International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 14
November 2017

Soil Erosion Prone Analysis for landform zone classification of Sita nadi watershed, Koppa Taluk, Karnataka – A Geomorphologic and Geo-Informatics Approach

Manohara T.H[1], Chandrashekarappa K.N[1], Nagesh P.C[2]
[1]*Department of Applied Geology, Kuvempu University,* [2]*Department of Geology, Bangalore University*
E mail:manohar_tke@yahoo.com

Abstract

Soil erosion is the loss of soil from land surface due to the action of wind, water, ice and gravity, its spatial and temporal distribution depends on the interaction of human and physical factors. It has to be monitored and assessed in regular interval of time, in this regard, Sita Nadi watershed has been considered for erosion prone analysis by using geomorphological and geo-informatics techniques. The study area is located in between N 13^0 $15^{'}$ and N 13^0 $30^{'}$ Latitude and E 75^0 15^1 to 75^0 $30^{'}$ E Longitude, with an aerial extent of 224.81 km^2. The thematic layers like geomorphology, drainages and contours has been prepared by SOI OSM series toposheet D43P7 on 1:50,000 scale and updated on IRS LISS-III satellite image of year 2009. The entire watershed has been divided into 4 km^2 grids by using fishnet tool in ArcGIS, then for each grid drainage frequency, drainage density, relative relief and dissection index values are calculated. The result indicates, about 11.33%, 10.71%, 29.86%, 34.18% and 13.92% of the area is very high, high, moderate, low and very low prone to soil erosion respectively, which indicates improper management of soil in Sita Nadi watershed. The latest technologies like remote sensing and geo-informatics are helpful in identification, assessment and management of Soil Erosion prone zones for sustainable future.

Keywords: *Morphometric analysis, Erosion Prone, Landform Zones, RS and GIS.*

1. Introduction

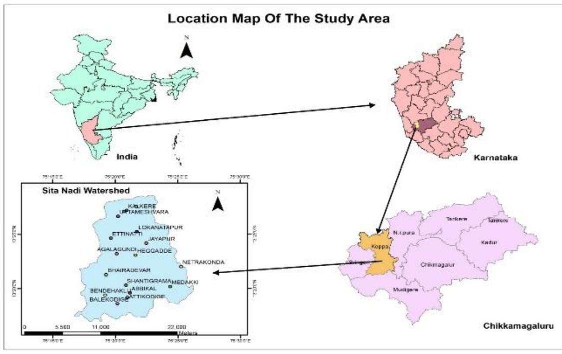
Soil erosion is the process of detachment, transportation and deposition of soil particles from land surface. It is associated with about 85% of land degradation in the world, causing up to a 17% reduction in crop productivity. Unless soil conservation and management practices are implemented properly, soil erosion can cause loss of plant nutrient, weak soil aggregation and finally low agriculture production. The proper assessment of soil erosion in space and time involve identification of source areas of sediments and their variability, which is difficult using conventional methods. The major factors responsible for soil erosion include rainfall, soil type, change in vegetation, topographic and morphological characteristics of the basin (Kothyari and Jain, 1997), these can be effectively mapped using geospatial techniques. In case of lack of data on rainfall and sediment yield, the relative vulnerability of watersheds can be assessed with respect to time independent factors like soil type, topography and geomorphology (S.K. Jain et al 2002). In recent years, the remote sensing data provide accurate, timely and real time information on various aspects of the watershed such as physiography, drainage characteristics and elevation, through these type of thematic layers potential erosion prone areas can be easily identified and quantified.

2. Study area

The study area Sita Nadi watershed is a part of Tunga bhadra catchment located in koppa taluk, which is approximately 57 km from west of Chikkamagaluru town. The aerial extent of the study area is situated between N 13^0 $15^{'}$ and N 13^0 $30^{'}$ Latitude and E 75^0 15^1 to 75^0 30^1 E Longitude at an elevation of 672 m above the MSL, with a geographical area of 224.81 km^2 as shown below. The majority of the climate in the study area is humid to sub humid during the year, with average annual temperature of 23.10°C and rainfall is 2874.43 mm respectively.

International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 14
November 2017



3. Material & Methodology

The data used for the study is SoI OSM series toposheet D43P7 of 1: 50,000 scale with datum WGS 1984, UTM 43N zone projection. The base layers were updated by using IRS LISS-III (Resolution: 24m, Quantisation: 8 bit) satellite image of year 2009. The thematic layers like drainage, waterbodies and contours are extracted by overlying transparent sheet on toposheet. These maps are utilised for the preparation of drainage frequency, drainage density, dissection index, relative relief, slope and erosion prone maps. The isopleths maps were constructed, by dividing the basin into grids of 4 km^2 using fishnet tool available in ArcGIS. The slope map has been prepared by Wentworth's (1930) formula by creating a 1 km^2 grid. These thematic layers are utilised for the preparation of high, moderate and low erosion prone zones by using geo-informatics approach.

