E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(11): 102-107
Received: 02-09-2024
Accepted: 06-10-2024

SB Deore
Ph.D., Research Scholer,SWCE, MPKV, Rahuri, Maharashtra, India

MG Shinde
Professor, SWCE, MPKV, Rahuri, Maharashtra, India

AA Atre
Professor, SWCE, MPKV, Rahuri, Maharashtra, India

BK Gavit
Professor, SWCE, MPKV, Rahuri, Maharashtra, India

SA Kadam
Associate Professor, IDE, MPKV, Rahuri, Maharashtra, India

AG Durgude
Associate Professor, SC&AC, MPKV, Rahuri, Maharashtra, India

Corresponding Author:
SB Deore
Ph.D., Research Scholer,SWCE, MPKV, Rahuri, Maharashtra, India

Estimation of soil erodibility for soil conservation in upper godavari sub basin of India

SB Deore, MG Shinde, AA Atre, BK Gavit, SA Kadam and AG Durgude

DOI: https://doi.org/10.33545/2618060X.2024.v7.i11b.1949

Abstract
Planning conservation initiatives and calculating soil erosion requires an understanding of soil erodibility or K-values. The soil erodibility in upper Godavari River Sub-basin was evaluated using field sampling, laboratory analysis, and geostatistical techniques. The soils in the area are primarily clayey and have an average organic carbon concentration of 0.49%. K-values showed a range of erodibility from low to high, from 0.17 to 0.47 t ha h/ha MJ mm. Kriging interpolation had been used to evaluate spatial distribution of K-values. K-values have been greatly impacted by human activity, underscoring the necessity of customized management approaches. To maximize the use of natural resources and support efforts to conserve soil and water, this research attempts to offer scientific and technological insights.

Keywords: Soil erodibility, GIS mapping

1. Introduction

Among the most precious natural resources are soils, which offer all terrestrial creatures a unique and varied ecological platform. All terrestrial animals can find a range of unique and uncommon habitat niches in the earth's soil, which is a precious natural resource. Only where they are now can they be replaced. Nonetheless, the population of the world has been growing at a constant pace of 1.16 percent globally and 1.25 percent in South Asian nations. Population increase is expected to reach 8.6 billion by 2030, 9.8 billion by 2050, as well as 11.2billion by the end of the current century, according to Chandan *et al*. (2020) [1]. According to estimates, major issues including wind, water logging, erosion from water, and salt affect 174 million hectares, or 53%, of India's 329 million hectares of land. Agriculture and related activities are thought to be responsible for 5334 m tons (16.4 tonnes/ha) of soil loss annually. In addition to the 2052 M tonnes (6.25 tonnes/ha) of disconnected soil that is deposited in reservoirs each year, rivers also carry about 480 M tonnes of silt. As a result, reservoir storage capacity is decreased by 1% to 2% per year. The reporting area is 304.9 million hectares (Mha) of India's total land area (328.7 Mha), of which 264.5Mha have been employed for grazing, forestry, agriculture, and other purposes.

As per NBSS&LUP, 146.8 Mha of land is in a deteriorated state. An average of 16.42 tonnes per hectare were lost due to soil erosion annually. As a result, every year, 5.3 billion tonnes of soil are lost nationally. Many kinds of land degradation, like wind as well as water erosion, pose a threat to most of India's land area. The movement, deposition, and separation of soil particles from one place to another is referred to as soil erosion. This natural process has been accelerated by a number of negligent human endeavors, including construction and excavation. The majority of factors affecting erosion include soil properties, farming patterns, conservation techniques, and climate. The susceptibility and vulnerability of soil to erosion is known as soil erodibility. It is a crucial hydrologic feature of soil that helps planners and academics in their analysis of the features of soil erosion. Soil erodibility is affected by various soil qualities, including texture, structure, permeability, as well as organic matter content. Soil erodibility is a crucial element in soil erosion prediction models like the USLE (Universal Soil Loss Equation) and the RUSLE (Revised Universal Soil Loss Equation). For a particular type of soil, it is typically considered an intrinsic soil characteristic.

