Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2019, Volume 32, Issue 1, Page 27-33

Determining and Mapping of Soil Erodibility Index for Nongpoh Watershed

Susanta Das[1*] • PK Bora[2] • Prafull Katre[1]

[1]Department of Soil and Water Engineering, SVCAET & RS, IGKV, Raipur
[2]College of PG Studies, CAU (Imphal), Umiam, Meghalaya

ARTICLE INFO

Article history:
Received 29 May 2018
Revision Received 22 October 2018
Accepted 10 January 2019

Key words:
Soil erosion, Soil erodibility, ArcGIS

ABSTRACT

The soil erodibility factor (K) is a derivative of the soil physical properties such as particles size distribution, soil aggregation, infiltration as well as soil organic matter content. Soils with faster infiltration rates, higher levels of organic matter and improved structure have a greater resistance to erosion. It is an important parameter in the estimation of soil erosion in models like Universal Soil Loss Equation and its modified forms. In the present study the main objective was to determine the soil erodibility indices of Nongpoh watershed of Meghalaya so that the values of the soil erodibility index can be established for future works. Soil Physical Properties Analysis method and interpolation techniques in ArcGIS environment were used for determination of 'K' factor in different transacts of Nongpoh watershed (Meghalaya). The K factor of the study area was ranging from 0.12 to 0.23 with an average of 0.18. The K factor was calculated separately for the three Transacts of the study area. The result showed that, the all Transacts having similar average K values of 0.18 to 0.19. The study indicated that the soil of study area is more susceptible to water erosion.

1. Introduction

Soil erosion occurs when soil particles are carried off by water or wind and deposited somewhere else. Erosion begins when rain or irrigation water detaches soil particles. Relf (2001) stated that when there is too much water on the soil surface, it fills surface depressions and begins to flow with enough speed; this surface runoff carries away the loosed soil. Generally, soils with faster infiltration rates, higher levels of organic matter and improved structure have a greater resistance to erosion (Wall *et al.,* 1987). Soil erosion is classified as geological erosion and accelerated erosion. Accelerated erosion is the process usually refers to the activities of human being which cause or accelerate soil erosion. The erosion process is influenced by various factors and the estimation of these factors is paramount to understand the individual effect of the factors so that soil conservation measures can be planned to mitigate erosion.

Empirical models are being developed and successfully used by various workers over the years. Universal Soil Loss Equation (USLE) is one of such empirical equation which is used extensively to estimate the soil loss from a given watershed (Wischmeier and Smith, 1965). The soil erodibility (K) factor is one of the most influencing parameter of USLE. Erodibility is a factor indicates proneness to erosion due to both detachment and transport. The soil erodibility factor (K) is a quantitative expression of the inherent susceptibility of a particular soil to erode at different rates when the other factors that affect erosion are standardized. Soil erodibility is related to the integrated effects of rainfall, runoff and infiltration on soil loss and is commonly called the soil erodibility factor (K) which represents the effect of soil properties and soil profile characteristics *viz.* soil textures, aggregates, stability, shear strength, soil structures, infiltration capacity, soil depth, bulk density, soil organic matter and chemical constituents on soil loss (Suresh, 2013). A soil with relatively high erodibility factor may show signs of serious erosion, yet a soil could be highly erodible and suffer little erosion (Nyakatawa *et al.* 2001).

*Corresponding author: susantad983@gmail.com

The organic and chemical constituents of the soil are important because of their influence on stability of aggregates. Soils with less than 2% organic matter can be considered erodible (Evans 1980). Most soils contain less than 15% organic content and many of the sands and sandy loams have less than 2%. Morgan (2001) suggested that soil erodibility decreases linearly with increasing organic content over the range of 0 to 10%. These physical characteristics of soils are much affected by the land use.

