PRIORITIZATION OF SUB WATERSHEDS OF A RIVER BASIN USING GEOGRAPHIC INFORMATION SYSTEM

BY

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PROJECT REPORT

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DECLARATION

We hereby declare that this project entitled**” PRIORITIZATION OF SUB WATERSHEDS OF A RIVER BASIN USING GEOGRAPHIC INFORMATION SYSTEM”** is a bonafide record of project work done by us during the course of project and the report has not previously formed the basis for the award to us for any degree, diploma, associateship, fellowship or other similar title of any other university or society.

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CERTIFICATE

Certified that this project report entitled "**PRIORITIZATION OF SUB WATERSHEDS OE RIVER BASIN USING GEOGRAPHIC INFORMATION SYSTEM**" is a record of project work done independently by Athulya.C and Sajira.A.K under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

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Athulya C

Sajira .A.K

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SYMBOLS AND ABBREVIATIONS

cm	-	centimetre
DEM	-	Digital Elevation Modal
Dept	-	Department
et al	-	and others
Etc	-	et cetra
Fig	-	Figure
HRU’s	-	Hydrologic Response Units
GIS	-	Geographic Information System
g	-	gram
h	-	hour
ha	-	hectare
HSG	-	Hydrologic Soil Group
ILWIS	-	Integrated Land and Water Information System
km^2	-	square kilometer
m	-	Metre
m^2	-	square metre
min	-	minute(s)
Mj.mm/ha.hr.	-	Mega Joule.millimetre/hectare.hour
mm	-	millimetre
K.C. A.E.T.	-	Kelappaji College of Agricultural Engineering and Technology
NBSS&LUP	-	National Bureau of Soil Survey & Land Use Planning
pp	-	page
SWAT	-	Soil and Water Assessment Tool
SCS	-	Soil Conservation Service
SYI	-	Sediment Yield Index
SOI	-	Survey of India
t	-	tones
t/ha/yr	-	tone/hactre/year
Trans	-	Transaction
USLE	-	Universal Soil Loss Equation
yr	-	year
<	-	less than
>	-	greater than
/	-	per
%	-	percentage
°	-	degree
’	-	minutes
”	-	seconds

Dedicated to

The Almighty,

Loving Parents and

Teachers

Introduction

Chapter 1

Introduction

A **river** is a natural watercourse, usually freshwater, flowing towards an ocean, a lake, a sea, or another river. In a few cases, a river simply flows into the ground or dries up completely before reaching another body of water. Rivers are part of the hydrological cycle. Water within a river is generally collected from precipitation falling in a drainage basin from surface runoff and other sources such as groundwater recharge, springs, and the release of stored water in natural ice and snow packs. Rivers play a major role in integrating and organizing the landscape, and moulding the ecological setting of a basin.

The State of Kerala is located at the extreme southern tip of the Indian Subcontinent, blocked between the Arabian Sea to the west and the Western Ghats to the east. It has a vast stretch of coast that extends to a length of 580 km. Width of the state is very narrow and varies between 35 and 120 km. The state receives about 300 cm of average annual rainfall and is blessed with 40 minor rivers and 4 medium rivers, chain of backwater bodies, tanks, ponds, springs and wells. Hence, Kerala is often considered as a land of water.

The Bharathapuzha**,** also known as Nila, is a river in India in the state of Kerala. With a length of 209 km, it is the second-longest river in Kerala, after the Periyar River.

The headwaters of main tributary of Bharathapuzha originates in the Anamalai Hills in the Western Ghats, and flows westward through Palakkad Gap, across Palakkad, Thrissur and Malappuram districts of Kerala, with many tributaries joining it. Kunthipuzha is one of the main tributaries.

Watershed is an area drained by river or a stream system. It is a basin like landform defined by high points and ridge lines that descending to lower elevations, valleys and streams. The major phases of hydrology which influences watershed characteristics are rainfall, infiltration, transpiration, evaporation, surface runoff and groundwater flow. It is a natural integrator of all hydrological phenomena pertaining to an area bounded by a natural divide and is a logical unit for planning the optimal development of soil, water and biomass resources. Accordingly, all water conservation and management programs should be planned on a watershed basis.

1.1 Remote Sensing, GIS and watershed modeling.

Remote sensing means acquiring information about a phenomenon object or surface while at a distance from it. In other words, remote sensing is the science and art of obtaining information about an object, phenomenon or an area through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation.

A Geographical Information System (GIS) is a computer system for capturing, storing, querying, analyzing and displaying geospatial data. It is a computerized tool analyses and manages spatial and non-spatial data. GIS combines two computer software technologies viz. data base management and digital mapping. Data base management is a systematic way of organizing and accessing tabular data.

ILWIS is an acronym for the Integrated Land and Water Information System. It is a Geographic Information System (GIS) with Image processing capabilities. ILWIS has been developed by the International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede, The Netherlands. As a GIS and Remote Sensing package, ILWIS allows inputting, managing, analyzing and presenting geo-graphical data.

SWAT is an acronym for Soil and Water Assessment Tool, a river basin or watershed scale model developed by Dr. Jeff Arnold for the USDA Agricultural Research Service (ARS). SWAT was developed to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, landuse and management conditions over long periods of time.

1.2 Watershed prioritization

In watershed management programme, particularly in case of large watersheds it may not be possible to treat the entire area of the watershed with land treatment measures. In such cases, the watershed should be divided into sub watersheds and which need treatment should be identified. Watershed prioritization is the ranking of different micro watersheds of a watershed according to the order in which they have to be taken up for development.

This project work has been undertaken with the following specific objective

1. To study the erosion status of Kunthipuzha river basin.

2. To prioritize the different sub watershed based on the rate of erosion details.

Review of literature

Chapter 2

Review of literature

Khan *et al* (2001) has carried out a study on watershed prioritization using GIS and remote sensing, from Guhiya, India. Using terrain information derived from Geocoded satellite data and 1:50,000 topographic maps, 68 watersheds were assessed on the basis of their erosivity, Sediment Yield Index (SYI) value. Thematic maps of land form, land use and land cover, and slope were digitized using ARC/INFO. On the basis of SYI value watershed were grouped into very high, high, moderate and low priorities. High priority watershed with very high SYI (>150) need immediate attention for soil and water conservation. Where as, low priority watershed having good vegetative cover and low SYI value have (<50), may not need immediate attention for such treatment.