Soil characteristics need to be evaluated for hydrological, environmental, and sustainable management.

Many types of land degradation, like wind as well as water erosion, pose a threat to most of India's land area. The global and geospatial upscaling of the soil erodibility factor is significantly influenced by the study's techniques and model. K-factors are directly impacted by the following properties: bulk density, permeability, organic matter, porosity, shear strength, aggregate size and shape, particle size distribution, as well as soil chemical composition (Chen and Zhou, 2013) [2]. The soil's property must be determined in situ for a more accurate estimation of soil erosion losses in soil erodibility. However, given the greater research region, the experimental estimation of the K-factor is constrained. The soil erodibility variables for Europe, as delineated by Panagos *et al*. (2014) [8], have been employed as input data for soil erosion models across Europe by many researchers and academics. Therefore, estimating soil erodibility over the Sub Basin is still a crucial step in creating policies and resources that will aid in creating plans for soil conservation and erosion mitigation. To assess soil loss at basin scale, we calculated soil erodibility factors over the Sub Basin.

2. Materials and Methodology

2.1 Study area

Trimbakeshwar, Maharashtra, is where the Godavari River, also called the "Dakshin Ganga," begins. It flows through several states before draining into the sea, making it India's second-longest river. The Godavari basin is separated into upper, middle, and lower divisions due to its enormous size. This study focuses on upper Godavari Sub-basin, encompassing a catchment area of 22,628 km². Figure 1 shows the research region, which is between longitudes 73°25'57.75" and 75°26'20.92" east and latitudes 19°06'15.41" and 20°19'27.81" north. Its east-west extension is 215.65 km, and its north-south length is 118 km. The Western Ghats to the west, the Ajanta Range to the south, and the Satmala Hills to the north enclose the area. The study area is primarily made up of agricultural land, which is indicative of its important significance in the local economy. Due to its unpredictable climate, the region, which is a portion of India's peninsular plateau, is heavily reliant on monsoonal rainfall. Precipitation generally increases from the eastern to the western parts, with most of the rainfall occurring between June and September.

