SRI ADICHUNCHANAGIRI SHIKSHANA TRUST ®

PROJECT ON

# QUANTITATIVE DETERMINATION OF SOIL EROSION IN WATERSHED AREA USING GIS AND REMOTE SENSING


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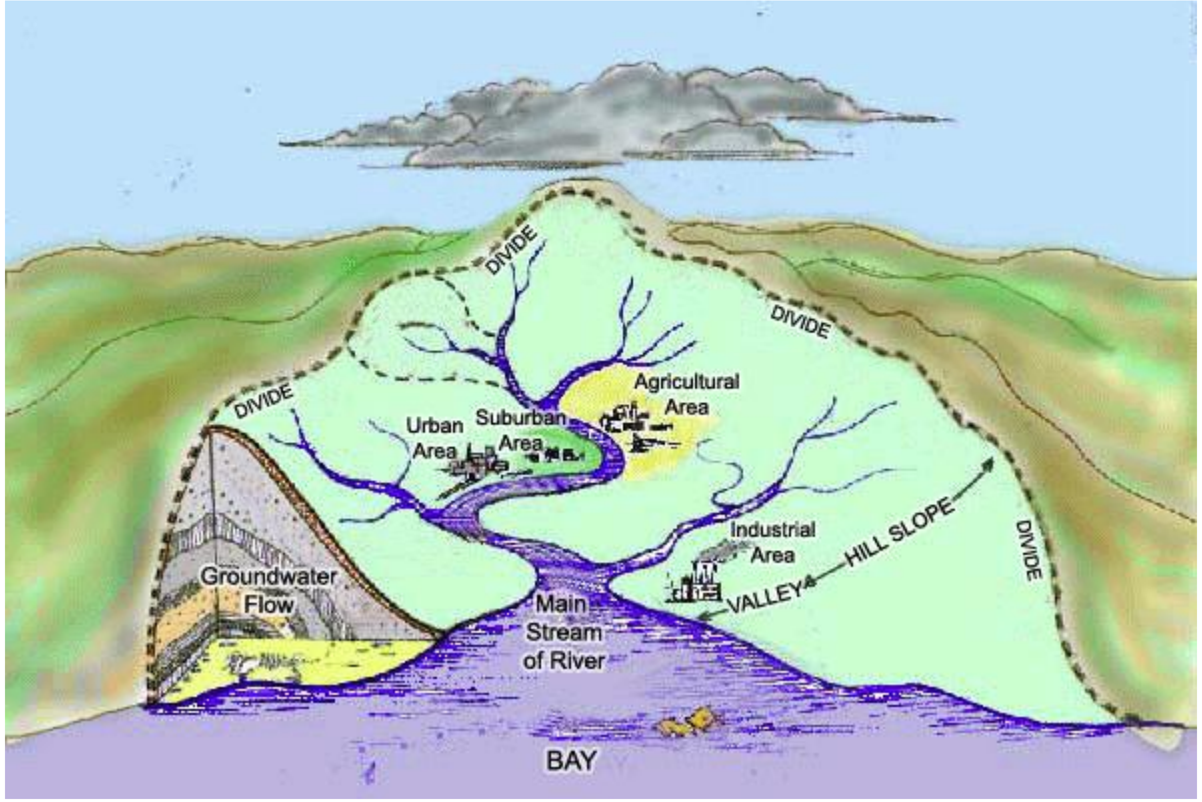
# CONTENT

