Caspian J. Env. Sci. 2012, Vol. 10 No.2 pp. 257~272

CJES
Caspian Journal of Environmental Sciences

[Research]

Conversion trends of rangelands to dry farming and its effects on erosion and sediment yield in Kardeh drainage basin

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(Received: Mar. 25-2011, Accepted: Jul. 13-2012)

ABSTRACT

Converting rangelands to arable land such as dry farming is widely practiced in many places in Iran. This activity could possibly contribute to the increase in downstream sedimentation. The effects of this activity on downstream watersheds are not well documented for many strategic areas in the country. One such area which is proposed for this study is the Kardeh drainage basin, located in the north east of Iran, having a catchment area of 570.9 km^2. In this study, an attempt was made to quantify the changes in land use, and the sediment yield of the basin, and to identify significant contributing factors that could possibly contribute to the increased downstream sedimentation between the years of 1970 and 2007. Available satellite images and aerial photos were analyzed for the extent of land use changes and an empirical model, Erosion Potential Method *(EPM)* was validated and applied to quantify the annual total sediment yield of the basin. Step-wise multiple regressions were used to justify that the changes in sediment yield is due to the increased dry farming activities. The results showed a drastic change in land use between these periods where dry farming area has remarkably increased to 91%, while there was a reduction in rangeland area of about 13%. The effect of increased dry farming activities is reflected on the two fold increase in annual total sediment yield of the basin. Statistically, about 95% of the changes in sediment yield is due to the effect of increased dry land farming area in the basin (R^2= 0.95, $\alpha < 0.05$).

Keywords: *Land Use Change, Rangeland, Dry Farming, Erosion, Kardeh drainage basin.*

INTRODUCTION

Human life on earth particularly in the recent decades i.e. the age of technology, has drastically changed the earth surface including degradation of rangelands & forests in wide areas and development of dry farming lands (Mahdavi, 2007). The aim of this study is to investigate conversion trends of rangelands to dry farming and the role of land use changes and vegetation cover on altering erosion and sediment yield in the Kardeh drainage basin, located in the northeast part of Iran.

Land use changes and the associated variety of natural environmental conditions has increasingly affected different regions. Because the control and measure of all factors involved are impossible, the application of models for discovering existing relations between different phenomena is common (Kim *et al.*, 2002). Several studies have been conducted in this regard of which the ones worth mentioning are that of Globevnic *et al.* (2006) who studied the effects of changes in land use on flow regime in a region with wide changes in land use in southeast Slovenia. They realized that forestation in these regions has significant effects on river hydrological properties so that soil loss decreased and wild life in the basin was affected by vegetation cover improvement.

Similarly Kasa et al (2001) investigated SDR (Sediment Delivery Ratio) for two periods, a 28-year and an 8-year period, in seven sub-basins of Wai Paoa River in the north of Island and some basins in New Zealand. In these basins, the gully erosion due to the forests degradation during the years between 1880 and 1920 provides the main resource of the sediment delivered to the river. Calculating SDR after forestation in the 1960s in order to reduce the sediment yield showed that sediment produced from gullies was reduced to 77% and sediment delivered from the drainage basins was reduced by 78%.

Lu and Higgitt (2005) studied the erosion and sedimentation in the Threegorgens dam in China using Cesium 137 method and estimated the sediment yield as 3500 $t/km^2/y$. They concluded that agricultural practices around dam and farming on the steep slopes have increased the sediment load so that about 60% of these sediments are resulted from the agricultural sloping lands.

Van Ramapaey *et al.* (2002) used modeling of land use changes during the past 250 years and studied its effects on sediment yield and erosion in Dijle drainage basin in Belgium using topographic maps related to the years 1774, 1840, 1930 and 1990. They concluded that the slight changing in land use of forests to agricultural lands and vice versa has significant influence on soil erosion and sediment yield.

Arnaez and Lasanta (2006) studied factors affecting runoff and erosion under simulated rainfall in Mediterranean vineyards. Data on surface runoff and soil loss on gentle slopes with vineyards are analyzed. Using a rainfall simulator, 22 rainstorms with varied intensities from 30 to 117.5 mm h^{-1} and return periods from 2 to 127 years were reproduced. The experimental plots were installed on vineyards planted in straight rows and oriented with the slope direction having a mean gradient of 3.88. Values of measured surface runoff varied from 7.2 mm h for low rainfall intensities (30 mm h^{-1}) and short return periods (2 years) to 41.9 mm h^{-1} with simulation experiments of higher rainfall intensity (104 mm h^{-1}) and long return periods (68 years).Runoff increased linearly with rainfall intensity resulting in soil losses that also increased with rainfall intensity (18.2 $g^{-2}m$ h^{-1} with storms of 30 mm h^{-1}, and 93.2 g m^{-2} h^{-1} with storms of 104 mm h^{-1}); however, r^2 explains only 36% of the variance.