Table 1. Shows the drainage parameters and their formulas.

Parameters	Formula	References
Drainage Frequency	Fs= ΣNu/A Where, Nu =No of Streams, A= Area of the grid	Horton (1932)
Drainage Density	Du=ΣLu/A Where, Lu =Length of Streams, A= Area of the grid	Horton (1932)
Relative Relief	RR = Z-z/A Where, Z= Highest elevation, z= Lowest elevation A= Area of the grid	Schumm (1956)
Dissection Index	Di = Z-z/Z Where, Z= Highest elevation, z= Lowest elevation	Nir (1957)
Slope	Slope = Tan^{-1} (N *C.I)/636.6 Where, N=No of contours, CI=Contour interval, constant=636.6	Wentworth (1930)

4. Results & Discussion

The soil erosion prone analysis and landform zone classification has been carried out by considering the drainage frequency, drainage density, relative relief, dissection index and slope map, these are discussed below.

4.1 Drainage Frequency (Fs)

Horton (1932) introduced drainage frequency, which is the total number of stream segments of all orders per unit area. The drainage frequency in the study area, varies from 6 to 17 as shown in Table 2. The majority of the area i.e., about 134.37 km^2 is moderate, 22.27 km^2 is low, 66.38 km^2 is high and 1.77 km^2 is very low. The higher drainage frequency is observed in south western and north eastern part of the basin as shown in Fig 2.

Table 2. Area statistics of Drainage Frequency in Sita Nadi Watershed

Range	Area in km^2	%	Category
< 6	22.29	9.90	Low
6-11	134.37	59.81	Moderate
11-17	66.38	29.50	High
>17	1.77	0.79	Very high
Total	224.81	100.00	-

4.2 Drainage Density (Du)

The drainage density is an important indicator of the linear scale of landform element in stream eroded topography, introduced by Horton (1932), it is a measure of the length of stream channel per unit area of drainage basin. According to Nag (1998), low drainage density generally results in the areas of highly resistant or permeable sub-soil material, dense vegetation and low relief. The drainage density varies from 0 to 10 km/km^{2,} and increases from south west to north east as shown in Fig 3.

Table 3. Area statistics of Drainage density in Sita Nadi Watershed

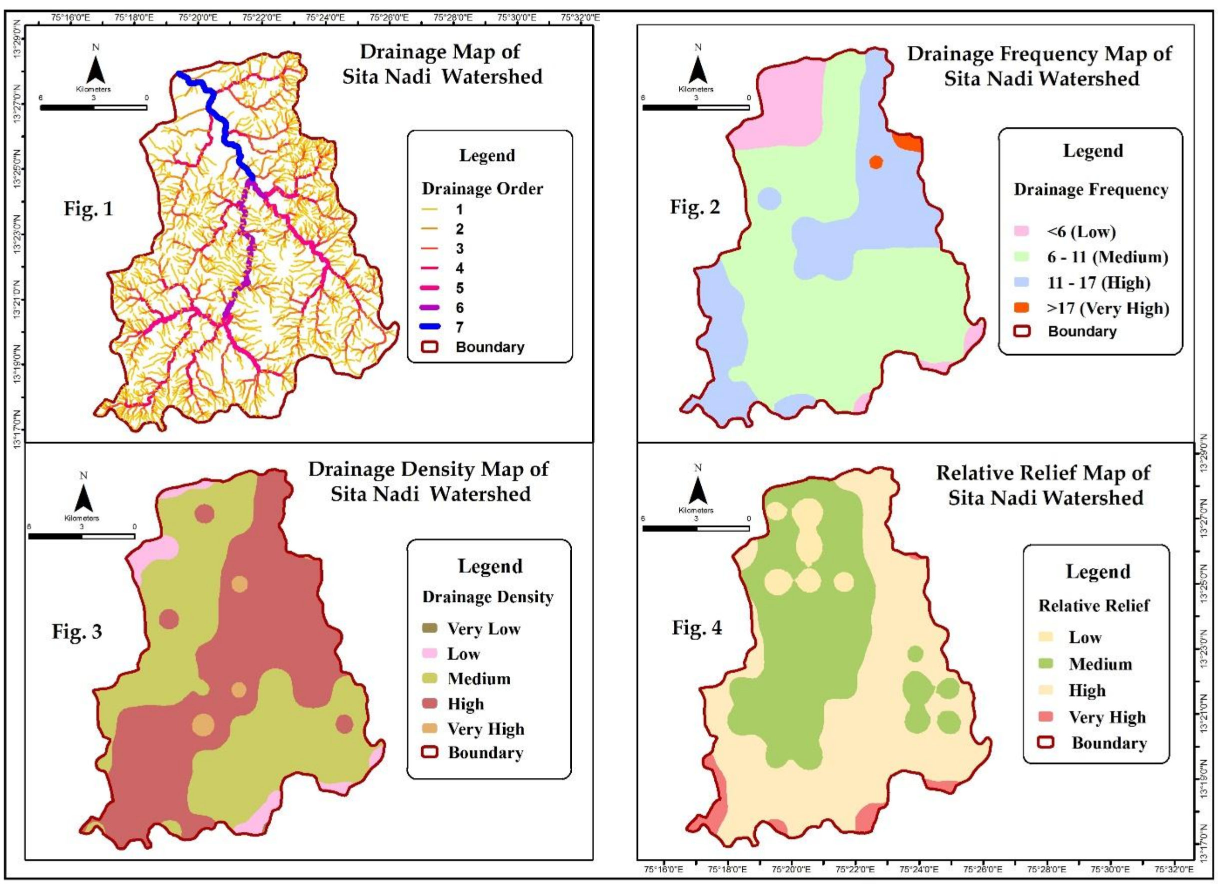
Range	Area in Km^2	%	Category
0-2	0.13	0.06	Very low
2-4	9.59	4.26	Low
4-6	107.55	47.89	Moderate
6-8	104.90	46.62	High
8-10	2.64	1.17	Very high
Total	224.81	100.00	-

