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Assessment of Soil Erosion in the Watershed of Upper Lake, Bhopal using Remote Sensing and GIS

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Abstract: ***Recognizable proof of soil erosion territories and to propose or apply preventive measures is significant advance in the management of watershed. For structuring a watershed and to conserve it appropriately assessment of soil erosion plays a significant role. With the headway of innovation and advancement of GIS and Remote Sensing researchers and scientists can assess soil erosion using various developed model. In this study, Universal Soil Loss Equation (USLE) has been utilized to gauge soil disintegration inside the Upper Lake Bhopal, India. Catchment territory of Upper Lake, Bhopal has been partitioned into 24 sub zones and every one of them were organized according to the erosion occurring. The normal yearly soil misfortune guide has been acquired by coordinating R, K, LS, C and P factor maps and it fluctuates from 0.00 to 2735.45 t/ha/yr over the watershed. All the 24 sub watershed have been named as Krishna's sub watershed (KW). The average soil loss from sub-watersheds have been figured and changes between 1.26 (KW-21) t/ha/yr to 99.04 (KW-3) t/ha/yr. The total soil loss in the watershed is determined as 19.6 t/ha/yr All sub-watersheds have been arranged into five classes specifically extremely high, high, moderate, low and low classifications based on final priority. Watersheds going under exceptionally high need covers 30.51% zone of study region, high need covers 22.31% zone, moderate need covers 25.46% zone of study territory, low need covers 14.45% region of study region, goes under extremely low need which spreads 7.26% zone of study region.***

Keywords: ***Catchment, erosion, prioritisation and subwatershed.***

I. INTRODUCTION

Economic development of a nation depends mostly on industrialization and agriculture. Both Agriculture and Industrialization depends directly or indirectly on the soil conservation where as crop yield has a direct correlation with soil loss. Around 2 billion hectare of land has been affected by soil erosion due to the involvement of humans. Soil erosion mainly occurs because water and wind. In the investigation it was discovered that 1100 Mha of land territory is influenced by soil disintegration and 550 Mha by wind disintegration (Saha 2003). Soil disintegration is the evacuation of top layer of the land surface.It may occur at a very slow rate or it may occur rapidly depending upon the various factors involved. The main factors responsible for the soil erosion is the intensity of rainfall, types of soil in that area, slope of land, different types of crop growing in that area and different types tools and machinery used for cultivation.

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Soil erosion is one of the major problems in the world because it affects the agricultural land by removing the top fertility of land. On the other hand it also affects the drinking water and irrigation by the siltation in the reservoirs. With the degradation of earth surface it affects nearly all the activities performed on this planet earth. Around 1300000 km^2 area of land out of 3060500 km^2 of total land surface of India (Kothyari, 1996), i.e., 42.5% is affected by serious soil erosion. Soil erosion diminishes transport capacity in waterways and capacity limit of repositories, contaminates water supplies, and expands water treatment costs. Suspended silt in water result in low light infiltration and influence oceanic life in streams, lakes, stores, and estuaries. Besides these sediments deposition diminishes the limits of channels and repositories and result in a general increment in flooding. David *et al* (1996) applied both RUSLE and USLE models using Land Condition-Trend Analysis (LCTA) data from the Yakima Training Centre, Washington. From the result analysis it was estimated that there is decrease in soil loss using RUSLE model compared to the USLE. The advancement, execution, and backing of institutionalized information accumulation strategies is significant if RUSLE is to be utilized to decide erosion status and patterns at armed force establishments. It was concluded that the effect of RUSLE and USLE model for the estimation of soil erosion will vary by location. It was also concluded that similar comparisons of RUSLE and USLE should be conducted for different other regions. Despite the different soil erosion model utilized, surface disintegration can fluctuate spatially and transiently inside and among range land networks because of climatic inconstancy, topographic changes, soil and geologic irregularities, and common and human-incited changes. Ganasri and Ramesh (2015) evaluated soil loss from the catchment of Nethravathi using Revised Universal Soil Loss Equation (RUSLE) located in the southwestern part of India. The Nethravathi Basin is situated in the south-western part of India and having a tropical coastal humid zone of having a drainage territory of 312800 ha. Various components in charge of the erosion were assessed and maps were produced utilizing remote detecting and GIS. The assessed precipitation erosivity, soil erodibility, topographic and crop the board components keep running from 2948.16 to 4711.4 MJ/mmha-1 hr - 1/year, 0.10 to 0.44 t ha - 1MJ - 1mm - 1, 0 to 92,774 and 0 to 0.63 respectively. The results demonstrated that the surveyed hard and fast yearly potential soil loss of around 473,339 t/yr is practically same which was estimated directly 441, 870 t/yr during the year 2002-2003 . Ashiagbor et al (2013) showed the spatial circulation of soil disintegration in Densu River Basin of Ghana using RUSLE and GIS gadgets and to use the model to examine the connection between slope and Land use and Land Cover (LULC) in the Basin.