Most of the methods applied in soil erosion studies are empirical models. These models are based on considering a number of important factors affecting soil erosion and providing an empirical model on the basis of observed and measured methods (Goldman *et al*., 2004). Although it is possible to calculate the total volume of annual sediment yield in a drainage basin but in these systems, the different types of erosion, spatial distribution of erosion and also formations sensitive to the erosion and sediment yield are not recognized. These disadvantages in soil erosion assessment or lack of data and information in most drainage basins cause using proper empirical methods in order to estimate soil erosion and sediment yield (Ahmadi, 2008).

By considering the above factors in this research, the Erosion Potential Method (EPM) was selected to estimate erosion rate and sediment yield in sub-basins with no data and in sub-basin with hydrometric stations (in order to compare the data of the stations with the values estimated by the model). The properties of EPM method are summarized below:

A) The factors used in this method are limited and valuable
B) The factors used in this method are among the factors affecting erosion
C) It is possible to evaluate the erosion qualitatively and quantitatively
D) It is easy to provide the map of sensitivity to soil erosion for the drainage basin
E) It is possible to estimate the sediment yield in the channels without hydrometrical stations and sediment statistics.

MATERIAL & METHODS

Location of study

The Kardeh drainage area located on the north east of Iran with 557.9 square kilometer area lies between the 59° 26′ 3′′ to 59° 37′ 17′′ E longitude and 36° 7′ 17′′ to 36° 58′ 25′′ N latitude (Fig. 1).

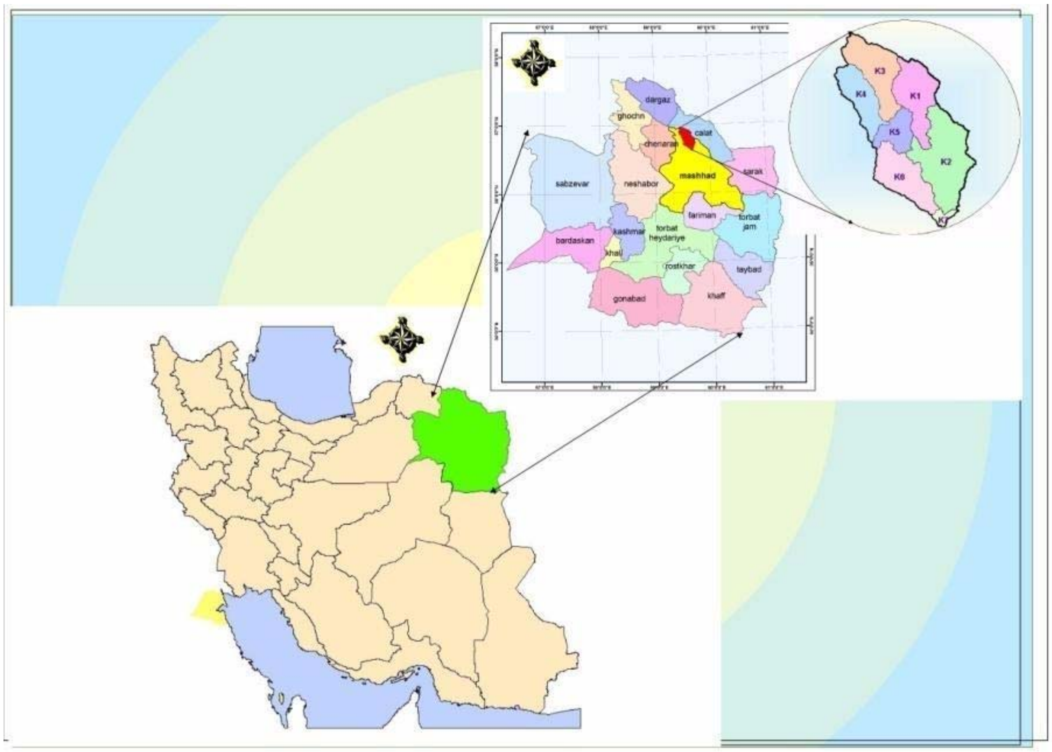

Fig 1. The location of Kardeh drainage area in Iran.

Kardeh is the main river in this area which flows from north to south. Due to its topographical condition Kardeh basin is mountainous with steep slopes. The range of elevation differs from 2977 (Hezarmasjed peak) to 1200 meters (outlet). The basin is lengthened and rectangular shaped with nearly 50 kilometre in length, 11 kilometers in width and 107 kilometres in perimeter. According to Ambergeh climate classification, its climate is semi arid and cold. The mean long term annual precipitation and temperature is 343 mm and 8.4 ^{o}C, respectively. The geological state of the basin is affected by Kopetdaghi zone. It consists of formations Kashafroud, Mozduran, Chamanbid, Shurijeh, Neogene's deposits and quaternary alluvial deposits. Rangeland and dry and irrigation farming are the main form of land use in the basin. The basin is equipped with climatology and hydrometric stations. There are 10 climatologically stations and 3 hydrometric stations in the region that provide data and proper statistics for statistically analysis.

