

Research Article

## Environmental Impact Assessment (EIA) and Assessment of Soil Loss in Sandur Taluk due to Mining Activity in and Around Bellary District, South India

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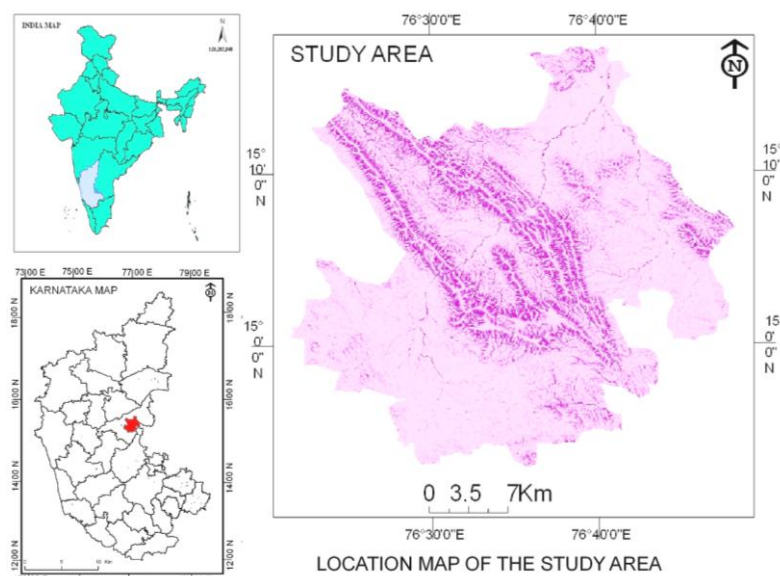
**Abstract** The catchment boundary of Sandur Taluk covers an area about 1254.02 sq km. It is well known for repository of Iron and manganese ore mineralization, more than hundred mining companies were operated within the Sandur Taluk and majority of hillocks have undergone by mining activity. The Sandur Taluk is affected by excavation of Iron ore. An attempt is made to Environmental Impact Assessment (EIA) by attributing various parameters like Land Use Land cover, Soil, Geomorphology, and catchment boundary etc., The erosion is a natural geomorphic process occurring continually over the earth's surface and it largely depends on topography, vegetation, soil and climatic variables and, therefore, exhibits pronounced spatial variability due to catchments heterogeneity and climatic variation. This problem can be circumvented by discrediting the catchments into approximately homogeneous sub-areas using Geographic Information System (GIS). Soil erosion assessment modeling was carried out based on the Revised Universal Soil Loss Equation (RUSLE). A set of factors are involved in RUSLE equation are A = Average annual soil loss (mt/ha/year), R = Rainfall erosivity factor (mt/ha/year), k = Soil erodibility factor, LS = Slope length factor, C = Crop cover management factor, P = Supporting conservation practice factor. These factors extracted from different surface features by analysis and brought in to raster format. The output depicts the amount of sediment rate from a particular grid in spatial domain and the pixel value of the outlet grid indicates the sediment yield at the outlet of the watershed.

**Keywords** *GIS; revised universal soil loss equation; soil erodibility; slope length factor; spatial analyst*

### 1. Introduction

Karnataka has a great history of mining activity that dates back to prehistoric times. In 1991 annual production of Iron ore between 2.75 to 4.5 million tones manganese ore between 0.13 million tones to 0.3 million tones. Now it has reached up to 150 MTPA (million tons per annum) by means of mechanized method. However the Sandur schist belt mining industry is facing increasing environmental pressure and regulatory controls. Whole regions are affected and in some cases devastated by the results of mining activities, and also by the more recent industrialized phase of mine development. The natural ecosystem of Sandur schist belt environments is extremely sensitive to human interference. The soil loss results in the decrease of arable land and its quality by