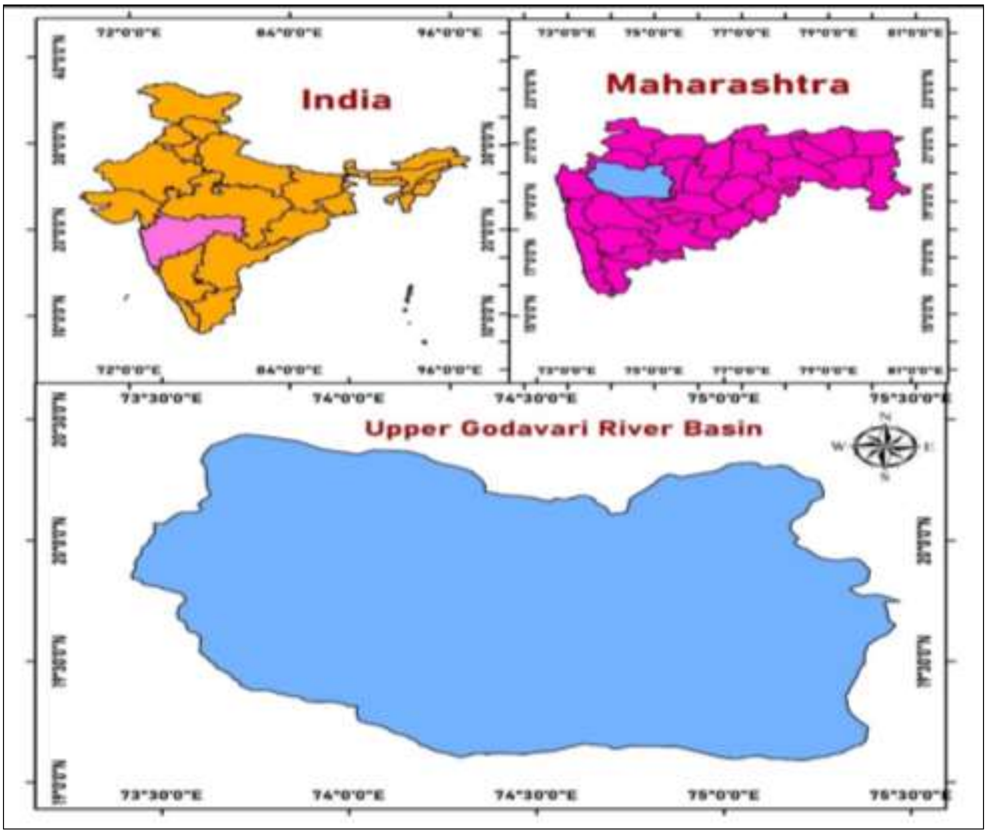

Fig 1: Location map of upper godavari sub basin

In terms of soil properties, the upper Godavari Sub basin exhibits a diverse range of soil types. The soils are predominantly alluvial, derived from the river's extensive drainage system, and are rich in nutrients, making them suitable for agriculture. However, the soil texture varies, with areas of sandy, loamy, and clayey soils observed throughout the basin. The alluvial soils are typically fertile but can be prone to erosion, especially during heavy monsoonal rains. Erodibility in the study area is a significant concern due to the combination of heavy monsoon precipitation and agricultural practices. The slope, soil texture, and patterns of land usage all affect the likelihood of soil erosion. Higher rates of erosion are caused by steeper slopes in the basin's north and west as well as heavy rains. In order to lessen soil erosion and preserve soil health in area, sustainable land management techniques are essential.

2.2 Collection of Soil Sample

A total of 135 soil samples had been collected from study area in May 2022.A GPS device with a one-meter precision was used to record the location of each sampling site, and samples were taken between 0 and 12 cm below the surface. Each sample, approximately one kilogram, was placed in plastic bags. Physical as well as chemical characteristics, including soil texture and soil organic carbon, were examined in lab following the collection of samples and their air drying in the shade. Location point of collected soil sample is shown in Figure 2.

