

# Erodibility of calcareous soils as influenced by land use and intrinsic soil properties in a semiarid region of central Iran

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**Abstract** The most important properties affecting the soil loss and runoff were investigated, and the effects of land use on the soil properties, together with the erodibility indices in a semiarid zone, central Iran, were evaluated. The locations of 100 positions were acquired by cLHS and 0–5-cm surface soil layer samples were used for laboratory analyses from the Borujen Region, Chaharmahal-Va-Bakhtiari Province, central Iran. To measure in situ runoff and soil erodibility of three different land uses comprising dryland, irrigated farming, and rangeland, a portable rainfall simulator was used. The results showed that the high variations (coefficient of variation, CV) were obtained for electrical conductivity (EC), mean weight diameter (MWD), soil organic carbon (SOC), and soil erodibility indices including runoff volume, soil loss, and sediment concentration (CV ~43.6–77.4%). Soil erodibility indices showed positive and significant correlations with bulk density and negative correlations with SOC, MWD, clay content, and soil shear strength in the area under investigation. The values of runoff in the dryland, irrigated farming, and rangeland were found 1.5, 28.9, and 58.7 cm<sup>3</sup>; soil loss in the dryland, irrigated farming, and rangeland were observed 0.25, 2.96, and 76.8 g; and the amount of sediment concentration in the dryland, irrigated farming,

and rangeland were found 0.01, 0.11, and 0.15 g cm<sup>-3</sup>. It is suggested that further investigations should be carried out on soil erodibility and the potential of sediment yield in various land uses with varying topography and soil properties in semiarid regions of Iran facing the high risk of soil loss.

**Keywords** Soil erosion · Sediment concentration · Runoff · Calcareous soils · Rainfall simulator

## Introduction

Soil erosion does not only lead to the degradation of the soil, but also results in off-site problems pertained to the sedimentation of downstream areas plus ground and surface water pollution (Uri 2001; Mokhtari Karchegani et al. 2011). Due to the erosion, the soil depth, plant nutrients, organic matter (OM), and the soil productivity are gradually lost (Afshar et al. 2010; Khaledian et al. 2017; Nearing et al. 2017). Factors such as land use change, overgrazing by livestock, deforestation, improper land use management, dryland farming in sloping land, and fire of rangelands and forests significantly increase the soil erosion (Keesstra et al. 2016; Rodrigo-Comino et al. 2018).

In arid and semiarid regions, i.e., soil having low plant coverage, the properties of soil play a significant role in the erodibility of soil in similar slopes and management practices (Nadal-Romero et al. 2014). To evaluate the soil erodibility, as cited by Morgan et al. (1998) and Nearing et al. (1989), various models

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and equations have been developed. One of the well-known approaches for the evaluation of soil erodibility is using the rainfall simulator (Martínez-Hernández et al. 2017; Rodrigo-Comino et al. 2017). Rainfall simulators are used in the field and laboratory to determine runoff production and soil erosion for selected tillage practices (Wang et al. 2017), such as studying plant cover effects (Casermeiro et al. 2004), identifying rill and inter-rill processes of erosion (Shen et al. 2016), and determining soil nutrient loss in runoff sediments (Yang et al. 2014).

Land use substantially affects runoff production and the soil loss (Bakker et al. 2008; Feng et al. 2016). A number of investigators have attempted to examine the influence of land use change on soil erosion. Navas et al. (1997) reported a significant influence of land use on soil erosion in the semiarid and the middle mountain environments in Spain. In the semiarid area, cultivation was a major factor causing erosion, and consequently, any attempt to reduce soil loss and off-site impacts should focus on controlling erosion on the cultivated lands (Borrelli et al. 2014; Panagos et al. 2014). In the middle mountain area, the higher productivity of crops equalizes the functioning of these two different land uses (pasture and arable land) (Navas et al., 1997). Nacinovic et al. (2014) measured soil erosion on various land management areas (native rainforest, olericulture with conventional tillage, forest restoration system, and pasture) in Brazil. The highest and the lowest soil erosions were found in olericulture plot with conventional tillage and pasture plot. Conventional tillage increased soil erosion mainly due to the decrease in soil inter-particle cohesion and infiltration in association with poor vegetation cover.

In the semiarid regions of Iran, soil erosion presents a significant environmental problem (Afshar et al. 2010; Ayoubi et al. 2012b; Rahimi et al. 2013; Hossini et al. 2017). Thus, it is essential to determine the main properties of soils and/or land uses that control soil erodibility so that the soil is preserved, and its degradation is reduced. We hypothesized that besides the slope gradient, as a well-known factor controlling the soil loss and soil properties, the land uses had great influences on soil erodibility in the semiarid regions of Iran. In this respect, the aims of the present investigation are (i) examining the most important properties of soil affecting runoff and soil loss and (ii) evaluating the influences of land use upon the properties of soil and erodibility indices in a semiarid region in central Iran.

