Effect of land use types and slope on soil Erodibility factor in Alborz province, Iran

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ABSTRACT: Erodibility is the qualitative and quantitative statement of the intrinsic susceptibility of a specific soil to detachment and transfer by the rain water and runoff. In the present study, using the Wischmeier's nomograph and the corresponding equation, the erodibility status of the soil in Zidasht, located in Alborz province, was determined and the effect of slope on soil erodibility with different land uses was analyzed. First, three slope classes consisting of 3-8%, 8-18%, and 18-40% were chosen for land use units including pasture, dry land farming, and irrigated farming, and soil samples in three repetitions. The samples were used for organic matter measurement, soil gradation and texture analysis, and bulk density measurement. Erodibility for pasture land use increased with slope percentage, which is statistically significant at the p<0.01 level. The same was true for dry land farming, i.e. erodibility increased significantly at the same p level with slope percentage. In the case of irrigated farming, lands with 8-18% slope had the highest erodibility; this shows a critical condition at this slope class. Lands with 18-40% slope had the lowest erodibility; this can be because of erosion at earlier times. In general, the results indicate that erodibility increases with slope percentage of lands with agricultural use. Without considering land use types, lands with 3-8% slopes had the lowest erodibility, while an increase in the slope led to an increased erodibility.

Key words: erosion, slope, erodibility, land use, Alborz province

INTRODUCTION

In recent years, much of the natural vegetation (forest, and pasture) has turned into agricultural lands; this change in land use can affect features related to soil erodibility. The consequences of such changes in land use are the intensification of natural disasters like destructive floods, casualties and financial losses, the irreversible erosion of the soil, and consequently economic and social problems which necessitate conducting research in the field. Erodibility is a complicated factor resulting from the effects of many of the soil characteristics and the interaction between them. Much effort has been expended so that based on the measurable characteristics of the soil in laboratories and the reaction of the soil toward rainfall, a simple index can be identified to show the erosion potential of a soil (Refahi, 1996).

Water and wind erosion cause complications such as: reduction of soil quality and fertility, environmental problems, and quality and quantity reduction of agricultural products (Devid et al., 2003). The simplest way of determining soil erodibility is using predictive equations; i.e. using simple, measurable, independent variables based on soil characteristics of high correlation to erodibility (Wischmeier et al., 1976).

In the universal soil loss equation, soil erodibility factor (K) is one of the effective factors on soil loss. Therefore, conducting research for its determination can be of high importance. Erodibility is the quantitative statement of the intrinsic susceptibility of a specific soil to detachment of its particles and transfer by the factors causing erosion (rain water and runoff); in fact, it’s due to the effects of many of the soil characteristics and the interaction between them. The definition of this factor in the universal soil loss equation is: the rate of soil loss per rainfall erosivity index unit for a specific soil in the standard plot condition, without vegetation and free from plant...
debris and weeds, in the condition of permanent fallow, and plowed in the direction of the slope. In such a condition, all factors of the equation equal one unit except rainfall erosivity index, and erodibility factor. As a result, erosion is directly proportional to these two factors, and erodibility is the amount of soil loss divided by rainfall erosivity index. Erosion sensitive lands are those less resistant to erosive factors, and their soil particles have a higher potential of detachment and transfer. Characteristics such as permeability rate, total water capacity, water-holding capacity, texture, structure, and colloids are effective in soil erosion sensitivity. The amount of soil erosion is high in Iran; one of the reasons is the inappropriateness of land use type and the soil potential of the area. Determining erodibility of land in different regions of the country is one of the essential moves in determining erosion potential, based on which officials can choose the best approach for application of erosion control management, including choosing the most appropriate use of a land according to the soil of the region.

METHODS

**Condition of the studied region; Zidasht**

The area under study consisted of the sub-area of Zidasht located in Savojbolagh County, Alborz Province. The studied region is located between the longitudes 36°, 5′, 40″ and 36°, 10′, 40″ and the latitudes 50°, 40′, 00″, and 50°, 44′, 00″, and is ---- kilometers away from -----. The area of the studied land was 6486 acres. The highest point of this region is 2875 meters from the sea level, while the lowest point is 1756 meters high from the sea level.