Shrimali *et al* (2001) did a work on prioritizing erosion-prone areas in hills using remote sensing and GIS. This paper presents a case study of the 42 km^2 Sukhna Lake catchment in the Shiwalik hills conducted for the delineation and prioritization of erosion-prone areas using RS and Geographic Information Systems. The catchment was classified into different classes. Using the U.S. Soil Conservation Service curve number method, runoff potential of each delineated hydrologic unit was computed in a grid-based analysis using an ARC/INFO GIS. Erosion-prone areas were classified further by integration of a digital elevation model or DEM-derived slope, aspect and flow length. To get an ordered priority of the erosion-prone areas, a cumulative erosion index was computed

Upadhye *et al* (2005) used remote sensing and GIS technique for prioritization of watershed for development and management in India. Remote sensing and GIS technique can be effectively used for priority delineation of sub-watershed. Initially polarization of watershed was mainly done with the help of aerial photographs and FCC. Then with progress in remote sensing and availability of data, work was carried out with visual interpretation techniques on LISS II and LISS III, PAN data as well as GIS techniques for overlapping maps. The maps were in 1:100000 scale. The satellite remote sensing technique provides data on land slope, land use and land cover which can be integrated with data on rainfall, erosivity and GIS to arrive quantitative estimation of soil loss.

Pandey.A *et al* (2006) conducted a study on watershed prioritization using USLE, GIS and remote sensing. In the study, prioritization of Karso watershed of Hazaribagh, Jharkhand State, India was carried out on the basis of average sediment yield data estimated from Universal Soil Loss Equation (USLE). Remote sensing (RS) technology provides the vital spatial and temporal information. Geographic Information System (GIS) was used as the tool to generate, manipulate and spatially organize disparate data for sediment yield modeling. Thus, the Arc Info GIS and RS (ERDAS Imagine 8.4) provided spatial input data to the model, while the USLE was used to predict the spatial distribution of the sediment yield on grid basis. The deviation of estimated sediment yield from the observed values in the range of 1.37 to 13.85 per cent indicates accurate estimation of sediment yield from the watershed. Subsequently, average sediment yields were estimated and the critical erosion prone areas of watersheds were arranged in the descending order of their sediment yields for prioritization purpose.

G.de.Winnaar *et al* (2007) conducted a study on GIS based approach for identifying potential runoff harvesting sites, at POTSHINI catchment, a small sub catchment in the Thukela river basin, South Africa. In this paper representation of spatial variation in landscape characteristics such as Soil .land use, rain fall and slope information is shown to be an important step in identifying potential energy harvesting sites. After which modeling the hydrological response in catchments where extensive runoff harvesting being considered can be performed and likely impacts assessed. Through the linked GIS, potential runoff harvesting sites are identified relative to areas that concentrate runoff and where the stored water will be appropriately distributed. Details of the spatially explicit method that were adopted in this paper are provided and output from the integrated GIS modeling system is presented using suitability maps.

Martin *et al* (2007) conducted a study on integrated approach of using RS and GIS to study watershed prioritization and productivity. Soil data obtained from soil resource inventory, land and climate were derived from the remote sensing satellite data (Land sat TM, bands 1 to 7) and were integrated in GIS environment to obtain the soil erosion loss using USLE model for the watershed area. The priorities of different sub-watershed areas for soil conservation measures were identified. Land productivity index was also used as a measure for land evaluation. The results obtained in this case study show the use of different kinds of data derived from different sources in land evaluation appraisals.

Chowdary *et al* (2007) pursued a research work on runoff and sediment yield modeling from a small agricultural watershed in India using the WEPP model. The present study was carried out to evaluate the physically based WEPP model for estimation of runoff and sediment yield from Karso watershed (India). The sediment yield computation was quite sensitive to interrill erodibility and effective hydraulic conductivity parameters. In pre-calibration, the WEPP model did not predict erodibility parameters satisfactorily in both surface runoff and sediment yield simulations, largely due to the empiricism involved in model equations. However, the present calibrated model results could be of use in erosion- based watershed prioritization and evaluation of cropping management practices in the study area.

Muhammad *et al* (2008) conducted a study on methodologies of preparing erosion features map using Remote Sensing and GIS, for Japrood sub basin in north east Tehran, Iran. The erosion feature map is one of the basic maps in erosion and sediment studies and watershed management program. In the first phase, four working unit maps were prepared by integration. (a) Land cover, geology and slope (b) land use geology and slope (c) land use, rocks sensitivity to erosion and slope (d) land use rocks sensitivity to erosion and land unit layers. In addition to these four maps three more maps were also evaluated in separating erosion features including (e) land unit (f) sensitivity of rock to erosion (g) image photo morphing unit.

Aiswarya *et al* (2009) conducted a study to suggest measures to rejuvenate river Bharathapuza using GIS and watershed simulation model. Bharathapuzha locally known as Ponnanipuzha which joins the Arabian Sea at Ponnani has been taken for this study. Study focused on measures for sustaining the river flow round the year with the specific objectives of modeling the topography of the river using GIS, studying the existing flow pattern of the river using simulation model, Sub watershed delineation was done by using GIS and Soil and Water Assessment Tool (SWAT). Digital Elevation Model (DEM), drainage network, soil map and land use map for the catchment were prepared by utilizing the integrated GIS and image processing capability of ILWIS.

Khanday *et al* (2009) made a study on Prioritization of sub watersheds based on morphometric and land use analysis using RS and GIS. This study makes an attempt to prioritize sub-watersheds based on morphometric and land use characteristics using remote sensing and GIS techniques in Kanera watershed of Guna district, Madhya Pradesh. Various morphometric parameters (linear and shape) have been determined for each sub-watershed and assigned ranks on the basis of value/relationship so as to arrive at a computed value for a final ranking of the sub-watersheds. Land use/land cover change analysis of the sub-watersheds has been carried out using multi-temporal data. The study demonstrates the significant land use changes. Based on morphometric and land use/land cover analysis; the sub-watersheds have been classified into three categories as high, medium and low in terms of priority for conservation and management of natural resources

Zeyad Makhamreh ***et al*** (2010) made an optimization study of watershed management in Mediterranean regions using remote sensing approach and surface landscape conditions.. The main objective of this work is to identify and optimize the potential water-harvesting sites in Jordan based on the characterization of surface landscape conditions using DEM and remote sensing techniques. In this study, the vegetation abundance and distribution was derived using spectral mixture analysis. In order to characterize the surface landscape conditions, a mathematical model has been established between soil colour and soil surface properties to derive the spatial distribution of soil organic and inorganic content using Landsat images. Based on these results the current distribution of the hydrological pattern has been derived, and hence the spatial pattern of run-on and run-off areas has been determined.

Sreenivasulu *et al* (2010) conducted a study on an integrated approach for prioritization of reservoir catchment using Remote Sensing and GIS techniques. This study is aimed at evolving a watershed prioritization of reservoir catchment based on vegetation, morphological and topographical parameters, and average annual soil loss using GIS and RS techniques. A large multipurpose river valley project, Upper Indravati reservoir, situated in the state of Orissa, India, has been chosen for the present work. This study integrates the watershed erosion response model (WERM) and USLE with GIS to estimate the erosion risk assessment parameters of the catchment. The total catchment is divided into 15 sub-watersheds. Various erosion risk parameters are determined for all the sub-watersheds separately. Average annual soil loss is also estimated for the sub-watersheds using USLE. The integrated effect of all these parameters is evaluated to recommend the priority rating of the watersheds for soil conservation planning.

