EFFECTS OF CONVERTING RANGELANDS TO DRY FARMING'S ON FLOODPRODUCTION, EROSION AND SEDIMENT YIELD IN KARDEH DRAINAGE BASIN, IRAN

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1. Introduction

Land use/cover changes from rangeland to agriculture and orchard areas could possibly affect water regime, erosion production and sediment yield. These problems are widely observed in many parts of Iran. For example the number of flood events during the last 50 years in Iran was reported to be 3700, of which about 53% was registered to happen during the last 10 years.

According to the current statistics, soil erosion of watershed areas has an increase from 500million to 3billion tons during the last 50 years in Iran. The eroded soil has moved from the country's basins and sited on seas, lakes, dams, internal holes, and river-beds.

Kardeh drainage basin in North-East of Iran has an area of 557.9 km2 and recently experienced devastating flood, increased soil erosion and sediment yield. In this research, the effects of plant coverage and land use change on basins floods will be analyzed and the role of land utilization methods affecting soil erosion and sediment yield will also be investigated. The figure 1 shows the basin location in Iran and in the province.

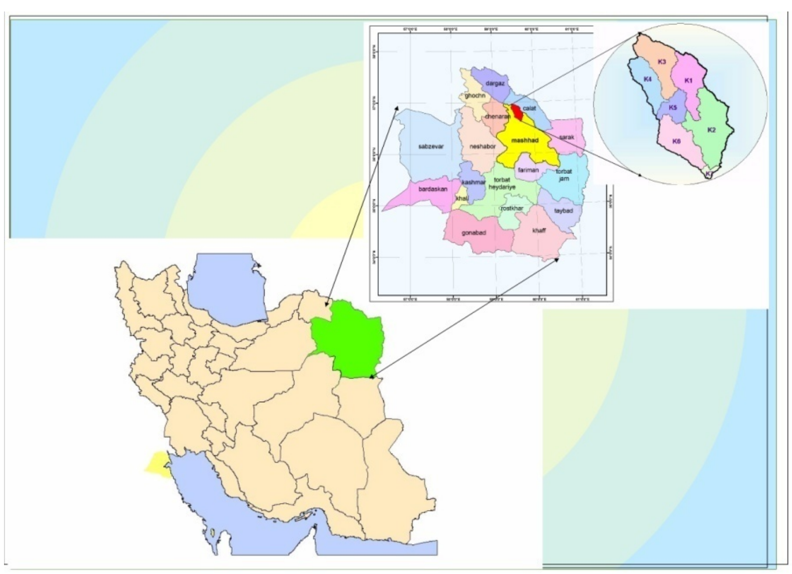

Figure 1. The location of Kardeh drainage basin in Iran and in the province

2. Research objectives

Separation of effects on vegetation cover and land use changes from other edaphically parameters of the basin.

To determine the impact factor of vegetation cover and land use changes in flood hydrograph of the basin (especially peak discharge and flood volume).

To determine the impact factor of vegetation cover and land use changes in erosion and sediment yield on the basin area.

Estimation of flood regime changes of the basin in lieu of various scenarios of land use change.

3. Methodology

Study 1. Flood

Step 1

3.1.1. Physiographical properties

Physiographical properties of the drainage basins are among the significant parameters in studying natural resources they are used to estimate and measure the average precipitation, temperature in the different elevations, time of concentration, etc. The most important physiographical properties of Kardeh basins and sub-basins are given in the table 1.

Table 1. The most important physiographical properties in Kardeh basin and sub basins