From the study it was concluded that 88% of the catchment area comes under low erosion hotspots, 6% comes under moderate erosion hotspots, 3% of the total catchment area as high erosion hotspots and 3% as severe erosion hotspots. The high and extreme disintegration were observed to be appropriated principally inside the regions of high slant slope and furthermore segments of the moderate forest LULC class. It was likewise closed from the investigation that the created model is useful for the quick evaluation of soil loss. Chang and Bayes (2013) used RUSLE model to locate the most erodible territories in Charles Mill Lake Watershed in Ohio having watershed region of 56200 ha. It was found that the disintegration hotspots are generally arranged in the domains of strip mine and cropland. It was also observed that soil erodibility has more important varieties in the northwest fragment than in the southeast section toward the mouth of the store. Numerous moves have been made by the legislature for correction of the issue and avoiding further pulverization of the soil layer. In current scenario the problems of deposition of sediments in reservoir and lakes are occurring in every parts of the world. One of the most important lake in the heart of India, Upper lake Bhopal is very important from all prospective. It is one of significant source of drinking water for the occupants of the city, serving around 40% of the inhabitants with 140,000 m3 of water for every day. Capacity of lake decreases due to soil disintegration, sewage from local regions and deposition of waste material. Looking into the problems of the society, this paper assesses soil loss using Universal Soil Loss Equation (USLE) in the catchment of Upper Lake Bhopal, India.

II. DESCRIPTION OF STUDY AREA AND DATA

The Upper Bhopal Lake has a catchment area of 362.35 square km. The land use pattern of about of the catchment is agricultural where as 5% is of forest and the rest is urban. It lies at the latitude of 23˚ 04'N, longitude of 72 ˚ 18' E, and at an altitude of 508.65 m above mean sea level. The storage capacity is 117.05 million cubic meters. The rain water is the only source of water in this lake.

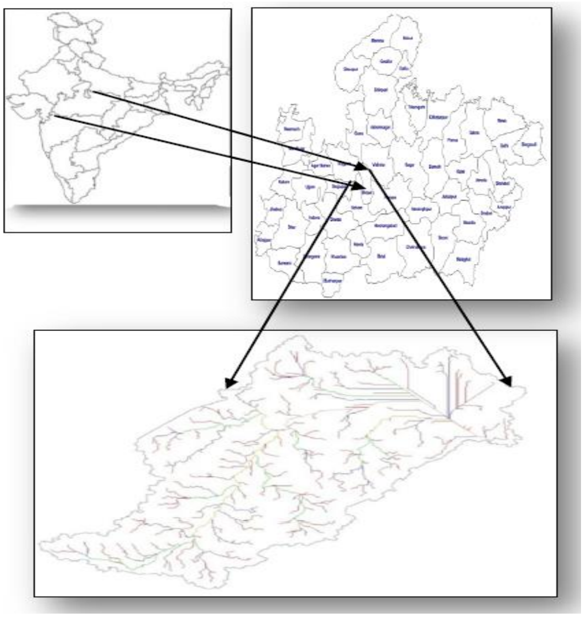


Figure 1 Study Area

Table 1 Description of the data.

