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Soil erodibility and its estimation for agricultural soils in China

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Abstract

Soil erodibility (the *K* factor in the Universal Soil Loss Equation, USLE) is an important index to measure soil susceptibility to water erosion, and an essential parameter needed for soil erosion prediction. To evaluate the appropriateness of the nomograph and other methods for estimating the *K* factor for the USLE and to develop a relationship for soil erodibility estimation for Chinese soils, a set of soil erodibility values was calculated using soil loss data from natural runoff plots at 13 sites in eastern China. The definition of soil erodibility in relation to the USLE was strictly followed. Comparing these measured values to those estimated using the nomograph method, the method adopted for the EPIC model and the formula of Shirazi and Boersma, we found that all these estimated soil erodibility values were considerably higher than the measured soil erodibility for these sites in eastern China. Soil erodibility for these Chinese sites is typically in the range from 0.007 to 0.02 t h (MJ mm)$^{-1}$ and consistently lower in comparison to the measured *K* values from the USLE database for the conterminous United States. Strong linear relationship between the estimated and measured *K* values were used to develop empirical formulas for soil erodibility estimation from soil survey data for sites in eastern China.

Keywords: Soil erodibility; *K* value estimation; Soil loss prediction; China

1. Introduction

Soil erodibility is thought of as the ease with which soil is detached by splash during rainfall or surface flow or both (Renard et al., 1997). It is generally considered as an inherent soil property with a constant value for a given soil type and widely adopted as an important factor in soil erosion prediction models, such as the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978), and the Revised USLE (RUSLE) (Renard et al., 1997). The erodibility factor, commonly known as the *K* factor, in the USLE was defined as the

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average rate of soil loss per unit of rainfall erosivity index from a cultivated continuous fallow plot, on a 9% slope 22.1 m long. As direct measurement of the K factor requires long-term erosion monitoring, which is costly and time-consuming, techniques have been developed to estimate the K factor values from readily available data on soil properties for soil erosion prediction and conservation planning for agricultural lands. Of particular interest to this study, Wischmeier and Smith (1978), Young and Mutchler (1977), and Romkens et al. (1977), proposed formulas for soil erodibility estimation under different conditions. The soil erodibility nomograph was published in the early 1970s, which relates the K factor to five soil and soil profile parameters (Wischmeier et al., 1971). Since then, the nomograph has formed the basis for soil erosion prediction in the United States and elsewhere in the world. As refinements of the nomograph method for clayey soils, formulas developed by Young and Mutchler (1977) and Romkens et al. (1977) were recommended for use in the RUSLE (Renard et al., 1997). To improve the accuracy of the USLE, Mutchler and Cater (1983) and Zanchi (1983) undertook research on the seasonal variation in soil erodibility, and proposed a computational procedure for monthly change of soil erodibiloity using the average temperature of each month. El-Swaify and Dangler (1977) and Hosoyamada (1986) suggested that separate erodibility value be used for the wet season and dry season in the USLE. Bajracharya and Lal (1992) concluded that there was little correlation between the change in soil erodibility and rainfall erosivity. Rejman et al. (1998) investigated the temporal and spatial change in soil erodibility for the loessial region in southeast Poland, and found that there was close correlation between the soil erodibility and the soil moisture content. Wall et al. (1988) pointed out that there was close correlation between the seasonal change of soil erodibility and soil properties.

Investigation of soil erodibility began in the 1950s in China. The USLE framework for soil erosion prediction and assessment was not widely adopted in China until the early 1990s, and soil erodibility (the K factor) values were calculated for major soils in a number of regions in China. Direct comparison of the K values estimated using the nomograph method with those measured in field, however, has been difficult to make because of the fact that many researchers have used a different rainfall erosivity index, or used a different definition of unit runoff plot. It is worth noting that few systematic attempts have been made to develop and validate soil erodibility indexes for soils in China, although the erodibility factor for the USLE has been estimated for major soils in such provinces as Inner Mongolia, Heilongjiang, Guangdong, Fujian, Jiangxi, Liaoning, and Yunnan (details in the study by Zhang et al., 2004). Since 2000, Zhang et al. (2000, 2001a, b) have advocated strategies to conduct research on soil erodibility in China and published the K factor values for soils on the Loess Plateau in China (Zhang et al., 2004) using the USLE framework for erosion prediction. Zhang et al. (2004) also showed that the soil erodibility nomograph could not be directly applied to the Loess Plateau region in China. No attempt has been made yet to estimate the soil erodibility value in China due to a lack of comparable field measured K values.