Sub basin	Area (km^2)	Perimeter (km)	Basin elevation (M)			Channel length (Km)		Drainage Density km / km^2	Gravelious Coefficient	Form factor	Slope (%)	
			Maximum	Minimum	Difference	Main	Total				Main channel	Basin
K_1	93.29	55.19	2638	1548	1090	24.95	463.91	4.97	1.61	0.16	4.37	20.69
K_2	153.17	73.88	2566	1299	1267	27.29	836.50	5.46	1.68	0.15	2.35	20.63
K_3	97.14	53.41	2530	1747	783	24.97	389.11	4.01	1.53	0.19	3.14	20.71
K_4	69.01	44.89	2781	1730	1051	18.46	370.44	5.37	1.52	0.19	5.70	17.50
K_5	44.71	36.53	2228	1631	597	11.29	237.70	5.32	1.54	0.19	2.74	15.49
K_6	91.26	48.98	2063	1297	766	22.75	502.60	5.51	1.45	0.23	3.36	15.88
K_7	9.31	17.13	1506	1280	226	4.04	44.09	4.73	1.58	0.17	2.24	11.32
Basin total	557.90	118.25	2530	1280	1250	55.90	2844.35	5.10	1.41	0.24	2.24	18.92

Step 2

3.2.1. Providing the land use map in the new period (2006)

Figure 2 shows the map obtained from interpretation of satellite image in the environment of software ARC-GIS (year 2006).

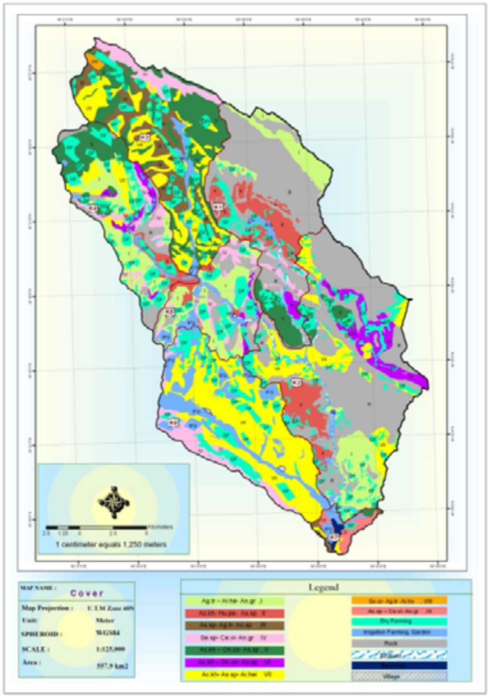

Figure 2. Map of different kinds of lands and vegetation in the year 2006

3.2.2. Providing the land use map in the old period (1970)

Figure3 is obtained from interpretation of aerial photos (year 1970) and determination of different kinds of land uses.

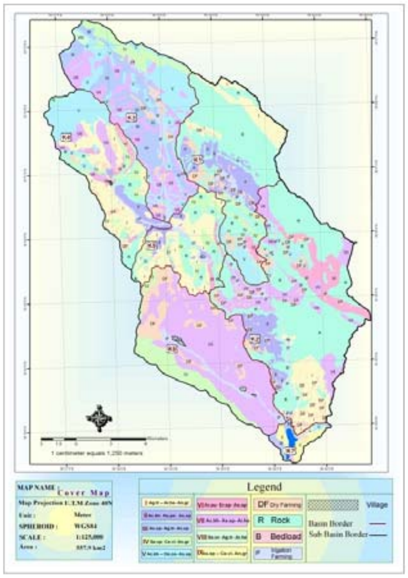

Figure 3. Map of land use types and vegetation in the year 1970

3.2.3. Investigation of changes in land use during the years 1970-2006

Table 2 shows these changes in percent. In these tables, increase in area of each use is displayed by positive numbers and decrease in area is displayed by negative numbers.

Table 2. Changes in land use during the years 1970-2006

Land use	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K
Dry farming	2.01	0.8	11.5	16.8	17.3	3.4	-0.3	6.6
Irrigation farming	0.01	0.3	0.7	0.9	6.0	0.0	4.7	0.9
Range	-2.09	-1.3	-12.3	-17.9	-23.5	-3.9	-4.6	-7.7
Rock	0.00	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Bed load	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
village	0.07	0.1	0.1	0.2	0.1	0.5	0.2	0.2

3.2.4. Provision of the soil hydrological groups map

The area of each sub basin has been given on the table 3

Table3. Areas of soil hydrological groups in the sub basins

Hydrological groups	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K
A	10.79	11.44	6.54	0.00	0.00	20.56	1.71	51.04
B	17.94	10.90	19.08	14.12	20.37	21.91	0.00	104.33
C	15.21	69.52	39.02	38.86	13.22	33.91	4.72	214.46
D	49.35	61.31	32.50	16.03	11.12	14.88	2.88	188.07
Total area	93.29	153.17	97.14	69.01	44.71	91.26	9.31	557.90

3.2.5. CN & antecedent moisture condition (A.M.C) determination of different land uses

Summary of the results for all sub basins are given in the table 4.