Mishra *et al* (2010) studied on morphmetric analysis and prioritization of sub watersheds using GIS and Remote Sensing techniques. The study area is one of the watersheds of Tel river, covering an area of 1515.45km2 and lies in Bhawanipatna area of Kalahandi district, Odesha, In the present study, the parameters considered for prioritization of sub watersheds are from the natural resources thematic data, including drainage density, groundwater prospects, irrigated area, forest cover and wastelands derived from satellite imagery and socioeconomic data. The thematic maps are derived from geo-referenced false color composite (FCC) satellite image. The entire study area has been further divided into sub watersheds and has been taken up for prioritization based on morphometric analysis using GIS and remote sensing techniques. The compound parameter values are calculated and the sub watershed with the lowst compound parameter is given the highest priority.

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Kumar *et al* (2010) has done a study on micro watershed characterization and prioritization using Geomantic technology for natural resources management. Their study area was Upper Sanjai river watershed in the western part of the Subarnarekha basin covering an area of about 893.48 sq. km in the Kolhan Division of Jharkhand... Proper planning of watershed is essential for the conservation of water and lands resources an attempt has been made to characterize and prioritize the entire study area at micro watershed level. The severity of the problem have been taken into consideration and based upon the land degradation, they are ranked in order to prioritize. Management of watershed encompasses various activities from watershed delineation to monitoring. Various method of suitability assessment is carried out based on combination of mathematical analysis. Saaty's analytic hierarchy process is used for scaling the weights of parameters.

Jyothish *et al* (2010) made a study on simulating the impact of check dams on river flow with a case study in Bharathapuzha river basin. Study area was Kunthipuzha, one of the major tributaries of Bharathapuzha. This study is aimed to improve the yield of Kunthipuzha. Micro watershed delineations and their topographic analysis were carried out with the help of ILWIS and SWAT. Digital Elevation Model (DEM), drainage network, soil map and land use map for the catchment were prepared by utilizing the integrated GIS and image processing capability of ILWIS.

Bouaziz *et al* (2011) carried ou ta study on optimal parameter selection for qualitative regional erosion risk monitoring using remote sensing and GIS. This study focus on the catchment basin of the Maleka Wakena reservoir, located in the south eastern portion of the main Ethiopian Rift, where erosion is the major environmental problem. This study uses remote sensing to describe the contribution of several factors that control erosion. Topography, land use, vegetation density, soil properties and climatic proxies are used to determine erosion risk and to provide basic maps of water and soil conservation practices. A hierarchical decision tree is used to sum and combine the weight of parameters controlling the erosion. The assigned weights of each spatial unit express the susceptibility to erosion. Three different combinations of the dominant controlling factors are yielded in this study. In order to optimize the qualitative erosion risk assessment, each combination is discussed and evaluated depending on the contribution of parameters involved in the erosion process.

Javed *et al* (2011) made a study on watershed prioritization using morphometric and land cover/ land use parameters using RS and GIS .for Jaggar watershed, a constituent of the Gambhir river basin, in eastern Rajasthan and cover an area of 352.82 km^2. The Jaggar watershed has been divided into fourteen sub-watersheds, designated as SW1 to SW14, for prioritization purpose on the basis of morphometric analysis and land use/land cover categories. Land use/land cover mapping has been carried out using IRS LISS III data of 1998. Various morphometric parameters (linear and shape) have been determined for each sub-watershed and assigned rank on the basis of value/relationship with erodibility. Based on morphometric and land use/land cover analysis and their ranks, the sub watersheds have been classified into four categories as very high, high, medium and low in terms of priority for conservation and management of natural resources.

Suryavanshi *et al* (2010) studied about the application of Remote Sensing &GIS Techniques, land resource characterization and watershed management, in Malagoan watershed region of Nasik Tehasil, which is located at the south western part of Nasik district, Maharashtra. They collected satellite data from three satellites covering Nasik Tehasil and generated thematic/ derived maps. Topographic map and soil survey report from all Indian soil and land use survey for the part of the study area was used as collateral data. Then they generated land use / land cover map by the classification of image. Supervised classification was carried out for the satellite data. Based on the studies on the different maps optimum land use resources development plan has been suggested.

Bipul Deka *et al* **(2011)** pursued a study on soil loss estimation on Remote sensing data and GIS techniques in Ghiladhari watershed of northern Brahmaputra watershed in Assam. Study was under taken to map the erosional soil loss in Ghiladhary watershed of the Northern Brahmaputra valley of Assam USLE and ARC/INFO GIS. Information of land use / land cover / Physiographic and terrain slope obtained from false colour composite of IRS-IC,LISS -3 imagery and topographic map where used to provide input to USLE model. The soil erosion map prepared by the integration of USLE factors revealed five soil erosion classes.

Materials and methods

Chapter 3
Materials and methods

3.1 Study area

Kunthipuzha, one of the major tributaries of Bharathapuzha is taken for the study Bharathapuzha is one of the major rivers of Kerala and lies in the central part of it with a total catchment area of 6400 sq.km. The remarkable feature of this river is its crystal clear water in all seasons. Kunthipuzha tributary originates from the north eastern part of Bharathapuzha river basin known as Silent valley national park . Kunthipuzha sub basin has a total catchment area of 940 km^2 and lies with in the geographical boundary of 10º 53' N, 76º 04' E to 11° 14' N, 76º 41' E. River flow and sediment data has been collected from Pulamanthole river gauging station (10º 53'50''N, 76º 11'50''E) manned by Central Water Commission, India. Catchment area corresponding to the gauging station is 822 km^2. It flows westward through Palakkad Gap, across Palakkad, Thrissur and Malappuram districts of Kerala, with many tributaries joining it, including the Tirur River. It discharges into the Arabian Sea at Ponnani. The river is enriched with flora and fauna.

3.2 Data used and their sources

3.2.1. Toposheets

Toposheets from survey of India (SOI) bearing numbers 58A/8, 58A/12, 58B/1, 58B/5 and 58B/9 prepared in 1:50000 scale.

3.2.2. Soil map

Soil map from National Bureau of Soil Survey and Land Use Planning (NBSS and LUP) prepared in 1:50000 scale.

3.2.3. Land use map

Land use map available in the geomatic division of the department Of LWRCE has been used in this study.

3.2.4. Rainfall Data

Daily rainfall data for the year 1996 to 2002 from Pattambi and Mannarkad rain gauge station.