## Materials and methods

### The description of the area studied

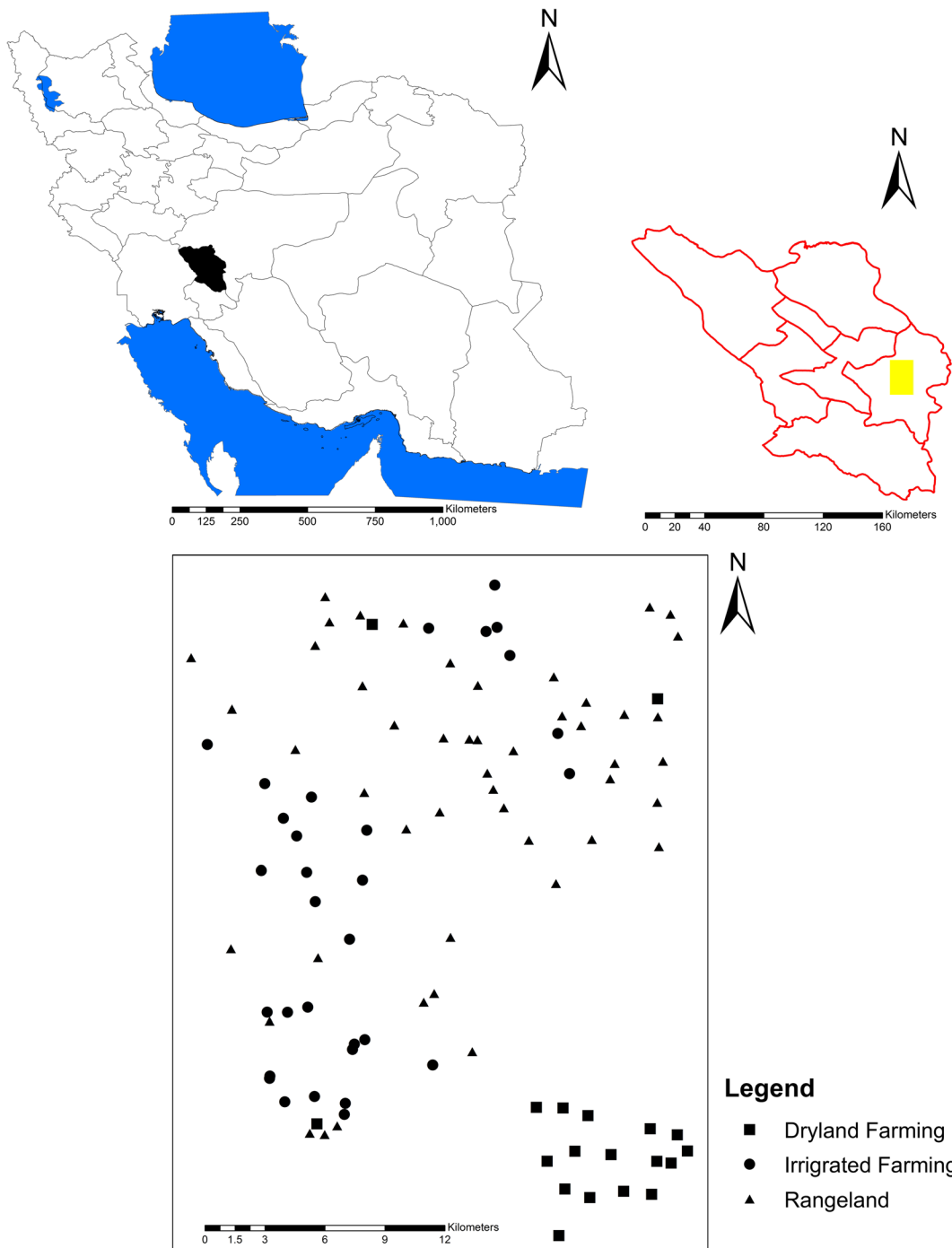
This study was carried out in an area covering approximately 86,000 ha. The area under investigation mostly similar to the one investigated in Zeraatpisheh et al. (2017) is located in Borujen Region, Chaharmahal-Va-Bakhtiari Province, Central Iran (Fig. 1), between 51° 19' 9" and 51° 20' 45" E longitudes and 31° 41' 00" and 32° 00' 00" N latitudes. The average annual temperature and rainfall are 10.7 °C and 255 mm, respectively. The mean elevation of the selected region is 2277 m a.s.l. Predominant crops in the agricultural lands included wheat, barley, and alfalfa; in the rangeland, the main crops were Milkvetch and *Bromus tectorum*. The main management practices in farmlands were based on the conventional tillage system. Major landscape units in the study area included mountains, hill-land, piedmonts, and low land.