# SOIL EROSION

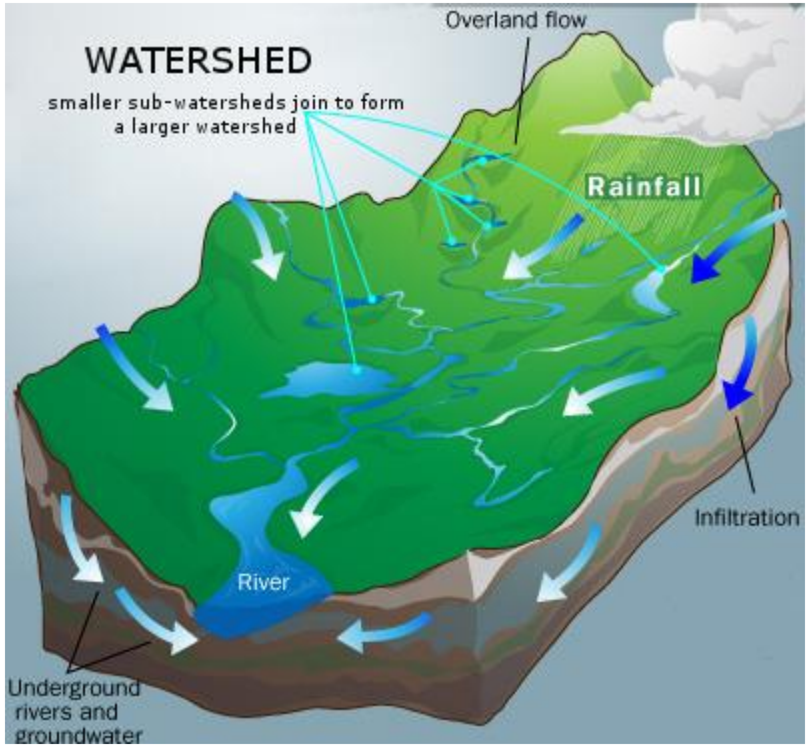
- Soil erosion is defined as the wearing away of topsoil. Topsoil is the top layer of soil and is the most fertile because it contains the most organic, nutrient-rich materials.
- All ecosystems have natural ways of decreasing the effect of erosion. The roots of trees and other vegetation in the watershed help to hold the soil in place during rainfall or flooding.
- Vegetation around streams in particular helps to strain out sediments and pollution before they get into streams where they can damage stream structure and destroy or damage fish habitats.
- Damage to large areas of vegetation in the watershed and particularly damage to areas around streams, or riparian areas, decreases the efficiency of the system to regulate and control erosion.
- Once these barriers to erosion are removed, the effects of erosion can become more and more severe, even hindering the reforestation and other vegetation growth as topsoil is removed and the ground becomes more unstable.

# WATERSHED AREA




- A watershed, also called a drainage basin or catchment area, is defined as an area in which all water flowing into it goes to a common outlet.
- Hydrologically, watershed is an area from which the runoff flows to a common point on the drainage system.
- Every stream, tributary, or river has an associated watershed, and small watersheds aggregate together to become larger watersheds.
- Water travels from headwater to the downward location and meets with similar strength of stream and then it forms one order higher stream.

- The stream order is a measure of the degree of stream branching within a watershed.
- The start or headwaters of a stream, with no other streams flowing into it, is called the first-order stream.
- First-order streams flow together to form a second-order stream.
- Second-order streams flow into a third-order stream and so on. Stream order describes the relative location of the reach in the watershed.
- Identifying stream order is useful to understand amount of water availability in reach and its quality; and also used as criteria to divide larger watershed into smaller unit.



# REMOTE SENSING

- Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it.

- This is done by sensing and recording reflected or emitted energy and processing, analysing, and applying that information.

- GIS is an organized collection of computer hardware, software, geographic data and personnel designed to turn the geographic data into information to meet the user’s needs.

# GEOGRAPHIC INFORMATION SYSTEM

- A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.

- GIS application is tools that allow end users to perform spatial query, analysis, edit spatial data and create hard copy maps.

- One of the most important features of the GIS is the capability to combine different layers to show new information. For example, one can combine elevation data, river data, land use data and many more to show information about the landscape of the area.

# APPLICATIONS OF RS AND GIS

- Remote sensing data help in regular management of water resources.
- For detection and monitoring of the water pollution, remote sensing prove useful etc.
- GIS is helpful in mapping, urban planning, transportation planning, in determining LULC ranges.
- GIS is helpful in Navigation (routing and scheduling), Flood damage estimation etc.

# USE OF GIS IN DETERMINATION OF SOIL EROSION

- The present study focuses application of most widely used Universal Soil Loss Equation (USLE) to determine soil erosion.