The objectives of the paper were: (1) to evaluate the K factor for 13 major soils using soil loss data from erosion plots in eastern China, (2) to assess the accuracy of nomograph and other erodibility estimators for these soils, and (3) to develop and evaluate new formulas for estimating soil erodibility in eastern China.

2. Materials and methods

The soil erodibility factor in the USLE was determined together with other factors according to the USLE and RUSLE guidelines (Renard et al., 1997; Wischmeier and Smith, 1978). This is important because all the factors in the USLE are intrinsically related. As the benchmark on which all factors are standardized, it is essential to delineate the dimension of unit runoff and erosion plot to obtain consistent and comparable soil erodibility K values. In the USLE/RUSLE, a unit plot is defined as having a uniform 9% slope steepness, 22.13 m long, and maintained in cultivated continuous fallow. According to topographic conditions, farming practice, and availability of historical data from field plots in China, Zhang et al. (2001a, b) suggested that the dimension of unit plot in China be a 15° slope, 20 m long, and in cultivated continuous fallow to facilitate comparative analysis of the soil loss data. According to the plot dimension described above, we established six field sites in Heshan and Binxian in Heilongjiang province to represent the black earth region of northeast China, Miyun in Beijing municipality to represent rocky soil region of north China, Suide in Shaanxi province to represent Loess Plateau of northwest China, Suining in Sichuan province to represent the purple soil region of southwest China, and Anxi in Fujian province to represent the red soil region of south China

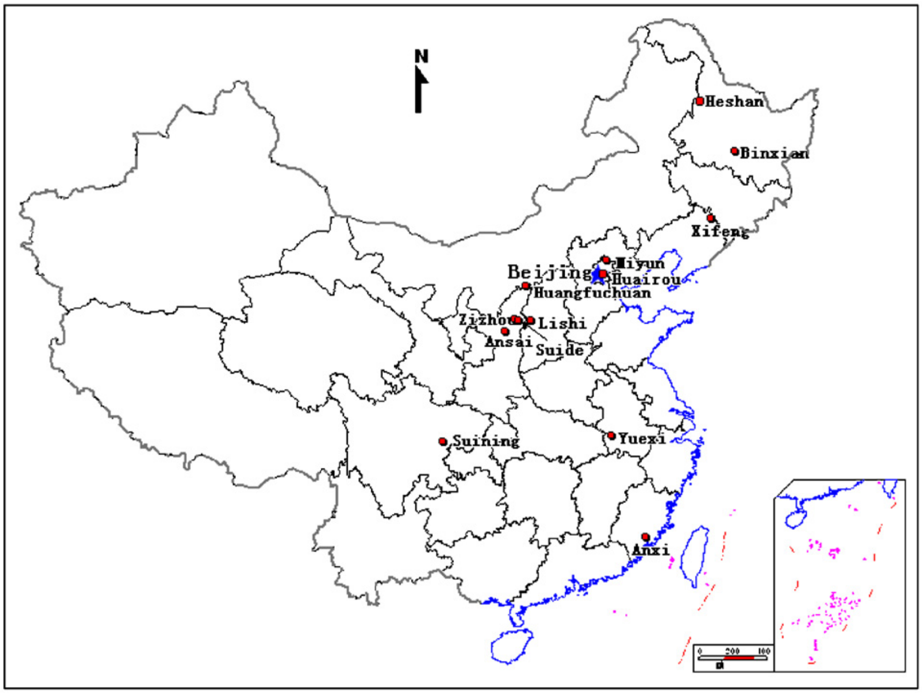

Fig. 1. Location map of the field sites for this study.

(Fig. 1). The field plots were all 20 m long, 8.75% slope in Heshan and 26.79% at all other locations. Runoff and soil loss were measured after each rainfall event; rainfall intensity was recorded using automatic rain gauges. Soil loss data from previous studies were used to calculate K values for Binxian and Suide, as few soil loss and runoff events occurred during the study period.