### Soil sampling

Soil sampling scheme was performed by applying the algorithm proposed by Minasny and McBratney (2006), i.e., the conditioned Latin hypercube sampling (cLHS). To do so, Matlab software was used (MathWorks 2009), and topographic and remote sensing data were regarded as covariates. Distribution patterns of 100 locations are illustrated in Fig. 1, discriminated based on their land uses. For laboratory analyses, since topsoil is the most erodible part of the soil solum, soil surface samples were gathered from the layers of 0–5 cm. All field experiments including rainfall simulation were done on the same locations.

### Soil loss and runoff measurement

For in situ measurement of runoff and soil erodibility, a portable rainfall simulator, designed in Isfahan University of Technology (Fig. 2), was employed for constant-rate rainfall, namely 115 mm h<sup>-1</sup> (Shahbineejad 2012). The land area affected by the simulated rainfall was 33 cm × 33 cm with the slope of about 5% for all locations. A runoff collector at the downslope end allowed sampling of all runoff and sediment from the area of 33 cm × 33 cm. The time of rainfall simulation of 3 min was considered for all locations. Collected runoff was measured and reported in cubic centimeters. The



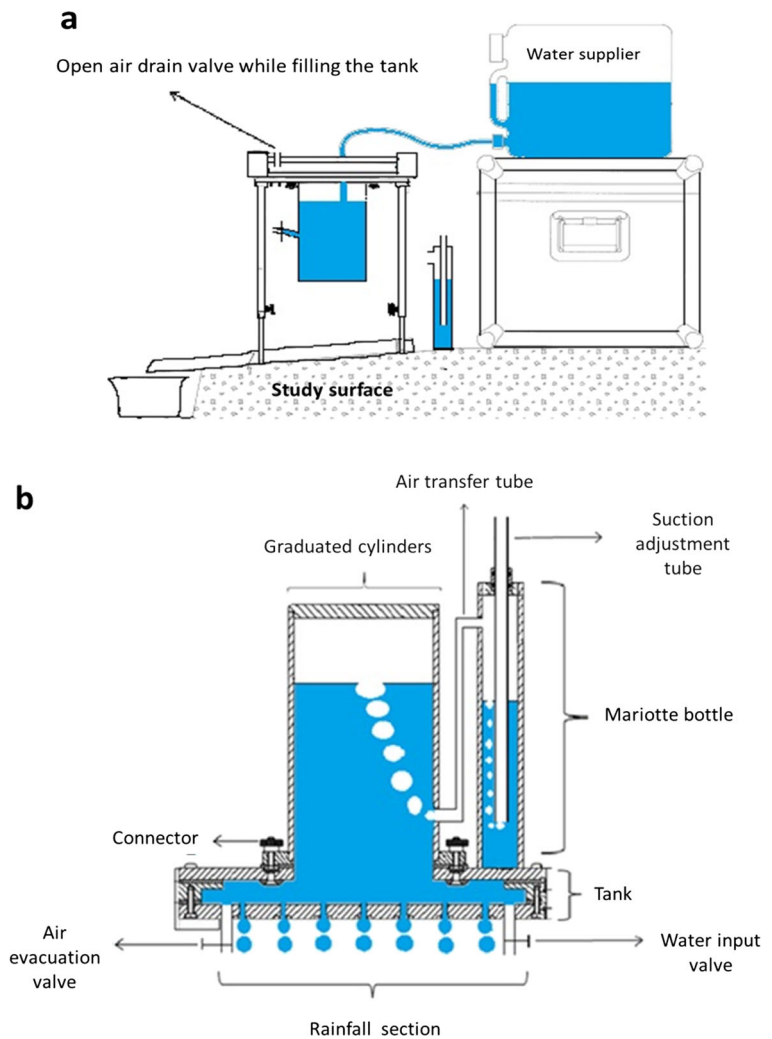
**Fig. 1** The location of the study area. The black area in the upper left of the figure identifies the Chaharmahal-Va-Bakhtiari Province among all of the provinces in Iran. The upper right part of the figure shows districts in the Province of Chaharmahal-Va-

Bakhtiari and the location of the study area. The bottom figure illustrates distribution patterns of 100 locations which are discriminated based on their land uses

amount of soil particles in runoff was specified next to heating the mixture, for 24 h, at 110 °C. The dried sediment was considered as “soil loss” whose value

per volume of runoff ( $\text{gcm}^{-3}$ ) was regarded as “sediment concentration.”

