and severity of floods.

Finally, it is important to notice that problems in the study area arise mostly from the ignorance of residents with the concepts of cooperation with corresponding organizations and also the lake of sustainable and integrated management and planning in Dough river watershed.

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