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# Estimation of Soil Erosion in Hiranyakeshi Basin Using RUSLE Model and Geospatial Techniques

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**Abstract:** Fertile land is the most vulnerable resource on the earth surface and it needs to be conserved from its degradation. Detachment and transport of top soil layer from upland to lowland area causes loss of fertile soil. It is also responsible for other problems like up-gradation of river channel, reservoir sedimentation and water pollution. Main objective of present research is to locate and calculate the susceptible areas of soil erosion in the Hiranyakeshi basin of Kolhapur district, Maharashtra. Rainfall-runoff erosivity (R), soil erosivity factor (K), slope length /steepness factor (LS), cover management factor (C) and conservation practice factor (P) are the basic parameters required to generate this model. Land use/ land cover map is prepared through supervised classification techniques by using IRS P-6 LISS-III data set of year 2007. CartoDEM satellite image applied for slope length and steepness calculation. Other parameters required for Revised Universal Soil Loss Equation (RUSLE) model were assessed and generated using geospatial technology to estimate soil erosion. Raster calculator of ArcGIS 9.3 software is used for data integration and finally annual average soil loss in ton/ha/year has been calculated. As per RUSLE analysis, Soil erosion map has been classified into 7 classes to represent the intensity of soil erosion. It reveals that around 78% area in the basin is having soil erosion less than 5 ton/ha/year which is under the low risk zone. 11% area lies between 5 to 20 ton/ha/year which have moderate risk of soil erosion, 5 % basin area is in high risk zone which have 20 to 50 ton/ha/year erosion rate and only 6 % basin area is under very critical risk zone which have annual soil erosion rate is above 50 ton/ha/year. Watershed development plan should be adopted for high risk zone areas which are more vulnerable for soil erosion. Upper sub-basins of Hiranyakeshi have been more intensity for very critical soil loss due to high elevation and steepness. Hence, such sub-basins need to give higher priority for soil loss prevention practices.

**Key words: Soil Erosion, RUSLE, Geospatial technique, LISS-III, Carto DEM, Prioritization.**

## I. Introduction:

Soil and water is essential a natural resource has needed to be conserve for environmental and social wellbeing. Utilization of surface water is basically needed to mitigate the water scarcity and drought problem and is equally important to reduce flood damage, land degradation and soil erosion. Hence, the study of rainfall regime and estimation of surface runoff rate of the basin have become necessary task to analyze the surface water status. Soil erosion is natural process which responsible for soil loss and land degradation. Grassland and forest cover is good for soil protection. Human activities like improper agriculture and irrigation practices, deforestation, construction of stream crossing and roads are the major sources of soil loss (Lewis,1998, Chang,2006). Soil loss leads to decrease the water holding capacity, nutrient availability and organic matter content and to reduction in the overall fertility of the arable land.

Controlling erosion and minimizing risk of water pollution require an understanding of hydrologic process at the watershed scale. The success and failure of erosion control depends on control measures which are implemented at watershed level (Mishra, 2001).In short, land and water resource management is an important issue with respect to conservation and protection of land and water. Hence, the conservation of soil and water have become necessary for controlling environmental damage and optimal utilization of the resources. The present research is being focused on peak runoff estimation and RUSLE model for soil erosion risk assessment.

## II. Research Objective

The objective of the present research is to estimate the rate of soil loss in Hiranyakeshi basin by using RUSLE model and calculate the sub-basin wise intensity of soil loss.

## III. Study Area

The region selected for present study is Hiranyakeshi basin of south Maharashtra which comprises an area of 722 Sq.km and lies between 16° 00' N to 16° '18 N latitude and 74° 00' E to 74° 30' E longitude in Ajra and Gadhinglaj tahsils of Kolhapur district and some part of Savantwadi tahasil of Sindhudurg District of southern Maharashtra. Minimum and maximum elevation of the area is 619 meter and 960 meter respectively. Sahyadri ranges lies in the west part of basin and slope of region is decreasing from west to east. Hiranyakeshi river flows from south west to north east direction and meets Ghataprabha river in Karnataka before it meets to Krishna. Rainfall is not evenly distributed in the basin and it decreases from west to east from about 2700mm/years to less than 1000mm/year respectively.