4.3 Relative Relief (RR)

The term relative relief means the actual variation of height i.e., different between maximum height and minimum height per grid is termed as relative relief (Schumn, 1956), it is useful in analysing landforms. The relative relief in the study area has been categorised into four classes based on the range, in which majority of the area is covered by high relative relief about 117.74 km^2 i.e., in the western part covered by Western Ghats as shown in Fig 4. In the northern part, covered by moderate class, with an area 89.63 km^2 and the rest other classes are shown in Table 4.

Table 4. Area statistics of Relative Relief in Sita Nadi Watershed

Range in Meters	Area in Km^2	%	Category
0-40	10.14	4.50	low
40-80	89.63	39.83	moderate
80-200	117.74	52.32	high
200-649	7.30	3.35	Very high
Total	224.81	100.00	-



International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 14
November 2017

4.4 Dissection Index (DI)

Dissection index is a parameter implying the degree of dissection or vertical erosion and expounds the stages of terrain or landscape development in any given physiographic region or watershed (Singh and Dubey 1994). The dissection index varies from 0 to 1 and in the given basin it varies from 0.06 to 0.41 suggesting fairly high degree of dissection. The Sita Nadi watershed is moderate to highly dissect in nature; with low dissection value occupies an area of 5.33 km^2 and high with 48.60 km^2 respectively as shown in Table 5. The southern and north eastern part are highly dissected, whereas, the terrain in the north western part are moderately dissected as shown in Fig 5.

Table 5. Area Statistics of Dissection Index in Sita Nadi Watershed

Range	Area in Km^2	%	Category
0.06-0.10	0.014	0.0062	Low
0.10-0.20	48.47	21.63	Moderate
0.20-0.30	109.35	48.60	High
0.30-0.41	66.98	29.76	Very high
Total	224.81	100.00	-

4.6 Slope

The slope, defined as loss or gain in altitude per unit horizontal distance in a direction, may be calculated by various methods. The slope (average slope) map prepared based on the Wentworth's formula (1930). By using the slope values of grids isopleths are drawn with an interval of 5^0 as shown in Fig 6**.** The average slope increase from $<5^0$ in the north to $>20^0$ on the southern side of the basin, the north western part of the basin is characterized by slope values less than 10^0. The southern end, central parts and area runs from south to north eastern parts are typically a terrain of high slope values (15 - 25^0).