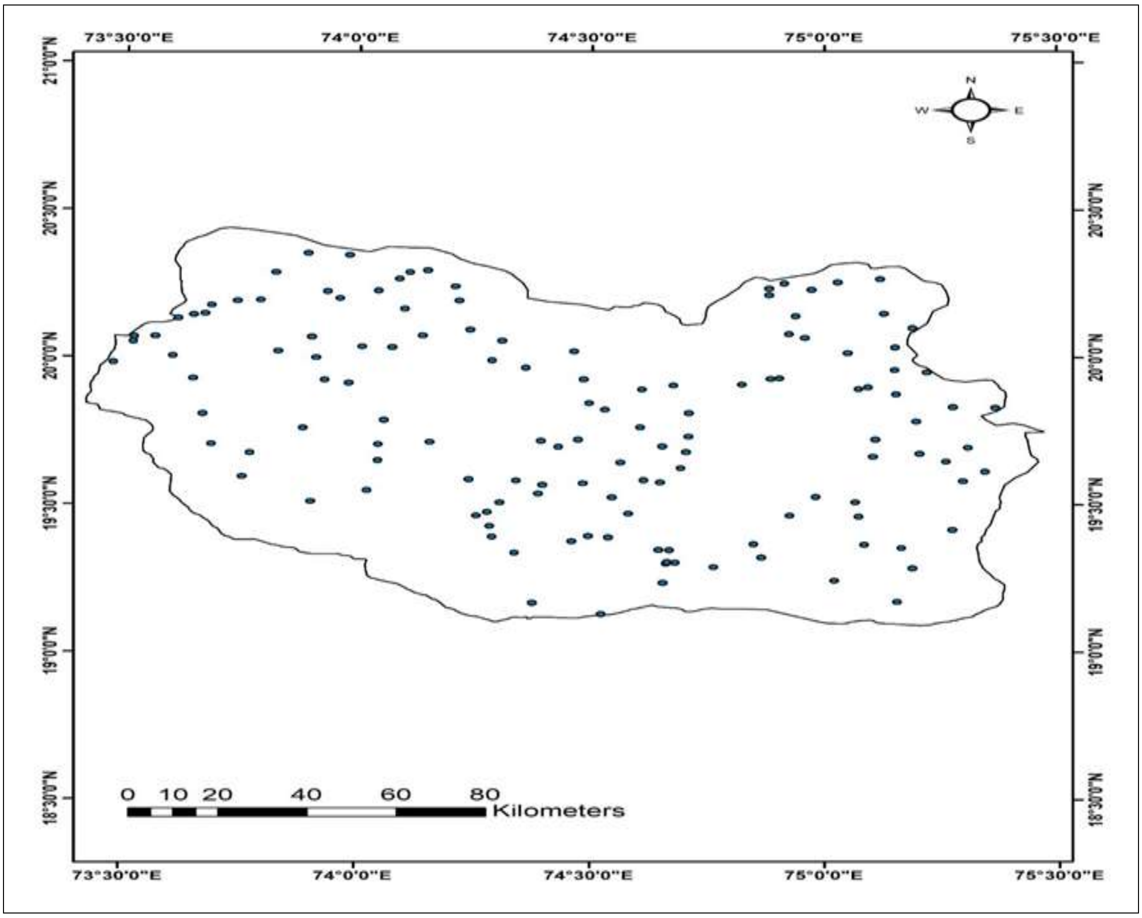

Fig 2: Location point of collected soil sample.

2.3 Soil Texture

Soil texture related to the proportionate amounts of clay, silt, as well as sand in soil. On the basis of proportions of soil particles, the U.S. Department of Agriculture (U.S.D.A.) employs a triangle categorization system to determine class of soil texture. The international pipette method was employed to analyze the particle size of soil samples, as described by Kilmer and Alexander in 1949 [4].

2.4 Soil Organic Matter

Organic matter, a crucial element of soil, significantly influences its chemical and physical properties. The precise quantification of organic matter is essential for soil analysis as it affects soil fertility, water retention, and overall soil health. To determine the organic carbon content in various soil samples, Walkley-Black titration method was employed. (Nelson SR and Sommers L Ee. 1982) [4]. This widely used method is recognized for its reliability in quantifying soil organic carbon by oxidizing the carbon and measuring the residue. Subsequent to the assessment of organic carbon content, the subsequent formula was employed to find out quantity of organic matter in soil:

$$\text{Organic matter} = \text{Organic carbon} \times 1.724 \qquad \text{...........(1)}$$

This conversion factor assumes that organic matter is composed of approximately 58% carbon, providing a standardized way to estimate the total organic matter from the measured organic carbon content

2.5 Soil Structure Code

The way that soil particles are arranged into aggregates clusters of particles that are bound together is referred to as soil structure. These aggregates form because of the cohesive properties of finer soil particles, like clay, and the influence of natural forces like water, air, and biological activity. The way these particles come together defines the soil's structure, which is crucial for understanding soil behaviour, including water retention, root penetration, and aeration. The structure can be classified as platy, granular, prismatic, or blocky. The textural class of the soil dictated its structural code. The soil structure classifications for each type of soil were established utilizing the soil textural pyramid developed by the United States Geological Survey (USGS).