The boundary of Kardeh drainage basin was recognized according to the water dividing line or ridges using topography maps (1:50000) published in 2005 by the Geographical Organization of the Iranian Army. The basin was divided into seven sub-basins according to the state of the main and accessory rivers (how the main and accessory branches are connected together). Each sub-basin has been titled according to the name of the village but on the map produced they are recognized as K_1 to K_7. The sub-basins are K_1 (Balghor), K_2 (Sijoal), K_3 (Kharkat), K_4 (Karimabad), K_5 (Mareshk), K_6 (Koshkabad), K_7 (Firouzabad).

Methodology

Preparing of the vegetation and land use map in 2007 and 1970

Comparison of aerial photos (1970) and satellite images (2007) clearly show that a large part of the region is mainly hills with steep slopes which used to be rangelands in the past and have been gradually changed to dry farming. In order to study land use in recent times, satellite images ASTER with resolution separation of 15m, combing of bonds 1, 2, and 3 to make false color composite were used.

For interpretation of these images and separation of land use types, unsupervised and supervised classified methods were applied (Lyon, 2006). Since a large part of the region is formed by poor range and dry farming, the resulting maps have large errors in separation of ranges and dry farming. The error is due to small reflection of poor vegetation cover compared to soil and stone type. The above mentioned image is interpreted by eye method so that in addition to color change and DN, other information such as farming lands, geometrical form, distance to residential zone, roads and earth surface slopes were used.

The EPM method requires identification of geomorphologic characteristics of the basin such as the types of slopes and geomorphologic facies at the basin level in order to prepare a map of the types of erosion. Then, based on this map, the erosion intensity coefficient (Z) was calculated for the years 1970 and 2007 respectively.

After preparing different erosion type maps, it is necessary to estimate (Z) for each erosion type. In EPM method, basin erosion intensity coefficient depends on four factors: erosion coefficient (Ψ), land use coefficient (Xa), coefficient of rock and soil sensitivity to the erosion (Y) and average basin slope (I). This is summarized in the following equation:

$Z = Y.\ Xa\ (\Psi + I^{0/5})$ [1]

In which

Z = erosion intensity coefficient

Y = coefficient of rock and soil sensitivity to the erosion

Ψ = erosion coefficient

Xa = land use coefficient

I = weighted average slope (%)

Determination of basin specific erosion

After determining the erosion intensity coefficient, it is possible to calculate total annual erosion rate per area unit (specific erosion) for the years 1970 and 2007. For calculation this parameter are used following equations:

$WSP = T.H.\pi.Z^{2/3}$ [2]

$$T = \left(\frac{t}{10} + 0.1\right)^{\frac{1}{2}} \quad [3]$$

In which

WSP = erosion rate in cubic meter per square kilometer per year

Z = erosion intensity coefficient (the value of erosion intensity coefficient has been obtained from sum of weighted values Z in each of erosion types.)

H = annual rainfall average depth in mm

Π (phi) = 3.14

T = temperature coefficient

t= average temperature in centigrade degree

Determination of basin sediment yield coefficient

Sediment yield coefficient in the EPM model can be estimated from the equation below:

$$Ru = \frac{4(P.D)^{\frac{1}{2}}}{L+10} \quad [4]$$

In which

Ru = drainage basin sediment yield coefficient

P = perimeter length of the drainage basin in km

L = basin length in km

D = depth difference in km

To determine D, the equation below is used:

$$D = D_{ave} - D_{out} \quad [5]$$

In which

D_{ave} = drainage basin average depth in km

D_{out} = the elevation of the outlet point in km

The sediment yield coefficient (Ru) is calculated in all sub basins for the years 1970 and 2007 in the environment of ArcGIS.

Determination of specific sediment discharge (GSP)

After determining the sediment yield coefficient, specific sediment discharge was determined for all sub basins for the years 1970 and 2007 in the environment ARC-GIS using the following equation:

$$GSP = WSP.Ru \quad [6]$$

In which

GSP = specific sediment discharge in $m^3/km^2/y$

WSP = specific erosion in $m^3/km^2/y$

Ru = drainage basin sediment yield coefficient

Determination of total sediment discharge

To calculate the total sediment discharge, the equation below was used (for both 1970 and 2007 for all the sub basins):

$Gs = GSP.A$ [7]

In which

Gs = total sediment discharge in m^3/y

GSP = specific sediment discharge in $m^3/km^2/y$

A = drainage basin area in km^2

The sediment weight in ton/ha was obtained (by assuming sediment apparent density =1.3 gr/cm^3) and changing the basin area to hectares.

Estimation of basin annual total sediment load using observed suspended sediment and bed load statistics in hydrometric station

After estimating basin outlet sediment load using EPM model, the hydrometric stations under observation, and annual sediment load was obtained for 1970 which is the reference year and for 2007 in order to compare the accuracy of the estimated sediment load based on EPM method.