**Fig. 2** Rainfall simulator and instrumentation layout. (a) Schematic of inverted tank to fill by water on the surface and (b) rainfall simulator and its components



In the field studies, soil shear strength was measured in all of the locations. To determine the in situ shear strength (SS) of the surface soil, at the saturation condition, a shear vane (model: BS1377-9) was applied. Soil surface was saturated 2 h before measurements.

#### Laboratory analyses

The soil samples from 100 studied locations at the ambient temperature were air-dried and then sieved using a 2-mm screen. Particle size distribution of the soil including its clay, silt, and sand contents was determined using the pipette method (Gee and Or 2002). Electrical conductivity (EC) was determined in the soil extracts of soil having 2.5:1 ratio of water to soil. To measure the soil pH, a glass electrode was used in a suspension of 2.5:1 ratio of water to soil. Calcium carbonate equivalent (CCE) was

determined by the back titration method of Nelson and Sommers (1982). To do wet-sieving procedure, a sample of soil comprising 100 g was passed through a sieve (4.75 mm). In the given analysis, sieve sets sized 2, 1, 0.5, 0.25, 0.1, and 0.053 mm were used. The aggregates were divided in seven size ranges (4.75–2, 2–1, 1–0.5, 0.5–0.25, 0.25–0.1, 0.1–0.053, and < 0.053 mm). Mean weight diameter (MWD, mm) of aggregates was measured after its fractionation using the equation proposed by Kemper and Rosenau (1986). The SOC content was determined by the wet oxidation method (Walkley and Black 1934). Undisturbed samples of soil taken from the topmost layer of soil (0–5 cm), by means of stainless steel cylinders (2.65-cm radius, 4.45-cm height, and 98-cm<sup>3</sup> volume), were exploited to measure the soil bulk density ( $\rho_b$ ). At 105 °C, the soil cores were dried for 48 h and subsequently weighed.

Statistical analyses

The descriptive statistics including the mean, median, maximum, minimum, skewness, standard deviation (SD), and coefficient of variation (CV) were calculated and reported for data obtained. Kolmogorov-Simonov test was used to evaluate the normality distribution of data, and then Pearson correlation coefficients were calculated among the parameters studied. A completely random design was exploited to analyze the data enjoying different land-use systems as the main treatment. Generalized linear model (GLM) procedure and least significant difference (LSD) test were used to quantitatively analyze the data in SAS (version 6.0; SAS-Institute 1990) and obtain the mean comparisons at  $p < 0.05$ .

Results and discussion

Descriptive statistics of soil parameters

Table 1 shows the descriptive statistics of the properties of the soils studied. Soil organic carbon (SOC) varied from 0.185 to 2.676 kg 100 kg<sup>-1</sup>, indicating low to moderate storage of organic carbon in the soil of the area studied. Among the characteristics, gravel content

(CV = 109.1 kg 100 kg<sup>-1</sup>), EC (CV = 43.7 kg 100 kg<sup>-1</sup>), MWD (CV = 61.1 kg 100 kg<sup>-1</sup>), and SOC (CV = 64.6 kg 100 kg<sup>-1</sup>) showed relatively high variability. These high variations mainly attributed to the topography and also to various management practices in different land uses. All soil erodibility indices showed high variability, CV = 66.1, 77.4 and 58.2 kg 100 kg<sup>-1</sup> for runoff volume, soil loss, and sediment concentration. The given high variability might be ascribed to high variability in soil properties and soil-forming factors which control soil erodibility. Furthermore, different management strategies throughout the large area studied, including grazing and dense tillage practices, presumably led to high variability in soil erodibility.

Relationships between soil erodibility and soil parameters

Table 2 presents correlation coefficients between soil erodibility indices and soil properties. Significant positive correlations were obtained between bulk density and soil loss ( $r = 0.24, p < 0.05$ ), and between bulk density and sediment concentration ( $r = 0.26, p < 0.01$ ) (Table 2), which may be due to the locations with higher degree of compactness in the soil induced by intensive grazing (in pasture) and intense tillage practices (in agricultural soils). In these locations, because of the