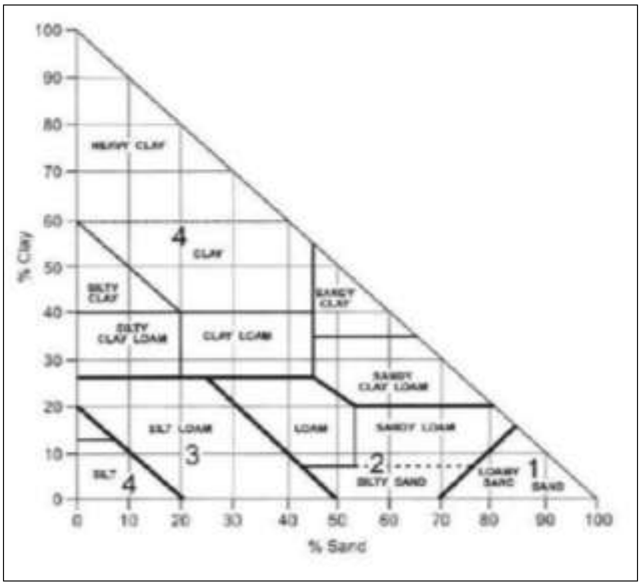

Fig 3: Soil structure code based on soil textural classification

2.6 Determination of Soil Permeability Code
The ability of porous materials to allow water to infiltrate or move through their interconnected spaces is known as permeability. The soil's permeability coefficient was determined based on its texture classification. Table 1 presents the soil permeability classifications according to soil texture.

Table 1: Permeability code from soil texture class (National Soil Handbook, USDA)

Soil "texture	Permeability code
Heavy clay, Clay	6
Silty clay loam, sandy clay	5
Sandy clay loam, clay loam	4
Loam, Silt Loam	3
Loamy sand, Sandy loam	2
Sand"	1

2.7 Computation of Soil Erodibility Factor 'K'
The word "soil erodibility" refers to a soil's inherent ability to resist erosion, procedure through which soil particles disaggregate and are transported by wind or precipitation. The erodibility of soil is a key factor in understanding how susceptible a soil type is to erosion, and it integrates several soil properties that affect how well the soil can absorb rainfall and resist particle detachment and movement. The subsequent formula is employed to evaluate the soil erodibility factor K values of soil samples (Wischmeier and Smith 1978).

$$100\ K = 2.1\times10^{-4}\times M^{1.14}(12 - a) + 3.25\times(b-2) + 2.5\times(c-3) \quad ....(2)$$

Here, "K=Soil erodibility factor, t ha h /ha MJ mm
M=(per cent silt + per cent very fine sand)×(100- per cent clay)
a=Percent organic matter content
b=Structure code utilized in soil classification
c=Soil permeability" code.

2.8 Classification of Soil Erodibility

Table 2: Classification of "soil erodibility

Class	Soil erodibility	K values (t ha /ha MJ mm)
1	Very low	0.00 to 0.10
2	Low	0.10 to 0.20
3	Moderate	0.20 to 0.30
4	Moderate high	0.30 to 0.40
5	High	0.40 to 0.50
6	Very" high	>0.50

The K values will be classified into 6 classes given by Manrique in 1988

3. Results and Discussion
3.1 The spatial variation soil physical and chemical properties

Fig 4: The USDA textural distribution of the studied soils

The physical characteristics of the soil, including its texture, as well as its chemical makeup, including its organic carbon, were examined. According to the laboratory analysis results, vast majority of the soil samples observed Clay in terms of texture. The soil texture in the research region is depicted in Figure 4 as Clay Loam, Sandy Clay Loam, Silty Clay, as well as Sandy Clay Loam. The coarse sand concentration has a mean of 11.33%, a standard error of 0.59%, a median of 9.27%, and a mode of 9.50%, according to the analysis of soil attributes from the research area. Its standard deviation is 6.90%, with a coefficient of variation of 61% and a sample variance of 47.59. Coarse sand exhibits a slight positive skew with kurtosis of 2.47 and skewness of 1.45. From a minimum of 2.15% to a high of 41.51%, the range of coarse sand content is 39.36%.