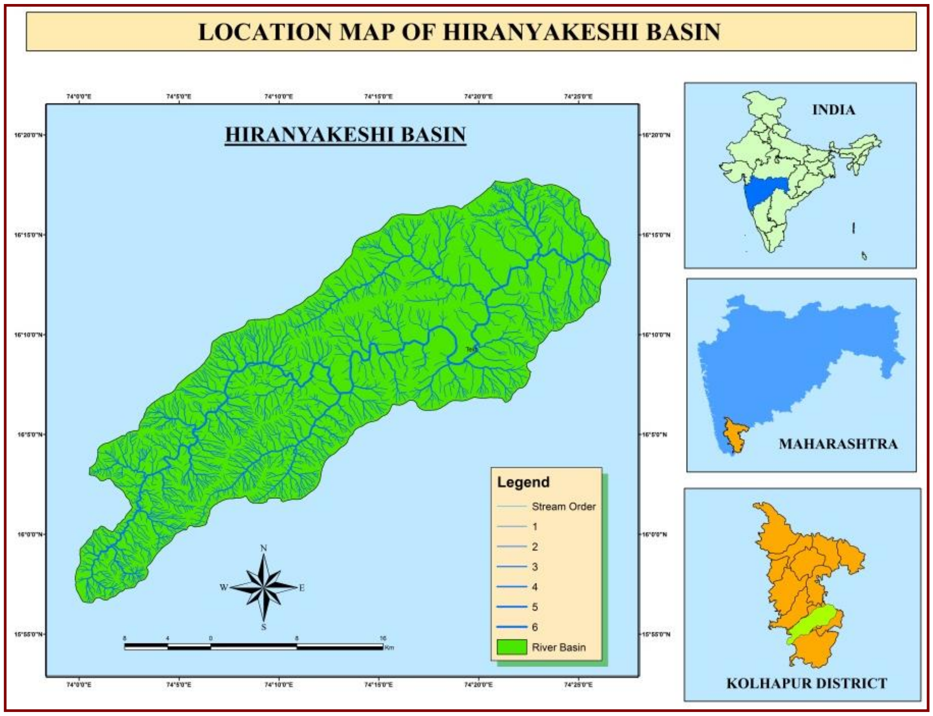



**Fig: 1 Study Area**

## IV. Data and Methodology

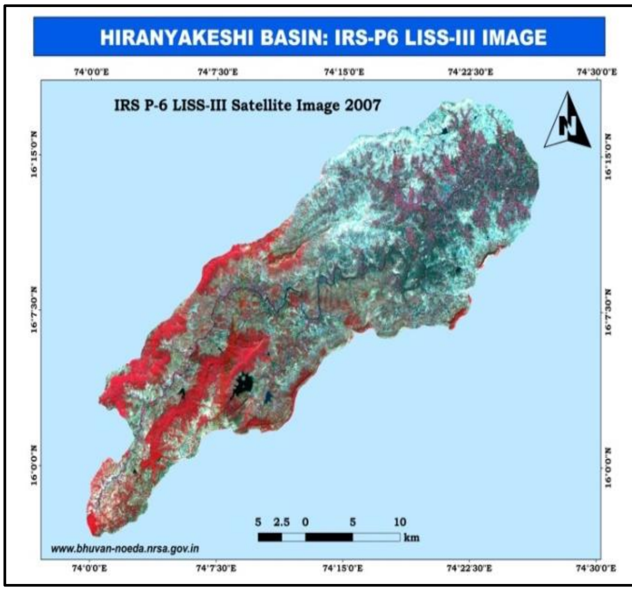
Table: 1.1 Hiranyakeshi Basin: Data used in RUSLE Model

In the present research various geospatial inputs like rainfall, slope, LU/LC, vegetation cover, soil texture etc. has been used for excecute RUSLE model.

| **Sr. No** | **Spatial / Non-Spatial Data** | **Source** |
|---|---|---|
| 1 | CartoDEM (Satellite Image) | Bhuvan Website |
| 2 | IRS-P6 LISS-III Satellite Image (2007) | NRSA, Hyderabad |
| 3 | Soil Texture | NBSS&LUP, Nagpur |
| 4 | Annual Rainfall data | IMD, Pune |

Table.1.1 shows details about the spatial data which have been used for execute RUSLE model.