**Table 1** Descriptive statistics of soil properties within the study area

Variable	Unit	Min	Max	Mean	SD	CV	Skew
$\rho_b$	Mg m <sup>-3</sup>	1.1	1.9	1.4	0.2	11.2	0.8
Clay	kg 100 kg <sup>-1</sup>	18.0	57.0	38.6	7.2	18.8	-0.3
Silt	kg 100 kg <sup>-1</sup>	19.0	60.0	40.1	5.9	14.7	-0.2
Sand	kg 100 kg <sup>-1</sup>	8.0	60.0	21.3	9.1	42.5	1.6
EC	dS m <sup>-1</sup>	0.01	0.6	0.3	0.1	43.6	1.0
pH	-	7.0	7.9	7.6	0.2	2.2	-0.7
SOC	kg 100 kg <sup>-1</sup>	0.2	2.7	0.9	0.6	64.6	1.4
CCE	kg 100 kg <sup>-1</sup>	10.8	72.0	32.9	11.5	35.1	0.6
MWD	mm	0.1	0.8	0.3	0.2	61.1	1.5
Shear strength	kPa	0.50	6.5	2.9	0.9	31.4	0.6
Runoff volume	cm <sup>3</sup>	0.0	90.0	38.1	25.2	66.1	-0.1
Soil loss	g	0.0	15.0	5.3	4.1	77.4	0.3
Sediment concentration	g cm <sup>-3</sup>	0.0	0.3	0.1	0.	58.2	-0.5

$\rho_b$  bulk density, EC electrical conductivity, SOC soil organic carbon, MWD mean weight diameter, Min minimum, Max maximum, SD standard deviation, CV coefficient of variation, Skew skewness

**Table 2** Correlation coefficients between soil properties and erodibility indices in the study area ( $N=100$ )

Variable	SOC	$\rho_b$	Clay	MWD	SS	Runoff	Soil loss	Sed. Con.
SOC	1							
$\rho_b$	-0.26**	1						
Clay	0.12	0.09	1					
MWD	0.83**	-0.12	0.19	1				
SS	-0.12	0.34**	0.22*		1			
Runoff	-0.43**	0.25*	0.26**	-0.49**	-0.44**	1		
Soil loss	-0.53**	0.24*	0.25*	-0.43**	-0.45**	0.92**	1	
Sed. Con.	-0.71**	0.26**	0.28**	-0.76**	-0.56**	0.83**	0.99**	1

SS shear strength, Sed. Con. sediment concentration,  $\rho_b$  bulk density, MWD mean weight diameter, SOC soil organic carbon

\*, \*\* Significant at 0.05 and 0.01 probability level, respectively

destruction of aggregates, infiltration capacity has been declined, and subsequently, runoff has been increased. In areas in which the risk of degrading the soil is high including semiarid one, the percentage of bulk density and stable aggregates has been identified as suitable indicators of the resilience of the soil to erosion (Guerero et al. 2001; García-Orenes et al. 2005).

Significant negative correlation ( $r=-0.25$ ,  $p<0.05$ ) was found between soil loss and clay content (Table 2) and similarly between sediment concentration and clay content ( $r=-0.28$ ,  $p<0.01$ ). These negative relationships confirmed that higher clay content led to lower soil erodibility and consequently lower soil loss. Clay-rich soils are resistant to runoff detachment, because of their high cohesion and aggregation, except when they have expandable clays (e.g., smectites) and low organic matter (Obalum et al. 2017). Concerning the tilled loess soils having high clay content, the research of Le Bissonnais et al. (1995) indicated the minimum erosion rate once the soils were rewetted; however, the soils having high content of organic carbon showed the least erosion rate in air-dry conditions.

Aggregate stability plays a vital role in soil loss reduction. Significant negative correlation was found between soil loss and MWD ( $r=-0.43$ ,  $p<0.05$ ). Furthermore, MWD and sediment concentration were observed to be negatively correlated ( $r=-0.76$ ,  $p<0.01$ ) (Fig. 3a). MWD is an indicator of aggregate stability and aggregation. Higher MWD, therefore, indicates higher water-stable aggregates, and subsequently structured soils have lower runoff and soil loss. Summarizing 24 years of direct drilling and stubble preserved activities, Zhang et al. (2007) have found a significant decline in runoff and soil erosion hazards as

