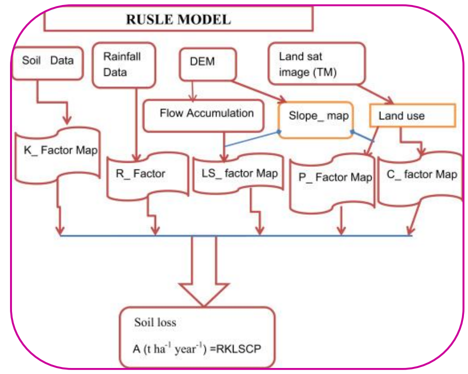
REVIEW OF RESEARCH

IMPACT FACTOR : 5.2331(UIF) UGC APPROVED JOURNAL NO. 48514 ISSN: 2249-894X

VOLUME - 7 | ISSUE - 9 | JUNE - 2018

SOIL LOSS ESTIMATION OF BHATGHAR RESERVOIR BY RUSLE MODEL USING REMOTE SENSING AND GIS TECHNIQUE



Suhas Kamble[1] and D.M. Wankhede[2]

[1]Research Scholar,Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur.

[2]Associate Professor,Department of Geography, Govt. Vidarbha Institute of Sciences and Humanities, Amravati.

ABSTRACT :

Estimation of soil loss for the bhatghar reservoir helps to finding the spatial distribution of soil erosion in Bhortaluka of Pune district in Maharashtra. In the present study using Shuttle Radar Topographic Mission (SRTM) data, RS-GIS technique, and the soil loss model, Revised Universal Soil Loss Equation (RUSLE) has been used to estimate soil loss in bhatghar reservoir catchment area. RUSLE factors (A = RKLSCP) multiplied together to calculatesoil erosion rates, and to generate soil erosion risk categories and soil erosion severity maps with the help of raster calculation in GIS tool. The results indicate that the distribution of soil erosion risk classes show that catchment has minimal soil loss is 73.98% ,low is 4.29%, moderate and severe is 1.24% and 1.95%, and extreme soil erosion occupies 18.54% of the catchment. The soil erosion severity zone map indicates that the 73.98% of the study area comes under very low and 19.22% area comes under very high severity zone. The spatial variance in surface erosion is recorded due to variation in rainfall, topography and morphological changes, variety of soil type and characteristics and anthropogenic disturbances. Hence from the present study, the applying techniques are doing vital role in realizing the soil loss of reservoir.

KEYWORDS : *Soil erosion, RUSLE, GIS, RS, SRTM, BhatgharReservoir.*

1. INTRODUCTION:

Deterioration of soil layer under gradual mechanical processes like runoff is termed as soil erosion. The soil erosion process is physical and biophysical in nature depending on nature of soil, climate, terrain, land use land cover and their interactions between them. Topographical factors that govern these processes are slope, length and shape. The most significant role is played by slope in runoff mechanism. More the slope, more the runoff velocity and thus reduces infiltration rate. The runoff creates from slope will find a pathway nearby and this would direct to erosion of soil as the velocity of the runoff increases. Erosion is a usual physical, biological, environmental. ecological geological, and geographical occurrence resulting from the deduction of soil particles by stream or storm, transporting them in another place, even as some human actions such as agricultural practice, renovation of forest to cultivation etc. would raise erosion rates. The severity of the soil erosion problem can be observer by accumulation of 10 to 15 centimeters at soil layer behind newly constructed walls in particular period. Soil erosion is one of the most important environmental concerns for nation like India, which carries 80% of rural population of its total population engaged in agricultural activities. Siltation of reservoirs due to soil erosion is a major problem in India has effect on the agricultural sector,degradation of soils, etc.

Loss of rich surface soil, raise in runoff from impermeable subsoil and reduce in accessibility of water to vegetation are all resultant causes originating from process that is termed as soil erosion, which hasten degradation of agricultural land. Compilation of data base for determination of Soil loss and identification of vulnerable area of erosion play significant role of preventive measures of soil erosion. E.g. Vegetation cover and rate of soil erosion are inversely proportional (Gyssels et al., 2005). Focusing on our country India, a large piece of land about 130 million hecters is seriously damaged by soil erosion which accounts for about 45% of total land avaliable (Kothyari, 1996). The major dynamics initiating sedimentation in reservoirs and river bed resulting in loss of soil fertility is soil erosion.