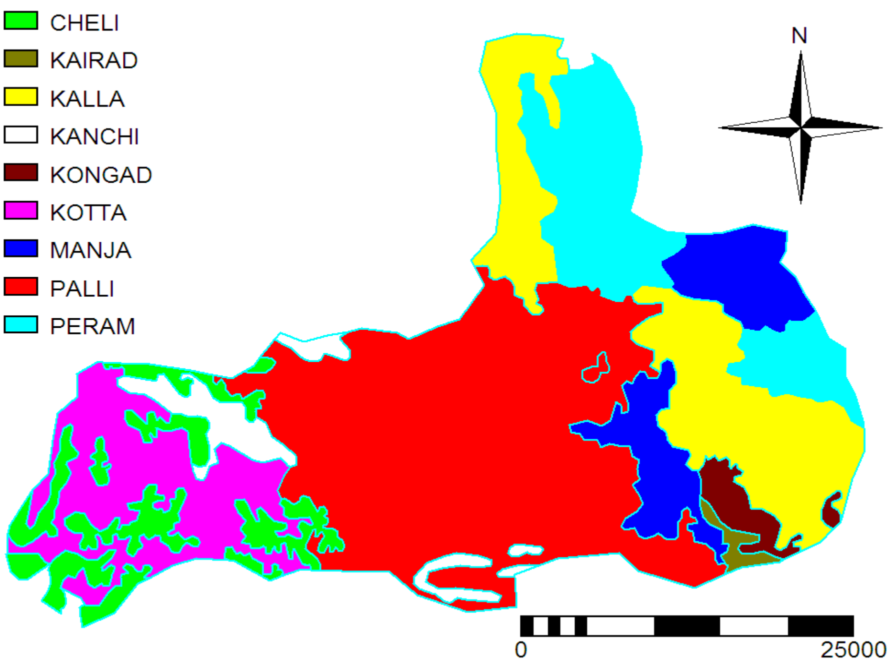


Figure 3.2.2: Soil map

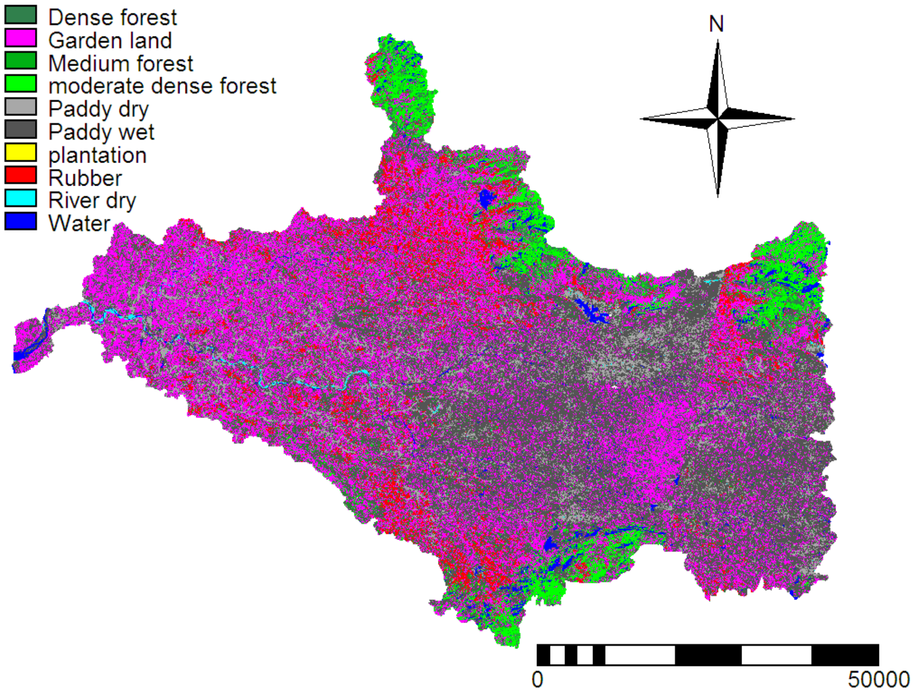


Figure 3.2.3: Land use map

3.3 Tools and techniques used

3.3.1 ILWIS

ILWIS (Integrated Land and Water Information System) is important remote sensing and GIS software. It allows inputting, managing, analyzing and presenting geo-graphical data. From the data, we can generate information on the spatial and temporal patterns and processes on the earth surface. ILWIS is developed by the International Institute for Aerospace Survey and Earth Science, Netherland. It is an integrated GIS software with image processing capabilities. Software is less complex, small in size in terms of computer memory and processor speed. The software is used very widely in the field of soil and water engineering.

3.3.2 SWAT

SWAT, the acronym for Soil and Water Assessment Tool, is a complex integrated river basin scale model which simulates the hydrologic processes of each HRUs on daily or hourly time step (Arnold et.al,, 1990 & 1993, Jayakrishnan et al., 2005 and Bouraoui et al., 2005).

It is designed to predict the impact of management on water, sediment and agricultural chemical yields in gauged and ungauged watersheds. The model is physically based, computationally efficient and capable of continuous simulation over long periods of time. Major model components include weather, hydrology, sediments and nutrients. In SWAT, a watershed is divided into multiple sub watersheds. These are further sub divided into hydrologic response units (HRUs) that consists of homogeneous land use, management and soil characteristics. The capability of SWAT model is particularly limited in terms of dealing with ground water flow, due to its lumped nature. For this study, SWAT is used for delineating the sub watersheds of the river basin under study.

3.4 Digitization of contour map

Toposheets representing the study area is scanned and imported into ILWIS environment using "file import" option of the software. Contour lines are digitized from the toposheets using on-screen digitization capability of the ILWIS software. While digitizing the contours, the contour lines lying at the outer premises of the river basin boundary were also included to make the interpolation of the contour values possible at the time of DEM generation. Corrections were applied to remove the errors caused due to line overlaps, dead end and intersections. After the error corrections, the segment contour map was rasterised using the segment to raster feature of ILWIS.

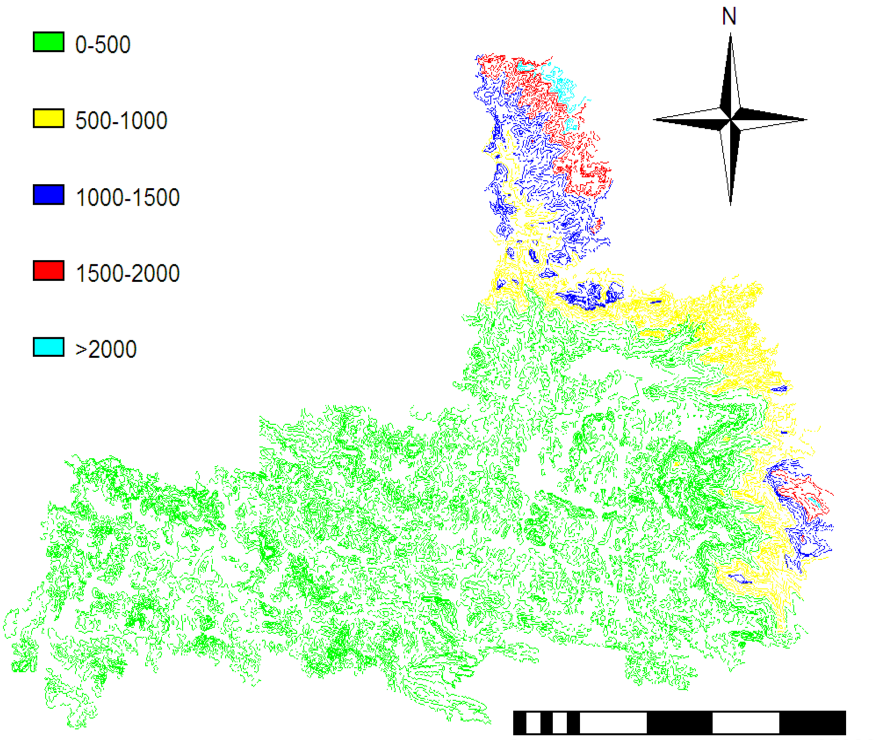


Figure 3.4: Contour map of Kunthipuzha river basin

3.5 Digital Elevation Model

Digital Elevation Model (DEM) stores continuously varying variables such as elevation, groundwater depth or soil thickness. Digital Terrain Models (DTM's) are digital representations of altitude and are frequently used in hydrological, erosion and engineering geological studies. Digital Elevation Models can either be stored in vector or in raster format.