depleting the top fertile soil and thereby affecting the land productivity as a whole (Pal and Samanta, 2011). Estimation of soil loss from a place is necessary to measure sediment deposition in any area (Bali and Karale, 1977). Linkage of GIS and erosion is made possible by the spatial format in which RUSLE factors are presented (Yitayew et al., 2007). The most common and effective method such as universal soil loss equation (USLE) by (Wischmeier and Smith, 1978) is investigated to construct soil erosion modeling in study area through spatial analysis tool in ArcGIS 9.2. The USLE algorithm widely accepted method to estimate soil loss at catchment scale (Jain et al., 2001). Erosion Models are helpful for evaluating the Impact of land use practices on soil losses, and are increasingly being used for establishing guidelines and standards for regulation purposes (Croke and Nethery, 2006). Coupling GIS and USLE/RUSLE has been shown in many cases to be an effective approach for estimating the magnitude of soil loss and Identification spatial locations vulnerable to soil erosion (Lim et al., 2005; Fu et al., 2006; Wachal, 2007). The USLE model actively involved in Raster grid in GIS environment to compute various parameters such as R factor, P factor, Ls factor and K factor, etc., The technology of remote sensing and GIS is gaining importance as a powerful tool in the management of information in agriculture, natural resources assessment, environmental protection and conservation.



**Figure 1: Study area location**

### 1.1. Geographical Location

The area, study area falls under parts of Survey of India toposheets, 57 A/8, A/12, A/16 and 57 B/9, between the latitudes 15° 00' N and 15° 15' N and 76° 20' E and 76° 55' E. The study area is well known for its Iron occurrences and there are several operating open pit mines and abandoned Manganese open pits are located in the area. The lowest elevation is 625m above the MSL and the highest elevation 997m above the MSL. Covers an area of 1224.91 sq km, within the Dharwar craton (Figure 1).

### Physiography and Drainage System

The study area lies in the Krishna Drainage system and the area exhibits dendritic drainage pattern (Figure 2). The Naarihalla stream flows along its north-eastern part of the Taluk. The Hire halla stream, later which joins the Kanigana halla, one of its right bank tributaries and a big stream itself, mark the eastern boundary of the Taluk. Both these major streams flow towards the north-east. The natural drainage of the Taluk is diverted in the opposite directions into these streams, the Naari halla

sharing about 75 percent of the water of the Taluk. The tributaries of the Hire halla and Kanigana halla flowing in the Sandur Taluk are Sige halla.