- Geographic Information System is applied to prepare various layers of USLE parameters which interactively estimate soil erosion at micro watershed level.

- The main advantage of GIS methodology is in providing quick information on the estimated value of soil loss for any part of the investigated area.

- The USLE, derived empirically, is $A = R \times K \times LS \times C \times P$

where soil loss (A) as a function of rainfall (R) amount and intensity; soil erodibility (K) related to texture, percentage of organic matter, structure, and permeability of soil; morphology, especially the length of the slope (L) and the slope gradient (S); vegetation cover (C); and erosion control practices (P).

# LITERATURE REVIEW

| SL.NO. | NAME OF THE AUTHOR | YEAR | TITLE | DESCRIPTION |
| --- | --- | --- | --- | --- |
| 1. | VipulShinde et.al | 2011 | "Quantitative determination of soil erosion using RS and GIS." | Their study focused on application of most widely used USLE equation for the quantitative study of soil erosion in Upper Damodar Valley Catchment.. It was concluded that annual average soil erosion for the entire basin is 22.04 tons/hectare/year. The area covered by high, medium and low erosion potential zones is 47.88%, 22.42% and 29.68% respectively. |
| 2. | SundaraKumar, Venkata Praveen and Anjanaya Prasad | 2016 | "Identification of critical erosion prone areas using RS and GIS." | The soil erosion is computed based on USLE equation. The results obtained based on the present findings, it can be inferred that the Sarada basin has 12.12% area is prone for soil loss of more than 80 ton per ha per year which is under very severe erosion class, 40-80 ton per ha per year under severe class, 11.95% under very high class and 3.10% under high class and27.78% under moderate class apart from 36.37% under not affected areas for soil erosion. |
| 3. | Alka et.al | 2017 | "Soil erosion modelling using RUSLE and GIS" | In this experiment the methodology adopted was RUSLE (Revised Universal Soil Loss Equation). Model is used to estimate soil loss from catchment. A = R*K*(Ls)*C*P. It is observed that the soil erosion for Dudhawa catchment is very less. |

| SL.NO. | NAME OF THE AUTHOR | YEAR | TITLE | DESCRIPTION |
|---|---|---|---|---|
| 4. | Jain and Kothyari | 2000 | "Estimation of soil erosion using GIS." | In this experiment the methodology adopted was grid based discretization procedure. In this method the cell size used for discretization should be small enough so that a grid cell encompasses a hydrologically homogenous area. Soil erosion within a grid cell was estimated via the USLE (Universal soil loss equation). |
| 5. | S.K.Jain et.al | 2001 | "Quantitative determination of soil erosion using RS and GIS." | In their study of soil erosion estimation, the same is carried out by two methods namely 'Model I (Morgan et.al) and Model II USLE.' The results from Model I show that soil loss from the dense forest is minimum. Model II also show that from forested areas soil loss is minimum. |