The creation of a Digital Elevation Model from contour map is done with the contour interpolation operation. A linear interpolation is made between the pixels with altitude values, to obtain the elevations of the undefined values in between the rasterized contour lines. The output of the contour interpolation is a raster map in which every pixel has a value.

3.6 Watershed delineation

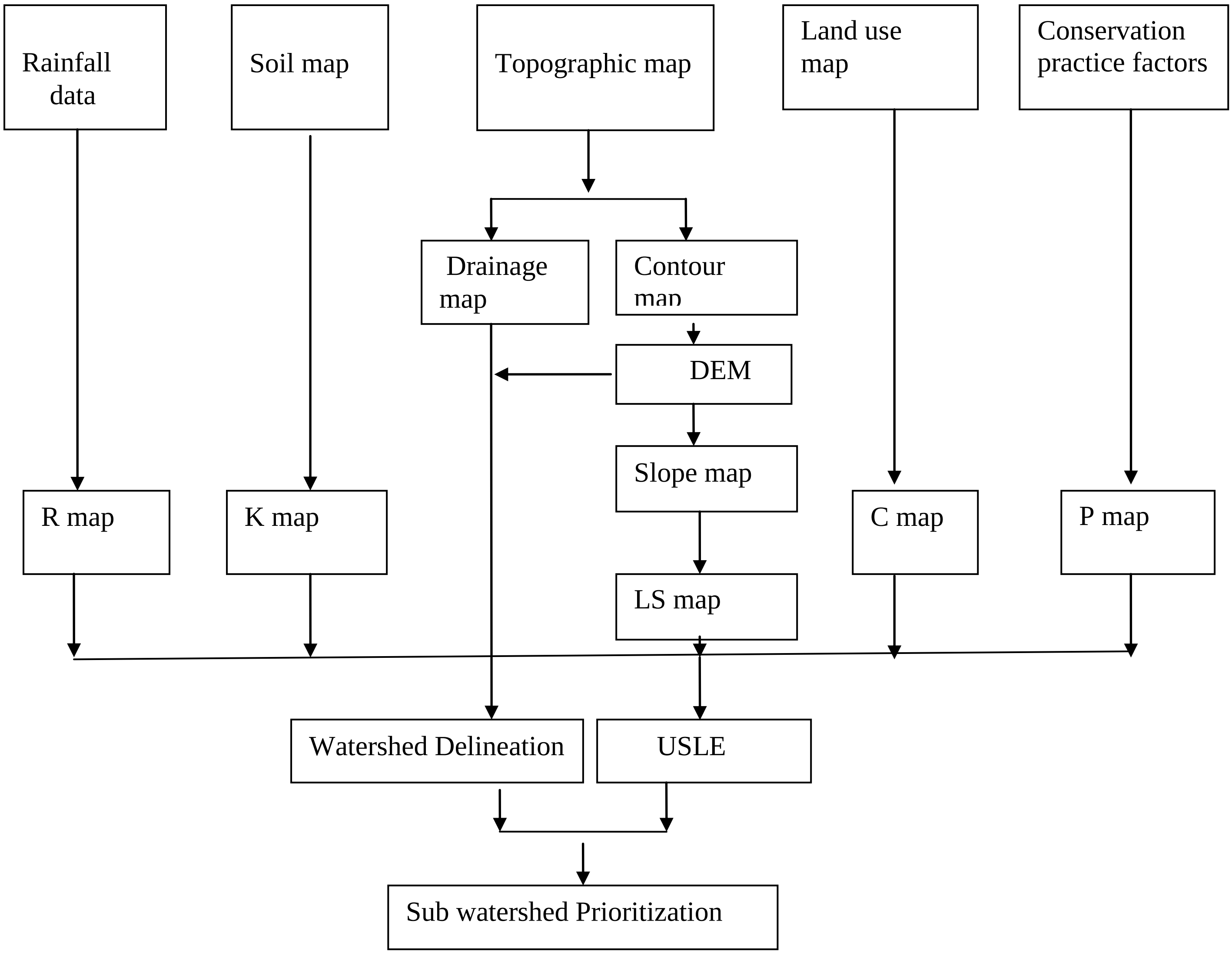
For giving practical, scientific and rational approach of using watersheds as unit of planning and development, a frame work of sub watershed for a river basin is a pre requisite.

Digital Watershed Delineation makes use of advanced GIS functions to aid in segmenting watersheds into several hydrologically connected sub-watersheds for use in watershed modeling. The delineation process requires a Digital Elevation Model (DEM) in Arc Info grid format as an input.

Key Procedures involved are:

1. The DEM is first loaded to the Arc-View - SWAT interface.
2. The digitized stream network is then loaded for the delineation to be accurate.
3. Preprocessing of the DEM is then done.
4. The minimum sub-watershed area (critical source area) is then specified.
5. The stream network points are then reviewed and edited.
6. The calculation of the sub basin parameters are then done in SWAT.

3.7 Flow diagram of the process of watershed prioritization



3.8 Generation of USLE map

3.8.1 Erosivity (R) Map

The study area has got two rain gauge stations viz.Pattambi and Mannarkad. Daily rainfall data in mm from the year 1996 to 2002 were collected from both rain gauge stations. Then, annual rainfall for each year is found out and R factor is calculated using the empirical equation given below.

$$R = 38.5 + 0.35*P \qquad \ldots(3.1)$$

Where,

R = rainfall erosivity factor

P = annual rainfall in mm

Table 1: Annual rainfall for the study area.

Year	Annual rainfall in mm	
	Pattambi	Mannarkad
1996	2217.6	2446.3
1997	3065.0	2594.9
1998	2687.6	3087.1
1999	2395.0	902.0
2000	2059.0	2311.0
2001	2413.9	2760.0
2002	2094.2	2132.7

For the R map, the boundary map of the study area is rasterised. Then point map of rain gauge station is created. Geographical location of the rain gauge stations are as follows.

Table.2

	Mannarkad	Pattambi
(X,Y)	(659809,1222063)	(629433,1200753)
Latitude, Longitude	10 59 23.52 N, 76 27 51.40 E	10 48 04.67 N, 76 11 07.15 E

A Thiessen polygon map is created using the point map of rain gauge stations. For that, 'nearest point' option of the software is used. Then, the thiessen polygon map so obtained is cut using rasterised boundary map of the study area. Histogram of the thiessen polygon map is opened and a column of R factor is added using 'add column' option of the software. Then the map is reclassified using the attribute table created.