Table 4. CN estimated for sub basins in the old and new period

Sub basin	Old			New		
	CN I	CN II	CN III	CN I	CN II	CN III
K_1	58	74	85	58	74	85
K_2	62	80	88	62	80	88
K_3	47	65	79	53	71	83
K_4	58	74	85	61	77	86
K_5	56	73	84	60	78	87
K_6	62	78	89	62	78	89
K_7	54	71	78	50	67	73

Step 3

3.3.1. Spatial distribution of rainfall

The figure 4 shows the spatial distribution of rainfall in the basin area and in 1 event in the environment ARC-GIS. Also the table 8 gives the average rainfall rate in each sub basin.

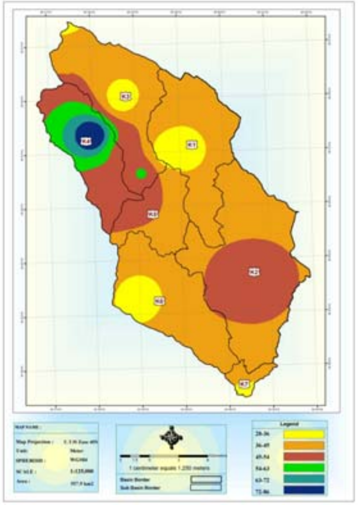

Figure 4. Spatial distribution of precipitation in the basin area in the event 26/03/2006

Table 5. Average rainfall in each sub basin

Data	K_1	K_2	K_3	K_4	K_5	K_6	K_7
11/06/1987	45	43.4	50	44.5	47.3	37.7	58.8
27/05/1991	20.3	21.2	21	22.2	23.7	22.8	16.7
05/04/1992	17.9	17.7	16	17.2	14.9	18.6	11.8
03/06/1996	40.6	37.3	61.4	44.3	52.5	39.8	57.8
30/04/2000	54.9	53	57	55.2	52.2	53.1	46.8
17/05/2001	19.5	19.8	19.2	19.7	19.5	20.5	18
08/05/2003	39.1	34.1	58	41.5	42.2	31.2	47.6
26/03/2006	11.1	12	9.4	12	15.3	15.5	4.1

Step 4

3.4.1. Flood routing parameters in the rivers

3.4.1.1. Estimation of Muskingum parameters

Table 6 shows the Muskingum coefficients X and K for different reaches.

Table 6. The Muskingum coefficients X and K for different reaches

Reach code	Reach length (m)	Average velocity (m/s)	Parameter K		Parameter X
			Hour	Minute	
Reach 1	5800	1.62	1.03	61.7	0.065
Reach 2	8300	1.84	0.53	31.5	0.100
Reach 3	11000	2.04	1.06	63.8	0.237