SN	Data Type	Source	Description
1	Digital Elevation Model	www.bhuvan.nrsc.gov.in	CARTO DEM (30m resolution)
2	Satellite image	www.bhuvan.nrsc.gov.in	LISS-3 Image
3	Soil data	The National Bureau of Soil Survey and Land Use Planning, India	Soil map
4	Rainfall data	Indian Meteorological Department, India	Rainfall data for a period of 30 years

III. METHODOLOGY

Issues related with soil disintegration, improvement and proclamation of residue in waterways, lakes and estuaries continue on through the geologic ages in essentially all parts of the earth. All things considered, the circumstance is bothered as of late with man's expanding mediations with nature. Along these lines, a plausible game-plan is to create and utilize experimental models. The absence of accessibility of information, for example, residue testimony information, precipitation power at shorter interims (under 30 min) in the examination region, has constrained the alternatives for choice of information serious models, for example, USPED, WEPP, soil disintegration module in SWAT (soil and water appraisal device) model. in this way, USLE model was picked and associated in study zone as it requires land use land spread guide that can be delivered by remote detecting pictures, the officials practices, soil types and properties. The other piece of breathing space of a decision of USLE is that the parameters of this model can be effectively joined with GIS for better examination. The rule purpose of present examination is to organize USLE model with remote detecting and GIS techniques for assessing the disintegration hazard in catchment zone of Upper Lake Bhopal. The system depicts the fundamental ideas, the methodology of the USLE model to assess parameters and parameter expectation of USLE model. The parameters of USLE model have been evaluated dependent on the precipitation occasions, DEM, soil type, and land spread.

A. Rainfall erosivity factors (R)

The Rainfall erosivity (R) factor for the study area was calculated by using the seasonal rainfall of the seven rain-gauge stations in the Upper Lake, Bhopal catchment. For creating R factor map the excel file having R factor value and latitude and longitude of the rain gauge station has been prepared. In the Arc GIS we have added the data to prepare point map.

Using Geostatistical Analyst tool the interpolation map has been prepared. By using extract by mask command the interpolation map has been extracted to the shape file of the catchment and the R factor map has been. The R factor map of the area and value of estimated seasonal R factor are reported in Table 2.

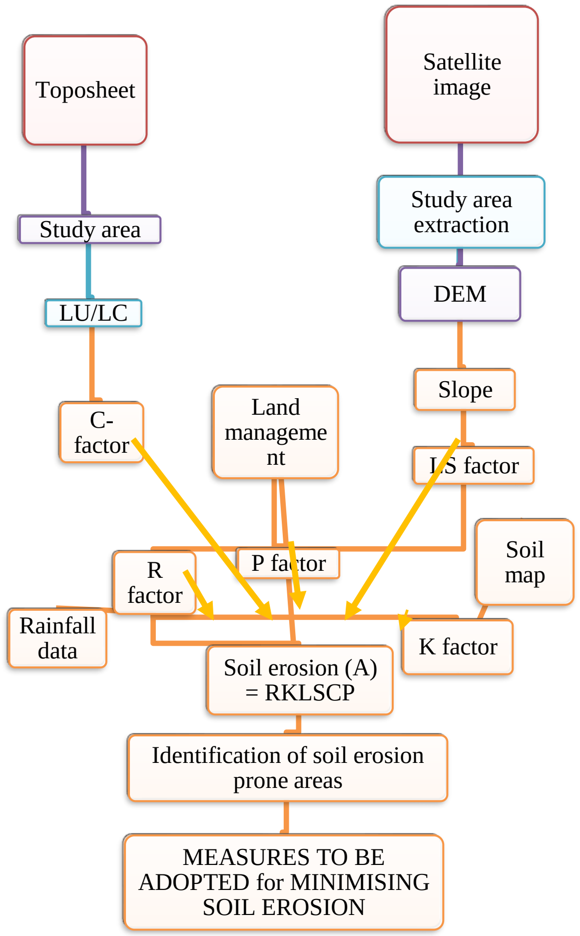


Figure 2 Flow chart of Methodology

Table 2 Estimated seasonal and annual rainfall erosivity factor for Bhopal lake catchment