Mapping of erosion vulnerable area on the basis of soil erodibility, using the integration of GIS, RS technique can identify the areas which are at potential risk of extensive soil erosion. The formulation of proper soil management for sustainable development requires an explicit inventory and rating of vulnerable areas. This information is very useful in the decision making context to avoid land degradation in erosion risk areas, or, alternatively, to recommend soil conservation measures to reduce soil loss if developments continue. The goal of this study was to determine the soil erodibility factor (K) for Nongpoh watershed of Meghalaya.

2. Materials and Methods

2.1 Description of the study area

The study area is a micro-watershed situated at Nongpoh of Ri-Bhoi district, Meghalaya. The study area lies between 25° 54' 0" to 25° 55' 05" N latitude and 91° 52' 54.7" to 91° 54' 17.7" E longitude and it covers an area of 268 ha (2.68 km^2). The location of the study area is shown in Figure 1

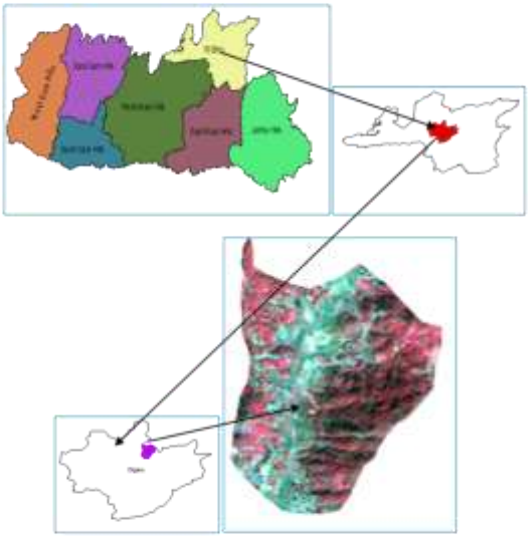

Figure 1. Location of the Study area

The micro watershed has been divided in to three Transacts (Figure 2) keeping the view on slopes and contours of the watershed. The Transact-1 is represented by the plane area of the watershed, where the runoff water from the other two Transacts of the watershed flows in.

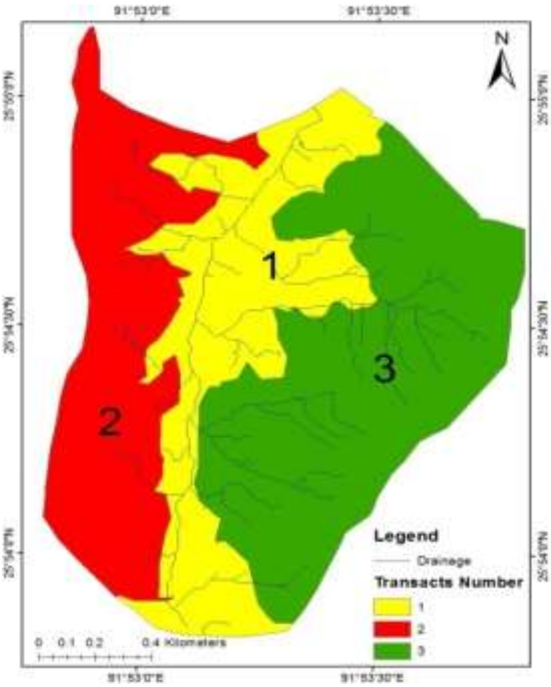

Figure 2. Diferent transacts of study area

The study area falls under per-humid sub-tropical climate. This is characterized by hot and moist summer and cool winter. April is the hottest month, with average minimum and maximum temperatures of 17.3ºC and 29.4 ºC, respectively and having December as the coldest month with an average minimum and maximum temperature as 7.60 ºC and 20.40 ºC, respectively. The study area has annual relative humidity (RH) of 39.14% whereas its mean annual rainfall is about 2600 mm, 77% of which is received during July to September. The study area has an average elevation of 469-760 m above the Mean Sea Level (MSL).