In the present study using soil loss model, Revised Universal Soil Loss Equation (RUSLE) and Shuttle Radar Topographic Mission (SRTM) data, RS-GIS technique has been used to estimate soil loss in bhatghar reservoir area. The aim of the present study is to understandthe soil loss from catchment area of bhatghar reservoir in pune district

2. STUDY AREA:

The Bhatghar reservoirlocated among the beautiful Western Ghats and falls under the Bhortaluka of Pune district in Maharashtra.Bhoris located midway between Satara and Pune and falls on NH 4 Dam can easily be accessed from Pune. It is about 50 Km by road where first impounding started in the year 1927. It is a multipurpose major project constructed on river yelwandi in sub-basin Kannad and basin Nira. Bhatghar Reservoir is located at 18^0 10’30”Latitude and $73^0$52’12.50” Longitude at village Bhatghar. Following map shows the location and extent of the study area. Total catchment area of the reservoir is 274.33sq km. Catchment has yearly average rainfall as 1000mm.

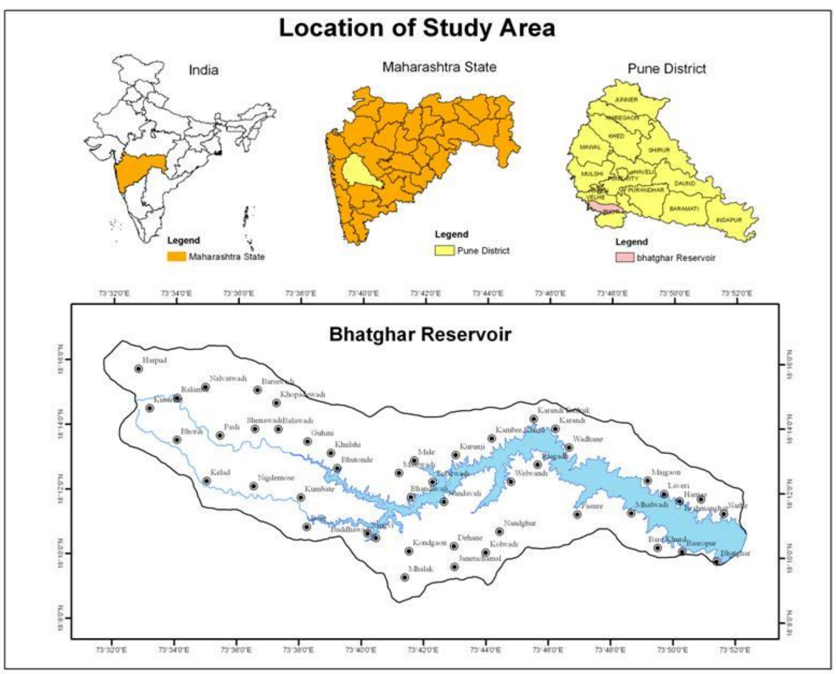


Fig no.1: Location map of Study Area

3 METHODS AND MATERIALS

The Revised Universal Soil Loss Equation (RUSLE) is considered an alternative and enhanced version of the original USLE model. (K. G. Renard et al., 1997). RUSLE fundamentally achieved the same observation principles and basic arrangements as the USLE model. It is applicable to more precise methods for estimating rainfall erosivity (R), soil erodibility (K), slope length and steepness (LS), land cover management (C) and conservation practice (P) factors.

The RUSLE model equation is expressed as:

A = R X K X LS X C X P .... .Eq. 1

Among them, A = soil loss per unit area [tons • ha-1 • year-1], R = runoff erosion coefficient, K = soil erodibility coefficient, L = slope length factor, S = slope steepness Coefficient, C = coverage management factor, P = support practice factor.

In this study, Arc GIS and related GIS software packages were used to calculate annual soil erosion rates and severity based on RUSLE in a GIS environment. Land use/coverage information obtained from 2011 LISS III satellite data (India-WRIS). The rainfall data used to calculate rainfall erosivity (R) was from Indian Metrological Department(IMD, India-WRIS) and soil data was from India-WRIS Web GIS Portal. SRTM data is used to prepare Digital Elevation Model (DEM) and slope map. The Survey of India (SOI) uses a 1:50000 ratioToposheet.