The K factor in the USLE was calculated using the following equation (Wischmeier and Smith, 1978):

$$K = \frac{A}{RLSCP} \tag{1}$$

where A is the mean annual soil loss in $\mathrm{t(ha\,yr)^{-1}}$, R is rainfall erosivity in $\mathrm{MJ\,mm(ha\,h\,yr)^{-1}}$. Storm energy and peak 30 min rainfall intensity were calculated using the recommended technique for the RUSLE (Renard et al., 1997). The R factor for these sites was the mean annual EI_{30} values for storms when soil loss occurred. The L and S factors were the slope length and steepness factors, respectively, and C was the crop cover factor. In this study, the S factor was evaluated using Eq. (2) (Liu et al., 1994):

$$S = 21.91 \sin\theta - 0.96 \tag{2}$$

where θ is the slope angle. The following equation for the USLE was used to evaluate the L factor:

$$L = \left(\frac{\lambda}{22.13}\right)^m \tag{3}$$

where m is slope length exponent. $m = 0.5$ if the slope is 5% or greater, 0.4 for slopes of 3.5–4.5%, 0.3 for slopes of 1–3%, and 0.2 for uniform gradients of less than 1% (Wischmeier and Smith, 1978). The C value was adjusted for crop cover and management effects. The data from all sites except Lishi, Zizhou and Suide were collected from fallow plots, and C was therefore set to unity. The plots in Lishi, Zizhou and Suide were cropped in a 3 year rotation of millet [*Setaria italica* (L.) Beuv.], soybean [*Glycine max* (L.) Merr.], and potato (*Solanum tuberosum* L.) similar to that in Ansai, so the C values of the three sites were adjusted using the C factor values for the Ansai site. It is assumed that rainfall increased the effectiveness of crop cover in controlling soil loss, that is, a greater rainfall would allow a better vegetation cover, and would lead to a lower rate of soil loss, thereby lower the C factor. So the C value in Ansai (average rainfall of 330 mm from July to

September) should be greater than that in Lishi (average rainfall of 368 mm from July to September), and less than that in Zizhou and Suide (average rainfall of 272 mm from July to September). Using measured soil loss and cover data from the Ansai site, the C value varied from 0.47 to 0.74, about 0.564 on average for main crops (Zhang et al., 2001a, b). Therefore, in this paper, we used adjusted C value of 0.5 for Lishi, and 0.7 for Zizhou and Suide sites. The support practice factor, P, was set to unity for all sites.

To assess the accuracy of estimators of the K factor, the nomograph by Wischmeier and Smith (1978), the estimator used in the EPIC model (Williams et al., 1984), and a formula proposed by Shirazi and Boersma (1984) were considered as they were widely used around the world. The nomograph is composed of five soil and soil-profile parameters: percentage of silt (0.002–0.1 mm), percentage of sand (0.1–2 mm), percentage of organic matter (OM), and structure and permeability classes. A useful algebraic approximation (Wischmeier and Smith, 1978) of the nomograph for those cases where the silt fraction does not exceed 70% is

$$K = \frac{[2.1(\times 10^{-4})M^{1.14}(12-\mathrm{OM}) + 3.25(s-2) + 2.5(p-3)]}{100} \tag{4}$$

where M is the product of the primary particle size fractions (% silt or the 0.002–0.1 mm size fraction) and (% silt + % sand), OM is the percent organic matter, s is the soil-structure code used in soil classification, and p is the profile-permeability class. K is expressed as t acre^{-1} per erosion index unit with the US customary units of t acre h (hundreds acre ft tonf in)$^{-1}$. In the EPIC (Williams et al., 1984), soil organic carbon and soil particle size distribution are used to calculate the K values, the formula is as follows:

$$K = \left\{0.2 + 0.3\exp\left[-0.0256\mathrm{SAN}\frac{(1-\mathrm{SIL})}{100}\right]\right\}\left(\frac{\mathrm{SIL}}{\mathrm{CLA}+\mathrm{SIL}}\right)^{0.3} \times \left(1.0 - \frac{0.25C}{C+\exp(3.72-2.95C)}\right)\left(1.0 - \frac{0.7\mathrm{SN1}}{\mathrm{SN1}+\exp(-5.51+22.9\mathrm{SN1})}\right) \tag{5}$$

where SAN, SIL and CLA are sand fraction (%), silt fraction (%), clay fraction (%), respectively. C is the soil organic carbon content (%), and SN1 equal to 1−SAN/100. Because Eqs. (4) and (5) require relatively large amount of data on soil properties which may not be widely available, Shirazi and Boersma (1984) suggested a simple formula only involving the geometric mean diameter (D_g, mm) to estimate the soil erodibility:

$$K = 7.594\left\{0.0017 + 0.0494\exp\left[-\frac{1}{2}\left(\frac{\log(D_g)+1.675}{0.6986}\right)^2\right]\right\} \tag{6}$$

In this paper, we have used the SI metric units for the K factor. To convert the rainfall erosivity index from SI metric unit of MJ mm (ha h)$^{-1}$ to the US customary units of hundreds ft tonf in (acre h)$^{-1}$, multiply by a factor of 0.0588. Multiply by a factor of 7.593 to convert the soil erodibility index in the SI metric unit of t h (MJ mm)$^{-1}$ to the US customary units of t acre h (hundred acre ft tonf in)$^{-1}$.