Rain Gauge Station	Geographical Area (km^2)	R factor annually MJmm/ha/h/yr	R factor Seasonally MJmm/ha/h/yr
Bairagarh	158.6782	490.31301	455.338
Bhopal	26.4627	504.44107	469.342
Chhapri	78.3786	516.39559	481.401
Dondi	29.52061	504.44107	469.342
Kishapura	5.674779	497.19591	462.34
Sehore	66.35277	506.25236	470.898

The estimated seasonal R factor varies from 455.3 MJmm/ha/h/yr to 481.40 MJmm/ha/h/yr.

B. Soil erodibility factor (K)

It is a quantitative portrayal of the natural properties of soil to be eroded. The K factor reflects the manner in which that different soils eroded at different rates when various parts that impact disintegration proceed as in the past. Soil surface is the chief reason influencing the K-factor, yet the soil structure, natural issue substance and permeability additionally contribute. K factor map was prepared by attributing K factor values to the digitized soil map. K factor was determined for various soil types and revealed in Table 3. The soil erodibility factor guide of the Bhopal lake catchment region was set up for estimation of soil disintegration. The K factor for various soil gatherings were accounted for in Table 3 from table obviously K factor lies between 0.38 to 0.80

C. Soil Length and Steepness Factor (LS)

The factors of slope length (L) and slope steepness (S) are combined in a single topographic index termed as LS factor. Many researchers have used these two L and S factors as combined LS factor. The LS map has been prepared using the DEM downloaded from www.nrsc.gov.in. Using Hydrogical command the flow direction, accumulation and finally slope map has been prepared and then using raster calculator and inserting the formula for LS the LS factor map has been prepared.

D. Crop Cover and Management Factor (C)

Data ashore use allows a superior comprehension of the land use viewpoints which are indispensable for improvement arranging examines. Different land use Remote detecting and GIS system can possibly produce a topical layer of land utilization of an area. The satellite image from NRSC has been taken and by using the extract by mask command the map has been extracted in the shape file of catchment area. Using the image classification tool different use of land like agriculture, forest, urban area, water bodies, scrub samples are identified and classified. C factor values taken according to USLE, were attributed to land use map. Harvest spread and the board factor was alloted to various land use examples utilizing qualities given in Table 5. Utilizing land use map and C factor esteems; C-factor map was set up in ArcGIS (10.5)

E. Conservation Practice Factor (P)

The P-factor is a proportion between disintegration happening in a field treated with preservation measures and another reference plot without treatment. Along these lines disintegration control practice factor depends on the soil protection practices worked in a specific zone. Protection practice factor was doled out to various land use examples utilizing qualities given in Table 5. For P factor map the DEM has been taken and the slope map has been prepared. Using classification tool for different values of slope the different P factor values has been attributed and P factor map was set up in ArcGIS (10.5)

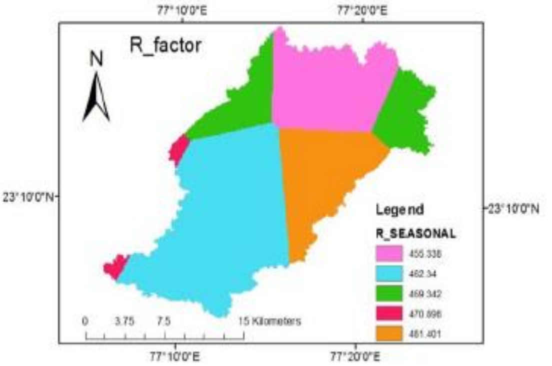
Table 3 K factor for different soil groups of Bhopal lake catchment