3.8.2 Erodibility (K) Map

Physical properties of different soil series coming in the study area are given in table 3.

Table 3: Physical properties of different soil series used in the study

Soil Code	Soil Series	Clay (%)	Silt (%)	Sand (%)	Organic carbon (%)	Bulk density (g/cm^3)	SOL_AWC (mm/mm)	SOL_K (mm/h)
PALLI	Pallippadi	27.00	9.00	64.00	0.99	1.36	0.06	5.00
KALLA	Kalladikkode	22.20	11.20	66.60	1.05	1.37	0.06	9.25
MANJA	Manjallor	45.00	7.90	47.10	1.83	1.17	0.07	0.25
KOTTA	Kottappadi	25.90	16.50	57.60	2.63	1.17	0.07	6.25
PERAM	Perambra	30.00	10.40	59.60	1.93	1.24	0.10	6.50
CHELI	Chelikkuzhi	33.70	8.00	58.30	2.18	1.20	0.08	2.50
KANCHI	Kanchirapuzha	33.00	8.60	58.40	2.24	1.20	0.08	2.75
KONGAD	Kongad	27.70	15.70	56.40	1.24	1.14	0.09	7.60
KAIRAD	Kairad	23.30	14.80	61.90	1.30	1.16	0.09	11.5
CHERU	Cheruvalli	34.50	6.10	59.40	2.54	1.10	0.06	2.00
ANAYA	Anayadi	27.80	8.50	63.70	0.89	1.18	0.08	6.00
PULLA	Pullangod	35.00	13.50	51.50	2.16	1.10	0.07	1.75
VIJAY	Vijayapuram	24.70	9.50	65.80	1.01	1.17	0.07	7.80

With this information, erodibility factor is calculated using following equation;

$$K=2.8*10^{-7} *M^{1.14} (12-a) +4.3*10^{-3}(b-3) +3.3*10^{-3}(c-3) \qquad \ldots (3.2)$$

Where,

M = (%silt+ %fine sand) (100-%clay)

a = Percent organic matter

b = Soil structure code (very fine granular, 1; fine granular, 2; medium or coarse granular, 3; blocky, platy or massive, 4)

c = Profile permeability class(rapid,1;moderate to rapid,2; moderate,3;slow to moderate,4;slow,5; very slow,6)

For the study area, the soil structure is taken as medium or coarse granular i.e. b =3

Table 4 gives the value of c in eqn (3.2).

Table.4: Soil permeability

Rate in mm/h	**Class**
<1.3	Very slow
1.3-5	Slow
5.01-20	Slow to moderate
20.01-50	Moderate
50.1-130	Moderate to Rapid
130.01-250	Rapid
>250	Very rapid

Table.5: K factor value

Soil series	K factor
Pallippadi	0.0622
Kalladikkode	0.0704
Manjallor	0.0406
Kottappadi	0.0557
Perambra	0.0517
Chelikkuzhi	0.0500
Kanchirapuzha	0.0507
Kongad	0.0596
Kairad	0.0637
Cheruvalli	0.0475
Anayadi	0.0584
Pullangod	0.0484
Vijayapuram	0.0661

For creating K factor map, a table was created from the domain of the soil textural map. Additional column for K factor was added to that table using the “add column” option in the software. For generating k map, existing soil map is reclassified into an attribute map using attribute table of calculated k factor.

3.8.3 Topographic Factor (LS) Map

DEM is the prerequisite for the creation of LS map. DEM is generated from contour map using contour interpolation option of ILWIS software. A linear interpolation is made between the pixels with altitude values, to obtain the elevations of the undefined values in between the rasterized contour lines. The output of the contour interpolation is a raster map in which every pixel has a value.

Slope map is prepared from DEM using filter operation.

Slope (%) map is generated using the equation;

$$\text{Slope} = (\text{hyp}\ (D_x, Dy)/\text{pixelsize(DEM)})\ *100 \qquad \ldots(3.3)$$

Where,

D_x = slope gradient in x direction

D_y = slope gradient in y direction

A slope length factor (L) map is prepared, as a prerequisite to LS factor map using the equation,

$$L = (X/22)^{m} \qquad \ldots(3.4)$$

Where,

L = Slope length factor

X = Slope length in meters

m = An exponent

Recommendation of exponent 'm' is given below

m= 0.5 if slope>5%

m= 0.4 if slope<=5% and > 3%

m= 0.3 if slope, <=3% and >1%

m= 0.2 if slope<=1%

Now, LS map is generated using the equation:

$$LS = (X/22)^{m} (0.065+4.56 \sin S+65.41 \sin^2 S) \qquad \ldots(3.5)$$

Where,

LS= LS factor

L= Slope length in m

S= Slope steepness in radians

Slope radians are computed from the slope map, first by converting the slope % to slope degree and then slope degree to slope radians. Slope in degree is obtained using the equation,

Slope degree = raddeg(atan (slope/100)) …(3.6)

Slope radians is computed using the equation, …(3.7)

Slope radians = degrad(slope degree). …(3.8)

3.8.4 Crop Factor (C) Map

C map is generated as an attribute map by creating a table of C factor from the domain of the land use map of the study area. Table of C factor is created by using "add column" option of the software. Then the land use map is reclassified into C map by using the table created for c factor. Crop factor values for different crops in the study area are given in Table 6.

Table.6. Values of crop factor.

Land use	C factor
Dense forest	0.001
Garden land	0.40
Medium forest	0.35
Moderate dense forest	0.08
Paddy dry	0.28
Paddy wet	0.40
Plantation	0.35
Rubber	0.35
River dry	0.28
Water	0.00

Crop factor (C) map is generated as an attribute map by adding a C column to the soil table. Values of crop factor are entered in the soil table according to the type of crop.

3.8.5 Conservation Practice Factor (P) Map

Conservation practices for the study area are not available, hence it is assumed that there are no appreciable conservation practices and its value is assumed as '1' for whole watershed.

3.9. USLE map

USLE map is generated by multiplying the 5 maps viz. R, K, LS, C and P using the "cross" option in ILWIS. Then the USLE map was classified using the “classify” function of the software. A group domain is needed for the classification and the range of values of each soil loss class is defined in that class.

3.10 Sub watershed erosion estimation

USLE map and sub watershed map are crossed using “cross option” in the ILWIS software. After the crossing, a table is obtained which gives soil erosion estimate of each sub watershed of the entire river basin.

3.11 Watershed prioritization

Watershed prioritization is the ranking of different micro watersheds of a watershed according to the order in which they have to be taken up for development.. On the basis of priority, sub watersheds can be classified into very high, high, medium and low priority category. For this study, prioritization is done on the basis of soil erosion taking place from individual sub watersheds.