3. Results and discussion

In this section, we first presented the result on the K values for major soils in China, and compared the magnitude of soil erodibility with that in the US in broad terms. We then assessed the accuracy of the three widely used erodibility estimators when applied to the 10 sites in eastern China, and recommended a set of empirical relationships to improve their accuracy for general use in eastern China using the USLE framework. Finally, we discussed the implications of this study for broader application of the USLE for soil erosion prediction in the world.

3.1. The K values of main soils in China

The K values of major soils in eastern China calculated using field observations showed that the K value varied from 0.001 to 0.04 (Table 1) in China. Most sites had a K value in the range from 0.007 to 0.02. The K values were relatively high for soils on Loess Plateau, typical black soil and albic bleached soil in northeast of China, and the purple soil, orginated from weathered purple shale and sandstone, in the Sichuan basin. The K

Table 1
Observed K values in China and for selected soils from the United States (source for the US data: Wischmeier and Smith, 1978)

Soil	Source of data	Computed K	Soil	Source of data	Computed K
Dunkirk silt loam	Geneva, NY	0.091[a]	Typical black soil	Heshan	0.0381
Keene silt loam	Zanesville, OH	0.063	Albic bleached soil	Binxian	0.021
Shelby loam	Bethany, MO	0.054	Brown earth	Xifeng	0.0097
Lodi loam	Blacksburg, VA	0.061	Framental cinnamon soil	Miyun	0.0018
Fayette silt loam	LaCrosse, WI	0.050[a]	Cinnamon soil	Huairou	0.0016
Cecil sandy clay loam	Watkinsville, GA	0.047	Cultivated loessial soil	Huangfuchuan	0.0154
Marshall silt loam	Clarinda, IA	0.043	Cultivated loessial soil	Zizhou	0.0234
Lda silt loam	Castana, IA	0.043	Cultivated loessial soil	Suide	0.0186
Mansic clay loam	Hays, KS	0.042	Cultivated loessial soil	Ansai	0.0096
Hagerstown silty clay loam	State College, PA	0.041[a]	Cultivated loessial soil	Lishi	0.0156
Austin clay	Temple, TX	0.038	Purplish soil	Suining	0.0191
Mexico silt loam	McCredie, MO	0.037	Red earths	Anxi	0.0073
Honeoye silt loam	Marcellus, NY	0.037[a]	Latosols	Yuexi	0.0018
Cecil sandy loam	Clemson, SC	0.037[a]	**Range**		**0.0016–0.0381**
Ontario loam	Geneva, NY	0.036[a]	**Mean**		**0.0144**
Ceril sandy loam	Watkinsville, GA	0.034			
Boswell find sandy loam	Tyler, TX	0.033			
Ceril sandy loam	Watkinsville, GA	0.030			
Zaneis fine sandy loam	Guthrie, OK	0.029			
Tifton loamy sand	Tifton, GA	0.013			
Freehold loamy sand	Marlboro, NJ	0.011			
Bath flaggy silt loam with surface stones >2 in removed	Arnot, NY	0.007[a]			
Albia gravelly loam	Beemerville, NJ	0.004			
Range		**0.004–0.091**			
Mean		**0.038**			

Note: the unit of erodibility value is t ha h (h MJ mm)$^{-1}$ and the unit plot is required by USLE.

$$K = \frac{A}{RLSCP}$$
$$S = 21.9 \sin\theta - 0.96$$
$$L = \left(\frac{\lambda}{22.13}\right)^{0.5}$$

C was calculated based on corresponding observation data, and P was set to unity in China.
[a]Evaluated from continuous fallow. All others were computed from rowcrop data.

values for latosols and red soil in southern China, and fragmented cinnamon soil in the rocky region of north China were relatively low. In addition, the K value could vary within one region. For example, the K value in Ansai in Shaanxi province and Lishi in Shanxi province, both in the southern part of Loess Plateau were lower than those in the northern part of the Loess Plateau. Interestingly, the K values in China were generally lower than those in the conterminous United States. The K value in SI unit in the US typically varied from 0.004 to 0.091, and mostly in the range from 0.03 to 0.05 (Table 1). This broad comparison of the magnitude of the K value between eastern China and conterminous United States suggests that nomograph-based estimators may over-predict soil erodibility when applied to regions in eastern China without adjustment.