CartoDEM satellite image acquired from Bhuvan website is used to prepare slope map, flow direction, flow accumulation and radiance map. IRS P-6 LISS-III satellite image of the year December 2007 has been obtained from NRSA, Hyderabad and used to assess vegetation (NDVI) and LU/LC condition. Soil map provided by NBSS&LUP, Nagpur is vectorized in ArcGIS software.



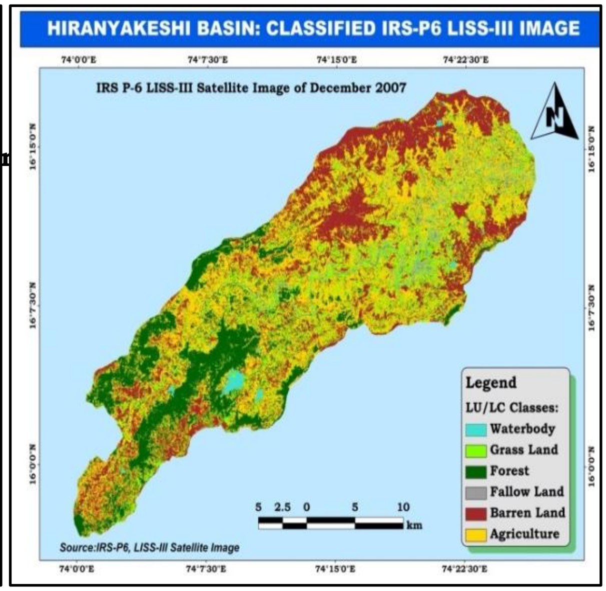
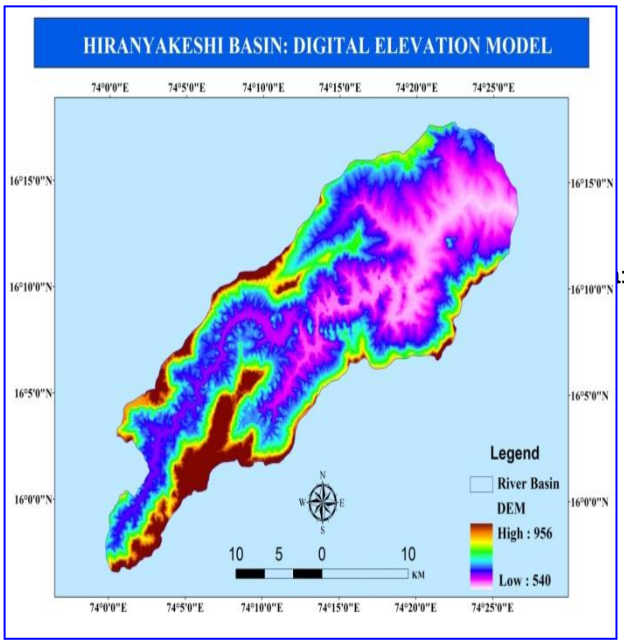