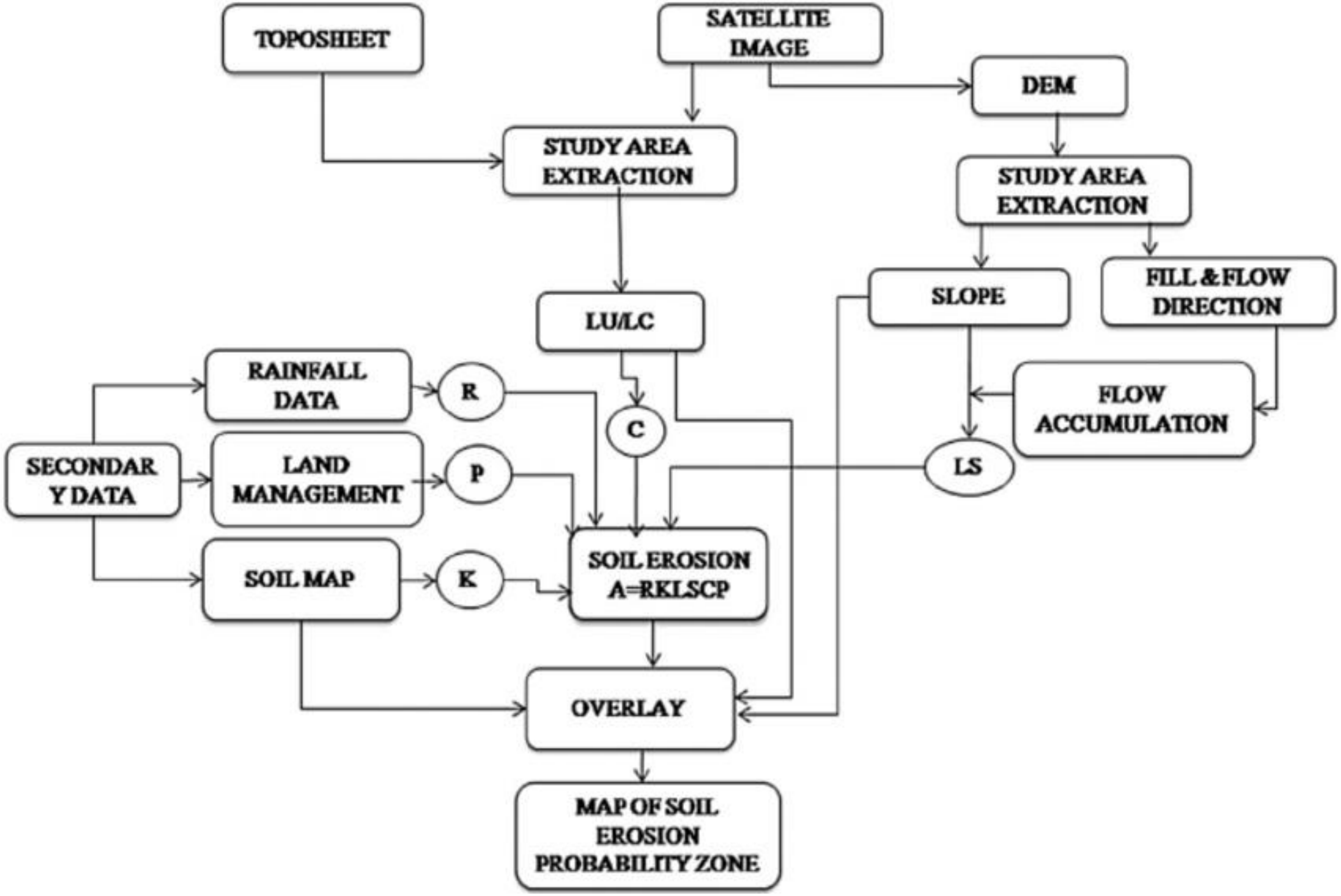
| SL.NO. | NAME OF THE AUTHOR | YEAR | TITLE | DESCRIPTION |
|---|---|---|---|---|
| 6 | SundaraKumar et.al | 2016 | “Identification of critical erosion prone areas using GIS.” | The soil erosion of the selected basin has been carried out using conservation practice factor, crop management factor, slope length factor, topographic factor and soil erodibility factor. Thematic maps have been prepared forthe above factors using RS and GIS technique.In viewof the study, it was found that 32.75% of study basin which has more than 20 ton for every hectare every year of Sarada basin requires prompt consideration from the soil conservation perspective. |
| 7 | V. Prasannakumar | 2011 | “Estimation of soil erosion risk within a small mountainous sub-watershed ” | In their study of soil erosion estimation, the same is carried out by two methods namely ‘Model I (Morgan et.al) and Model II USLE.’ The results from Model I show that soil loss from the dense forest is minimum. Model II also show that from forested areas soil loss is minimum. |

# OBJECTIVES

- To develop rainfall erosivity factor and soil erodibility factor for the catchment.
- To identify critical area of soil erosion and probable land slides.
- To predict soil erosion with varying soil slopes using Remote Sensing data and GIS.
- To estimate the soil loss in a catchment.