For this purpose to calculate the sediment rate the exploration of discharge and sediment data in all three hydrometric stations of the basin for the years 1970 and 2007 is needed. Then two correlation models were used to investigate the existence of correlation between water discharge and sediment discharge (Goldman et al., 2004; Mirabolghasemi and Morid, 1999; Begueria and Vicente, 2006):

1. Linear regression model the equation of which is as follows:

$$Qs=a+b\,Q_w \quad [8]$$

2. Power or multiplicative model the equation of which is as follows:

$$Qs= a\,Q^b_w \quad [9]$$

In which

Qs = flow suspended load in ton/day

Qw = discharge in m^3/s

a and b are coefficients

Estimation of the sediment yield in the sub basins

The sediment yield of each sub basin was estimated using EPM model (Due to lack of hydrometric stations in all the outlets of sub basins).

The average values of the erosion intensity coefficients (Z) for each sub basin estimated in the years 1970 and 2006, were used to calculate the sediment yield at each sub basin outlet for the same year.

Estimation of river discharge in each sub basin

Empirical methods were normally used to estimate the river discharge in the sub basins (since there is no hydrometric station in the outlets of all sub basins). The approach used in this research is National Resources Conservation Service (NRCS) suggested in accordance with the several observations in representative basins (National Resources Conservation Service, 2003). Depth of surface runoff from rainfall is obtained from the equation below:

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \quad [10]$$

In which:

Q = depth of runoff in mm

P = depth of rainfall in mm

S = depth of interception, soil infiltration and surface detention in mm

Factor S is called surface detention or potential maximum retention. Considering initial leakage in mm, S will be estimated in metric system using the formula below:

$$S = \frac{25400}{CN} - 254 \quad [11]$$

CN value is obtained from soil properties, land use, antecedent moisture condition, soil hydrologic groups of the basin and the tables related to CN.With calculating depth of runoff, the rate of maximum instantaneous discharge (Q_{max}) in each sub basin is obtained from equations below:

$$Q_{max} = \frac{2.083\,A.Q}{t_p} \quad [12]$$

$$t_p = \sqrt{t_c} + 0.6\,t_c \quad [13]$$

$$Q_{max} = \frac{2.083\,A.Q}{\sqrt{t_c} + 0.6\,t_c} \quad [14]$$

In which:

Q_{max} = maximum instantaneous discharge in cubic meters per second

Q = depth of runoff in centimeters

t_P = time of initiation of flood hydrograph rising limb until reaching the peak in hours

t_c = time of concentration in hour

A = drainage basin area in square kilometers,.

Factors affecting sediment yield

In order to determine the major factors affecting the sub basins sediment yield, two groups of factors including land use change (range, dry farming and irrigation farming) and hydrologic changes (rainfall and discharge) were considered as the varying factors. The effects of these factors on the sediment yield were investigated in each sub-basin. The factors were investigated through establishing a multiple regression by stepwise method using software SPSS. In this analysis, the average annual rainfall, the average annual discharge from sub basins and areas of different land uses (range, dry farming and irrigation) in each sub basin were considered as independent variables and the annual sediment yield from the sub basins were considered as dependent variables.

RESULTS AND DISCUSSIONS

Investigation of changes in land use between the years 1970-2007

Comparing figures 2 and 3 recognizes the rate of changes in land use during the year investigated. Table 1 shows these changes in percent. In this table, increase in area of each use is displayed by positive numbers and decrease in area is displayed by negative numbers.

Table 1. Changes in land use between 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

Most changes in land use are related to changes of ranges to the dry lands. In the other words, the study showed a drastic change of land use for the period of 37 years especially in the increment of dry land (91%) and reduction of rangeland (about 13%).

The total sediment discharge estimated for the year 1970 and 2007

The total estimated sediment discharge is given in the Table 2.

Table 2. The parameters of EPM model with respect to the estimated year for Kardeh drainage basin

Parameter \ Period	1970	2007
Erosion intensity coefficient (Z)	0.61	1.32
Basin area (A) (km^2)	557.90	557.90
Annual average temperature (C^0)	7.45	7.96
Rainfall average depth (H) (mm)	289.87	301.89
Basin perimeter length (P) (km)	118.25	118.25
Basin length (L) (km)	47.90	47.90
Basin elevation difference (D) (km)	725.02	725.02
Temperature coefficient (T)	0.91	0.94
Sediment yield coefficient (Ru)	0.64	0.64
Specific erosion rate (WSP) (m^3 / km^2 / year)	612.73	1069.27
Specific sediment discharge (GSP) (m^3 / km^2 / year)	392.14	684.33
Total sediment discharge (GS) (m^3 / year)	209,975.67	381787.7
Total sediment discharge (GS) (ton / year)	272,968.3	496,324.0

According to the results, annual average total sediment produced based on EPM method for the basin in the period 1970 is equal to 272,968.3 tons/year and that for the period of 2007 is equal to 496,324 tons/year.