Step 5

3.5.1. Entering the data and performing the HEC-HMS model for the observational events

3.5.1.1. Kardeh drainage basin model

Figure 5 shows the schematic view of Kardeh drainage basin

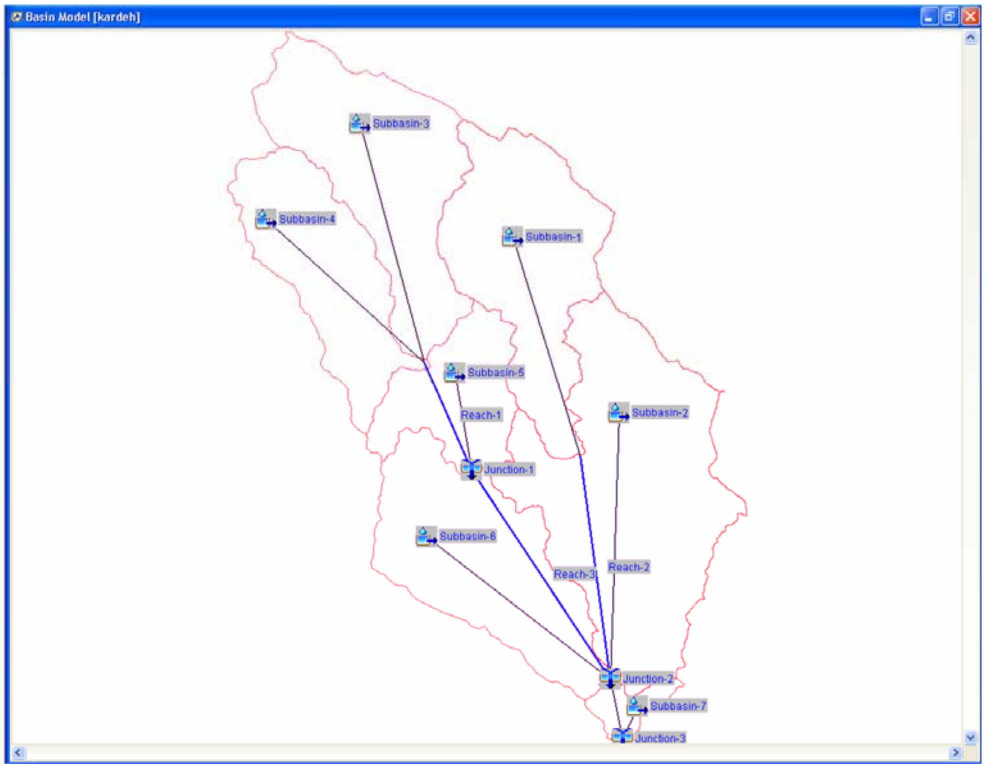

Figure 5. Schematic view of Kardeh drainage basin

Loss rate

In this section, the initial loss rate and effective rainfall is determined. In this research, SCS-CN method has been used.

Transform

In this section, the basin direct runoff is modeling. In this research, the unit hydrograph SCS method is used.

River reach

In the HEC-HMS model, the flood hydrograph is routing in each reaches. As mentioned before, the Muskingum method was used in this research. In this method, it is required to enter the parameters X and K in reaches into the model.

Entering the observed flood hydrograph

In this section, the observed flood hydrograph in the basin enters into the model. As previously described, there are three water gauge stations. The data's related to each station entered to the model separately.

Kardeh basin meteorological model

The rate of flood-creating rainfall and its spatial distribution was determined using inverse distance squared method and its time distribution was determined using statistics of recording rain gauges. In this stage, flood-creating rainfalls for each sub basin entered to the meteorological model using user hyetograph method.

Control specification

In this section, it is required to introduce the simulation start date and end date and its interval to the model. The interval must be less than 29% of basin lag time.

Performing the model for observed rainfall-runoff data

The observed rainfall-runoff data were performed after entering the data and implementing the basin model, the meteorological model and control index. Then the simulated hyetograph was obtained.

Step 7

Sensitivity analysis of the model with respect to the parameters:

In order to determine appropriate parameters for model calibration, sensitivity analysis is used. To do so, initial losses (Ia) and lag time were changed in each sub basin and the results were investigated in the basin outlet. Thus, the values of both parameters were changed from -20% to +20% with intervals 5% and its effect on the flood peak discharge was determined.

The results of model implementation in two periods:

In order to compare changes in hydrological conditions of the region in two different periods, two methods are considered:

Observational rainfalls which have created floods in the new period were exactly implemented in the old period (with the same soil moisture condition in the old period).

The difference between sub basins peak discharges in the old and new periods were simulated for different return periods using plan rainfall.