# METHODOLOGY

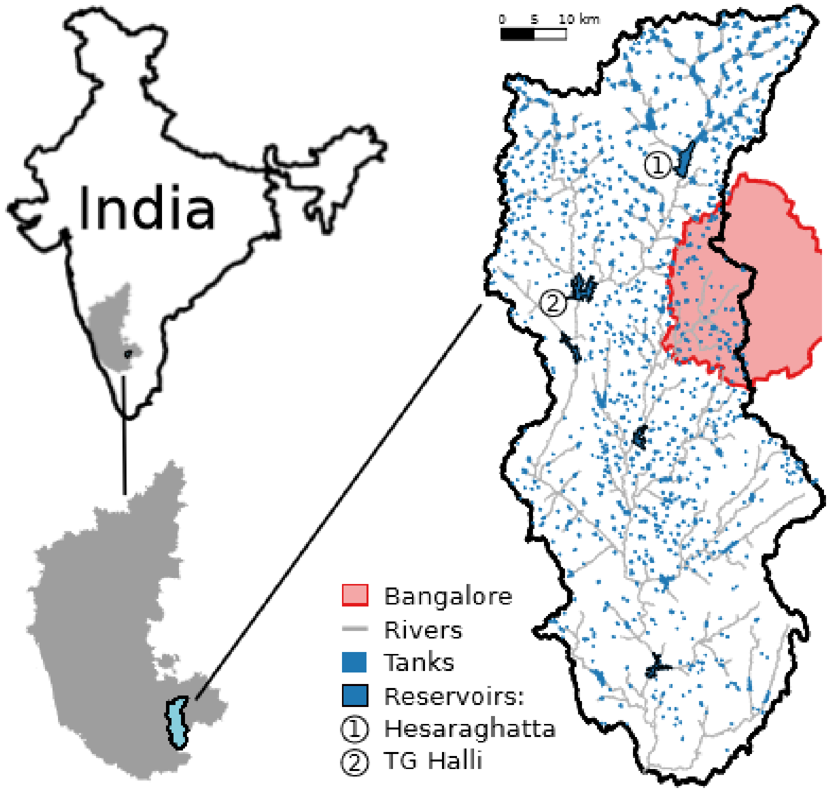
- Collection of primary and secondary data.
- Primary data includes the data collected from toposheets and DEM (Digital Elevation Model) of high resolution (30m).
- Extraction of study area and hydrological factors such as slope and flow direction from DEM.
- Secondary data includes collection of annual average rainfall data, LULC (Land Use Land Cover) data and soil map.
- Overlaying of primary and secondary data using GIS software (Arc GIS 10.2V or Q GIS).
- Generation of probable soil erosion map.


TOPOSHEET
SATELLITE IMAGE
DEM
STUDY AREA EXTRACTION
STUDY AREA EXTRACTION
LU/LC
SLOPE
FILL & FLOW DIRECTION
RAINFALL DATA
R
C
FLOW ACCUMULATION
SECONDAR Y DATA
LAND MANAGEMENT
P
LS
SOIL MAP
K
SOIL EROSION A=RKLSCP
OVERLAY
MAP OF SOIL EROSION PROBABILITY ZONE

# WORK PROGRESS

- Selection of water-shed – Arkavathy River
- Obtaining salient features of the watershed area.
- Collection of necessary data for the computation of soil loss.
- Collection of Topographic map from Survey Of India, Bangalore.

# ARKAVATHY WATER-SHED AREA AND ITS FEATURES



- Location map. (left, top) India. (left, bottom) Karnataka. (right) Arkavathy watershed, including the two historical drinking water reservoirs, TG Halli and Hesaraghatta (both reservoirs are now dry).

- The Arkavathy Catchment lies between latitude 12° 55' 44.505" N and 13° 22' 47.346" N and longitude 77° 19' 26.11" E and 77° 41' 16.047" E.

- Survey of India topographic maps of Numbers 57G/7, 57G/8, 57G/11, 57G/12 and 57H/5 cover the entire area of 987.58 sq.km. of the study area.