Natural vegetation and land use:

The study area is having a mixed forest type of vegetation. *Albizia ssp.* Bahuniavariegate, *Duabanga ssp*. Toona ciliate, *Aporosa ssp. Castanopsis ssp*. and *Ficus ssp*. are the predominant trees commonly found in the study area. The economy of the area revolves around agriculture and livestock. Paddy, French-bean, carrot, tomato, potato, cabbage, cauliflower, ginger, turmeric, pea, black paper, areca nut, betel leaf, broomstick are commonly grown under the agriculture land. The land use land cover map of Nongpoh has been given in Figure 3.

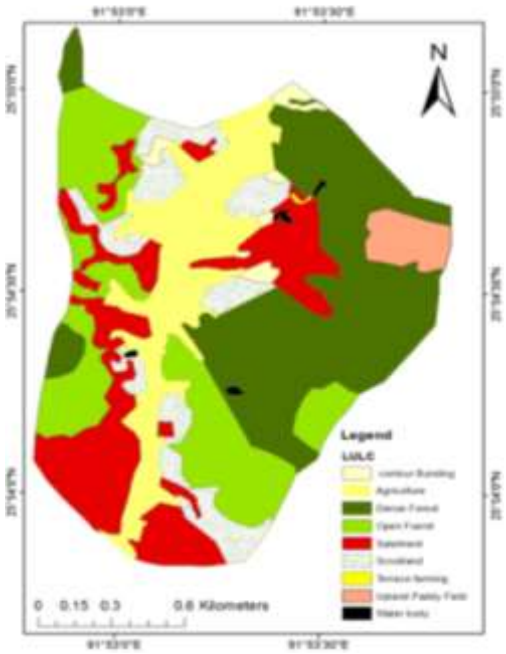

Figure 3. LULC of the study area

Based on tonal and colour variation in the satellite imagery (LISS-IV) and ground truth, the major land use / land cover (LULC) classes identified. The spatial distribution of LULC categories such as contour bunding, Agriculture, Dense Forest, Open Forest, Settlement, Scrubland, Terrace farming, Upland Paddy Field, Water body, *etc.* was prepared by 1:25,000 scale. The data on the statistics of the LULC categories identified in Nongpoh micro-watershed are presented in Table 1**.**

Table 1. Land Use Land Cover map of the study area

LULC	Area (ha)	Area (%)
Contour Bunding	4.20	1.57
Agriculture	44.29	16.52
Dense Forest	78.80	29.39
Open Forest	55.15	20.57
Settlement	49.37	18.41
Scrubland	26.48	9.88
Terrace Farming	0.19	0.07
Upland Paddy Field	8.86	3.30
Water Body	0.81	0.30
Total	268.15	100.00

Soil Erodibility Factor (K):

Soil erodibilty factor (K) depends on soil and, or geological characteristics, such as parent material, texture, structure, organic matter content, porosity, catena and many more. Generally, soils become of low erodibility if the silt content is low, regardless of corresponding high content in the sand and clay fractions (Mhangara *et al.,* 2012). Soil erodibility factor represents the vulnerability of soil or surface material to erosion, transportability of the sediment, and the amount and rate of runoff given a particular rainfall input, as measured under standard condition. Higher the K- factor, higher the erodibility. For calculation of K factor Soil Physical Properties Analyses method was adopted.This method was proposed by Wischmeier *et al.* (1971). In this method physical property of soil *viz.* soil texture, soil structure, soil permeability and soil Organic carbon (OC) have been used to calculate the K factor. The K factor will be calculated as below:

$$K=27.66\times M^{1.14}\times 10^{-8}\times(12-a)+0.0043\times(b-2)+0.0033\times(c-3) \quad (1)$$

Where,

M= silt (%) + very fine sand (%) x (100-cay%)

a= organic matter (%)

b= structure code [1-very structured particulate, 2-fairly structured, 3-slightly structured and 4-soild]

c= Profile permeability [1-rapid, 2- moderate to rapid, 3-moderate, 4-moderate to slow, 5-slow and 6-very slow]

For calculation and mapping of K factor, 35 soil samples were collected from the different points of the study area. The soil sampling points are shown in Fig: 4. The textural analysis of soil was done by using international pipet method (Piper, 1966) and percentages of organic carbon were determined by Walkley & Black (1934) method.