Table 7: Comparison of peak discharge with different return period in sub-basins

Sub basin	Period	Return period					
		Tr=2	Tr=5	Tr=10	Tr=20	Tr=50	Tr=100
K_1	1970	16.8	23.9	30.2	32.4	39.7	45.6
	2006	16.8	23.9	30.2	32.4	39.7	45.6
	Changes (%)	0.0	0.0	0.0	0.0	0.0	0.0
K_2	1970	18.9	26.7	32.4	36.1	39.5	44.6
	2006	18.9	26.7	32.4	36.1	39.5	44.6
	Changes (%)	0.0	0.0	0.0	0.0	0.0	0.0
K_3	1970	20.4	31.2	41.7	49.6	58.9	68.3
	2006	34.9	50.6	61.8	73.1	83.5	99.5
	Changes (%)	71.1	62.2	48.2	47.4	41.8	41.3
K_4	1970	30.3	45.1	55.6	66.7	81.2	91.1
	2006	35.4	51.8	63.2	73.5	88.3	97.7
	Changes (%)	16.9	14.9	13.7	10.2	8.8	7.3
K_5	1970	47.7	69.3	82.9	94.4	112.2	125.9
	2006	53.6	77.6	91.6	103.7	121.9	136.1
	Changes (%)	12.4	11	10.5	9.9	8.7	8.1
K_6	1970	21.6	28.4	37.2	41.8	47.5	52.3
	2006	21.6	28.4	37.2	41.8	47.5	52.3
	Changes (%)	0.0	0.0	0.0	0.0	0.0	0.0
K_7	1970	5.2	11.1	13.2	16.3	23.4	28.2
	2006	1.8	4.7	6.6	8.9	13.5	16.9
	Changes (%)	-65.4	-57.7	-50.0	-45.4	-42.3	-40.1

Study 2. Erosion & Sediment Yield

Step 1

Calculation of the total sediment discharge in each time section of study by Erosion Potential Method (EPM)

The results are given in the table 8.

Table 8. Calculation of the parameters of EPM model in each period in Kardeh drainage basin

Parameter \ Period	1970	2006
Erosion intensity coefficient (Z)	0.63	1.12
Basin area (A) (Km^2)	557.90	557.90
Annual average temperature (C^0)	8.8	8.8
Rainfall average elevation (H) (mm)	342.89	342.89
Basin perimeter length (P) (Km)	118.25	118.25
Basin length (L) (Km)	47.90	47.90
Basin elevation difference (D) (Km)	0.95	0.95
Temperature coefficient (T)	0.99	0.99
Sediment yield coefficient (Ru)	0.64	0.64
Specific erosion rate (WSP) (m^3 / km^2 / year)	531.6	1268.9
Specific sediment discharge (GSP) (m^3 / km^2 / year)	340.0	811.7
Total sediment discharge (GS) (m^3 / year)	189703.9	452847.1
Total sediment discharge (GS) (T / year)	284555.9	679270.6

Step 2

3.1.3. Estimation of annual suspended load

After providing sediment rating curves of hydrometric stations in each time section using stations daily discharges, the annual suspended load was estimated. By putting each one of the daily discharges in the time section studied in the equations, the daily sediment was obtained in ton per day for each period and sediment yield was estimated in ton per year by summing them. According to the calculations performed, the annual average sediment rates in the period 1970-71 was equal to 275831.17 ton per year and in the period 1971-2006, it was 661712.83 ton per year. Table 9 shows the suspended load calculated during study periods.

Table 9. Suspended loads observed in the hydrometric stations during study periods

Station name	1970 – 71					1971 – 2006				
	Area (ha)	Suspended specific load (T/h/y)	Bed specific load (T/h/y)	Specific sediment total (T/h/y)	Delivery sediment calculated (T/y)	Area (ha)	Suspended specific load (T/h/y)	Bed specific load (T/h/y)	Specific sediment total (T/h/y)	Delivery sediment calculated (T/y)
Mareshk	18405	4.57	1.15	5.72	105376.73	18405	11.60	2.91	14.51	267126.46
Al	27328	4.00	1.01	5.01	137186.54	27328	9.60	2.40	12.00	328081.15
Koshkabad	9126	2.91	0.73	3.64	33267.90	9126	5.82	1.46	7.28	66505.22
Basin total	54859	11.48	2.89	14.37	275831.17	54859	27.02	6.77	33.79	661712.83

Step 4

3.1.4. Comparison of the observed sediment and the estimated sediment

In this stage, it is possible to get the role of each sub-basin in specific degradation and its sediment yield with regard to the sediment yield rate of basin by EPM method and total produced sediment calculated for the basin by measuring sediment in the sediment rating stations. The results are given in the table 10.