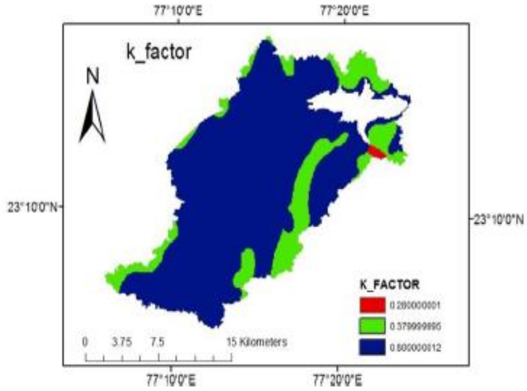
S. No.	Soil group	K factor
1	210	0.38
2	228	0.38
3	303	0.28

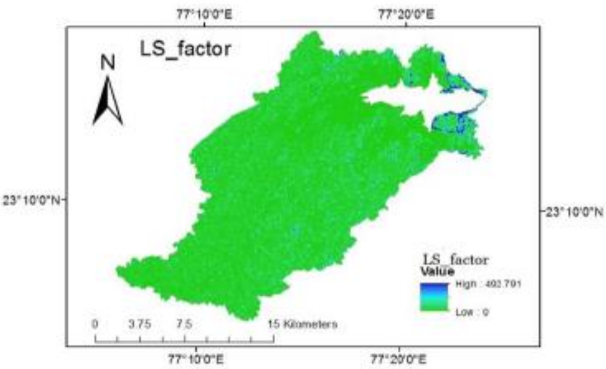
4	332	0.8
5	344	0.38
6	379	0.8
7	399	0.8

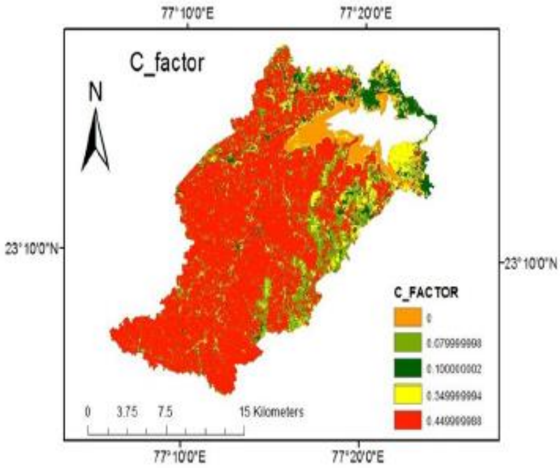
Table 4 Land use pattern of Bhopal lake catchment

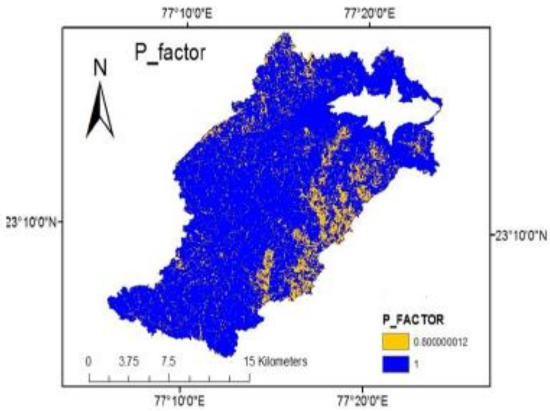
S. No.	Type of Land use	Area (km^2)	Land use area in %
1	Agriculture	229.1634	66.36723
2	forest	44.6148	12.92074
3	Urban area	21.3372	6.179394
4	Scrub	32.6277	9.449197
5	Water bodies	16.7634	4.854791