Table.7

Priority category	**Soil loss range**
Very high priority	>50 tons/ha/year
High priority	15 – 50 tons/ha/year
Moderate priority	5 – 15 tons/ha/year
Low priority	< 5 tons/ha/year

Results and Discussions

Chapter 4

Results and Discussion

4.1. Kunthipuzha sub basin

Kunthipuzha watershed boundary with the drainage network is shown in fig.4.1.Maximum length and width of the basin are 57413m and 34697m respectively. Elevation ranges from 20.6m to 1844.4m.

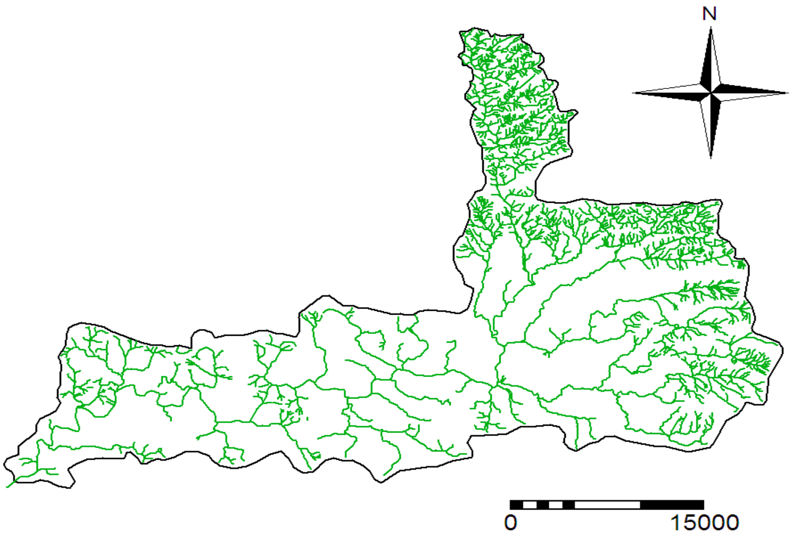


Figure 4.1: Kunthipuzha river basin with drainage network.

4.2 Digital Elevation Model (DEM)

DEM of the basin is shown in fig.4.2. The distribution of elevation of the basin is 20.6m to 1844.4m.

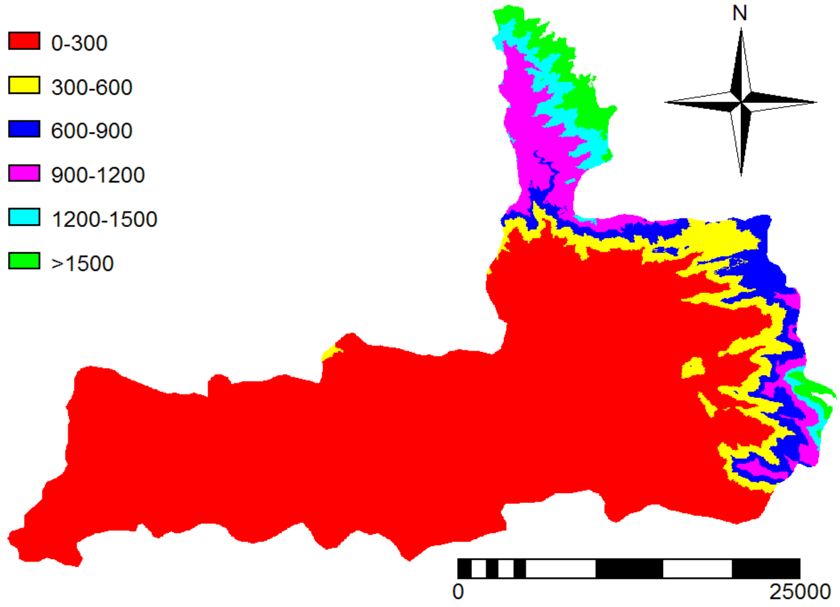


Figure 4.2: Digital elevation model of Kunthipuzha river basin

4.3 R map

Rainfall erosivity factor map (R map) showing R values in the Kunthipuzha watershed region is shown in fig 4.3. Map shows R factor of different regions in the Kunthipuzha watershed based on rainfall values obtained from two raingauge stations. Value of R factors for the two raingauge stations are 850.2 & 885.1.

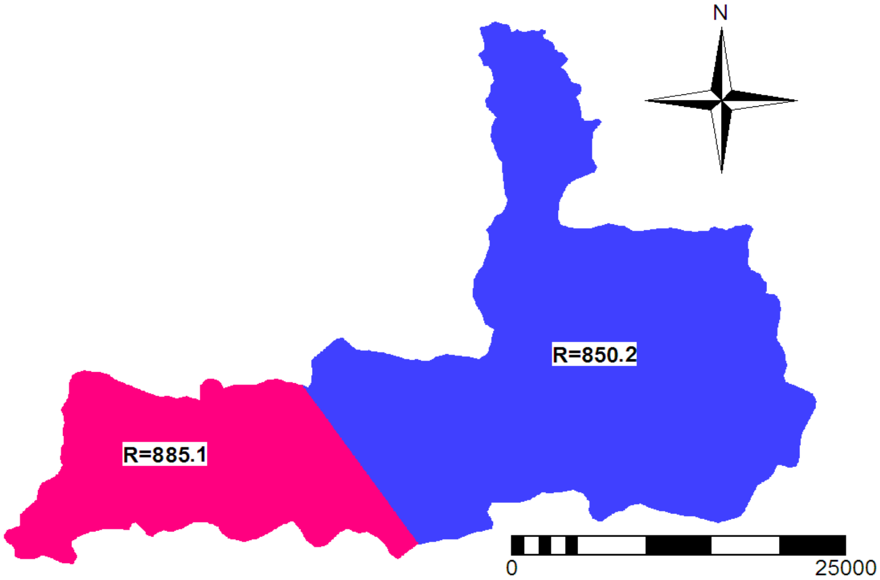


Figure 4.3: R map of Kunthipuzha river basin

4.4 K map

Soil erodibility map (k map) is prepared from the existing soil map of the Kunthipuzha watershed as an attribute map of K factor. For the study area, value of K factor varies from 0.04 to 0.07. K map is shown in fig.4.4.

