Sediment production by gully erosion in the southwest of Iran, Fars province

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1. Abstract

This paper presents the results of a research plan conducted in Fars province. Six gully regions with an eroded area larger than 5sq.km were selected in different climatic zones. In each region, 15 gullies were selected and measured. The volume of gully development was measured using historical evidence, topographic map, and field surveying. Several factors such as drainage area above headcuts, vegetation cover, bare soil, surface gravel, slope percent , clay, silt and sand and Ec were measured in the watershed above haedcuts and in the lab. The form factors of watersheds were calculated using topo maps and rainfall records used from the nearest rainfall stations. The volume of gully development was used as dependent factor and others as independent variables to indicate the effects of dominant factors on sediment production. Statistical analysis has been performed using stepwise method and Duncan in SPSS software.

Results indicated that sediment production due to gully erosion was affected by slope gradient above headcuts, maximum daily rainfall, sand and form factor. The most important factor was slope with coefficient β equal 0.414 and the least important factor was form factor with β equal 0.221. The final equation is as follows :

$$Y = 496.7 + 27.89slope - 4.68sand + 275.28formfactor - 2.36\max imumdailyra\inf all$$

Standard coefficient (β) of slope, sand, form factor and maximum daily rainfall are 0.414, 0.23, 0.221 and 0.25 respectively.

Keywords: sediment production, gully erosion, Iran, Fars, slope, drainage area, form factor, gully development

2. Introduction

Gully erosion is a widespread feature in the arid and semiarid regions around the world. Gully erosion covered an area over 500 km^2 in Fars province. Due to its onsite damages such as road and bridge destruction and off site damages such as siltation of reservoirs gully erosion has attracted more attention in recent years in Iran. Gully erosion is a complex phenomenon and many factors effect it. Many researchers referred to physiographic factors such as drainage area and slope gradient as important factors for gully formation and/or development (Montgomery and Dietrich, 1994; Campos *et al*., 2000; Nachtergaele and Poesen, 2002; Poesen *et al*., 2003). Kukal and Matharu (2002) in their research on gully erosion in Pinjab, India, found that factors such as slope gradient, drainage area, form factor. Soil surface and sub-surface erodibility, average rainfall had positive correlation with gully formation and vegetation cover negatively correlated with that. They concluded that the first two factors were the most important ones. Vandeckerchove *et al*.(2003) found that gully development in the southeast of Spain had power relationship with drainage area above the gully heads. They referred to the importance of surface runoff for gully development in the arid and semiarid regions.

3. Methods

Six regions with gully erosion in different climate zone were selected from previous study had been done by Soufi (2004). The boundary of watersheds and gullies were determined on the topographic maps with a scale of 1:25000 using Arcview software and GIS. In each watershed, 15 gullies were selected. The length of the gullies were measured on the topographic map with a scale of 1:25000 (acquired in 1994) and in the field in 2006. Each gully was divided into segments different lengths. The interval between gully segments was maximum 5 meters. In each segment, depth, top and bottom width of gully cross section were measured by tape meter. Soil samples were taken from each segment and a compound samples was provided for lab measurement. The area and slope gradient above headcuts were measured in the field. Vegetaion cover, gravel and bare soil were measured using ten 1 m^2 quadrates above headcuts. Particle size, PH, EC, OM, of soil samples were measured in the lab. The volume of gully development was calculated using partial volumes and was considered as sediment produced by gully erosion in the period 1994 and 2006 (13 years). Partial volumes were calculated by multiplying cross section area by distance between cross sections. Watershed characteristics such as form

factor and length between headcuts and watershed divides were determined on the topographic maps. Maximum 24-hour rainfall data was collected from the nearest rain station. The volume of gully development was used as dependent factor and others as independent variables to indicate the effects of dominant factors on sediment production. Statistical analysis was performed using stepwise method and Duncan in SPSS software.

4. Results

The results indicated that average sediment production by each gully was 122.38 m3 in a 13 year period (1994-2006). Table 1 indicates collected and measured data from six gully regions.

Table 1 Characteristics of six regions with extensive gully erosion in Fars province

Variable	Minimum	Mean	Maximum	Mean standard error	Standard deviation
Sediment:1994-2006(m3)	0.61	122.38	1284.50	26.91	255.28
Drainage area above headcuts(m2)	13.68	3399.53	20852.50	493.17	4678.57
Vegetation cover(%)	0.00	11.93	95.00	2.49	23.62
Bare soil(%)	0.00	70.46	100.00	3.72	35.30
Surface gravel(%)	0.00	17.61	96.00	2.94	27.91
Slope(%)	2.80	5.38	9.30	0.40	3.79
Clay(%)	2.08	18.82	39.00	0.82	7.82
Silt(%)	3.36	26.41	42.00	0.97	9.16
Sand(%)	32.12	54.53	94.56	1.32	12.54
EC(ds/m)	0.26	4.24	39.85	0.75	7.10
Form factor	0.03	0.28	0.97	0.02	0.20
Maximum 24-rainfall(mm)	128	147.00	207.00	2.90	27.49

Statistical analysis indicated that sediment production due to gully development had significant correlation with gradient slope above headcuts ($P<0.01$), Drainage area above headcuts ($P<0.05$) and form factor ($P<0.05$). Final equation for sediment production due to gully development in Fars province indicated in Table 2. The results revealed that gully development was affected by four variables, slope gradient (X5), Sand (X8), Form factor (X0) and Maximum 24-hour rainfall (X11). The most important factor for gully development was slope gradient with B1= 0.414 and the least effective factor was form factor with B3= 0.221 (Table 2).

Table 2 Predictive equation and important factors for gully development in some part of Fars province

Equation	Standard coefficient				Adjusted R2	P
	B1	B2	B3	B4		
Y= 496.7 + 27.89 X5 _ 4.68 X8 + 257.28 X10 – 2.36 X11	0.414	0.23	0.221	0.25	0.426	0.01

Where X5= slope gradient, X8= sand, X10= form factor and X11= maximum 24-hour rainfall

The results (Table 2) revealed that increasing one unit of slope gradient(X5) increases 0.414 unit of gully development. These data indicated that effective factors for sediment production due to gully erosion were slope gradient, 24-hour maximum rainfall, sand and form factor respectively. It implies that physical and watershed characteristics were the most important factors for gully development.

5. Conclusion

The results of this research revealed that slope, maximum daily rainfall, sand and form factor influenced gully development in Fars province. Among these factors, slope gradient is the most important factor with standard coefficient equal to 0.221 for gully development. This result implies that surface runoff is the dominant hydrological process for gully development and sediment production in this part of Iran.

The comparison of standard coefficient (β) indicated that increasing one unit of slope lead to an increase in gully volume up to 0.414 (β = 0.414) and increasing one unit of form factor , increased the volume of gully erosion up to 0.221.

6. References

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