**Fig 2 : IRS-P6 LISS-III Image**

**Fig 3 : IRS-P6 LISS-III Classified Image**



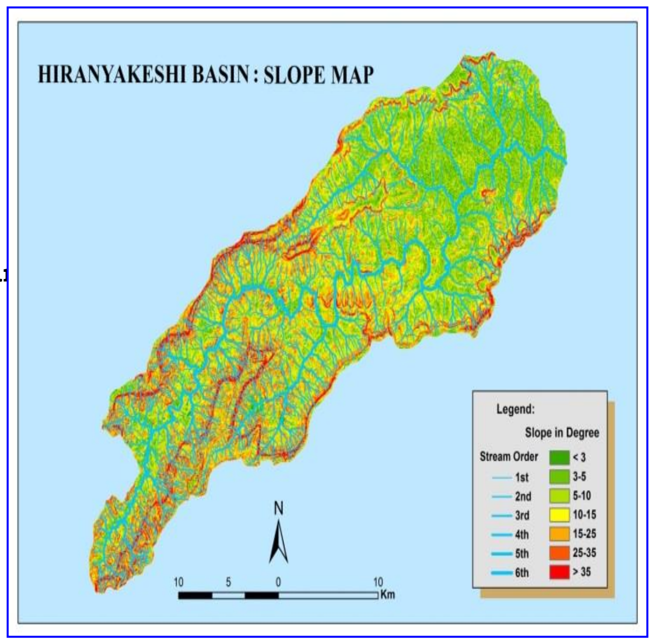




**Fig 4 : DEM of Basin Area**

**Fig 5 : Slope of Basin Area**

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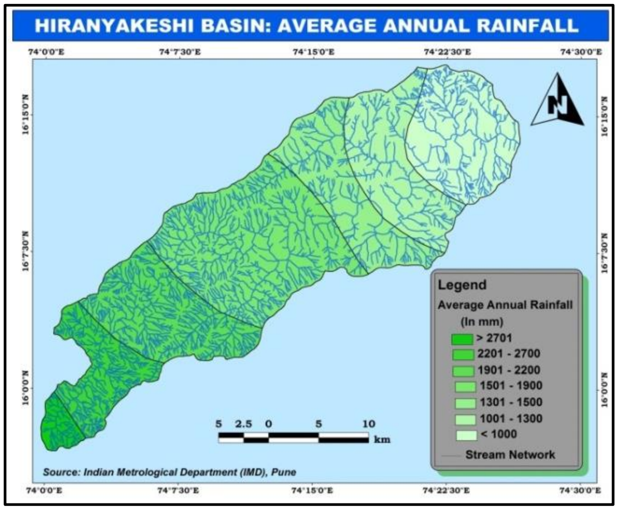


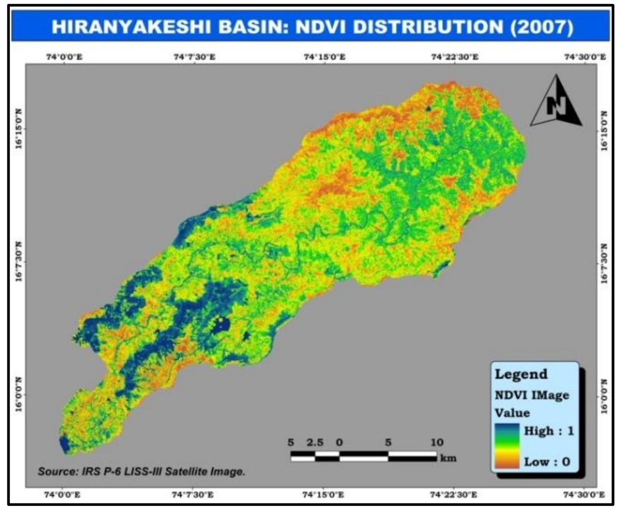


**Fig: 6 Rainfall Distribution** **Fig: 1.7 NDVI Map**

ArcGIS 9.3 software has been applied with its raster calculator tool for database generation, coding and spatial analysis. Rainfall factor (R), soil erosivity factor (K), Slope length and steepness (LS) factor, cover (NDVI) management (C) factor and conservation practice (P) have been multiplied in raster calculator to estimate annual average soil loss in the Hiranyakeshi basin. Fig:5.2 depicts the methodology chart of RUSLE model.