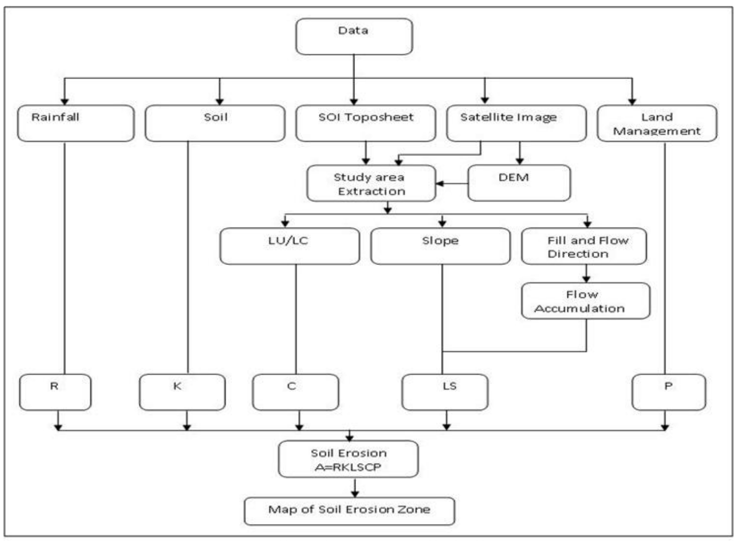


Fig.No.2 Flow chart of methodology

4. CALCULATION OF RUSLE FACTORS

4.1 Rainfall Erosivity (R)

The quantitative representation of erosivity of local average annual precipitation and runoff resulting in soil erosion is defined as Rainfall Erosivity (R), it is computation of erosive strength of a specific raifall. Higher 'R' factor exhibits more erosive weather conditions. R values are generally computed from isoerodent maps, tables or are calculated from historic data. (K.G Renard et al., 1997). In present study, rainfall data of 30 years average collected from Indian Meteorological Department (IMD) was used to calculate R values based on the equation developed by (Ram Babu et al. 2004). The fallowing equation used to compute R values:

R = 81.5 + 0.380P …………………Eq. 2

Where, R is the average annual erosion index, P is the average annual rainfall (mm).

R factor for the Bhatghar reservoir catchment was computed from available IMD gridded data, because the catchment has no record of daily rainfall intensity. In terms of GIS layers, spatial distribution of average annual rainfall (R) in the study area is estimated using Inverse Distance Weighted (IDW) interpolation method for assessing the spatial variability in the rainfall and rainfall erosivity in the catchment. In the process of interpolation, 30 years rainfall data for 8 grids in and around the study area were considered. In the study area the height rainfall occurred in western part and the lowest rainfall in the eastern part.

4.2 Soil Erodability Factor (K)

The soil vulnerability to detachment and moving of soil elements under an amount and rate of runoff for particular rainwater calculated under regular plot is termed as soil Erodability Factor 'K' The 'K' factor is scaled on scale from 0 to 1. Where '0' value indicates soil with minimum susceptibility to erosion and '1' value indicates soil highly susceptible to erosion by water. Despite of corresponding high content in the sand and clay fraction the soil becomes of stumpy erodability with minimum silt content. (P. Mhangara. et al., 2012).Nomograph is used to verify K factor for a soil, based on its texture; % silt plus very fine sand, % sand, % Organic matter, Soil structure, and permeability (Wischmeier and Smith, 1978). The K factor was calculated by the following equation:

$$K = 27.66m^{1.14} X\ 10^{-8} X\ (12-a) +0.0043X\ (b-2) +0.0033X(c-3) \ldots\ldots\ldots\ldots\ldots\ldots \text{Eq. 3}$$

Where: **K** = Soil erodibility factor ,**m** = (Silt% + Sand%) × (100 − clay%); **a** = % organic matter., **b** = structure code: 1) very structured or particulate, 2) fairly structured, 3) slightly structured, and 4) solid., **c** = profile permeability code: 1) rapid, 2) moderated to rapid, 3) moderate, 4) moderate to slow, 5) slow, 6) very slow. Categories of soil in the study area were recognized from the soil data. (India-WRIS. 2011) Fig.No.3