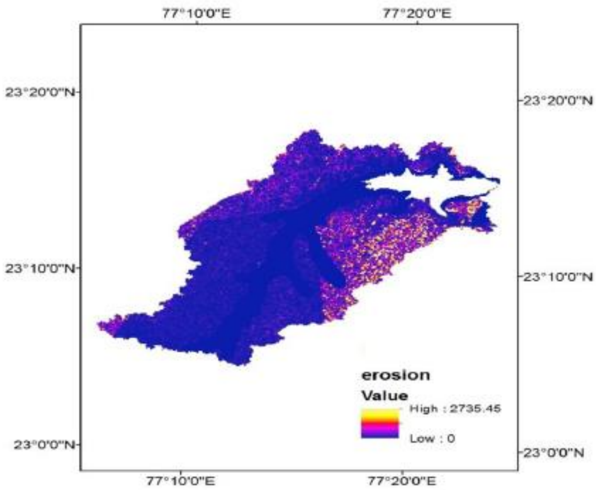


Fig 3 (a) R factor map (b) KFactor Map (c) LS Factor Map (d) C Factor map (e) P Factor Map (f) Annual soil loss of Bhopal lake catchment

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Table 5 Cover and management factor (C) and Conservation Practice Factor (P) factor for Different land use classes.

S. No.	Land use	C-factor	P-factor
1	Agriculture	0.45	1.00
2	Forest	0.08	0.80
3	Urban area	0.1	1.00
4	Water bodies	0.0	1.00
5	Scrub	0.35	1.00

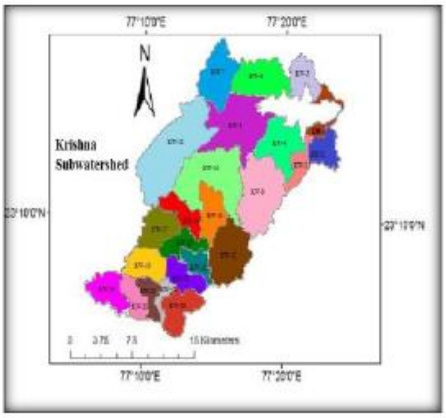
IV. RESULTS AND DISCUSSIONS

A. Average Soil Loss of Study Area

The soil erosion for each of the 24 Krishna's sub watersheds was determined by utilizing Universal Soil Loss Equation (USLE). The thematic map arranged for each for example R,K,LS,C,P have been utilized for estimation of soil misfortune. The yearly soil loss of the watershed is 19.6 t/ha/yr. The soil erosion for various Krishna's sub watersheds differs from 1.26 to 99.05 t/ha/yr in Table 6. Considering the monstrous interest in the watershed improvement program, it is essential to design the advancement exercises on need reason for accomplishing productive outcomes which additionally encourage tending to the risky zone to land at appropriate arrangement. The assets based methodology is observed to be practical for sub-watershed prioritization since it includes a coordinated methodology. Outline of sub-watersheds from the investigation region and their prioritization is required for legitimate arranging and the board. The last need of each sub-watershed are resolved and needs of all sub-watersheds are gathered in five classifications and spatially delineated. Based on Soil Erosion out of 24 Krishna's sub-watersheds 5 sub-watersheds go under the very high priority, 4 sub-watersheds come under the high priority,6 sub-watersheds go under the moderate priority,6 sub-watersheds come under the low need and 3 sub-watersheds go under the very low classification. Prioritisation of Krishna's subwatershed has been given in figure no 4. 10.12 % of total area has been categorised as very high risk zone which contributes about 40% of the total soil erosion. Soil loss every year comes out to be 711700 tone.

B. Erosion Stressed Area

All 24 Krishna's subwatershed has been prioritized under different categories and given in figure 4. Different categories with area and percentage of area and loss of soil in tone per year have been given in detail in Table 6



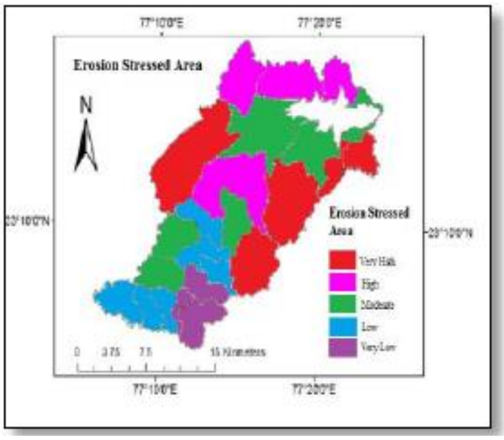


Figure 4. (a) Watershed divided into 24 Krishna Sub watershed (b) Erosion Stressed Area..