Table 10. Comparison of the observed and estimated annual sediments in each period of the study

Period	measured (T/y)	estimated (T/y)	difference
1970-71	275831.17	271295.56	4535.61
1971-2006	661712.83	653458.29	8254.54

The results show that the trend of changes in sediment is increasing from one period to the other period.

Step 4

The results obtained from investigation of the effects of the factors effective on the sub basins sediment yield

After performing the multi-variable regression operation between the sediment variable as a dependent variable and independent variables, the outlet discharge from the sub basins, average rainfall, the areas of the lands with range use, dry and irrigation agriculture.

The period 1970-71

In this period, the equation below has been obtained using the multi-variable regression between the sediment and independent variables:

$Y= 28437.76\ X_{1+} 29.585\ X_2 + 3185.34$

$(R^2 = \%76.4, \ \ a= 0.01)$

The Period 1971-2006

In this period, the equation below has been obtained establishing multi-variable regression using step-by-step method between the sediment estimated in each sub basin and independent variables:

$Y= 5.463\ X_1 + 98.65\ X_2 + 78564.78$ $(R^2 = \%76.4, \ \ a= 0.01)$

4-Conclusion

- Changes in CN in the region

Comparison of CN map in two periods and the CN estimated for each sub basin show that there are three trends in CN changes in the basin.

Increasing in CN in the new period: CN value has been increased in the sub basins K3, K4 and K5 due to increasing in dry framings areas and decrease in ranges areas and also existence of increased pressure on the ranges.

Decreasing in CN in the new period: in the sub basin K_7, CN value has been decreased in the new period due to the existence of the irrigation lands and gardens (which are of richer cover) in the greater areas.

Lack of changes in two periods: in the sub basins K1, K2 and K6 CN value hasn't been changed due to the appropriate topographic conditions of changes in land use and vegetation.

Spatial changes in rain storms

Investigation of rainfall in the present stations shows that the spatial distribution of the rainfall has no constant pattern. For example, Kharkat station which is one of the highest stations in the region sometimes has recorded the lowest rainfall and sometimes has recorded the greatest rainfall. This is true in the stations Mareshk and Kartian but in general it I said that the station Al is among the stations with highest rainfalls and the station Toos is among the stations with the lowest rainfalls.

Effect of land use change on peak discharge and runoff volume

Land use changes have the greatest effect on the peak discharge. The results of model performance for observational rainfalls in the old and new conditions show that the peak discharges of the sub basins have been changed from -57.9% to +119.3% while the runoff volumes have been changed slightly (from -39.7% to +61.9%). Also the results of model performance for the rainfalls with certain return periods show that increasing in return period decreases the changes rate because in the less rainfalls, greater percentage of the rainfall will change to the losses.

Effect of land use change on hydrograph times

Land use change has small effect on the hydrograph times so that the concentration time changes from 16% to -12%. Lag time which is obtained by applying a coefficient of concentration time, has same trend. Time to peak hydrograph occurred due to the changes in land-use has been changed from 15.4% to -11.5%.

Analysis of the results obtained from investigation of basin erosion and sediment yield

the results in the period 1970-2006 show that there is significant relationship between the outlet sediment from sub basins and the variables discharge and dry lands areas (R^2=0.78) and about 78% of increase in sediment yield in this period has been provided by discharge and changing the ranges to the dry land (vegetation degradation), so, it is clear that it is required to prevent changing ranges to dry land in order to decrease or quite this increasing trend . On the other hand, it is required to conduct the region natural vegetation which has degradations trend toward the improvement and finally toward the climax.