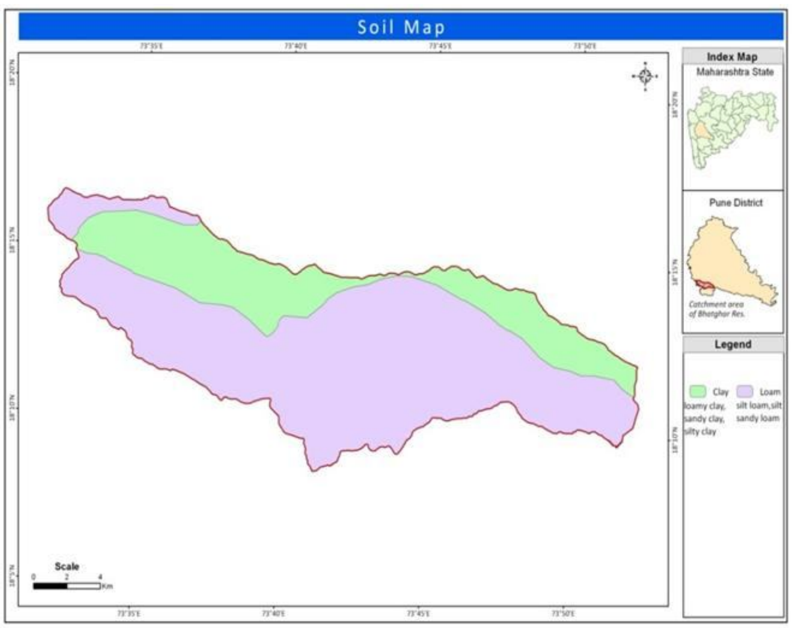


Fig.No.3 Soil Map

4.3 Slope Length and Steepness Factor (LS)

The effect of local topography on soil erosion rate is expressed as Slope Length (L) and Steepness Factor (S). It is observed that with increase in slope steepness there is increase in soil erosion causing increase in the velocity and erosivity of runoff. (D. Zregat 2013) fabricated supplementary precise method to calculate the LS factor to estimate soil erosion at regional landscape scale. In current study the Digital

Elevation Model (DEM) with a resolution of 30 m was used to calculate L and S parameters. The DEM was downloaded from SRTM web site. The following formula was adopted to calculate the LS factor.

$LS = [QaM / 22.13]^{y} \times (0.065 + 0.045 \times Sg + 0.0065 \times S^{2}g$…………………Eq. 4

Where:

LS = Topographical factor; Qa = Flow Accumulation grid; Sg = Grid slope in percentage; M = Grid size (X x Y), y = dimensionless exponent that assumes the value of 0.2 - 0.5

The changeable values of exponent m for different slopes depends on slope steepness, being 0.5 for slopes exceeding 4.5%, 0.4 for 3 - 4.5% slopes, 0.3 for 1 - 3%, and 0.2 for slopes less than 1%. (Wischmeier and Smith.1978). The slope map was created with the help DEM for the catchment as shown in (Fig.No.4)

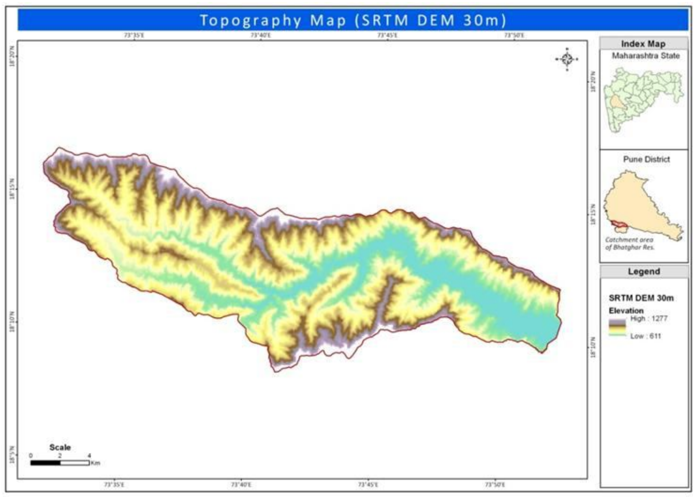


Fig.No.4 Digital Elevation Model (DEM) (SRTM 30m)

4.3.4 Crop Management Factor (C)

The protection of soil by cover type and density is represented in terms of Crop Management Factor (C).The relationship between erosion and exposed soil with that of erosion observed under cropping system is referred as Crop Management Factor (C). The crop management factor C is combination of three aspects firstly the plant cover, level of production and lastly the related cropping practices. The comparative impact of management alternative can simply be evaluated with making vary in the C- factor which varies from close to zero for a well-protected land cover to 1 for unproductive areas. Indian remote sensing (IRS) satellite data was used for extracting of ten land use-land cover classes using supervised classification method in ERDAS imagine software. The ground truth information was gathered with the help global position system (GPS). (Fig.No.5).