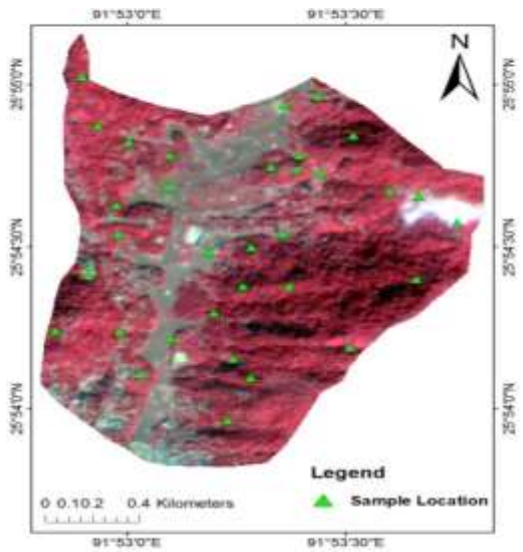

Figure 4. Location of soil samples

3. Results and Discussion

Soil Properties

Soil erodibility factor (K) represents the vulnerability of soil or surface material to erosion, transportability of the sediment, and the amount and rate of runoff given a particular rainfall input, as measured under standard condition. Higher the K factor indicates the, probability of high soil erosion. The different parameters (*viz.* % of very fine sand, % silt, % clay, OC, Structural class and Permeability class) were calculated for estimating the K factor of the study area. Geo-spatial technology helps in mapping of spatial variations of point data over the spatial domain. Interpolation technique (Kriging) in ArcGIS environment was adopted for finding out the spatial variation of the different parameters and K factor in the study area. Structural class and permeability class are given in Table 2.

Table 2. Soil structural class and permeability class (Wischmeier *et al.,* 1971)

Structural class	Range	Aggregates size(dia.),mm
1	Very fine granular	1 to 2
2	Fine granular	2 to 3
3	Medium or coarse granular	3 to 5
4	Blocky, platy, or massive	>5 Usually construction sites

Permeability Class	Range (mm/hr)	Class	Soil Characteristics
1	150	Rapid	Sandy to gravelly soils
2	50 to 150	Moderate rapid	Sandy Loam
3	12 to 50	Moderate	Loam, Silty loam soils
4	5 to 15	Slow to moderate	Clay loam, silt soils
5	1 to 5	Slow	High clay content or compressed soils of other textural group
6	>1	Very slow	High clay content, poor aggregation

In the study area, very fine sand was ranging from 14.25% to 21.18% with an average of 17.46% (Figure 5), the silt % was ranging from 5.78% to 15.63 % with an average of 12.48% (Figure 6), and the clay was ranging from 32.15 to 37.88 % with an average of 34.82 % (Figure 7). The textural analyses of the soil samples show that the soil of the study area comes under the textural class of sandy clay. The organic carbon (OC) of the study area was ranging from 1.84 to 2.35 with an average of 2.05 (Figure 8).