3.2. Erodibility estimators

Of the 13 soils in eastern China, soil property data were available for 10 of these sites to test and validate Eqs. (4)–(6) to assess the accuracy of these erodibility estimators. No soil property data were available for Heshan, Miyun and Huairou. Estimated soil erodibility was denoted as K_{nomo} using Eq. (4), K_{epic}, using

Eq. (5) and K_{sb} using Eq. (6). The estimated K values using Eqs. (4)–(6) all considerably higher than the measured K values for these sites in eastern China (Fig. 2). Direct application of the erodibility estimator without adjustment would lead to over prediction of soil erosion rates in eastern China. The estimated K values using Eqs. (4)–(6) were some 0.6–30 times greater than the measured values, and the estimated K value was on average higher than the measured value by a factor 7.0 using Eq. (4), 5.2 for Eq. (5) and 4.3 Eq. (6) (Table 2). We changed the abscissa of Fig. 2 and re-plotted the data as Fig. 3, it could be seen that a good linear relationship existed between the measured and estimated values except for some outliers. They were albic bleached soil of Binxian in Heilongjiang province and brown soil of Xifeng in Liaoning province, both in northeast China. Soil erosion mechanism and processes in this region are more complex and different from those in other regions because of the effects of freezing and thawing in the cold climates of the northeast. If we remove the two outliers and fit linear regression lines to correct, hence improve, the estimated K values, a set of empirical relationships as follows:

$$K_4 = -0.03336 + 0.7449K_{\mathrm{nomo}}, \quad r^2 = 0.52 \tag{7}$$

$$K_5 = -0.01383 + 0.5158K_{\mathrm{epic}}, \quad r^2 = 0.38 \tag{8}$$

$$K_6 = -0.00911 + 0.5507K_{\mathrm{sb}}, \quad r^2 = 0.50 \tag{9}$$

In terms of this set of empirical relationships for erodibility estimation, Eq. (7), when coupled with Eq. (4), was by far the best of the three estimators followed by the combination of Eqs. (6) and (9). The recommended procedure to estimate the K values for soils in eastern China would involve using measured soil properties and Eq. (4) and then apply the empirical relationship (7) to adjust estimated K values. When only the soil particle size data is available, Eqs. (6) and (9) should be used in combination. Fig. 4 shows a comparison between the measured and estimated K values using Eqs. (7)–(9) for eight soils from eastern China excluding the northeast. It could be seen that estimated K values using Eqs. (7)–(9) were much improved in comparison to the original estimates (cf. Figs. 2 and 4). The relative error was reduced to less than 30% for most sites, although the estimated K value for Yuexi was still relatively inaccurate (Table 3). To further improve the accuracy of the estimated soil erodibility, we used the average of the three original estimators (Eqs. (4)–(6)) as yet another estimator of the soil erodibility for these sites to derive the following improved estimator of soil erodibility for

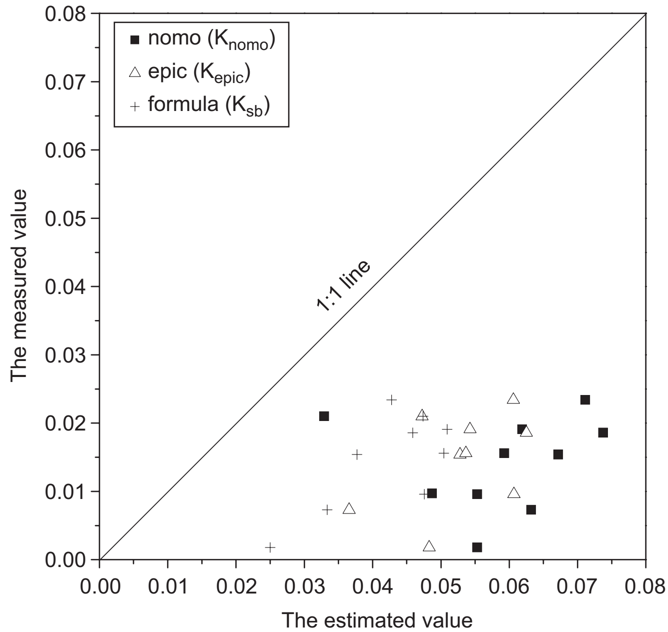

Fig. 2. A comparison of the measured and estimated K values for 10 soils in eastern China.