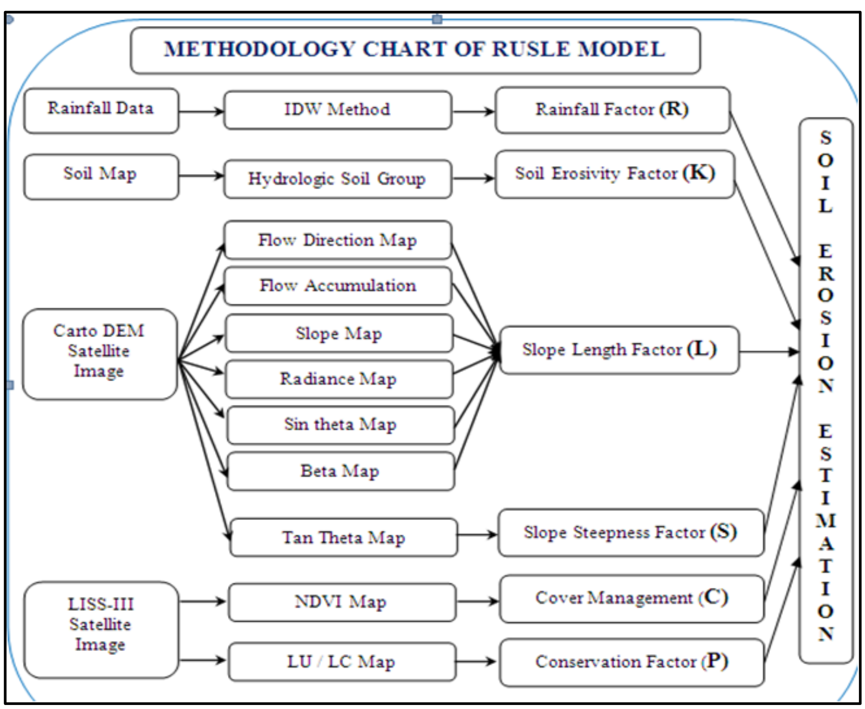


**Fig: 1.8 Methodology Chart of RUSLE Model**

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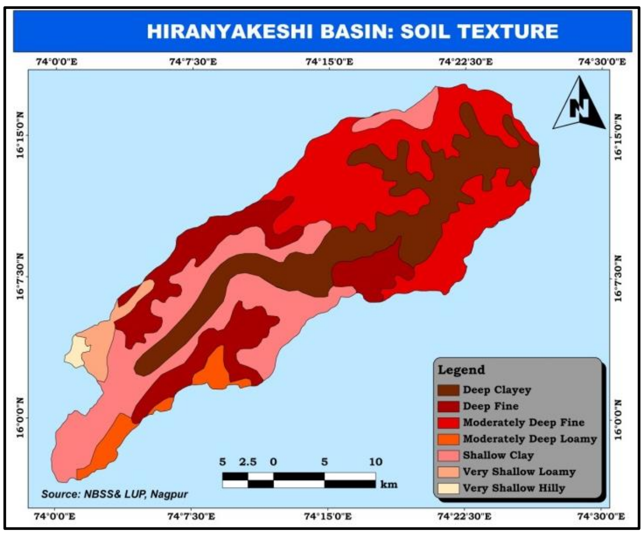
## V. Result and Discussion

### 1. Annual Soil Loss Estimation in Hiranyakeshi Basin:

Improper land management, agricultural practices is the basic problems in the India. Adversly effects has been occuredof soil loss on natural resources, vegetation, land resources, agriculture and socio-economic development of the area for a long period. However, soil erosion estimation at micro level is required to study the intensity of soil loss for effective watershed development planning. In Hiranyakeshi basin soil loss potential estimated into seven classesfor getting spatial variability in the erosion. Table 1.2 shows the class wise annual soil loss estimation in the basin.