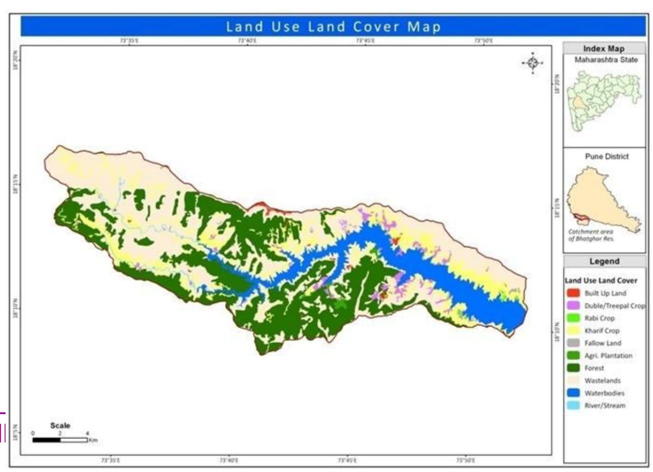


Fig.No.5 Spatial distribution of Land Use / Land Cover Map

4.3.5 Conservation Practice Factor (P)

The effect of conservation practices that minimize the quantity and rate of runoff water resulting into reduction of erosion is termed as Conservation Practice Factor (P).The same is computed as ratio of soil loss to that of specific support practice on croplands to the analogous loss with slope parallel tillage (A. Rabia, 2012). Techniques like Strip cropping, Contouring and terracing ect are included in conservation practice factor (P). The value of P factor ranges from 0 to 1, minimum value tending zero, indicates good conservation practice and the value trending towards 1 indicates poor conservation practice.

5.RESULTS AND DISCUSSION

In the present work soil erosion map was generated for bhatghar reservoir catchment, which corresponds to most of the topography characteristics of Western Ghats.With the help of GIS spatial analysis tools, estimate of soil loss from the RUSLE factors.(Fig.No.6).

5.1 Rainfall Erosivity (R)

The rainfall erosivity factor (R) for eight grids location was found to be in the range of 758.30 and 1302.57 tons/ha./yr(Fig.No.6). The distribution of R values assumed to be varied and consistent with annual precipitation across the watershed. The highest R values (1204.32 – 1302.57 tons/ha.yr) prevail in the upper catchment, and lowest R values (758.30 – 925.30 tons/ha.yr) prevail in the lower catchment.

5.2 Soil Erodability Factor (K)

K factor values were allocated to relevant soil category in soil map to create the soil erodibility map The map of K values for the whole catchment (Fig.No.6) shows a highest value is 0.4 in the lower and small upper catchment in southern part, particularly where silt loam and sandy loam soils are dominant. The lowest K value is 0.15 in the upper catchment present clay soils is dominant.

5.3 Slope Length and Steepness Factor (LS)

The influence of slope length and slope steepness on erosion process is represented by the topographic factor. LS factor was calculate using Eq. 4, in Arc GIS raster calculator. From the investigation, it is noted that the value of topographic factor increases in a range of 0 - 42 as the flow accumulation and slope increases. High LS values are connected with steep slopes greater than 20° - 30° and more than 30° slope category in the upper stream catchment. The low LS factor values connected with the middle and lower part of the catchment, basically major river and its tributary beds (Fig.No.6).

5.4 Crop Management Factor (C)

The spatial distribution of crop management factor C shows values between 0 and 0.63 (Fig.No.6). The C factor value of forest area and water body is low because forest and water body area save from harm soils beside erosion, while the open barren land has a high C-value (0.63). Likewise, the varied land use land cover (built up area) has a C-value of (0.09). The model explain valid results after concern the unspecified C values for each land-cover class, with a movement of rising erosion with small plants cover.

5.5 Conservation Practice Factor (P)

Conservation practices factor (P) value was 0 to 1, it consists of the upper values in areas of upper catchment area with no protection practices (forest, waste land) and minimum values for P factor are obtained for other area covered under major agriculture activities and water body in the catchment.

Through difference, maximum P values correspond to crop-land with comparatively reduced conservation practices in the middle and upper catchment. P values reduce in the downstream area. (Fig.No.6).