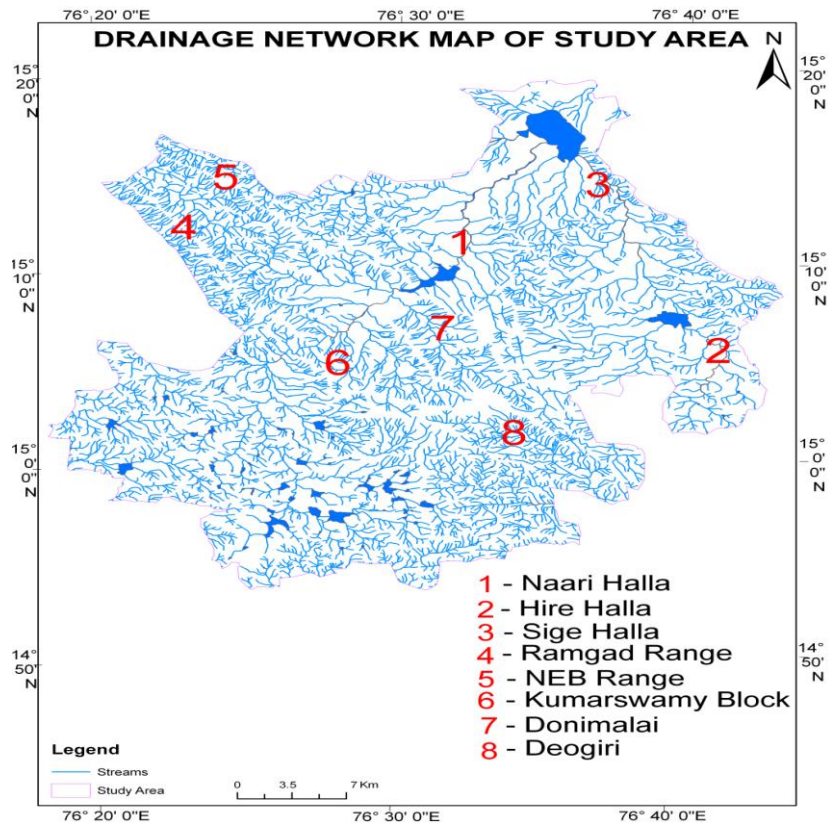


Figure 2: Drainage system of study area

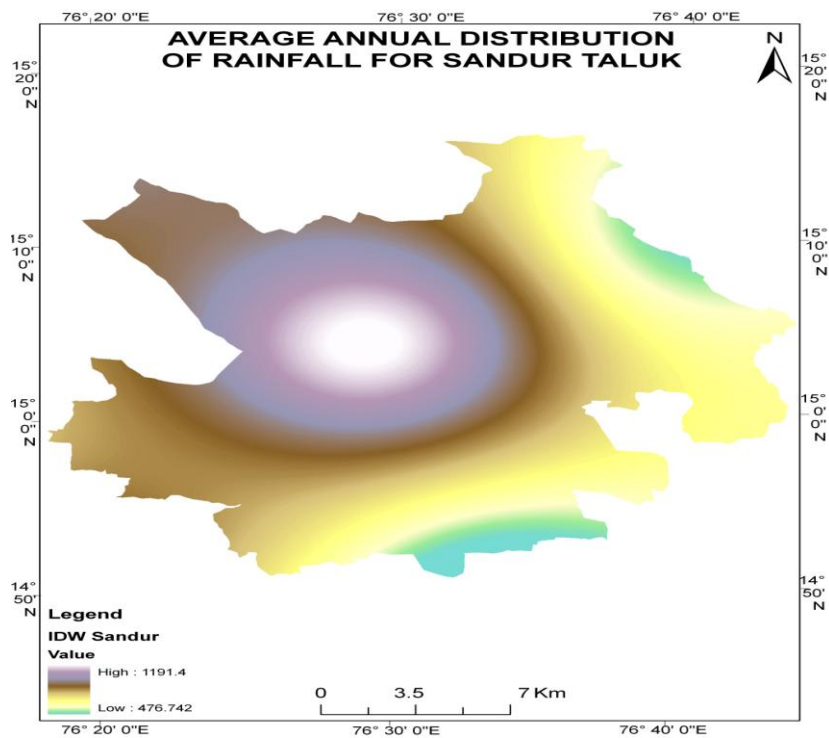


Figure 3: Spatial distribution of rainfall

### Spatial Distribution of Rainfall

Spatially, Rainfall level is varies place to place. The average annual rainfall is 600 mm and the maximum and minimum rainfall level is varying from 400 mm to 600 mm in monsoon. A sub-tropical climatic condition is favorable in this region. The central part of the Taluk is structured by hillocks and mountain ranges covered by thick vegetation. Central part of the Taluk receives high rainfall when compared to other parts of the Taluk whereas South and South Eastern part of the Taluk receives low rainfall (Figure 3).

## 2. Methodology

Soil erosion assessment is done by using Geographical Information System (GIS) based on the Revised Universal Soil Loss Equation (RUSLE). A set of factors are involved in the RUSLE to assess the soil loss in watershed. The RUSLE can be done by following the equation,  $A = R \times k \times LS \times C \times P$  where,  $A$  = Average annual soil loss (mt/ha/year),  $R$  = Rainfall erosivity factor (in  $t / ha / year$ ),  $k$  = Soil erodibility factor,  $LS$  = Slope length factor,  $C$  = Crop cover management factor,  $P$  = Supporting conservation practice factor. The equation groups the numerous interrelated physical and management parameters that influence the erosion rate under six major factors, of which site specific values can be expressed numerically (Singh et al., 1981).

### 2.1. Calculation of Rainfall Erosivity Factor (R factor)

The rainfall erosivity factor (R factor) represents the erosion potential caused by rainfall (Renard et al., 1997). The capacity of the rain to remove soil particles is one of the most important parameters in the RUSLE as this is a quantitative factor expressed in tone/hectare/year. The evaluation of  $R$  is given as,  $R \text{ factor} = 79 + 0.363 * r$ , where  $r$  = Mean annual rainfall (mm). The mean annual rainfall data from three rain gauge station located at different place in study area which spatially interpolated using Kriging method of spatial analyst tool in ArcGIS 9.2 software. Here the value high represents intensity of rainfall within the Taluk.