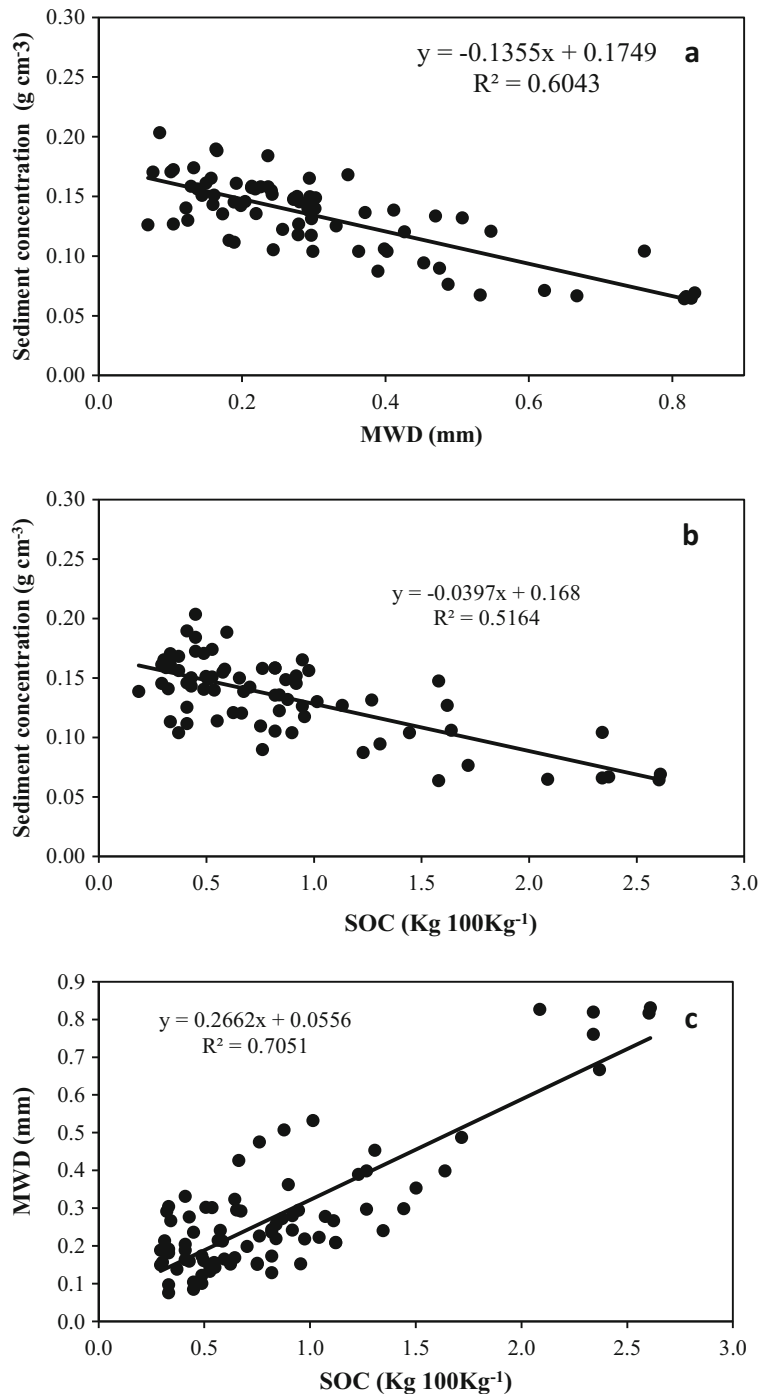
the structure of the soil significantly changed, that is, to say higher stability of the aggregates in soil and higher surface soil macroporosity.

Soil organic carbon and soil loss ( $r=-0.53$ ,  $p<0.01$ ) and SOC and sediment concentration ( $r=-0.71$ ,  $p<0.01$ ) were negatively and significantly correlated (Fig. 3b). The amount of suspended sediment concentration decreased with an increase in SOC. In other words, SOC had inhibitory effect on the soil destruction during detachment processes. Soil organic carbon increased the inter-particle bond strength and resulted in stable aggregates. This was confirmed with the strong relationship ( $r=0.83$ ,  $p<0.01$ ) between SOC and MWD in the area studied as presented in Fig. 3c. Soil organic matter played a significant role in soil aggregation (Lu et al. 1998; Ayoubi et al. 2012a; Khaledian et al. 2013; Zeraatpishe and Khormali, 2012). Aggregate stability is linked to the interaction between organic constituents and primary particles to form stable aggregates, affected by different elements pertained to environmental conditions of the soil and management practices (Celik 2005; Caravaca et al. 2004; Elustondo et al. 1990).

There was a negative relationship between bulk density and SOC ( $r=-0.26$ ,  $p<0.01$ ), indicating that porosity increased with increasing SOC. Havaee et al. (2014) also reported strong and negative relationship between  $\rho_b$  and OM ( $r=-0.63$ ) in central Iran; in line with the findings reported by Ekwue (1990) and Mosaddeghi et al. (2000), they emphasized that soil compactness and compactibility were mainly controlled by OM.

The surface soil shear strength has been suggested as a measure of the resistance of soil to water erosion

**Fig. 3** Relationship between some soil quality factors, (a) correlation between MWD and sediment concentration, (b) correlations between SOC and sediment concentration (soil loss), and (c) correlations between SOC and MWD



(Zhang et al. 2001). Soil strength is linked to seal formation (Bradford and Huang 1992) and soil erosion and detachment (Torri et al. 1987). Negative significant correlation coefficients were obtained between the soil erodibility indices and soil shear strength (Table 2). Consistent with the findings cited

in the literature (Misra and Teixeira 2001; Wuddivira et al. 2013), our results showed that the soil loss ( $r = -0.45$ ,  $p < 0.01$ ) and sediment concentration ( $r = -0.56$ ,  $p < 0.01$ ) significantly and linearly declined once the shear strength of the soil increased (see Tables 2 and 3).