Correlation between water discharge and sediment discharge

After a separate arrangement of the data related to water and sediment discharge in three hydrometric stations of the basin for the years 1970 (the base year) and (1971-2007), the sediment rating curves and the proper correlation equations were obtained according to the regression coefficient calculated for each station using the SPSS software and statistical analysis to define correlation relationships. Figures 5 to 10 separately show the sediment rating curves for three hydrometric stations of the basin for the years 1970 and 2007.

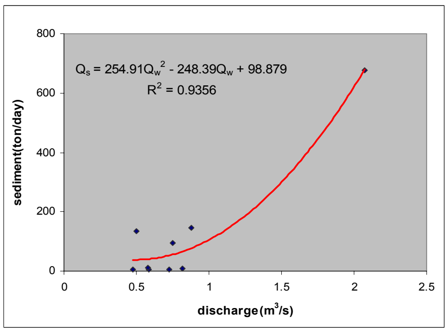

Fig 5. Sediment rating curve (Al station -1970)

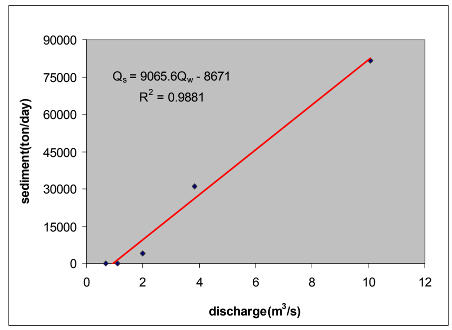

Fig 6. Sediment rating curve (Mareshk station -1970)

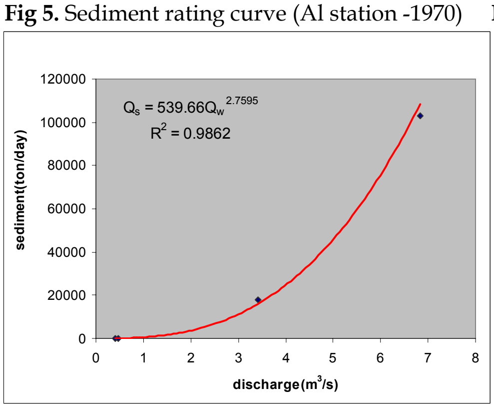

Fig7. Sediment rating curve (Koshkabad station -1970)

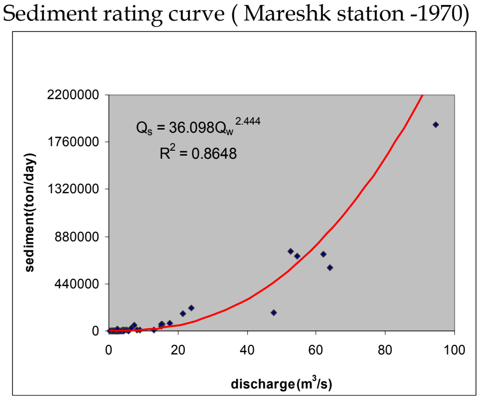

Fig 8. Sediment rating curve (Al station -2007)

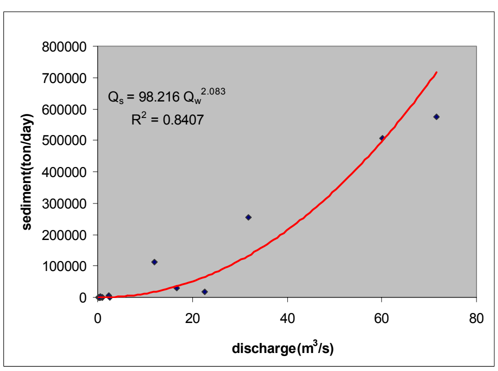

Fig 9. Sediment rating curve (Mareshk station -2007)

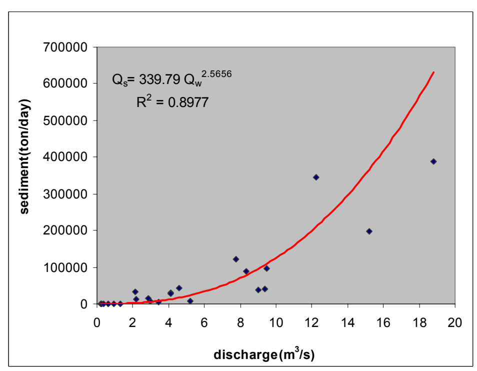

Fig 10. Sediment rating curve (Koshkabad station – 2007)

After determining the correlation of water discharge and its sediment discharge, the annual suspended load was estimated by putting each one of the daily discharges in the time section studied in the equations. In the hydrological calculations, the bed load rate is considered to vary between 10-60 percent of the suspended load (Mirabolghasemi and Morid, 1999; Casanovas and Bosch, 2000; Mirzaii, 2007) while in Kardeh basin, this rate is about 20%. On the basis of the above mentioned and calculations, suspended load rate and bed load and the total sediments degraded in each hydrometric station of Kardeh basin is presented in table 3.