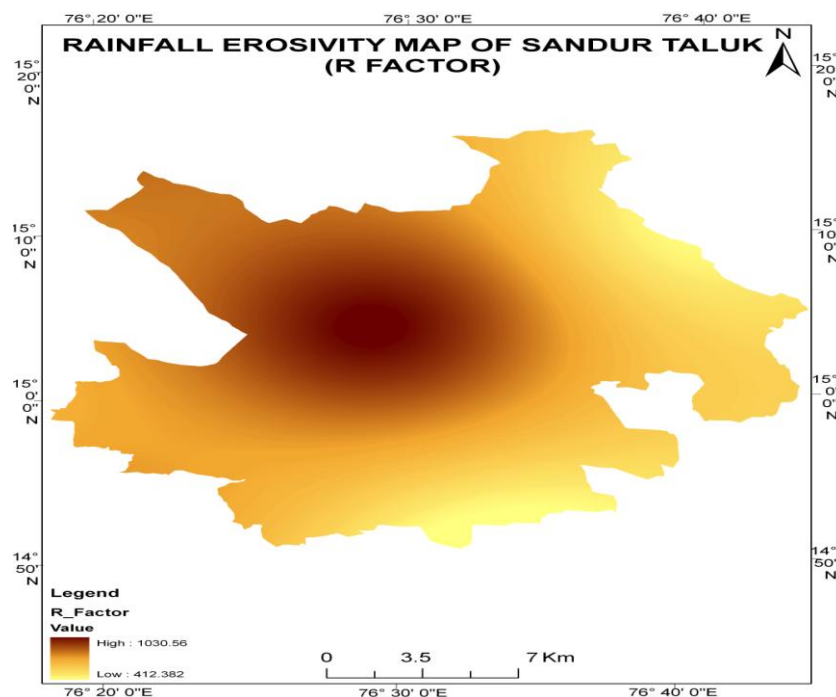


Figure 4: R-Factor

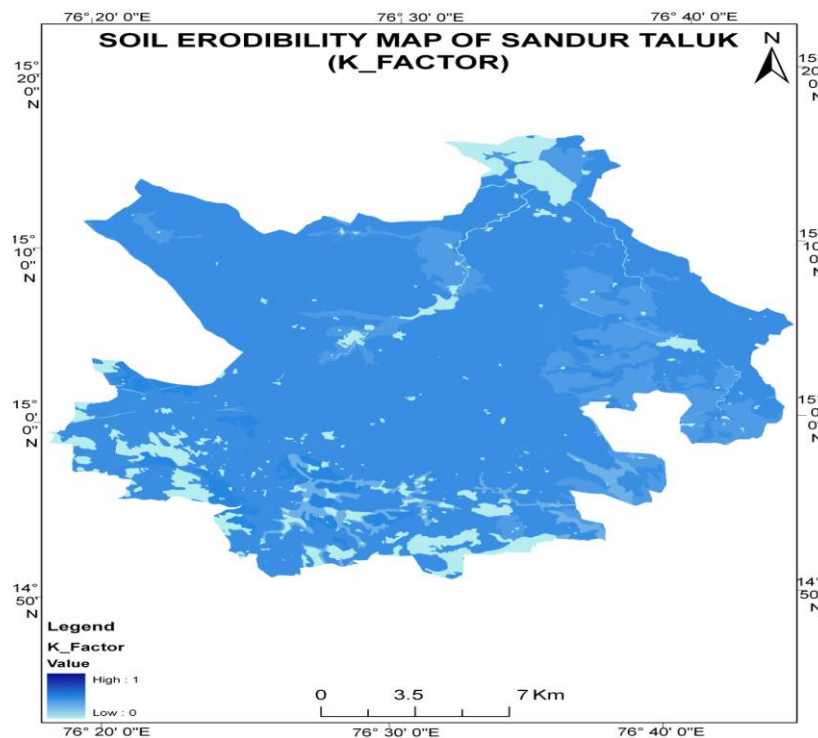


Figure 5: K-Factor

## 2.2. Calculation of Soil Erodibility Factor (K factor)

It is a measure of soil susceptibility to detachment and transport, by the erosion agents of the soil particles. The variation of K factor over the study area is shown in Figure 4. This is estimated by using the formula,  $K = 2.8 \times 10^{-7} M^{-1.14} (12 - a) + 4.3 \times 10^{-3} (b-2) + 3.3 \times 10^{-3} (c-3)$ , where, K = Soil erodibility factor, M = Particle size parameter (% silt + % very fine sand) x (100 - % clay), a = % of organic matter, b = Soil structure code (very fine granular 1; fine granular 2; medium or coarse granular 3), c = Profile permeability class (rapid 1; moderate to rapid 2; moderate 3; slow to moderate 4; slow 5; very slow 6).