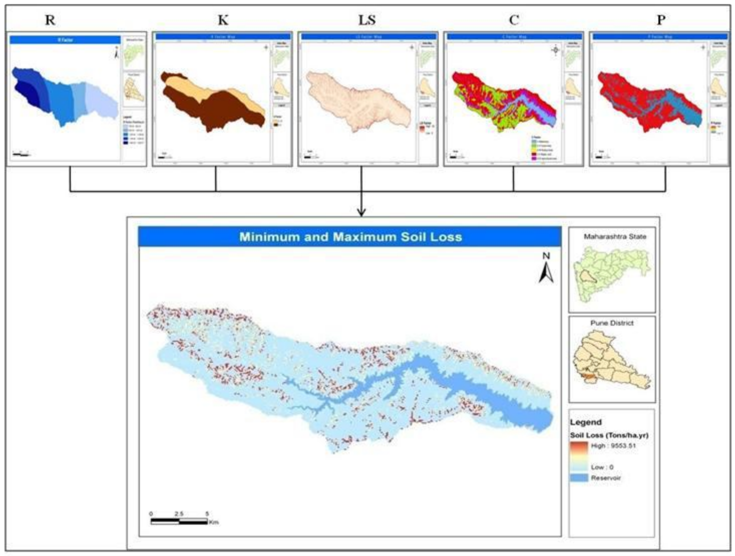


Fig.No.6 RUSLE Factors Result

The final soil loss map was designed using the RUSLE model designate a minimum of 0.0 to a maximum of 9553.51 ton·ha−1·year−1 (Fig.No.6). The estimated (A) high values reflected higher rate of sediment yield and vice versa. The low value represented lower rate of sediment yield. Based on the data analyzed the whole (V. Prasannakumar.et al., 2011) The study area was divided into five soil erosion risk classes (Fig.No.7) show that catchment has minimal soil loss is 73.98% , low is 4.29%, moderate and severe is 1.24% and 1.95%, and extreme soil erosion occupies 18.54% of the catchment. The soil erosion severity zone map indicates that the 73.98% of the study area comes under very low and 19.22% area comes under very high severity zone. (Fig.No.8)

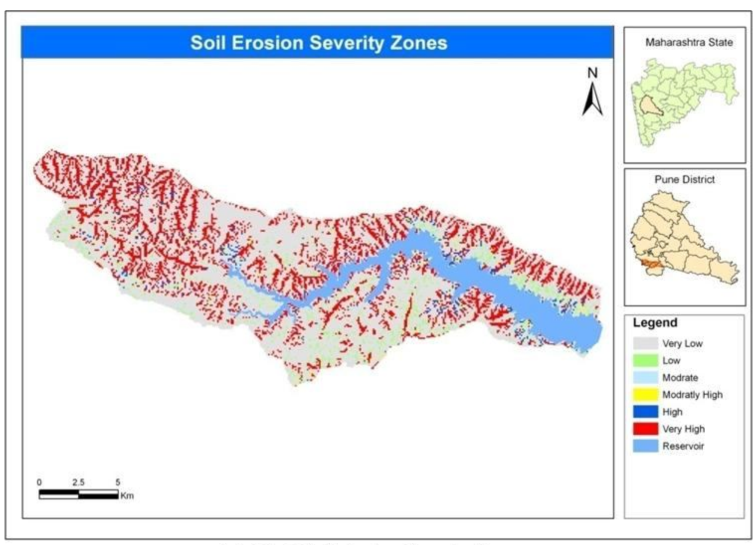


Fig.No.8.Soil Erosion Severity Zone

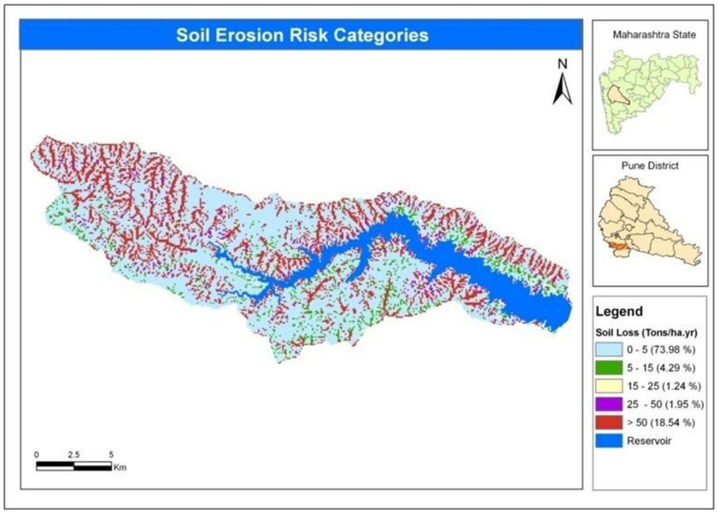


Fig.No.7. Soil Erosion Risk Categories

6. CONCLUSION

GIS based RUSLE model was used to recognize the spatial distribution of various soil erosion risk class and soil erosion severity zones in the study area .It is observed that the above mention factors and techniques are suggested that the study area is extremely vulnerable to soil erosion. Hence the study area needs instant concentration to take up soil conservation measures. To avoided soil erosion hazards and disasters.