**Table 3** Correlation coefficients between erodibility indices in the study area in different land use

Variable	Runoff	Soil loss	Sed. Con.
Irrigated farming			
Runoff	1		
Soil loss	0.70**	1	
Sed. Con.	-0.44**	0.30	1
Rangeland			
Runoff	1		
Soil loss	0.67**	1	
Sed. Con.	-0.18	0.61**	1

\*, \*\* Significant at 0.05 and 0.01 probability level, respectively

### Impacts of land use on the properties of the soil

Table 4 indicates the means of comparing some properties of the soil in three land uses studied. Compared to rangelands, bulk density was significantly higher in croplands. Land use may directly (e.g., compaction, because of agricultural field practices) or indirectly (e.g., effects of land use upon the content of OM) influence the state of the soil packing (Franzluebbers et al. 2000; Murty et al. 2002). Khormali et al. (2009) and Ayoubi et al. (2012a, 2014) reported a significant increase in  $\rho_b$  with changing land use from forest/grassland to croplands. Lemenih (2004), Nietoet al. (2010), and Kizilkaya and Dengiz (2010) indicated that, after soil plowing and manipulation,  $\rho_b$  increased because of the soil compaction and loss of SOC. Kelishadi et al. (2014) showed that the highest degree of compactness was seen in pasture because of the compaction of the soil by livestock overgrazing and non-loosened (no-tilled) status of soils.

The highest MWD was observed in irrigated farming and showed significant difference compared to drylands and rangelands (Table 4). Although less stable aggregates are usually expected to be seen in irrigated soils, the higher content of organic matter in this land use has led to higher aggregation. On the other hand, water stable aggregates are lower in dryland farming, because of the low OM content and improper tillage practices and in rangeland due to very low OM content and overgrazing. Inverse trends of SOC and MWD values shown in Table 4 confirm this interpretation. In contrast to previous studies (Celik 2005; Ayoubi et al. 2014) finding significant MWD changes after pasture alteration to dryland farming, no significant differences were found in this study between these two land uses. This finding may be related to similar OM and other intrinsic soil properties in the two land uses.

Table 4 illustrates the lowest (2.85 kPa) and highest (3.15 kPa) values of shear strength discerned in the rangelands and irrigated farming, respectively. However, the three land uses did not significantly reveal any differences. Interrelation complexity of SS data in relations to land uses is presumably attributed to the complicated variables that can affect the SS, including OM and particle size distribution (Knapen et al. 2007), soil aggregation (Baumgartl and Horn 1991), water content/matric potential (Bradford and Grossman 1982), network of plant roots and vegetation cover (Franti et al. 1999; Knapen et al. 2007; Torri et al. 2013), stone size (Léonard and Richard 2004), bulk density (Gilley et al. 1993), soil clay types, tillage systems, and time (Knapen et al. 2007).

The CCE content was different among the land uses studied (Table 4). The CCE content was significantly higher in rangelands and drylands compared to irrigated land. As all parent materials distributed in the area studied were calcareous (Zeraatpisheh et al. 2017), all

**Table 4** Means' comparisons for some soil properties among the studied land uses. In each column, figures with different letters are significantly different (LSD 0.05)

Soil properties/ Land use	$\rho_b$ (Mg m <sup>-3</sup> )	MWD (Mm)	SOC (kg 100 kg <sup>-1</sup> )	Shear strength (kPa)	CCE (kg 100 kg <sup>-1</sup> )
Irrigated farming	1.42a	0.45a	1.22a	3.15a	24.8b
Dryland farming	1.41a	0.23b	0.86b	3.03a	35.6a
Rangeland	1.32b	0.22b	0.73b	2.85a	37.9a



soils were normally enriched with CCE. Rangelands and drylands were distributed in steep slopes with the high rate of soil erosion; lower horizons enriched by calcium carbonate were usually exposed to the surface. This process has already been reported by Khormali et al. (2009) in the north and by Ayoubi et al. (2012a) in the west of Iran.

Land use impacts on soil erodibility indices

It is well-known that water infiltration into the soil, controlling runoff generation, may be influenced by soil temperature, geometry of soil pores, soil surface properties and chemical composition of soil solutions (Durner and Flüßler 2006). These properties are significantly affected by the soil land use. Soil loss and sediment concentration are affected by erosivity and soil erodibility. As we speculated that forces involved in erosivity were similar in all experiments, therefore, any changes in soil loss and runoff would be attributed to the variability in soil properties and land attributes.