Table 3. Suspended loads observed in the hydrometric stations during study periods

Station name	1970					2007				
	Area (ha)	Suspended specific load (t/h/y)	Bed specific load (t/h/y)	Specific sediment total (t/h/y)	Delivery sediment (t/y)	Area (ha)	Suspended specific load (t/h/y)	Bed specific load (t/h/y)	Specific sediment total (t/h/y)	Delivery sediment (t/y)
Mareshk	18405	4.77	1.15	5.72	105,276.60	18405	9.1	1.82	10.92	201,018.85
Al	27328	3.98	0.79	4.77	130,473.42	27328	6.71	1.83	8.05	220,129.30
Koshkabad	9126	3.44	0.93	4.12	37641.16	9126	6.94	1.39	8.33	76072.19
Basin total	54859	4.15	0.83	4.98	273,391.18	54859	7.55	1.51	9.06	497220.34

According to the calculations performed, the annual average sediment rate in 1970 was equal to 273,391.18 tons per year and in 2007, it was 497,220.34 tons per year.

Comparison of the observed sediment and the estimated sediment

Comparison of the sediment observed at the hydrometric stations with the sediment estimated by EPM model through the calculation of relative difference shows that there is a slight difference between the observed and estimated values. The estimation of relative difference was performed according to the following equations:

$$\frac{Difference\ (t/y)}{Measured\ (t/y)} * 100 \Rightarrow \frac{4535.61(t/y)}{273391.18(t/y)} * 100 \Rightarrow 1.6\% \cong 2\% \qquad \text{(Year 1970)}$$

$$\frac{Diffrence\ (t/y)}{Measured\ (t/y)} * 100 \Rightarrow \frac{8254.54\ (t/y)}{497220.34\ (t/y)} * 100 \Rightarrow 1.6\ \% \cong 2\% \qquad \text{(Year 2007)}$$

As observed, the relative difference between observed values and estimated values is less than two percent in the years 1970 and 2007. In other words, these values are as close as 98% in these periods. The results are given in table 4.

Table 4. Comparison of the observed and estimated annual sediments in each period of the study for the basin

Period	Measured (ton /y)	Estimated (ton /y)	Difference (ton /y)
1970	273,391.18	268,855.57	4535.61
2006	497220.34	488965.8	8254.54

The results clearly show that the trend of changes in sediment load increases from the year 1970 to the year 2006 and the rate of this increase in calculated and measured values is about 82%.

Sediment yield and river discharge in the sub basins

Since it has been validated that the estimated annual sediment yield using EPM method is estimated in a similar way to the observed annual sediment yield at the hydrometric station, sub basin annual sediment yield was also estimated using EPM model. Also, the annual runoff for each sub basin in both 1970 and 2007 was calculated. The results are listed in table 5.

Effective factors on the sub basins sediment yield based on step wise multiple regressions

The specific data used in the stepwise regressions for both years (1970 and 2007) are listed in Tables 6 and 7 respectively.

Table 5. Sediment yield and river discharge in Kardeh sub basins for the years 1970 and 2007 using EPM and NRCS models

Sub basin	1970		2007	
	Sediment yield (t/y)	Q_{max} (m^3/s)	Sediment yield (t/y)	Q_{max} (m^3/s)
K_1	49077.3	21.77	93201.5	24.43
K_2	70873.0	16.82	117671.6	16.55
K_3	52193.4	8.96	95288.9	12.69
K_4	39026.1	10.71	69141.1	11.19
K_5	20820.9	9.48	39417.4	11.27
K_6	36864.8	22.30	74246.3	25.39
K_7	4112.8	1.95	7358.2	0.71

Table 6. Data used in regression model during the year 1970

Sub basin	Range (ha)	Dry farming (ha)	Irrigation farming (ha)	Precipitation (mm)	Discharge (m^3/s)	Sediment yield (t/h)
K_1	3652	821	157	294.23	21.77	49077.3
K_2	5741	2307	311	293.23	16.82	70873.0
K_3	9124	249	333	308.28	8.96	52193.4
K_4	6403	375	115	312.31	10.71	39026.1
K_5	4258	64	147	292.84	9.48	20820.9
K_6	7863	791	459	292.76	22.30	36864.8
K_7	835	38	57	289.65	1.95	4112.8

Table 7. Data used in regression model during the year 2007

Sub basin	Range (ha)	Dry farming (ha)	Irrigation farming (ha)	Precipitation (mm)	Discharge (m^3/s)	Sediment yield (t/h)
K_1	3418	1048	158	310.49	24.43	93201.5
K_2	5429	2567	364	301.50	16.55	117671.6
K_3	7938	1360	405	315.73	12.69	95288.9
K_4	5177	1534	175	321.12	11.19	69141.1
K_5	2923	1124	416	316.54	11.27	39417.4
K_6	7477	1145	462	301.74	25.39	74246.3
K_7	694	135	100	298.81	0.71	7358.2