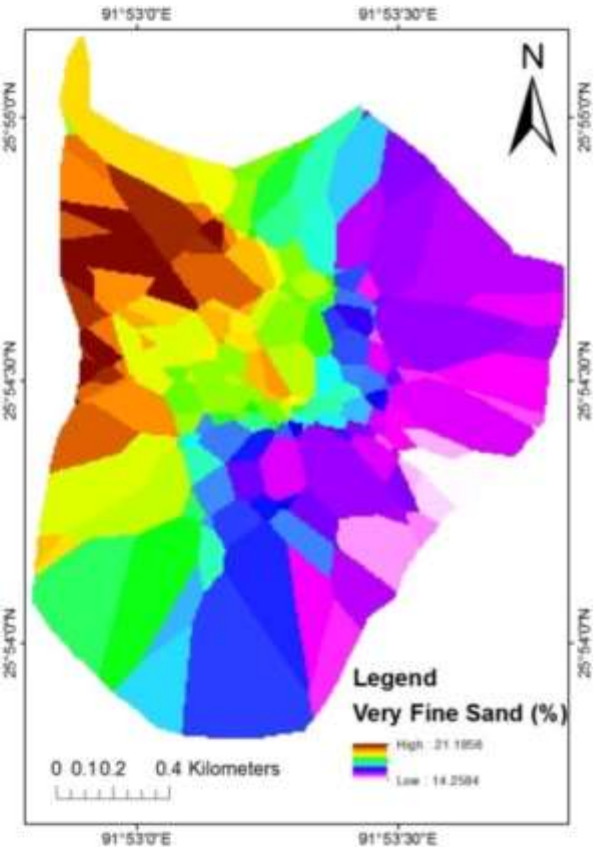

Figure 5. % of very fine sand

The area is having more organic carbon because major part of the watershed is covered by the forest. Most of the study area is having structural class 2 and 3 and it comes fine to medium granular whereas the study area is having moderately high permeability because of soil texture and structure. Maps for soil structural classes and soil permeability classes are presented in Figure 9 and Figure 10, respectively.