Table 6 Watershed priority

Erosion Categories	Soil Loss t/ha/year	Area (ha)	Area (%)	Soil Loss(t/year)
Very Low Risk	0.00-4.00	4656	13.48	13680
Low Risk	4.00-8.50	8140	23.58	45625
Moderate	8.50-25.00	11973	34.68	152244
High Risk	25.00-75.00	6263	18.14	214536
Very High Risk Zone	75.00-200.00	3496	10.12	285615
Total		34528	100	711700

Soil loss occurring in the watershed every year on all different categories have been presented in the form of histogram in Figure 5

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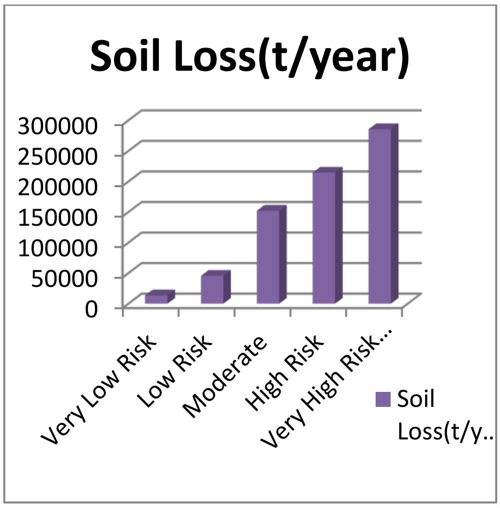

Figure 5 Histogram for the soil loss.

V.CONCLUSION

Observational soil disintegration models, however moderately basic, are anything but difficult to translate physically, require negligible resources and can be worked out with promptly accessible contributions to improve the zones exposed to high disintegration hazard. The recognizable proof disintegration focused on territory of sub-watershed supportive in legitimate treatment of the catchment region. RS and GIS are the most development instruments for concentrates on prioritization of watersheds for their improvement and the board. In the present study, soil erosion from the study area has been estimated using USLE model. Various maps representing spatial distribution of different factors R, K, LS, C & P have been prepared in ArcGIS (10.5). The average annual soil loss map has been obtained by integrating R, K, L, S, C and P factor maps and it varies from 0.00 to 2735.45 t/ha/yr over the catchment area. The average soil loss from sub-watersheds have been computed and varies between 1.26 and 99.04 t/ha/yr. All 24 Krishna's sub-watersheds have been classified into five classes namely very high, high, moderate, low and very low categories on the basis of final priority. The examination of potential soil erosion with real soil loss helps in surveying the erosion effect of different editing framework and preservation support practices. Krishna's sub-watersheds goes under extremely high need covers 30.51% region of study territory, are goes under high need which spreads 22.31% region of study region,, The annual soil loss of the watershed is 19.6 t/ha/yr. The sub-watersheds which are having very high and high priority ranking should be treated first. The main aims of soil conservation are to protect the soil from erosion and to maintain the productive capacity of the soil. The biological methods helpful in checking the soil erosion are agronomic practices, agrostological methods and dry farming practices. Agronomic practices like contour farming, tillage and keeping the land fallow, crop rotation, sowing of leguminous crops and mixed cropping, mulching and strip cropping. The important agrological practices are cultivation of grasses, retiring the land, afforestation and reforestation, checking of overgrazing. Mechanical methods for soil conservation are: basin leaching, pan breaking, sub soiling, contour terracing, contour trenching, terrace outlets, gully control, digging of ponds and reservoirs, and stream bank protection. The mechanical measures for soil preservation measure are packed in extremely high and high priority watersheds. The agronomic and natural measures have been recommended in all sub-watersheds, while mechanical estimates just in very high and high priority sub-watersheds of Upper Lake Bhopal Catchment. GIS-based USLE approach was utilized to recognize the spatial conveyance of various erosion inclined regions in the catchment of Upper Lake Bhopal. The result would take reasonable erosion control measures in the seriously influenced territories. The outcomes got from the examination can help with creating the board situations and give choices to strategy creators to overseeing soil erosion risks in the most proficient way for prioritization of various locales of the basin for treatment.