From the soil reports of the study area, the above parameters are computed for various types of soil in the study area and the K factor values calculated by inputting the above parameters and transformed in to Raster grid format by determining each pixel with K-Factor value. Lower values represent detached suspended soil sediment particles collected in surface water bodies.

## 2.3. Calculation of Slope Length Factor (LS factor)

Estimation of LS factor poses more problems than any other factors in RUSLE and it is a particular problem in applying to real landscape as part of a GIS. Data on aspect, land use and slope maps are overlaid to map the slope length. The LS factor of the study area is shown in (Figure 6) L and S are treated as combined factor to find the LS factor,  $LS = (n+1) \times (As / 22.13)^n \times (\sin \beta / 0.0896)^m$ , where, LS = Slope length factor, n = 0.4 (a constant),  $\beta$  = Local slope angle, m = 1.3 (a constant), As = Contributing area.

It is known that the amount of runoff increases due to the continuous accumulation down the slope as the slope length (L factor) increases; the velocity of runoff increases as the slope steepness (S factor) increases (Kim, 2006). Here the map shows north-west and south-east part of the Study area represents high slope steepness, where the erosion rate will be more.



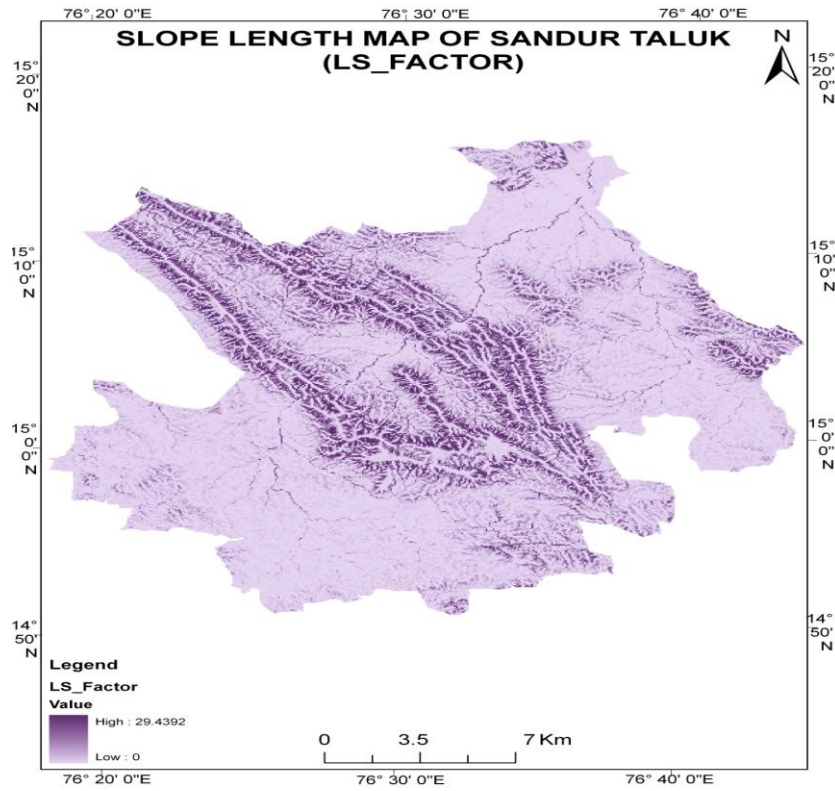


Figure 6: *LS-Factor*

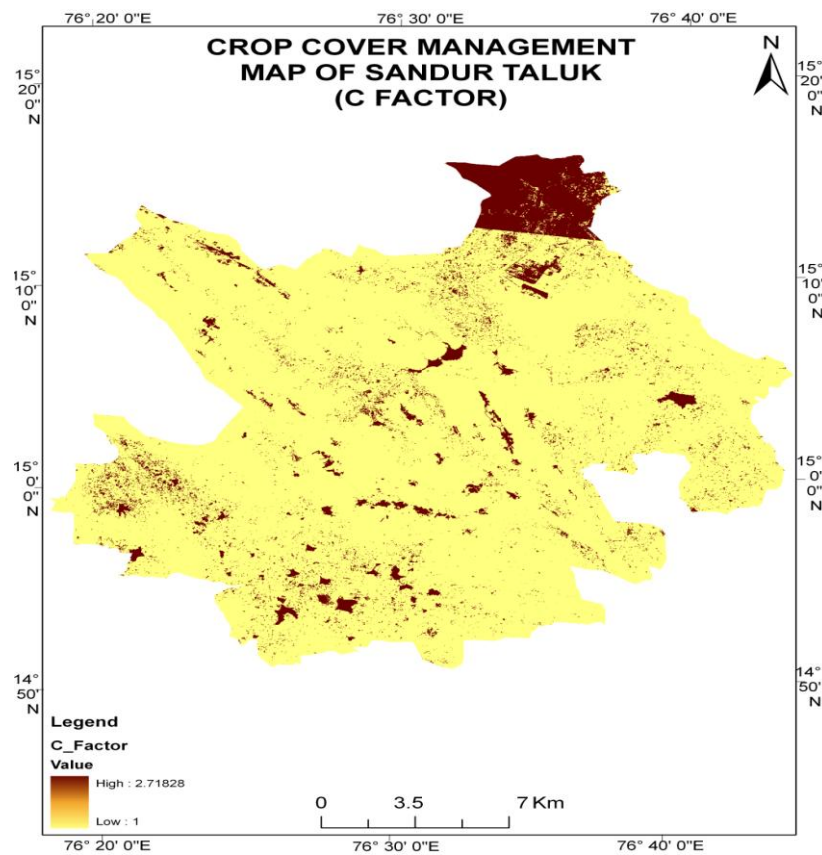


Figure 7: *C-Factor*