Table 2
Relative errors in the estimated K values using Eqs. (4)–(6)

Site	Eq. (4)		Eq. (5)		Eq. (6)	
	K_{est}	Relative error (%)	K_{est}	Relative error (%)	K_{est}	Relative error (%)
Binxian	0.0329	56.7	0.0472	124.8	0.0474	125.7
Xifeng	0.0487	402.1	n/a	n/a	n/a	n/a
Huangfuchuan	0.0672	336.4	0.0528	242.9	0.0377	144.8
Zizhou	0.0738	296.8	0.0625	236.0	0.0459	146.8
Suide	0.0711	203.8	0.0606	159.0	0.0428	82.9
Ansai	0.0553	476.0	0.0607	532.3	0.0476	395.8
Lishi	0.0593	280.1	0.0537	244.2	0.0504	223.1
Suining	0.0619	224.1	0.0543	184.3	0.0509	166.5
Anxi	0.0632	765.8	0.0366	401.4	0.0333	356.2
Yuexi	0.0553	2972.2	0.0483	2583.3	0.0250	1288.9

Note: The K_{est} is the estimated K value using Eqs. (4)–(6), the relative error is $(K_{est}-K_{mea})/K_{mea}$ as percent.

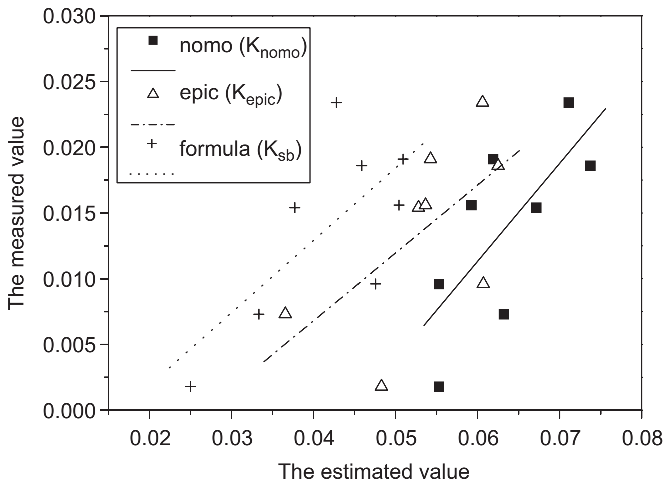

Fig. 3. The fitted line between the estimated and the measured K values for 10 soils in eastern China.

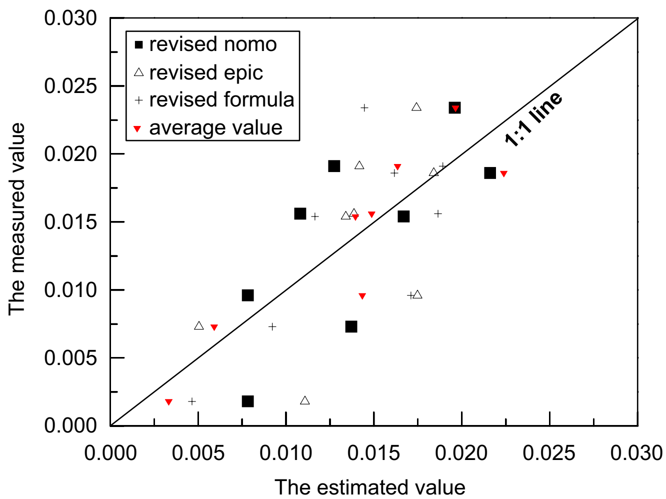

Fig. 4. A comparison of the measured and estimated K value using the modified empirical Eqs. (7)–(10) for 10 soils in eastern China.