The results on applying the step wise regression model for the year 1970 and 2007 are explained as follows:

I. The period of 1970

Table 8 represents the summary of the stepwise of multiple linear regression models for the year 1970. Also, assumption test {H0: B0=B1=B2=B3=B4=0} and {H1: Bi Bi $\neq$ 0} is performed (H0 is the null hypothesis and H1 is alternative hypothesis, Bi are the coefficients of variables and B0 is the constant coefficient) in the analysis variance table or ANOVA (Table 9) and tested at significant level ($\alpha < 0.05$). If α value in the ANOVA table is less than 0.05, the assumption H0 is rejected i.e. it is possible to fit the regression equation.

For the year 1970, α= 0.001 and it is less than 0.05, so the assumption H0 is rejected so that it will be possible to fit the regression equation to these variables

Table 10 represents the results obtained from coefficients. This table shows the coefficients values (β) and significance level (α).Except for the discharge as variable, other independent variables such as (range, rainfall, dry farming, irrigation farming) showed significant levels (α) higher than 0.05, thus they are not placed in equations and will be deleted from the model.

Considering these tables, the appropriate regression model for the year 1970 is as follows:

Y= Sediment yield
X1= Discharge, X2 = Dry farming, X3 = Range, X4= Irrigation farming, X5= Precipitation

$$Y = a + b X1 + c X2 + d X3 + e X4 + f X5$$

$$Y = 3.595 + 0.166 X1 + 0.346 X2 + 0.238 X3 + 0.274 X4 - 0.054 X5$$

(Sig X2, X3, X4, X5 > 0.05)

$$Y = 3.595 + 0.166 X1$$

In which
Y= the outlet sediment from sub basins (t/ha)
X1= the outlet discharge from sub basins (m3/s)

With regard to the equation, it can be concluded that with the probability of 95%, the discharge variable is the only factor affecting sediment yield. Therefore, in this stage only one of five independent variables including outlet discharge from sub basins has been entered into the equation.

II. The Period of 2007

Table 11 shows the model summary for the year 2007.

In the analysis variance (ANOVA) table, $\alpha = 0.001$ and significance level ($\alpha \leq 0.05$), since $\alpha < 0.05$, so the assumption H0 is rejected that is regression is significant (Table 12). Table 13 gives the results obtained from coefficients. These tables represent the coefficient values (β) and significant level (α).

Except for the dry farming as variable, other independent variables such as (range, rainfall, discharge, irrigation farming) showed significant levels higher than 0.05, thus they are not placed in equations and will be deleted from the model. Regarding these tables, the appropriate regression model for the year 2007 is as follows:

Y= Sediment yield
X1= Discharge, X2= Dry farming, X3= Range, X4= Irrigation farming, X5= Precipitation

$$Y = a + b X1 + c X2 + d X3 + e X4 + f X5$$

$$Y = 4.410 + 0.333 X1 + 0.00039 X2 + 0.209 X3 - 0.007 X4 + 0.391 X5$$

(Sig X1, X3, X4, X5 > 0.05)

$$Y = 4.410 + 0.00039 X2$$

In which
Y = the outlet sediment from sub basins (t/ha) X2 = the areas with dry land use (ha). Considering the equation, it is concluded that in this period, among the five factors considered only the factor of dry land use areas plays an important role. With the probability of 95%, the variables dry land use areas control the sediment yield changes in the periods 1971-2007.

Table 8. The summary of the model for the year 1970

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,901[a]	,813	,775	,125

a. Predictors: (Constant), DISCHARG

Table 9. The analysis variance table or ANOVA for the year 1970

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,377	1	,377	50,641	,001[a]
	Residual	,037	5	,007		
	Total	,414	6			

a. Predictors: (Constant), Discharge

b. Dependent Variable: sediment1

Table 10. The coefficients values for the year 1970

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3,595	,209		17,203	,000
	DISCHARG	,166	,036	,901	4,655	,006

a. Dependent Variable: SEDIMEN1

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	RANG	,238[a]	1,033	,360	,459	,700
	DRYFARMI	,346[a]	1,775	,150	,664	,692
	IRRIGATI	,274[a]	1,534	,200	,609	,927
	PRECIPIT	-,054[a]	-,189	,859	-,094	,578

a. Predictors in the Model: (Constant), DISCHARG

b. Dependent Variable: SEDIMEN1

Table 11. The summary of the model for the year 2007

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,958[a]	,918	,902	,09209

a. Predictors: (Constant), Dryfarming

Table 12. The analysis variance table or ANOVA for the year 2007

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,477	1	,477	56,190	,001[a]
	Residual	0.042	5	0.0084		
	Total	,519	6			