The mean of the comparisons of soil loss, sediment concentration and runoff are presented in Table 5. The highest (58.7 cm<sup>3</sup>) and lowest (1.5 cm<sup>3</sup>) values of runoff volume were obtained in rangelands and dryland farming, respectively (Table 5). Irrigated farming showed intermediate values of runoff compared to the other land uses. Similar trends were observed for sediment concentration and soil loss within the three land uses (Table 5).

High levels of soil loss, sediment concentration, and runoff in the rangelands could be due to the lower infiltration rate in rangeland soils due to the aggregate destruction caused by livestock. Animal grazing which provides a livelihood for farmers can exert destructive environmental effects (Zhou et al. 2010). Stroosnijder

(1996) stated that grazing had direct effects through trampling for instance on the soil bulk density. Its indirect effects are weak structure of the surface soil due to SOC reduction and low macroporosity due to low soil biological activities. Destruction of soil aggregates leads to the formation of seals and reduced rate of infiltration during rainfall; most of the precipitation contributed to runoff and subsequently sensitive soil particles is detached and transported by runoff.

Zhou et al. (2010) investigated the grazing influences on the physical quality of the soil and topsoil erodibility in northern loess plateau of China. According to their results, the maximum soil bulk density, the minimum water content of soil, scouring resistance ability, rate of infiltration, and stable aggregate proportions were all attributed to the track trampled by stock. They also concluded that trampling and grazing by livestock seemingly deteriorated the physical quality of the soil and increased soil erodibility.

The lowest runoff, soil loss, and sediment concentration were observed in dryland farming (Table 5), which might be attributed to temporary beneficial influences of tillage on pore system of the soil that increased infiltration rate and reduced runoff. In this context, Ferreras et al. (2000) and Pelegrin et al. (1990) stated that when saturated hydraulic conductivity ( $K_s$ ) was measured, in situ tilled soils showed much higher  $K_s$  than untilled soils. They reported that plowing through the destruction of mesopores and their rearrangements together with increasing the frequency of soil macropores could increase  $K_s$ . Normally, on tillage events,  $K_s$  rises and then decreases during the growing season, due to the soil settlement (Messing and Jarvis 1993). Since our experiment was done in drylands when soils were already tilled, the higher  $K_s$  in this land use led to very low runoff and subsequently lower soil loss. Coquet et al. (2005) showed that the influence of tillage was great: reducing the unsaturated hydraulic conductivity ( $K$ ) from dry end up to a matric potential of  $-0.1$  kPa and increasing near-saturated  $K$  due to the redistribution of pore sizes and continuity modifications, possibly by forming large interconnected voids, inter-aggregates, or inter-clods.

**Table 5** Means' comparisons for runoff, soil loss, and sediment concentration among the studied land uses

Land use	Runoff (cm <sup>3</sup> )	Soil loss (g)	Sediment concentration (g/cm <sup>3</sup> )
Irrigated farming	28.9 ± 1.73 b	2.96 ± 0.18 b	0.11 ± 0.01 b
Dryland farming	1.5 ± 0.02 c	0.25 ± 0.002 c	0.01 ± 0.005 c
Rangeland	58.7 ± 1.88 a	8.76 ± 1.88 a	0.15 ± 0.01 a

In each column, figures with different letters are significantly different (LSD 0.05)

**Conclusions**

The impacts of intrinsic soil properties and land use upon soil erodibility were investigated using a portable

rainfall simulator in a semiarid region, central Iran. Research findings were:

1. High variations were obtained for some soil properties including EC, MWD, SOC, and soil erodibility indices (sediment concentration, soil loss, and runoff volume) in the area studied. The high variations mainly were due to the topography and various management practices in different land uses.
2. Significant positive correlations were obtained between bulk density and soil loss or sediment concentration. This might be attributed to the locations with higher soil bulk density induced by intensive grazing (in pasture) and tillage practices (in agricultural soils). In our study, MWD and SOC showed negative relationships with soil loss and sediment concentration. This confirmed the significance of aggregate stability for soil erosion. Soil shear strength and soil erodibility indices were negatively and significantly correlated in the area studied.
3. The rangelands showed the maximum values of sediment concentration, runoff, and soil loss due to the aggregate destruction and higher compactness caused by livestock trampling in this land use.
4. Drylands revealed the minimum values of sediment concentration, runoff, and soil loss, which might be attributed to the temporary beneficial impacts of tillage upon the pore system of the soil that increased infiltration rate and reduced runoff and soil loss.

The results of this study could provide valuable information for land use planning across the studied watershed to minimize the soil loss and land degradation.

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