Table 6: Area Statistics of Slope in Sita Nadi Watershed

Range (in Degree)	Area in km^2	%	Category
0-5	0.09	0.17	Very low
5-10	32.10	14.26	Low
10-15	76.01	33.78	Moderate
15-20	67.11	29.89	High
20-25	49.5	21.9	Very high
Total	224.81	100.00	-

4.7 Erosion Proneness

The geomorphic character such as relief of the tropics and sub-tropics is the major factor for the accelerated erosion, Soil erosion hazard maps can be an essential tool in erosion prone areas as they explain and display the distribution of hazards and areas likely to be affected to different magnitudes. Therefore, it is very useful to planners and policy makers initiating remedial measures and for prioritizing areas. In the present study the technique involving the interpretation of the thematic maps has been used to access the erosion proneness of the terrain. This method has been used because of its practical feasibility. This method envisages the general assessment of erosion proneness and the spatial distribution of erosion prone areas. Basic procedures are as follows:

1. Evaluation of the density distribution of source and junction points of streams of all orders.
2. Preparation of the average slope map of the area.

Superimposition of the maps emerging from the above two steps as a way of integration. To delimit the erosion prone areas of various degrees based on the combination of slope grades and the number of streams, the following classification has been used as shown in Table 7.

Table 7. Scheme of Erosion proneness Index (after Chattopadhyay et al., 1985)

Grades of Slopes	Density of source and Junction points (Numbers/km^2)			
	<6	6-11	12-17	>17
>25	H	VH	VH	VH
20-25	H	H	VH	VH
15-20	M	M	M	M
10-15	L	L	L	L
05-10	VL	VL	L	L
<5.0	VL	VL	VL	VL

VH – Very high erosion proneness; **H** – High erosion proneness, **M** – Medium erosion proneness; **L** – Low erosion proneness, **VL** – Very low erosion proneness

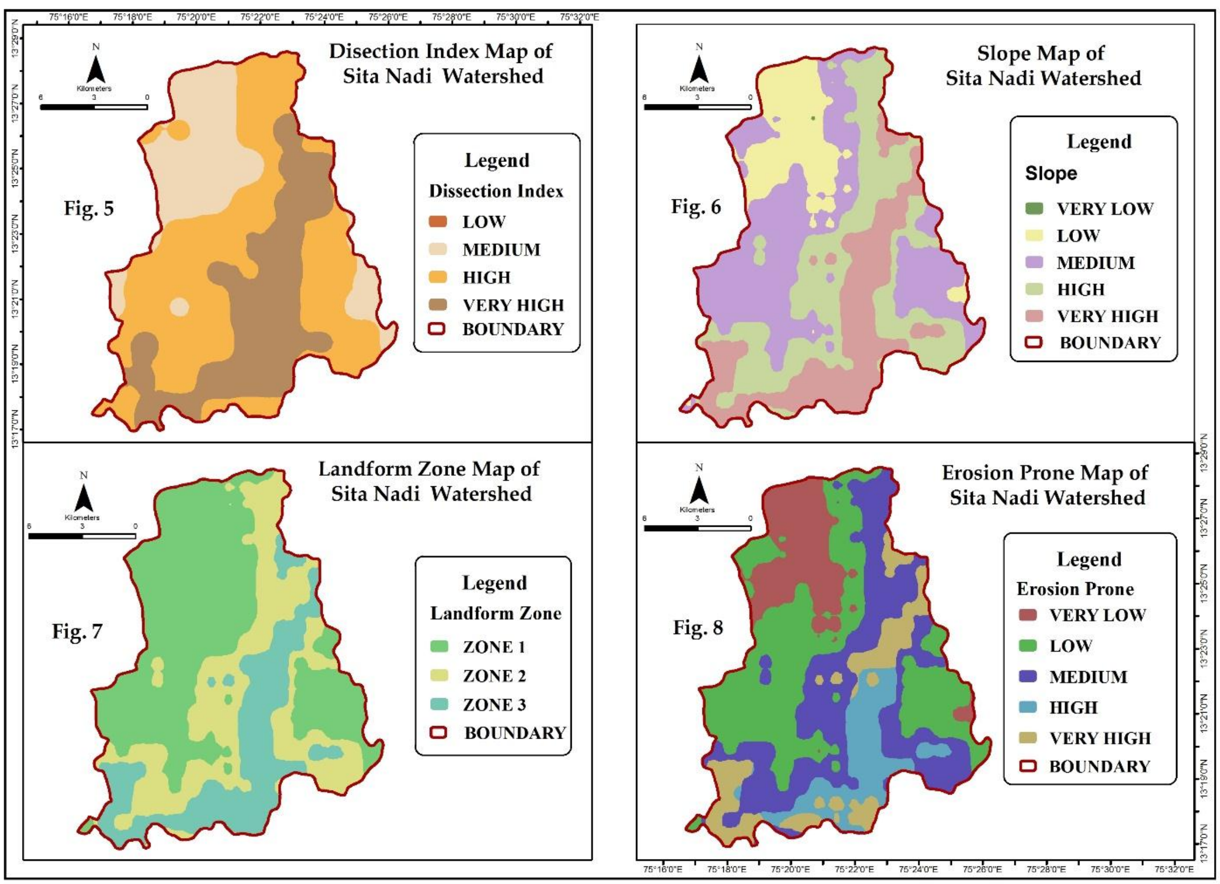
From the Fig 8, it can be seen that about 22 % of the basin area is high to very high prone to erosion because the area being hilly terrain, the drainage density, frequency, relative relief, dissection index, slope of this area is very high. The area coverage of moderately prone to erosion is 30% and rest 48 % of the area is less prone to the erosion as this is a plain terrain and