7. REFERENCES

Census of India (2001): District Census Handbook, Pune District. pp.765.

D. Zregat, "Analysis of Forest Land-Cover Changes in WadiKufranja, Jordan (1978-2010) Using GIS and RS Techniques," in press, 2013.

Fernandez, C., Wu, J.Q., McCool, D.Q., Stockle, C.O., 2003. Estimating water erosion and sediment yield with GIS, RUSLE and SEDD. Journal of Soil and Water Conservation 58 (3), 128e136.

George Joseph (2005): Fundamentals of Remote Sensing, universities press (india) Pvt. Ltd, Hyderabad, pp. 490.

Gitas, I.Z., Douros, K., Minakoul, C., George N.S. and Christos, G.K. (2009) Multi- Temporal soil erosion risk assessment in chalkidiki using a modified USLE raster model.EARSeLeProceedings 8:40-52.

HyeonSik Kim (2006): Soil Erosion Modeling Using RUSLE and GIS on the Imha Watershed, South Korea

Kale V.S. and Avijit Gupta (2001): Introduction to Geomorphology, Orient longman pub, pp.267.

Kalvit S. K., S.N.Kulkarni, (2010): Remote Sensing For Monitoring Sedimentation in Lakes In Maharashtra *Lake: Wetlands, Biodiversity and Climate Change* Page 1

Kothyari, U.C., 1996. Erosion and sediment problems in India. In: Proc. of the Exeter Symposium on Erosion and Sediment Yield: Global and Regional Perspectives July 1996, pp. 531e540. IAHS Publ. No. 236.

Laura M. Brady, Floyd Gray, Craig A. Wissler, and D. Phillip Guertin,(2001): Spatial variability of sediment erosion processes using GIS analysis within watersheds in a historically mined region, Patagonia Mountains, Arizona,USGS Science for changing world.

National Bureau of Soil Survey and Land Use Planning (1995): Soil of Maharashtra for Optimising Land Use, NBSS&LUP Publ.54 (5), pp.96

P. Mhangara, V. Kakembo and K. Lim, "Soil Erosion Risk Assessment of the Keiskamma Catchment, South Africa Using GIS and Remote Sensing," *Environmental Earth Science*, Vol. 65, No. 7, 2012, pp. 2087-2102. http://dx.doi.org/10.1007/s12665-011-1190-x

Ram Babu, Dhyani B.L. and Kumar N.(2004) Assessment of erodibility status and refinediso-erodent map of India. Indian Journal of Soil Conservation 32(3):171-177.

Renard, K., Foster, G.,Weesies, G., McCool, D., Yoder, D., 1997. Predicting Soil Erosion by Water: a Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE).US Government Printing Office, Washington, DC.

Renschler, C.S., Mannaerts, C., Diekkrüger, B., 1999. Evaluating spatial and temporal variability in soil erosion risk - rainfall erosivity and soil loss ratios in Andalusia, Spain.Catena 34, 209e225.

Savindra Singh (2003): Physical Geography, Prayagpustakbhawan, Allahabad, pp. 642.

Savindra Singh (2005): Geomorphology, Prayagpustakbhawan, Allahabad, pp. 612.

Todd Breiby: Assessment of Soil Erosion Risk within a Subwatershed using GIS and RUSLE with a Comparative Analysis of the use of STATSGO and SSURGO Soil Databases.

V. Prasannakumar, H. Vijith, N. Geetha and R. Shiny, "Re- gional Scale Erosion Assessment of a Sub-Tropical High- land Segment in the Western Ghats of Kera, South India," *Water Resources Management*, Vol. 25, No. 14, 2011, pp. 3715-3727. http://dx.doi.org/10.1007/s11269-011-9878-y

Wischmeier, W.H and Smith, D.D. (1978) Predicting rainfall erosion losses – A guide to conservation planning.Agriculture Handbook No. 537, USDA.