Table 3
Relative errors in the estimated K value using the modified empirical Eqs. (7)–(10)

Site	Eq. (7)	Eq. (8)	Eq. (9)	Eq. (10)
	Relative error (%)	Relative error (%)	Relative error (%)	Relative error (%)
Huangfuchuan	8.27	−13.01	−24.28	−9.4
Suide	−16.17	−25.51	−38.26	−16.1
Ansai	−18.34	82.04	77.97	49.5
Zizhou	15.99	−1.05	−13.18	20.4
Lishi	−30.89	−11.28	19.58	−4.7
Suining	−33.26	−25.89	−0.92	−14.4
Anxi	88.10	−31.15	26.70	−19.0
Yuexi	335.52	515.02	158.69	85.1
Average	68.32	88.12	44.95	27.33
Average[a]	30.15	27.13	28.70	19.07

[a]Average is the result summarized by removing the data from Yuexi site.

eastern China:

$$K_o = -0.01044 + 1.753K_{ave}, \quad r^2 = 0.82 \tag{10}$$

where K_o is the measured value and $K_{ave} = (K_4 + K_5 + K_6)/3$. The average relative error reduced to less than 20% if Yuexi were excluded (Table 3).

3.3. Implications of this study

The K factor is one of the key parameters required for soil erosion prediction in China and elsewhere in the world. At present, long-term monitoring of soil loss from natural runoff plots is the only way to obtain the K value for the soil. However, China has a vast territory with a wide range of soils. It is difficult and impractical to set up runoff plots for each and every soil type. Therefore, there is a genuine need for estimators of soil erodibility from soil data that are more readily available. Testing and validating these estimators of soil erodibility has been one of the primary objectives of the research. This study highlighted the confidence in and the limitation to soil erosion prediction using the USLE framework in China. This study shows that gross over-prediction of soil erosion would have occurred if nomograph-based estimates of soil erodibility were used for erosion prediction with the USLE in China. It is therefore critical to field test nomograph based estimates of soil erodibility before regional application of the USLE.

The systematic discrepancy between nomograph-based estimates of the K value and measured K value from this study lent support for a simple adjustment using linear regression techniques (Eqs. (7)–(10)). Selection of these estimators will depend on the type of soil property data that are available, with minimum data requirement of geometric mean diameter, i.e. Eq. (9) in conjunction with Eq. (6). We suggest that the original estimators (Eqs. (4)–(6)) together with Eqs. (7)–(10) be used to calculate soil erodibility using soil survey data in areas without natural runoff plots in the eastern part of China. For the soils in northeast of China, other methods for soil erodibility estimation need to be developed.

In recent years, there has been widespread application of USLE/RULSE coupled with GIS technology, especially in developing countries or regions of the world, e.g. Lu et al. (2004) in Central and South America, Kim et al. (2005), Onyando et al. (2005) in Africa, and Vezina et al. (2006) in Asia, to cite just a few. For most of these large-scale applications of USLE/RUSLE for erosion risk assessment and conservation planning, the nomograph-based method has been extensively applied to estimate K values with little or no independent field validation. The nomograph has made the K factor readily computable and the GIS technology has allowed efficient computation of the erodibility factor at large scales. Repeated and widespread application of the technique for erosion prediction has, as it seems, reinforced the validity of the approach. This study has shown that testing and validation of the estimated soil erodibility using measured soil loss from the standard

USLE/RULSE runoff plots are critical for unbiased assessment of the magnitude and spatial distribution of soil erosion at the large-scale.

4. Conclusions

Using the measured soil loss from natural runoff plots from 13 sites in different regions in China, this paper has presented a set of measured *K* values and a set of formulas to guide soil erodibility estimation for areas without natural runoff plots, and the main conclusions are as follows:

(1) The *K* values in eastern China range from 0.001 to 0.04 t h $(\mathrm{MJ\,mm})^{-1}$, and most in 0.007–0.02. The *K* values of black soil, albic bleached soil, cultivated loessial soil, and purplish soil are relatively high, while those of Latosols, red earths and fragmental cinnamon soil are relatively low.
(2) Compared to those in the USLE database for the conterminous United States, the *K* values in China are generally low, and the *K* value estimation method developed using datasets from the United States cannot be directly applied to soils in China.
(3) There are strong linear relationships between the measured values and those calculated from the existing soil erodibility estimators, although the calculated values are systematically higher than measured *K* values. A set of empirical formulas has been developed to estimate the *K* factor for soil loss prediction in eastern China.