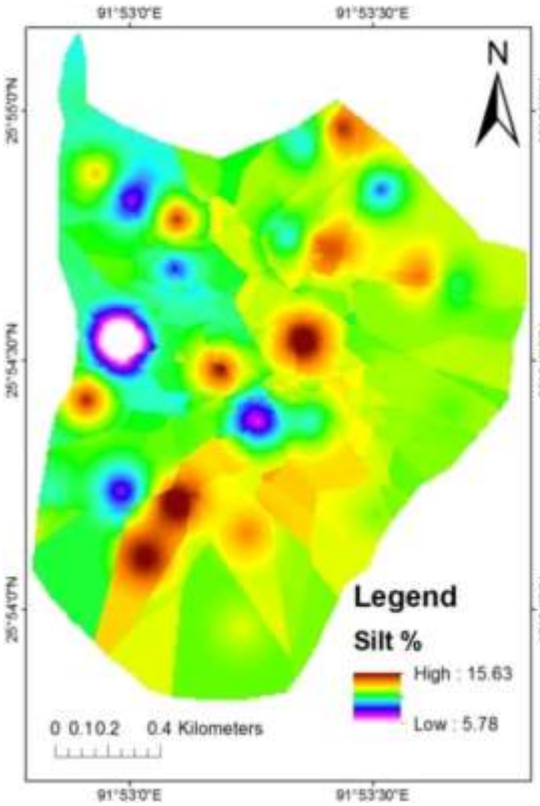

Figure 6. % of silt

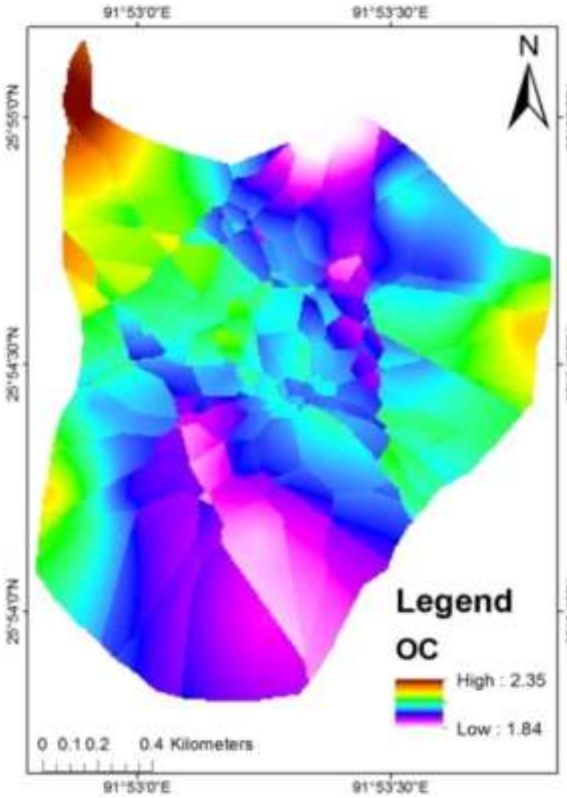

Figure 8. Organic carbon

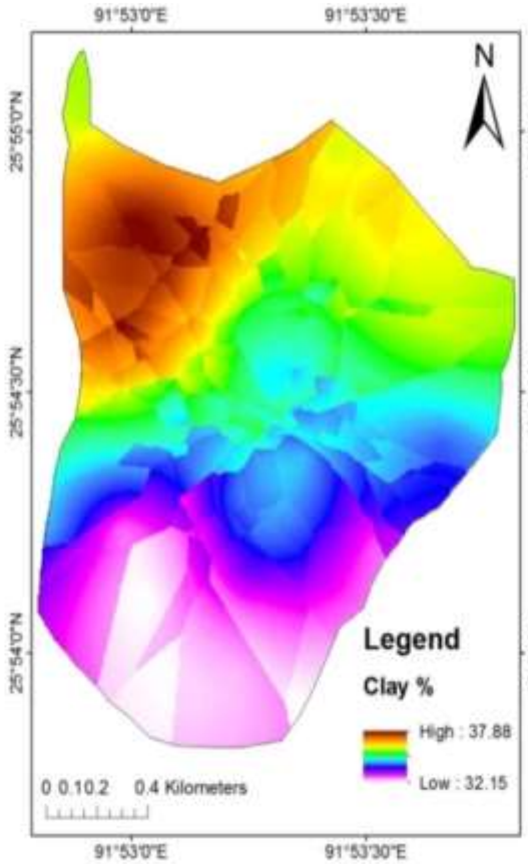

Figure 7. % of clay

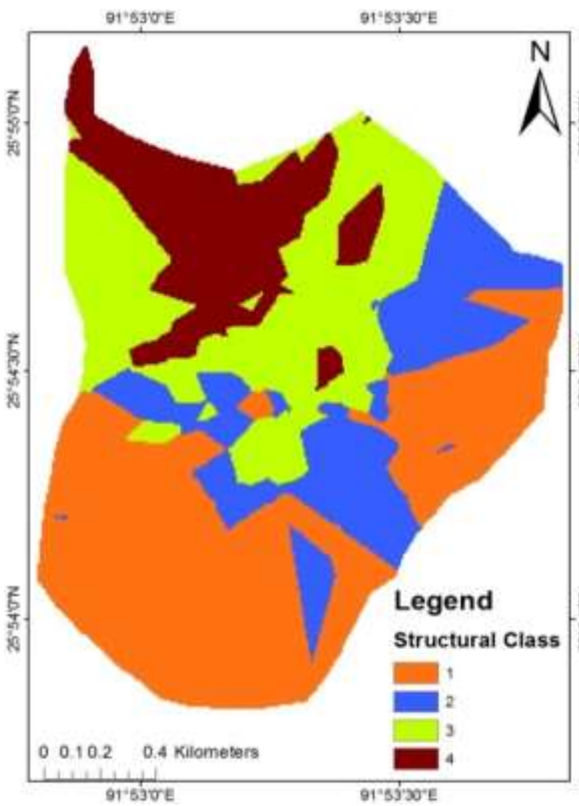

Figure 9. Structural class of the soil

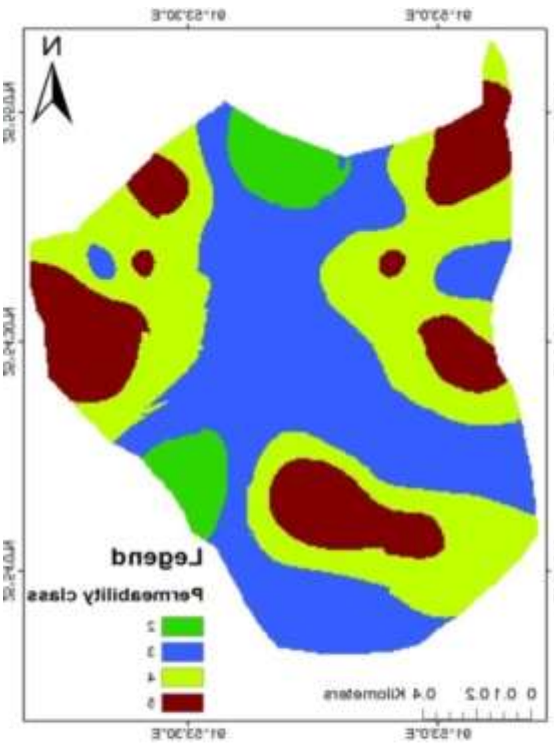

Figure 10. Permeablity class of the soil

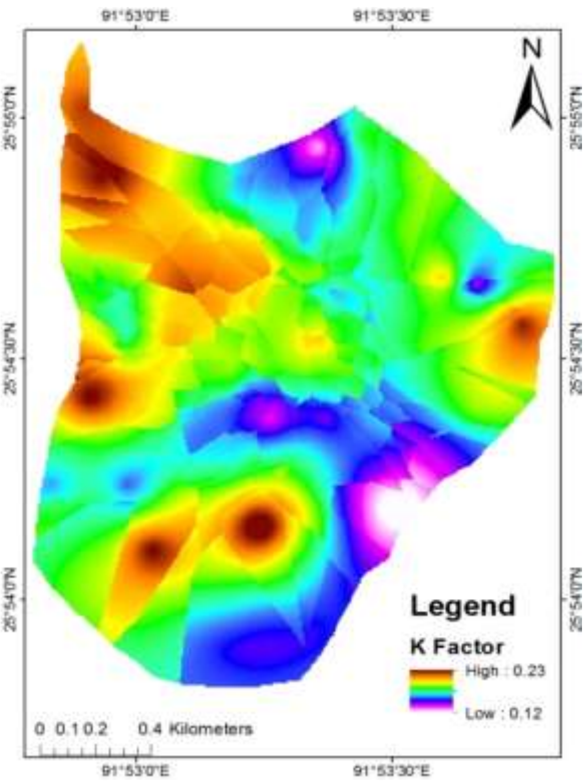

Figure 11. K Factor of the study area

Soil Erodibility Factor (K):

The K factor of the study area was ranging from 0.12 to 0.23 with an average of 0.18 (Figure 11). The K factor was calculated separately for the three Transacts of the study area. The result showed that, the all Transacts having similar average K values of 0.18 to 0.19. The K factor of the different transacts of the study area was shown in Figure 12. Similar; K factor had been also reported by various workers for mountainous watersheds. In the mountainous sub-watershed in Kerala, India the K factor was found 0.13 to 0.30 (Prasannakumar, *et al.,* 2012). Where the organic matter is moderately high and taxonomical class of the soil of that area was mainly clay loam soil which was more susceptible to get erosion. South Koel Basin, Jharkhand was having the K values from 0.23 to 0.37 (Parveen and Kumar, 2012). The texture of this area was mainly sandy loam, loam, clay loam and silty clay and which was also more susceptible to get erosion. In Nongpoh watershed the soil texture was sandy clay with high organic matter and the structural class and permeability was moderate to high. The K values obtained in the study conformed the general concept of soil susceptibility to erosion.