## 2.4. Calculation of Crop Management Factor (C factor)

This expresses the role of plants and of their management techniques on the water. The crop management factor includes the effects of crop cover, crop sequence and productivity level, length of growing season, tillage practices, residual management and expected temporal distribution of erosive rainstorms.

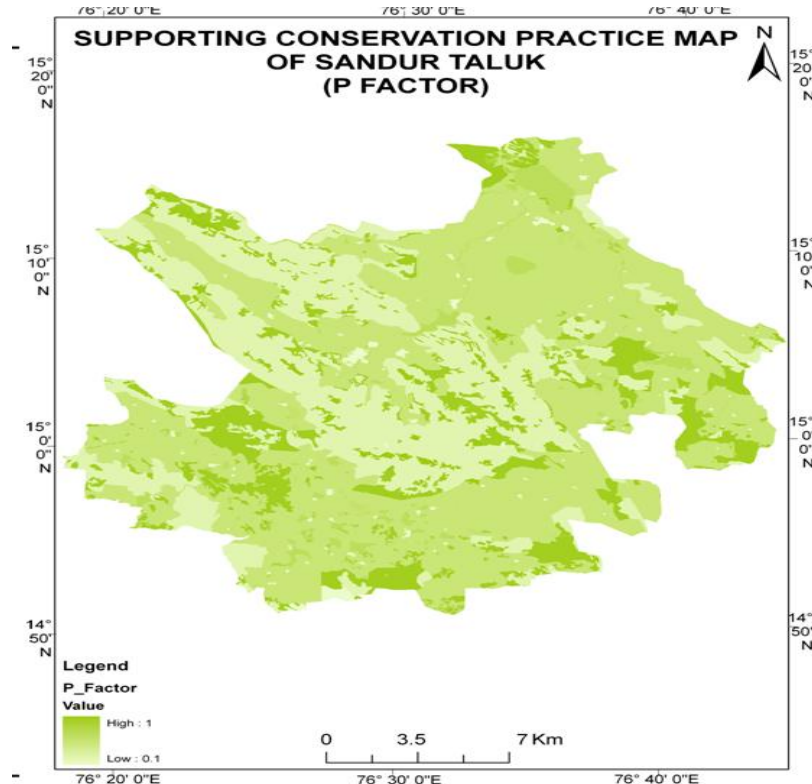


Figure 8: P-Factor

Table 1: Mean of coefficient of P factor

| Land use          | % Slope | P Factor |
|-------------------|---------|----------|
| Agricultural land | 0-5     | 0.11     |
|                   | 5-10    | 0.12     |
|                   | 10-15   | 0.14     |
|                   | 15-30   | 0.19     |
|                   | >35     | 0.25     |
| Waste land        |         | 1.00     |
| Forest categories |         | 0.8      |
| Grassland         |         | 0.10     |
| Built-up areas    |         | 0.00     |
| Water bodies      |         | 0.00     |
| Fallow land       |         | 1.00     |

## 2.5. Calculation of Conservation Practice Factor (P factor)

The effect of watershed management or conservation practices depends on the changes induced on manifold factors such as flow speed, surface roughness, infiltration etc., The standard values of particular soil estimated by calculating its means of co-efficient as in Table 1. According to the

values given in table, the map shows high erosion intensity and low erosion intensity in the study area. The bright colored are represents hillocks contributed to high erosion.