The geographical location was determined using digital maps with a 1:25000 scale and the ArcGIS software. Determining the coordinates of the appropriate places for taking samples from lands with different land uses was done so that the land uses were the closest to each other. This was done to avoid sharp difference of the soil parent material between the samples. Preparation of DEM (digital elevation model) and extraction of slope maps, direction and elevation, the length and shape of slope. Ground referencing of the maps was done with Universal Transverse Mercator, UTM. Chipping and overlaying the layers of slope and determining the homogenous units. Different land uses included pasturage, dry land farming, and irrigated farming. In order to determine land uses and their classification according to slope, it was essential to prepare basic information including slope, land uses, geology, and the road. Each land use was put into three slope classes 3-8%, 8-18%, and 18-40% using GIS software. After field observation, samples were collected from each and every land in each slope class to measure organic matter, determine soil texture and the percentage of its components, and also untouched samples were collected to measure bulk density. Sampling was done with three repetitions (total number of 27 samples). Samples were collected from the surface horizons (0-20 cm). The following actions were taken: removing organic matter of soil samples using Hydrogen peroxide to determine soil texture, analyzing soil gradation and determining the percentages of clay, silt (0.002-0.05 mm) and very fine sand (0.1-0.05 mm) using Hydrometer method for 48 hours, determining percentage of sand (0.1-2 mm) using sieve analysis, determining soil structure class and the corresponding codes based on the classification of Wischmeier et al., measuring the amount of organic matter using Walkley-Black method (1954), measuring permeability using double-acting cylinders with two repetitions and determining permeability classes based on the classification of Wischmeier et al., and estimating soil erodibility in each sample using Wischmeier’s nomograph and the corresponding formula. Data analysis was done using SAS, and Excel, and comparison was drawn between erodibility of soils in different uses and slopes.

RESULTS

Graph 1 shows that in posture land use, erodibility increases with slope percentage. The average erodibility amounts for 3-8%, 8-18%, 18-40% slopes were estimated at 0.401, 0.415, and 0.456 [(mg/ha) (ha.h/mj.mm)] respectively, which shows significant changes. The increase in erodibility with slope can be due to the decrease in land vegetation; since it decreased with an increase in slope. The increase in erodibility can be due to the decrease in vegetation as the slope percentage increases. This finding is in line with Alizadeh (1989) who stated loss of vegetation as the most important factor in increases in erodibility. As figure 1 shows organic matter amounts in pastures decrease with the increase in slope; so that at 3-8%, 8-18%, and 18-40% slopes, organic matter amounts are 0.75%, 0.66% and 0.63% respectively, which are not significant at p<0.05 level. The amount of clay in the three slope classes were measured 24.48%, 23.36%, and 17.20% respectively. These changes are statistically significant at p<0.01 level (graph 1). The soil structure class is three for the first, second, and third slopes. Permeability class is 4 for 3-8% slope, and 5 for 2-18% and 18-40% slopes. Permeability was not significant at p<0.01 level for 3-8% and 8-18% slopes; however this change was significant for 18-40% slope. Overall, it
seems that with increasing slope, decrease in permeability, and increase in silt and very fine sand are the main factors in the considerable increase in soil erodibility.

Erodibility factor increases with slope for the irrigated farming at the study area. This factor equals 0.431 and 0.462 with 3-8% and 8-18% slopes. As expected, the effect of slope on this factor is clearly seen in the results. The effect of slope on changes in soil texture is as follows: as slope increases, silt and very fine sand particles get detached from the soil of steep slopes easily and with the lowest amount of force, and accumulate in the downstream (low slope and flat lands). For the 8-18% slope, the considerable increase in the percentage of silt and decrease in permeability led to the increase in soil erodibility factor which is 0.462; however, for the 3-8% and 18-40% slopes, due to the interactions among organic matter, the percentage of silt compared to very fine sand, and permeability, a similar erodibility has been seen. On the other hand, the decrease in erodibility factor for steep slopes is due to the increase in the amount of sand in the soil (0.1 to 2 mm) which moved to a lesser degree because of its greater weight. Moreover, graph 2 shows that clay particles moved away from lands of the second slope class into the lands of the first slope class. The amount of clay in the three slope classes are measured 20.88%, 16.60%, and 9.65% respectively. These changes are statistically significant at p<0.01 level (graph 2). Soil structure class is 4 in all three slope classes. Permeability class is 5 in all three slope classes. Permeability was significant at p<0.01 level for 3-8% and 8-18% slopes, but not for 18-40% slope.

The average erodibility factor for 3-8% slope in dry land farming is 0.426 which is lower than the 8-18% slope; this increase in significant at p<0.01 level. For 18-40% the amount of this factor is 0.448 which is higher than the 8-18% slope (graph 3). The increase in erodibility factor in dry land farming for 8-18% and 18-40% slopes is due to the decrease in organic matter, decrease in permeability, and weakening of soil structure. Permeability class is 4 in 3-8% and 8-18% slope classes and 5 in 18-40% class. Permeability showed statistically significant changes at p<0.01 level for 3-8% and 18-40% slope classes, but not for 18-40% slope class.

Geological map of the region shows that the soil parent material was the same in this land use type for the first two slope classes. Graph 3 shows that clay was removed from the places with 8-18% and 18-40% slopes by the runoff and accumulated in downstream areas. As graph 3 shows, the amount of organic matter has decreased with the increase in slope, so that this amount for 3-8%, 8-18%, and 18-40% slopes is 0.86%, 0.80%, and 0.71% respectively. This change is significant at p<0.05 level.