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 14
November 2017

the values of drainage density, frequency, relative relief, dissection index, slope is low.

Table 8: Area statistics of Erosion proneness in Sita Nadi watershed

Erosion Prone Index (EPI)	Area in km^2	%
Very Low	31.32	13.92
Low	76.85	34.18
Moderate	67.11	29.86
High	24.08	10.71
Very high	25.45	11.33
Total	224.81	100.00



5. Conclusions

Erosion proneness map is prepared by using the geomorphologic and multi criteria overlay analysis techniques. Based on the analysis of geomorphic parameters, the basin has been divided into three major landform zones as shown in Fig 7. The Zone I is classified as low erosion prone area because of plain topography, which extends from north to north west, Zone II extends from north east to south west, classified as moderate erosion prone area because of undulating terrain and Zone III is high prone to erosion covering southern part, which is a dissected hilly terrain and the criteria for classification is shown in Table 9. The results can be utilised for achieving sustainable LULC development, slope management studies with soil conservation methods like social forestry, silvi pasture and boulder checks.

Table 9: Landforms Zone classification of Sita Nadi Watershed

Landform Zones	Drainage Density	Drainage Frequency	Relative Relief	Dissection Index	Slope in degree	Erosion Proneness	Area in km^2
Zone I	0 - 4	0-6	0 - 40	0.06 – 0.10	0 - 10	Low	108.15
Zone II	4 - 6	6 - 11	40 - 80	0.10 – 0.20	10 - 15	Moderate	67.11
Zone III	6 - 10	>11	80 - 649	0.20 – 0.41	15 - 25	High	49.54

6. Acknowledgement

Authors would like to thank the Chairman and all faculty members for their support and to utilize the facilities in the Department of Applied Geology, Kuvempu University, Jnanasahyadri, Shankaraghatta-577 451.

7. References

[1] Hortan.R.E. (1932) Drainage Basin Characteristics. Trans. Amer. Geophy., Union. V.13. pp.350-361.

[2] Horton.R.E (1945) Erosional development of Streams and their Drainage Basins. Bull. Geol. Soc. Amer. V. 56. No. 1, pp.275-370.

[3] Judson, S. (1965). Physical Geology. Prentice Hall. NJ, USA. 3rd Edition, pp. 143-144.

[4] Jain, M. K. & Kothvari. U. C. (2000) Estimation of soil erosion and sediment vield using GIS. Hydro! Sei. J. 45(5) 771-786.

[5] Nag SK (1998). Morphometric analysis using remote sensing techniques in the Chaka sub-basin purulia district, West Bengal." J. Indian. Soc. Rem. Sens., 26: 69–76.

[6] Nir, D. 1957. "The Ratio of Relative and Absolute Altitude of Mt. Carmel." Geographical Review 27: 564-569.

[7] Schumn SA (1956) Evolution of drainage systems and slopes in Badlands at Perth Amboy. New Jersey. Geol Soc Am Bull 67:597–646.

[8] Strahler, A.N., (1969) Physical Geography. John Wiley and Sons, Inc., New York, pp. 361-376.

[9] Singh, S., and Dubey, A. (1994). Geo-environmental planning of watersheds in India, Allahabad, India: Chugh Publications, 28 (A), 69.

[10] S.K. Jain, M.K. Goel, Assessing the vulnerability to soil erosion of the Ukai Dam catchments using remote sensing and GIS. Hydrol. Sci. J. 47(1), 31–40 (2002)

[11] Wentworth, C.K. (1930): A Simplified method of determining the average slope of land surface. America Journal of Science, Series 5(Newhaven Connecticut), 20: 184-190