## 2.6. Estimation of Soil Loss using RUSLE Equation

The factors and parameters of soil loss estimation (RUSLE) equation have been analyzed in Spatial Analyst Tools of Arc GIS 9.2. The 3D Analyst Tool used to create the layers of R, K, L, S and P factors. As per the RUSLE algorithm, each raster grid of R, K, LS, C and P factors are multiplied to estimate the soil loss per hectare / year in the unit of Metric tons. The analysis spatially carried out to detect intensity of soil erosion in every parcel of grid. The output layer brought in to reclassification to categorize the area in to severe, moderate and less based on intensity of soil erosion.

## 3. Conclusion

In this study, the Geo-Statistical algorithm of RUSLE equation investigated to measurement of soil loss in the study area. This makes understanding on GIS capability in soil loss modeling. Estimation of soil loss is prim factor to compute sediment yield in watershed and catchment level studies. Spatially computed soil removal from most of the catchment area is estimated to 0.0052 MT/Ha/year to 0.43 MT/Ha/years. However, the range of sediment yield is depending upon the soil loss in and around the area. Deposition of sediment resulted at grids of the water bodies occurred with different level, the transportation of sediment depending on soil characteristics and slope condition. This is considerably primary study carried out to finding the changes of water resources in the study area, this may effective input for future study regarding to this analysis. The volume of each grid considers estimating the amount of soil loss in an area. As the result of soil loss estimation from the study area, there are following places were detected with severe soil erosion such names are Ramagad forest block, Devagiri hills, Northern parts of Donimali Village, North Eastern Block (NEB) hills and middle eastern parts of the Taluk including Tarangar village and Bommagatta village. The water tanks are highly affected in these areas due to deposition of sediment continuously.

## References

- Bali, Y.P. and Karale, K.L. 1977. A sediment yield index as a criterion for choosing priority basins. *Erosion and Solid Matter Transport in Inland Waters*, Paris, pp.180-188.
- Croke, J. and Nethery, M. 2006. Modeling runoff and soil erosion in logged forests: scope and application of some existing models. *Catena*, 67, pp.35-49.
- Fu, G., Chen, S. and McCool, D.K. 2006. Modeling the impacts of no-till practice on soil erosion and sediment yield with RUSLE, SEDD, and Arcview GIS. *Soil and Tillage Research*, 85, pp.38-49.
- Jain, S.K., Kumar, S. and Varghese, J. 2001. Estimation of soil erosion for a Himalayan watershed using GIS technique. *Water Resources Management*, 15, pp.41-54.
- Kim, H. 2006. Soil Erosion Modeling using RUSLE and GIS on the IMHA Watershed, South Korea.
- Lim, K.J., Sagong, M., Engel, B.A., Tang, Z., Choi, J. and Kim, K. 2005. GIS - based sediment assessment tool. *Catena*, 64, pp.61-80.
- Pal, B. and Samanta, S. 2011. Estimation of soil loss using remote sensing and geographic information system techniques (Case study of Kaliaghai River basin, Purba & Paschim Medinipur District, West Bengal, India). *Indian Journal of Science and Technology*, 4(10), pp.1202-1207.



Renard, K.G., Foster, G.R., Weesies, G.A., McDool, D. and Yoder, D. 1997. Predicting soil erosion by water: a guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). *Agricultural Handbook 703*, USDA-ARS.

Singh, G., Chandra, S. and Babu, R. 1981. Soil loss and prediction research in India. Central Soil and Water Conservation Research Training Institute, Bulletin No. T-12/D9.

Wachal, D.J. 2007. Integrating GIS and erosion modeling: a tool for watershed management. *ESRI - International User Conference*, Paper No. UC 1038.

Wischemier, W.H. and Smith, D.D. 1978. Predicting rainfall erosion losses-a-guide to conservation planning. *Agricultural Handbook No. 537*, Washington DC, USA.

Yitayew, M., Pokrzywka, S.J. and Reward, K.G. 2007. Using GIS for facilitating erosion estimation. *Journal of Applied Engineering in Agriculture*, 15(4), pp.295-301.