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References

Bajracharya, R.M., Lal, R., 1992. Seasonal soil loss and erodibility variation on a Miamian silt loam soil. Soil Science Society of America Journal 56, 1560–1565.
El-Swaify, S.A., Dangler, E.W., 1977. Erodibilities of selected tropical soils in relation to structural and hydrologic parameters. In: Foster, G.R. (Ed.), Soil Erosión: Prediction and Control Proceedings of the National Conference on Soil Erosion, W. Latayette, IN, pp. 105–114.
Hosoyamada, K., 1986. The effects of rainfall and soil properties on farmland conservation. Irrigation Engineering and Rural Planning Japan Society Irrigation Reclamation Engineering 9, 5–14.
Kim, J.B., Saunders, P., Finn, J.T., 2005. Rapid assessment of soil erosion in the Rio Lempa Basin, Central America, using the universal soil loss equation and geographic information systems. Environmental Management 36 (6), 872–885.
Liu, B.Y., Nearing, M.A., Risse, L.M., 1994. Slope gradient effects on soil loss for steep slopes. Transactions of the ASAE 37 (6), 1835–1840.
Lu, D., Li, G., Valladares, G.S., Batistella, M., 2004. Mapping soil erosion risk in Rondonia, Brazilian Amazonia: Using RULSE, remote sensing and GIS. Land Degradation & Development 15 (5), 499–512.
Mutchler, C.K., Cater, C.E., 1983. Soil erodibility variation during the year. Transactions of the ASAE 26, 1102–1104.
Onyando, J.O., Kisoyan, P., Chemelil, M.C., 2005. Estimation of potential soil erosion for River Perkerra catchment in Kenya. Water Resources Management 19 (2), 133–143.
Rejman, J., Turski, R., Paluszek, J., 1998. Spatial and temporal variations in erodibility of loess soil. Soil and Tillage Research 46, 61–68.
Renard, K.G., Foster, G.A., Weesies, D.A., McCool, D.K., Yoder, D.C., 1997. Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE), Agriculture Handbook No. 703, USDA, Washington DC.
Romkens, M.J.M., Roth, C.B., Nelson, D.W., 1977. Erodibility of selected clay subsoils in relation to physical and chemical properties. Soil Science Society of America Journal 41, 954–960.
Shirazi, M.A., Boersma, L., 1984. A unifying quantitative analysis of soil texture. Soil Science Society of America Journal 48, 142–147.
Vezina, K., Bonn, F., Van, C.P., 2006. Agricultural land-use patterns and soil erosion vulnerability of watershed units in Vietnam's northern highlands. Landscape Ecology 21 (8), 1311–1325.
Wall, G.J., Dickinson, W.T., Rudra, R.P., Coote, D.R., 1988. Seasonal soil erodibility variations in southwestern Ontario: II. Results and discussion. Canadian Journal Soil Science 68, 417–424.

Williams, J.R., Jones, C.A., Dyke, P.T., 1984. A modeling approach to determining the relationship between erosion and productivity. Transactions of the ASAE 27 (1), 129–144.

Wischmeier, W.H., Smith, D.D., 1978. Predicting Rainfall Erosion Losses: A Guide to Conservation Planning, Agriculture Handbook No. 537. USDA, Washington, DC.

Wischmeier, W.H., Johnson, C.B., Cross, B.V., 1971. A soil erodibility nomograph for farmland and sites. Journal of Soil and Water Conservation 26, 189–193.

Young, R.A., Mutchler, C.K., 1977. Erodibility of some Minnesota soils. Journal of Soil and Water conservation Conservation 32, 180–182.

Zanchi, C., 1983. Inlufenza dell' azione battente della pioggia edei rescellaniento nel processo erosivoe variazioni dell'erodibilitta del suolo nei diversi periodi atagionali. Annali Istituto Sperimentale Studio e Difesa Suolo 14, 347–358. Florence, Italy.

Zhang, K.L., Liu, B.Y., Cai, Y.M., 2000. The standard of unit plot in soil loss prediction of China. Geographical Research 19 (3), 297–302 (in Chinese with an English abstract).

Zhang, K.L., Cai, Y.M., Liu, B.Y., Jiang, Z.S., 2001a. Evaluation of soil erodibility on the loess plateau. Acta Ecol. Sinica 21 (10), 1687–1695 (in Chinese with an English abstract).

Zhang, Y., Liu, B., Shi, P., Jiang, Z., 2001b. Crop cover factor estimation for soil loss prediction. Acta Ecol. Sinica 21 (7), 1050–1056 (in Chinese with an English abstract).

Zhang, K., Li, S., Peng, W., Yu, B., 2004. Erodibility of agricultural soils on the Loess Plateau of China. Soil and Tillage Research 76, 157–165.