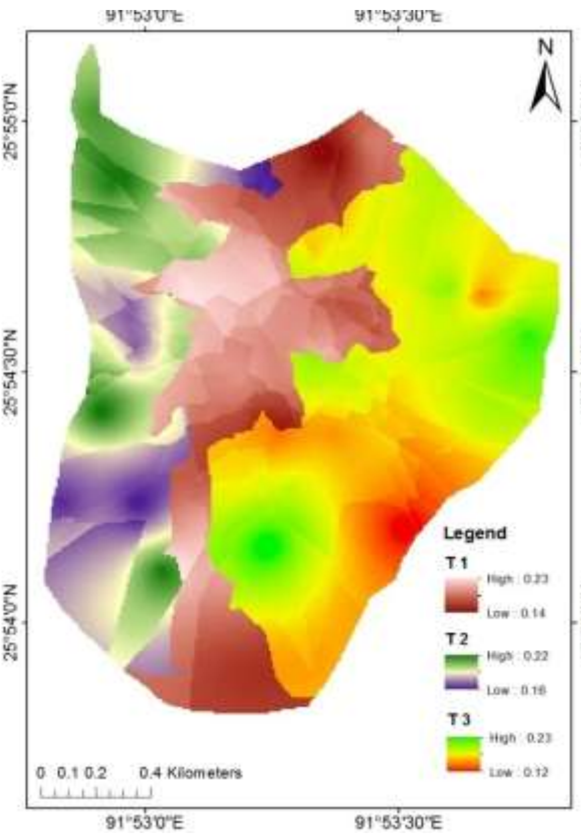

Figure 12. K factors for the different Transacts of the study area

Conclusions

The soil erodibility index of the study area was ranging from 0.12 to 0.23 with an average of 0.18. All the three transacts were of similar types of soil physical properties and aggregation and hence similar erodibility values were obtained. The erodibility index of Nongpoh watershed was considered to be moderately high and therefore required prioritised attention for soil conservation measures. The soil erodibility index map as developed in this study would serve as the reference for future soil erosion assessment and land use plans.

Acknowledgements

The author acknowledge the assistance extended to him in this study by the College of Post-Graduate Studies, Central Agricultural University (Imphal), Umiam, Meghalaya and North East Space Application Centre, Umiam, Meghalaya.

References

Evans R (1980). Mechanisms of water erosion and their spatial and temporal controls: an empirical viewpoint. In: Soil erosion (eds M.J. Kirkhy& R.P.C. Morgan), *J. Wiley, Chichester*, pp. 109-12X.

Mhangara P, Kakembo V, Lim K (2012). Soil Erosion Risk Assessment of the Keiskamma Catchment, South Africa Using GIS and Remote Sensing. *Environmental Earth Sciences.* 65(7): 2087-2102.

Morgan RPC (2001). A simple approach to soil loss prediction a revised Morgan-Morgan-Finney model. *Catena*, 44: 305-322.

Nyakatawa EZ, Reddy KC, Lemunyon JL (2001). Predicting soil erosion in conservation tillage cotton production systems using the revised universal soil loss equation (RUSLE). *Soil Tillage Research.* 57: 213-224.

Parveen R, U Kumar (2012). Integrated Approach of Universal Soil Loss Equation (USLE) and Geographical Information System (GIS) for Soil Loss Risk Assessment in Upper South Koel Basin, Jharkhand. *Journal of Geographic Information System*, 4: 588-596.

Piper C S (1966). Soil and Plant Analysis. Hans Publisher, Bombay

Prasannakumar V, Vijith H, Abinod S, Geetha N (2012). Estimation of soil erosion risk within a small mountainous sub-watershed in Kerala, India, using Revised Universal Soil Loss Equation (RUSLE) and geo-information technology. *Geoscience Frontiers*, 3(2): 209-215.

Relf D (2001). Reducing Erosion and Runoff Virginia Cooperative Extension, Pub., USA, pp: 426-722.

Suresh R (2013). Soil and water conservation engineering. pp: 743-744.

Walkley AJ, Black CA (1934). An estimation of method for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Science.* 27: 29–38.

Wall G, Baldwin CS, Shelton I.J (1987). Soil erosion - causes and effects. *Ontario Ministry of Agriculture and Food Factsheet Agdex*.572, Canada.

Wischmeier WH, Smith DD (1965). Predicting rainfall erosion losses from crop land east of the Rocky Mountains: U. S. Dept. of Agric. AH, 282.U.S. Government Printing Office, Washington D.C.

Wischmeier WH, Johnson CB, Cross BV (1971). A soil erodibility nomograph for farm-land and construction sites. *Journal of Soil and Water Conservation.* 26, 189–193.