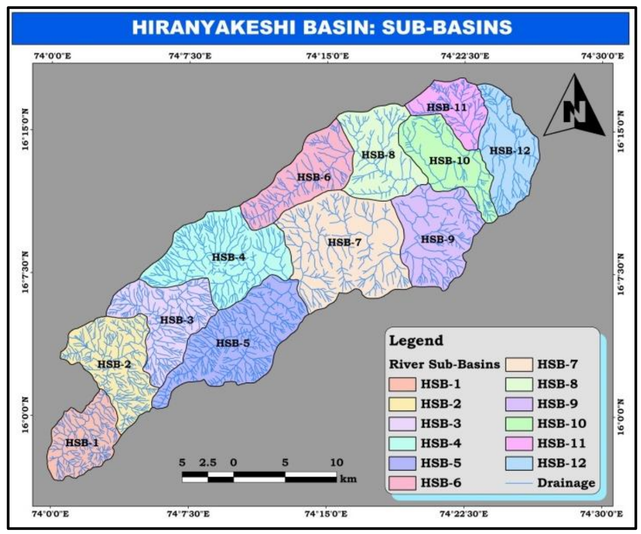




**Fig: 9 Soil Texture and** **Fig: 10 Hiranyakeshi Sub-Basins**

**Table: 2 Hiranyakeshi Basin: Annual soil loss estimation**

| Soil Loss (Tons/ha/Year) | Area in Sq.Km | Area in % | Erosion Intensity | Erosion Risk |
|---|---|---|---|---|
| < 1 | 423.40 | 58.63 | Slight | Lower |
| 1 - 3 | 92.15 | 12.75 | | |
| 3 - 5 | 45.17 | 6.25 | Light | Low |
| 5 – 10 | 55.70 | 7.71 | | |
| 10 - 20 | 27.41 | 3.80 | Moderate | Moderate |
| 20 - 50 | 36.22 | 5.01 | Sever | High |
| > 50 | 42.10 | 5.85 | Very Sever | Very High |
| **Total Area:** | **722.16** | **100** | | |

***Source: GIS analysis based on data compiled by researcher.***

The analysis reveals that around 59% area in the basin has soil loss intensity below 1ton/ha/year which indicates that major part of the area has low risk of soil erosion mainly due to low gradient and thick forest cover. 30 % area is under medium soil erosion risk and ranges between 1 to 20 ton/ha/year soil loss. About 11 % area is under high risk of soil erosion which has annual soil loss above 20 ton/ha/year. Whereas, high soil erosion risk area is observed in the upper course of the basin which has high rainfall, high elevation, high slope and high velocity of the water. For soil loss prevention, it is necessary to study the sub-basin level intensity of the soil loss and to prepare sub-basin wise priority for the adoption of soil loss prevention measures. Figure show the annual potential of soil loss in the basin.

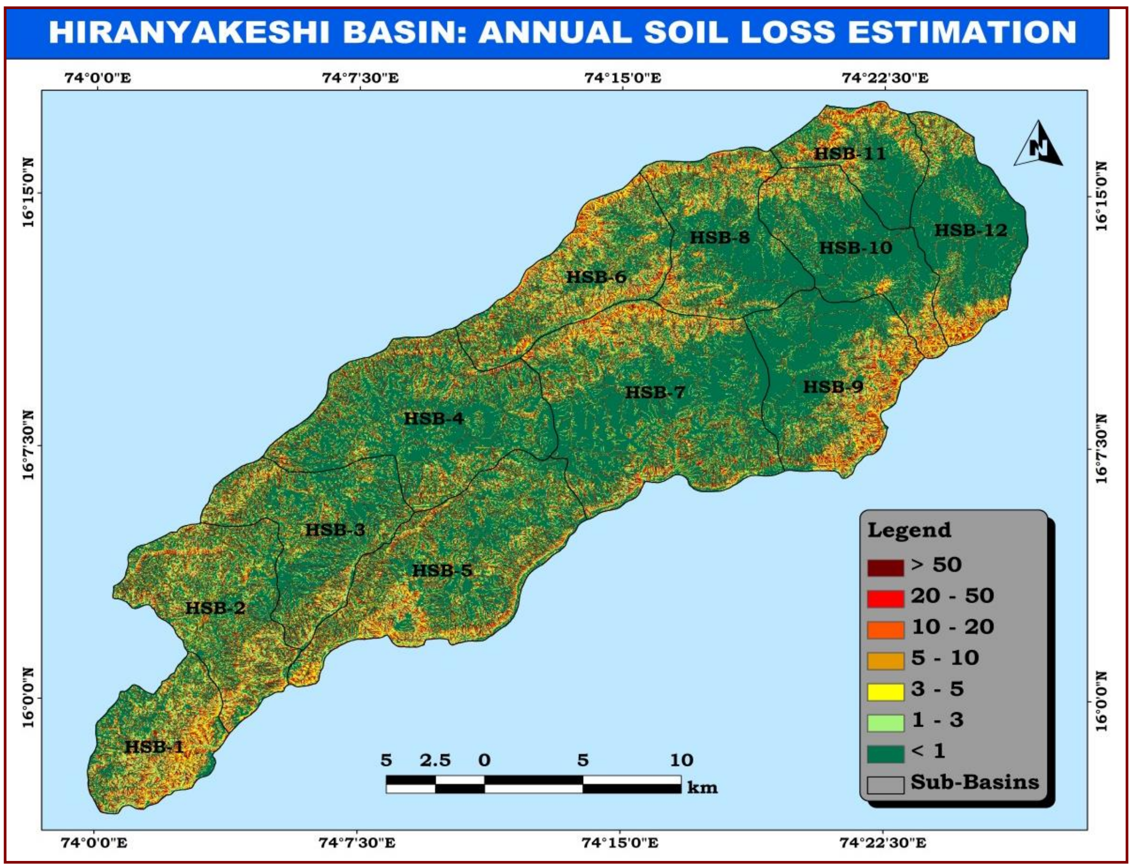



**Fig: 11 Annual Soil Loss Estimation**

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**2. Sub-basin wise annual soil loss estimation**