Soil structure code is 3 for the first slope class (3-8%), and 4 for the next two slope classes (8-18% and 18-40%), which respectively indicate granular structure and dense structure (prismatic, columnar, and blocky). The amount of clay for all three slope classes were measured 21.82%, 17.65%, and 15.95% respectively, which were statistically significant at p<0.01 level (graph 3).
Erodibility is a complicated factor resulting from the effects of many of the soil characteristics and the interaction between them. Much effort has been expended so that based on the measurable characteristics of the soil in laboratories and the reaction of the soil toward rainfall, a simple index can be identified to show the erosion potential of a soil (Refahi, 1996). Slope is effective on soil permeability. Therefore, this matter is examined in irrigation projects. Soil erodibility is introduced as an independent factor so as not to cause danger for irrigation of slope farmlands (Wischmeier et al., 1976).

Water and wind erosion cause complications such as: reduction of soil quality and fertility, environmental problems, and quality and quantity reduction of agricultural products (Deivid et al., 2003). The simplest way of determining soil erodibility is using predictive equations; i.e. using simple, measurable, independent variables based on soil characteristics of high correlation to erodibility (Wischmeier et al., 1976). Soil erodibility factor

**DISCUSSION**

![Figure 2](image2.png)

Figure 2. The comparison of average erodibility factor and the effective parameters in its changes in irrigated farming; a, b, and c indicate significant changes in organic matter at $p<0.05$, and in other factors at $p<0.01$

![Figure 3](image3.png)

Figure 3. The comparison of average erodibility factor and the effective parameters in its changes in dry land farming; a, b, and c indicate significant changes in organic matter at $p<0.05$, and in other factors at $p<0.01$
indicates the soil susceptibility to detachment and transfer of its particles to another point (Refahi, 1996). Due to increasing water-holding capacity, soil organic matters lead to the production of stable aggregates and improvement of soil structure, and play an important role in decreasing soil erodibility (Gupta, 2002).

Permeability and stability of the soil structure are two very important soil properties which affect its erodibility factor (Gupta, 2002). Zimmerman et al. (2005) analyzed and proved the effect of land use change on soil hydraulic properties which have a role in the production of runoff. Azooz and Arshad (1990) during their studies found out that conventional tillage operations cause compaction of subsurface layers of the soil, destroy interconnected pores from the surface and increase decomposition of plant residues, and finally with aggregate destruction and surface crust creation limit permeation process and saturated hydraulic conductivity of soil. On the other hand, using conservation tillage systems improve the soil structure and by preservation of large surface soil pores, increase permeation and saturated hydraulic conductivity.

Zang (2004) showed in an experiment that there’s a negative significant correlation between the amounts of clay and soil erodibility factor. The results of Saha (2007) shows that land surface coating and root system of plants increase soil organic carbon and help the improvement of aggregates, and while improving water transfer and permeation, decrease soil erodibility. Sodic soils are strongly erodible, and the ditch erosion step is more quickly arrived at; normally these soils are less stable (Juang et al., 1998). When pasture lands are cultivated and then released, in most cases the inhibiting factors slow down their return to the normal and primary state (Bewket, 2003).

Improper use of soil and changing the use of pasture lands often cause severe erosion because of decreasing vegetation and destructing surface soil (Yousefifard, 2007). Bayramin et al. (2008) assessed the effects of adjacent land uses including agricultural and pasture lands in the pasture and semi-arid lands of Turkey. Their studies showed that soil characteristics changed significantly with land use changes, and the soils were more sensitive to water erosion. They announced the reason to be the significant decrease in organic matter and the hydraulic conductivity of the soil in the region. Due to the effects of the type of land use on the quality of soil no-normative land use changes which result in environmental destruction and changes in soil properties, leaves a negative effect on the ecosystem (Sunchez et al., 2002).

The changes in land use and management, and physicochemical properties of soils cause major changes in their sensitivity to erosion. Because of the considerable decrease in vegetation and slope percentage, releasing lands which have been under cultivation intensively, causes an increase in erosion (Zho et al., 2008).

Morgan et al. (1995) reported that clay usually reduces erodibility. The calcium cations have an effective role in connecting soil colloids and reducing erodibility. According to the reports, permeability and stability of the soil structure are two very important soil properties (Gupta, 2002) which affect its erodibility factor. In a study carried out by Lin et al. (2005) the effects of organic carbon was analyzed on the physical properties of the soil. The results showed that the amount of organic carbon has a positive effect on soil porosity and the plant’s available water capacity. The reason for the increase in soil erodibility with slope is related to the increase in the amount and intensity of water, and displacement of particles such as clay, very fine sand, and silt. The results of this study approved this claim. In the comparison between the erodibility for dry land farming in different slope classes, the results indicate that the lower the slope percentage is, the lower will be the erosion. This difference is statistically significant.

**REFERENCE**


Zhao X, LIN HS, White EA. 2008. Surface soil hydraulic properties in four soil series under different land use and their temporal change. Catena. 73, P: 180-188.