a. Predictors: (Constant), DRYFARMI

b. Dependent Variable: SEDIMEN1

Table 13. The coefficients values for the year 2007

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4,410	,075		58,947	,000
	DRYFARM	.00039	,000	,958	7,496	,001

a. Dependent Variable: SEDIMEN1

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	RANG	,209[a]	1,549	,196	,612	,701
	IRRIGATI	-,007[a]	-,044	,967	-,022	,807
	PRECIPIT	,391[a]	2,130	,100	,729	,284
	DISCHARG	,333[a]	1,029	,362	,457	,154

a. Predictors in the Model: (Constant), DRYFARMI

b. Dependent Variable: SEDIMEN1

Economic and social reasons for land use changes

In addition, the morphology, high slope, vegetation loss, irregular rainfall, rainfall intensity, the sudden turn of the last few years, land and water shortages, social and economic factors as well as cause environmental disaster area.

Social and economic factors that have contributed to land use changes include the following:

Poverty and low income, low literacy levels and skills, land Ownership, lack of culture policies, lack of planning on how to exploit the land and lack of supervision. The Kardeh basin located on the north east of khorassan razavi provenc, this region was environmental , economical, and human characteristics have intervened in forming the major centers of population and activity in the region. The , locating in arid and semi-arid region,caused natural particularities . The above particularities, on one hand, and improper settlement of the population as well as inappropriate activity and exploitation of the regional resources, on the other hand, caused severe shortage of water resources. The low rate of rainfall and higher degree of evaporation, transpiration, and natural isolation as well as severe dispersion of habitats and spatial disorders.

CONCLUSION

The Kardeh basin has undergoes significant land use changed from 1970 to 2007. Decreasing of rangeland to dry farming has been identified as one of the major factor that contribute to the increased in soil erosion and sedimentation within basins. These problems happened because there is no proper land use regulation that restricts the conversion of rangeland to dry farming. The natural resources organization of Khorasan Razavi Province has apply several preventive structures to reduce the problem of soil erosion and sediment downstream, however, with limited success because the structures can only be applied to the stream channel and not at the farm land level due to the problem of land ownership.

In order to reduce the future impact of downstream soil erosion and sedimentation it is suggested that the farmers association of the basin advised the farmers:

a) To change dry farming to cultivation of forage crops such as alfalfa, clover and sainfoin.
b) Apply land management practices such as terracing and contour furrow.
c) To educate the farmers concerning the problems of soil erosion and their activities.

Recommended the following measures be taken to reduce erosion:

- Balance of livestock and pasture in the region
- Assigning ranges
- Watershed measures have
- Rainfed farms converted to pasture

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تبدیل مراتع به اراضی دیم و اثرات آن بر فرسایش و رسوب سالانه در حوضه کارده

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(تاریخ دریافت: ۹۰/۱/۶ - تاریخ پذیرش:۹۰/۵/۲۳)

چکیده :

استفاده از مراتع نظیر تبدیل آن به اراضی دیم به طور گسترده ای در بسیاری از مناطق ایران رایج است. این فعالیت می تواند باعث افزایش رسوب در مناطق پایین دستی شود. اثرات این فعالیت در حوضه های پایین دستی برای بسیاری از مناطق استراتژیک در کشور به خوبی شناسایی نشده است. یکی از مناطق که در این مطالعه به آن پرداخته شده حوضه رودخانه کارده، واقع در شمال شرق ایران است، این حوضه دارای ۵۷۰۹کیلو متر مربع وسعت است. در این مطالعه، تلاش شده است به تغییر کمی میزان رسوب از حوضه در طی سالهای ۱۳۵۰ تا ۱۳۸۶، پرداخته شود. برای برآورد میزان تغییرات بهره برداری از اراضی از تصاویر ماهواره ای و عکس های هوایی و یک مدل تجربی رگرسیون چندگانه گام به گام برای توجیه تغییرات در رسوب مورد استفاده قرار گرفته است. نتایج نشان دهنده تغییر قابل ملاحظه ای در استفاده از زمین(گسترش کشت دیم) در طی این دوره - افزایش ۹۱ درصدی رسوب و کاهش ۱۳ درصدی مراتع – می باشد. از نظر آماری حدود ۹۵ درصد از تغییرات سالانه رسوب به علت افزایش زمینهای کشت دیم در حوضه بوده است .($R2= 0.95, \alpha < 0.05$) را در بر می‌گرفت. سیستم آنالیزکننده یک دستگاه اسپکترومتر جذب اتمی (Perkin-Analyst 100) بود. در بررسی‌های جذب و واجذب مشاهده شد که پلیمرهای سنتزی وابستگی شدیدی به pH داشتند که بر روی کارایی حذف شدیداً موثر بود. رفتار جذبی از همدماهای فروندلیش و لانگموير پیروی می‌نمود. مطالعاتی در زمینه بازیابی جاذب نیز انجام شد.

*مولف مسئول