REFERENCES

1. Ashiagbor, G., Forkuo, E. K., Laari P. and Aabeyir, R. (2013) Modeling soil erosion using RUSLE and GIS tools, *International Journal of Remote Sensing & Geoscience* **2**(4), 7-17.
2. Bhattarai, R. and Dutta, D. (2009) Estimation of soil erosion and sediment yield using GIS at catchment Scale, *Water Resources Management*, ***21***(10), 1635-1647.
3. Biswas, S., Sudhakar S. and Desai, V. R. (2002) Remote sensing and geographic information system based approach for watershed conservation, *Journal of Surveying Engineering*, **128** (3), 108-124.
4. Ganasri, B. P. and Ramesh, H. (2015) Assessment of soil erosion by RUSLE model using remote sensing and GIS - A case study of NethravathiBasin, *Geoscience Frontiers* xxx1- 9.
5. Gonzalez, A. M. R. (2008) Soil erosion calculation using remote sensing and GIS in Río Grande de Arecibo watershed, *Annual Conference Portland, Oregon,* April 28-May 2, 2008.
6. Hacisalihoglu S., (2007) Determination of soil erosion in a steep hill slope with different land-use types, *Journal of Environmental Biology*, **28**(2), 433-438.
7. Jones, D. S., Kowalski, D. G. and Shaw R. B. (1996) Calculating Revised Universal Soil Loss Equation (RUSLE) Estimates on Department of Defense Lands: A Review of RUSLE Factors and U.S. Army Land Condition-Trend Analysis (LCTA) data gaps. *Center for Ecological Management of Military Lands Technical Publication Series*, 8-19.
8. Kandrika, S. and Dwivedi, R.S. (2003) Assessment of the impact of mining on agricultural land using erosion-deposition model and space borne multispectral data, *Journal of Spatial Hydrology* **3**(2), 1-18.
9. Kumar, S. and Kushwaha, S.P.S. (2012) Modelling soil erosion risk based on RUSLE-3D using GIS in a Shivalik sub-watershed, *Journal of Earth System Science*, **122**(2) 389-398.
10. Lanuza, R. L., Paningbatan, Jr E.P. (2010) Validation and Sensitivity Analysis of Catchment Runoff and Erosion Simulation Technology A GIS-assisted Soil Erosion Model at Watershed Level, *International Congress on Environmental Modelling and Software* July 5 - 8 2010, Ottawa, Ontario, Canada.
11. Narayana, D. V. V. and Babu R. (1983) Estimation of Soil Erosion in India, Journal of Irrigation and Drainage Engineering, 111(4), 407-415.
12. Pham, T.G., Degener, G. and Kappas, M.(2018) Integrated universal soil loss equation (USLE) and geographical information system (GIS) for soil erosion estimation in A Sap basin : Central Vietnam, *International Soil and Water Conservation Research* **6,** 99–110
13. Saha, A., Ghos, P. and Mitra, B. (2018) GIS based soil erosion estimation using RUSLE model: A case study of upper Kangsabati watershed, West Bengal, India, *International Journal of Environmental Sciences & Natural Resources*, **13**(5). 01-08.
14. Saha, S.K. (2002) Water and wind induced soil erosion assessment and monitoring using remote sensing and GIS, *Satellite Remote Sensing and GIS Applications in Agricultural Meteorology*, 315-330.
15. Ustun, B. (2008) Soil erosion modelling by using GIS & Remote Sensing : A Case Study, Ganos Mountain, *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.* **37**(7), 1681-1684.

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