Table 3: Summary of descriptive statistics of the soil property sample collected from the study area

	Coarse Sand	Silt	Clay	Fine Sand	Organic Carbon	K
Mean	11.33	22.16	48.83	16.20	0.49	0.28
Standard Error	0.59	0.82	1.23	0.70	0.02	0.01
Median	9.27	21.05	51.20	14.51	0.46	0.26
Mode	9.50	17.50	28.70	10.36	0.30	0.42
Standard Deviation	6.90	9.55	14.39	8.16	0.23	0.07
Coefficient of variation	61	43	29	50	47	25
Sample Variance	47.59	91.18	207.19	66.53	0.05	0.01
Kurtosis	2.47	3.54	-0.60	1.95	1.66	-0.26
Skewness	1.45	1.60	-0.39	1.30	0.74	0.68
Range	39.36	58.00	70.50	41.77	1.47	0.30
Minimum	2.15	0.25	5.95	4.88	0.03	0.17
Maximum	41.51	58.25	76.45	46.65	1.50	0.47

The mean silt content is 22.16%, with a standard error of 0.82%. The median silt content is 21.05%, while the mode is 17.50%. The silt content has a standard deviation of 9.55%, a coefficient of variation of 43%, and a sample variance of 91.18. Its distribution is more peaked, as indicated by a kurtosis of 3.54, with a positive skewness of 1.60. The silt content ranges widely, from 0.25% to 58.25%.

The clay content has a median of 51.20%, a mode of 28.70%, a mean of 48.83%, as well as a standard error of 1.23%. The coefficient of variation is 29%, and the standard deviation is 14.39%. The clay content has a sample variance of 207.19, a flatter than normal distribution with a kurtosis of -0.60, and a slight negative skewness of -0.39. The clay content ranges from 5.95% to 76.45%. The average content of fine sand is 16.20%, with a standard error of 0.70%. 10.36% is the mode, and 14.51% is the median. The standard deviation is 8.16%, and the coefficient of variation is 50%, with a sample variance of 66.53. With a kurtosis of 1.95 and a skewness of 1.30, the fine sand content exhibits a positive skew, with a low of 4.88% and a maximum of 46.65%. The sample's mean level of organic carbon is 0.49%, with a standard error of 0.02%. With a mode of 0.30%, the median content is 0.46%. The sample variance is 0.05, the coefficient of variation is 47%, and the standard deviation is 0.23%. Organic carbon shows a positive skew with a kurtosis of 1.66 and skewness of 0.74, ranging from 0.03% to 1.50%. The estimate the soil erodibility by using equation 2. The standard error of the soil erodibility factor (K) is 0.01 and its mean is 0.28. It has a mode of 0.42 and a median of 0.26. With a sample variance of 0.01 and a coefficient of variation of 25%, the standard deviation of K is 0.07. K values, which range from 0.17 to 0.47, indicate a slightly flatter distribution than usual, with a kurtosis of -0.26 and a skewness of 0.68.

3.2 Spatial Variability Characteristics of Soil Erodibility K-Values

K-values in the subbasin were interpolated using a spherical theoretical model, kriging interpolation, and the geostatistical analysis module Geostatistical Analyst Geostatical Wizard in Arc Map10.8. Figure 5 displays the K-Values' spatial variation.