- The study area also covers parts of Doddaballapur, Devanahalli, Nelamangala, Magadi, and Bangalore North. It occupies an area of 467.19 sq.km.(47.30 per cent of the total study area) in Doddaballapur taluk 55.34 sq.km. (5.60 per cent of the total study area), Devanahalli taluk 77.29 km2 (7.82 per cent of the total study area), Nelamangala taluk 349.03 km2 (35.34 per cent of the total study area), Bangalore North taluk 38.71 km2 (3.91 per cent of the total study area) and Magadi taluk 38.15 km2 (3.86 per cent of the total study area).

- Water from River Arkavathy is provided to Bangalore through 1970, which is adjacent to and partially overlaps the Arkavathy, and supplied a sustainable network of surface water irrigation that existed for centuries to support agriculture in the remainder of the watershed.

- Over the last 50 years, water reservoirs in the Arkavathy have mostly gone dry, including two major reservoirs that supplied to Bangalore.

- The study area has an uneven landscape with plains, hills and valleys. The prominent physiographical features of the area are the Nandi hills in the northeastern corner of the catchment. The highest elevation is identified over the Nandi hills as 1,369.79 m above the mean sea level, the lowest elevation is 800 m above the MSL near the Thippagondanahalli reservoir.

- Most of the area represents broad undulating plain with elevation ranging from 800m to 920 m above the MSL. The terrain has a gentle slope towards the southwest.

# VISIT TO SURVEY OF INDIA,BANGALORE


A visit to the Survey of India by the team members to collect the toposheets of the watershed area .

# EXTENDED METHODOLOGY

• Continued literature survey on USLE and RUSLE equations.

The inference from the research papers are as follows:

• The value of **Precipitation and Runoff factor** - **R** in the equation depends upon the average annual rainfall.

•The value of **soil erodability factor** - **K**, depends upon the percentage of silt, sand and clay content in the soil.

•The **vegetation cover factor C** varies from zero to one.( **C=0** for highly vegetated area and **C=1** for barren lands, the value of which can be assumed from the research papers.)

•Support **Practice Factor**, **P**, depends upon the LULC. It varies from 1 on bare soil with no erosion control to about 1/10 with tied ridging on a gentle slope.

•**Topographic factor** - **SL** ,the topographic factor depends upon the length and gradient of the slope.

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•Delineation of the study area using the topographic maps.

•Collection of the rainfall data and other necessary data to aid for the computation of soil loss

| YEAR | JAN | | FEB | | MAR | | APR | | MAY | | JUN | | JUL | | AUG | | SEPT | | OCT | | NOV | | DEC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R/F | %DEP | R/F | %DEP | R/F | %DEP | R/F | %DEP | R/F | %DEP | R/F | %DEP | R/F | %DEP | R/F | %DEP | R/F | %DEP | R/F | %DEP | R/F | %DEP | R/F | %DEP |
| 2013 | 0.0 | -100 | 6.9 | 19 | 2.3 | -70 | 38.9 | 7 | 119.6 | 28 | 81.5 | 14 | 83.7 | -9 | 75.8 | -36 | 268.5 | 57 | 130.7 | -24 | 59.8 | 8 | 5.1 | -62 |
| 2014 | 0.0 | -100 | 0.1 | -98 | 19.6 | 158 | 11.0 | -70 | 92.5 | -1 | 61.4 | -14 | 90.1 | -2 | 162.6 | 38 | 202.3 | 18 | 267.2 | 56 | 35.4 | -36 | 3.9 | -71 |
| 2015 | 19.0 | 1020 | 0.0 | -100 | 28.4 | 273 | 112.0 | 209 | 162.1 | 74 | 107.5 | 51 | 55.8 | -39 | 99.9 | -15 | 238.2 | 39 | 78.8 | -54 | 189.4 | 242 | 11.2 | -17 |
| 2016 | 8.9 | 424 | 0.0 | -100 | 17.6 | 132 | 2.3 | -94 | 146.8 | 58 | 141.3 | 98 | 226.6 | 147 | 32.3 | -73 | 48.8 | -71 | 51.6 | -70 | 9.1 | -84 | 68.7 | 409 |
| 2017 | 0.9 | -47 | 0.0 | -100 | 12.4 | 63 | 36.9 | 2 | 207.6 | 123 | 27.6 | -61 | 36.1 | -61 | 199.1 | 69 | 376.8 | 120 | 335.0 | 95 | 16.2 | -71 | 11.3 | -16 |