Sub-basin wise annual soil loss analysis reveals the spatial variation in soil loss. It is evident that in the Hiranyakeshi basin upper sub-basins are more vulnerable to soil erosion. It is due to steep slopes and high rainfall which triggers risk of soil erosion. It results in high soil erosion in the upper and middle sub-basins (HSB-1, HSB- 2, HSB-5, HSB-6 and HSB-7). These sub-basins have soil erosion estimation above 50 ton/ha/year. The lower sub-basins (HSB-8, HSB-9, HSB-10, HSB-11 and HSB-12) have lower rate of soil erosion due to low gradient and low water velocity which results in low soil erosion and high deposition in the lower reaches of Hiranyakeshi river.

**Table: 1.3 Hiranyakeshi Basin:Sub-basin wise soil erosion estimation (fig. in sq.km)**

| Soil Loss Tone/Acre → Sub-Basin ↓ | 1<br>< 1 | 2<br>1 – 3 | 3<br>3 – 5 | 4<br>5 – 10 | 5<br>10 – 20 | 6<br>20 – 50 | 7<br>> 50 | Total Area |
|---|---|---|---|---|---|---|---|---|
| **HSB-1** | 13.77 | 8.72 | 3.84 | 4.60 | 2.25 | 3.05 | 3.60 | 39.83 |
| **HSB-2** | 27.58 | 9.90 | 4.23 | 6.29 | 3.05 | 3.83 | 4.35 | 59.23 |
| **HSB-3** | 33.99 | 6.87 | 2.99 | 4.40 | 1.94 | 2.67 | 3.29 | 56.15 |
| **HSB-4** | 55.52 | 7.63 | 3.80 | 5.45 | 2.45 | 3.10 | 3.76 | 81.71 |
| **HSB-5** | 44.25 | 11.70 | 5.90 | 7.90 | 3.73 | 4.95 | 5.72 | 84.15 |
| **HSB-6** | 32.58 | 9.68 | 4.75 | 5.10 | 2.60 | 3.72 | 4.30 | 62.73 |
| **HSB-7** | 70.17 | 11.61 | 5.56 | 7.05 | 3.36 | 4.50 | 4.80 | 107.05 |
| **HSB-8** | 32.90 | 6.77 | 3.01 | 3.61 | 1.80 | 2.46 | 2.52 | 53.07 |
| **HSB-9** | 37.52 | 7.39 | 4.25 | 4.37 | 2.16 | 3.17 | 3.84 | 62.7 |
| **HSB-10** | 24.47 | 4.32 | 2.25 | 2.48 | 1.20 | 1.56 | 1.60 | 37.88 |
| **HSB-11** | 17.26 | 3.66 | 2.17 | 2.26 | 1.12 | 1.55 | 1.75 | 29.77 |
| **HSB-12** | 35.13 | 3.82 | 2.38 | 2.21 | 1.14 | 1.64 | 1.52 | 47.84 |
| **Total** | **425.36** | **92.07** | **45.13** | **55.72** | **26.8** | **36.2** | **41.05** | **722.11** |

***Source: GIS analysis based on data compiled by researcher.***

## VI. Result and Discussion

The analysis based on RUSLE model reveals that about 59% area falls in the class of below 1tone/ha/year soil loss, 30% area comes under the range between 1 to 20 ton/ha/year soil loss and about 11% area in the basin have more than 20tone/ha/year soil loss. In the sub-basins of Hiranyakeshi, high rate of soil erosion has been observed in the upper sub-basin and the south and north ridge lines of the basin. It is due to the presence of high slope, coarse soil and high water velocity. Hence, the upper sub-basins are more susceptible to soil erosion.

## VII. Acknowledgement

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