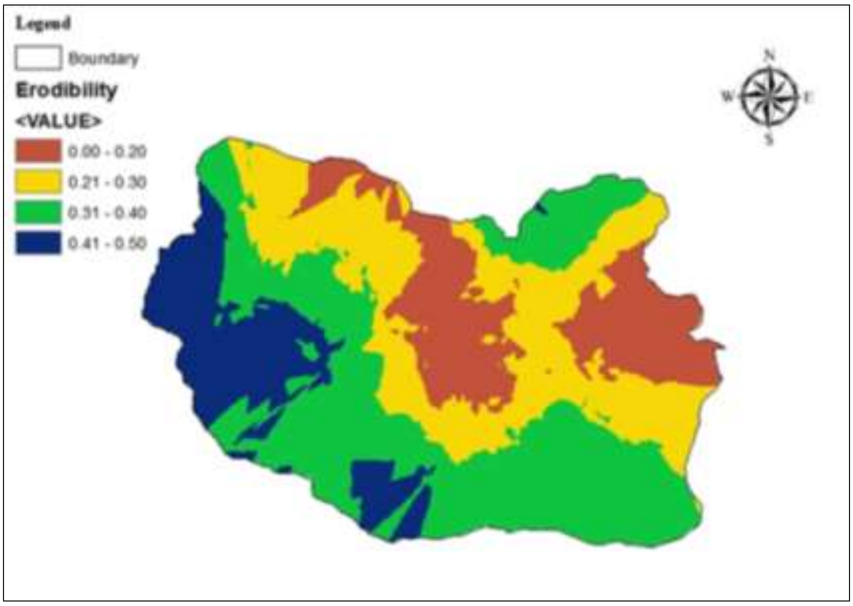

Fig 5: Displays the K-Values' spatial variation.

4. Conclusions

The author has reached the following results following a thorough investigation into determination of K (Soil Erodibility Factor) for soils in the upper Godavari subbasin:

1. **Soil Erodibility Variability:** The research demonstrated that the K (Soil Erodibility Factor) exhibits significant spatial variability across the study area with mean value 0.28 t·ha·h·ha−1 ·MJ −1 · mm−1.
2. **Soil Erodibility Mapping:** North-West part of Basin has high to Moderate soil erodibility, so this part needs attention for reduction of erosion on priority.
3. **Soil Conservation Recommendations:** Based on the study's results, specific soil conservation strategies were proposed to mitigate erosion in vulnerable areas. It is possible to successfully lower soil erosion and preserve soil health by putting techniques like contour farming, terracing, cover crops, and decreased tillage into practice.

5. Acknowledgments

We acknowledge MPKV, Rahuri, for providing support to complete this research. We acknowledge the financial support from the Chhatrapati Shahu Maharaj Research Institute (SARATHI) in Pune, which enabled the execution of the study.

6. References

1. Chandan B, Singh NJ, Handique BK. Hyperspectral

spectroscopic study of soil properties - a review. Int J Plant Soil Sci. 2020;32(7):14-25.
2. Chen X, Zhou J. Volume-based soil particle fractal relation with soil erodibility in a small watershed of purple soil. Environ Earth Sci. 2013;70:1735-1746.
3. Jassim FA, Altaany FH. Image interpolation using Kriging technique for spatial data. Can J Image Process Comput Vis. 2013;4(2):16.
4. Kilmer VJ, Alexande LT. Method of making mechanical analyses of soils. Soil Sci. 1949;68:15-24.
5. Nandgude S, Kambale A, Shinde S, Mahale D, Shinde V. Soil erodibility estimation for soil conservation in Dapoli region of Maharashtra. Trends Biosci. 2014;7(6):486-490.
6. National Bureau of Soil Survey & Land Use Planning (NBSS & LUP). Soil map (1:1 million scale). Nagpur, India: NBSS & LUP; c2004.
7. Nelson SR, Sommers LE. Total organic carbon and organic matter. In: Page AL, editor. Method of Soil Analysis, Part II. Madison, USA: American Society of Agronomy Inc.; c1982, p. 539-79.
8. Panagos P, Meusburger K, Ballabio C, Borrelli P, Alewell C. Soil erodibility in Europe: A high-resolution dataset based on LUCAS. Sci Total Environ. 2014;479:189-200.
9. Renard KG, Foster GR, Weesies GA, Porter JP. Rusle: revised universal soil loss equation. J Soil Water Conserv. 1991;46:30-33.
10. Wischmeier WH, Smith DD. Predicting rainfall erosion losses: A guide to conservation planning. Department of Agriculture, Science and Education Administration; c1978.