Previous 5 Year Rainfall data

# Soil Erodibility Factor

**Table 2.** K Factor Data

| **Textural Class** | **K Factor tonnes/hectare (tons/acre)** | | |
|---|---|---|---|
| | **Average OMC*** | **Less than 2% OMC** | **More than 2% OMC** |
| Clay | 0.49 (0.22) | 0.54 (0.24) | 0.47 (0.21) |
| Clay loam | 0.67 (0.30) | 0.74 (0.33) | 0.63 (0.28) |
| Coarse sandy loam | 0.16 (0.07) | – | 0.16 (0.07) |
| Fine sand | 0.18 (0.08) | 0.20 (0.09) | 0.13 (0.06) |
| Fine sandy loam | 0.40 (0.18) | 0.49 (0.22) | 0.38 (0.17) |
| Heavy clay | 0.38 (0.17) | 0.43 (0.19) | 0.34 (0.15) |
| Loam | 0.67 (0.30) | 0.76 (0.34) | 0.58 (0.26) |
| Loamy fine sand | 0.25 (0.11) | 0.34 (0.15) | 0.20 (0.09) |
| Loamy sand | 0.09 (0.04) | 0.11 (0.05) | 0.09 (0.04) |
| Loamy very fine sand | 0.87 (0.39) | 0.99 (0.44) | 0.56 (0.25) |
| Sand | 0.04 (0.02) | 0.07 (0.03) | 0.02 (0.01) |
| Sandy clay loam | 0.45 (0.20) | – | 0.45 (0.20) |
| Sandy loam | 0.29 (0.13) | 0.31 (0.14) | 0.27 (0.12) |
| Silt loam | 0.85 (0.38) | 0.92 (0.41) | 0.83 (0.37) |
| Silty clay | 0.58 (0.26) | 0.61 (0.27) | 0.58 (0.26) |
| Silty clay loam | 0.72 (0.32) | 0.79 (0.35) | 0.67 (0.30) |
| Very fine sand | 0.96 (0.43) | 1.03 (0.46) | 0.83 (0.37) |
| Very fine sandy loam | 0.79 (0.35) | 0.92 (0.41) | 0.74 (0.33) |





* Organic matter content

# Length and Slope Factor

**Table 3A.** LS Factor Calculation

| **Slope Length: m (ft)** | **Slope (%)** | **LS Factor** |
|---|---|---|
| 30.5 (100) | 10 | 1.38 |
| | 8 | 1.00 |
| | 6 | 0.67 |
| | 5 | 0.54 |
| | 4 | 0.40 |
| | 3 | 0.30 |
| | 2 | 0.20 |
| | 1 | 0.13 |
| | 0 | 0.07 |
| 61 (200) | 10 | 1.95 |
| | 8 | 1.41 |
| | 6 | 0.95 |
| | 5 | 0.76 |
| | 4 | 0.53 |
| | 3 | 0.39 |
| | 2 | 0.25 |
| | 1 | 0.16 |
| | 0 | 0.08 |
| 122 (400) | 10 | 2.76 |
| | 8 | 1.99 |
| | 6 | 1.35 |
| | 5 | 1.07 |
| | 4 | 0.70 |
| | 3 | 0.52 |
| | 2 | 0.30 |
| | 1 | 0.20 |
| | 0 | 0.09 |

# Supporting Conservation Factor

**Table 5.** P Factor Data

| Support Practice | P Factor |
|---|---|
| Up & down slope | 1.0 |
| Cross slope | 0.75 |
| Contour farming | 0.50 |
| Strip cropping, cross slope | 0.37 |
| Strip cropping, contour | 0.25 |

Further project progress will include the following:

•Delineation of the study area from the obtained topographic map.

•Collection of land slope, management factor and other important parameters through various references.

• Overlaying the extracted study area and give the necessary input in-order to determine the soil loss using GIS. ( ARC / Q.GIS).

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