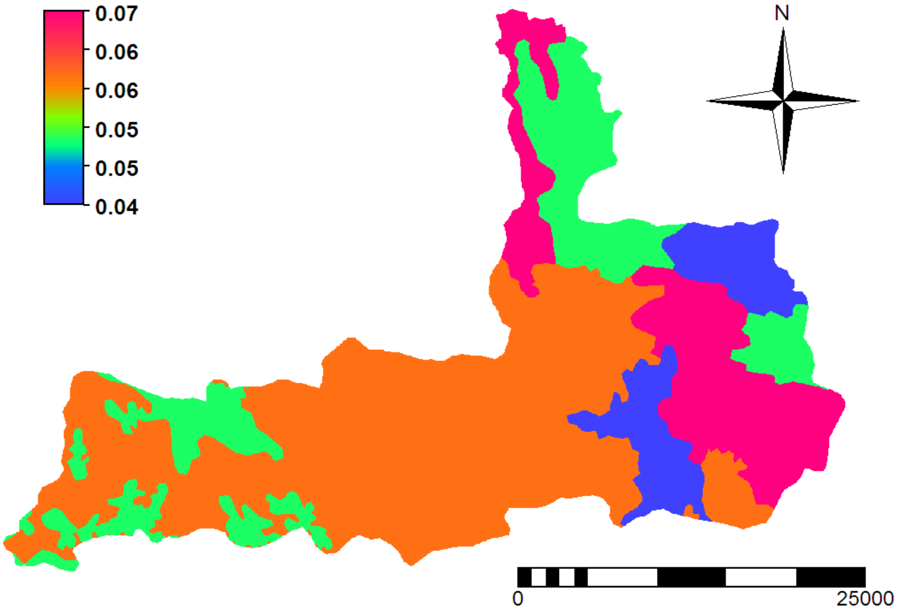


Figure 4.4: K map of Kunthipuzha river basin

4.5 Slope map and Topographic factor map (LS map)

Slope map prepared from DEM is shown in fig 4.5.1. Slope is varying from 0 to 404.4. An LS map obtained from slope map is presented in fig 4.5.2

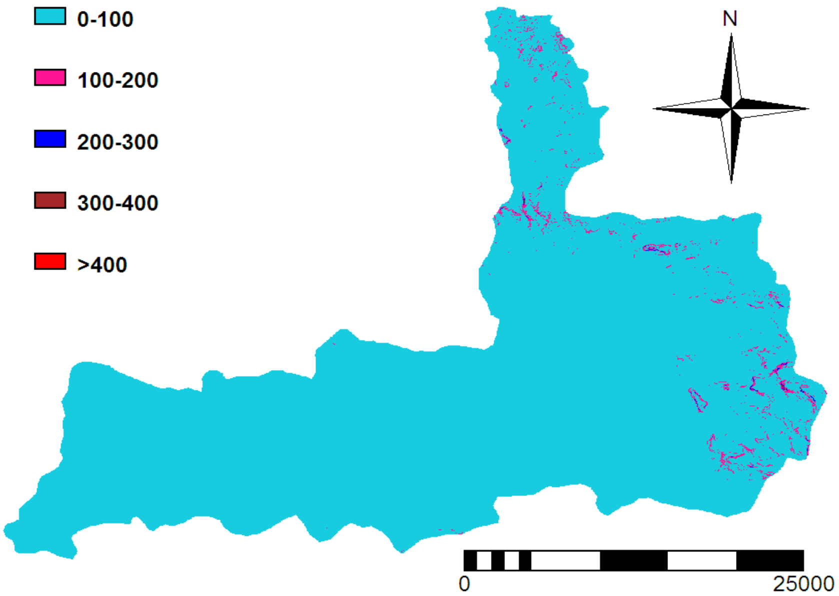


Figure 4.5.1: Slope map of Kunthipuzha river basin

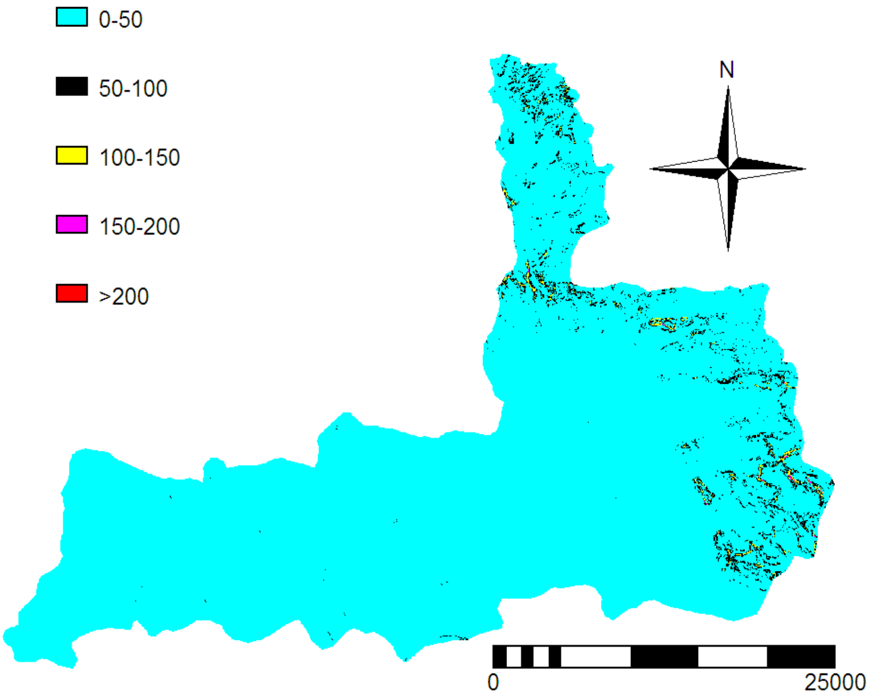


Figure 4.5.2: Topographic factor (LS) map

4.6 C map

Crop factor map is prepared from existing land use map of the watershed. The crop factor values of the watershed vary from 0 to 0.40 with an average value of 0.21. In the watershed, 59.07% of the total area is having a crop factor value of 0.4.

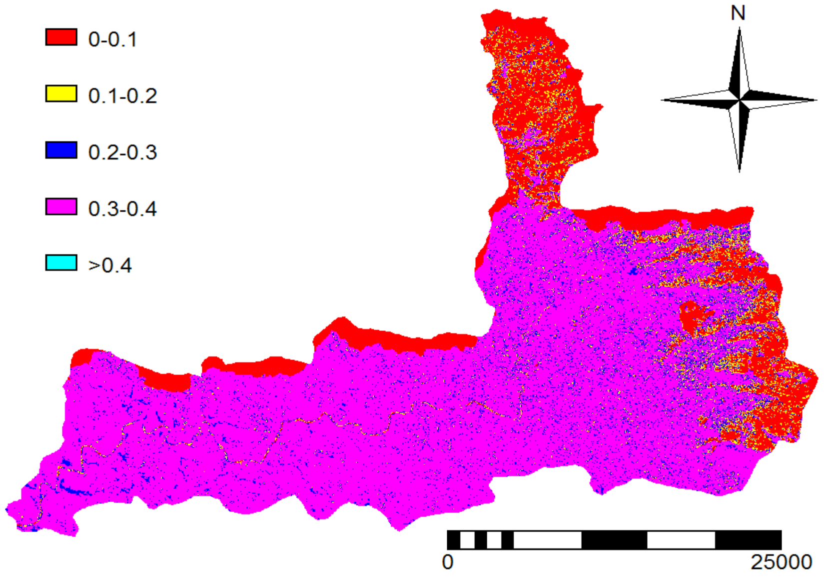


Figure 4.6: C map of Kunthipuzha river basin

4.7. USLE map

USLE map of Kunthipuzha watershed region generated by crossing R map, K map, LS map & C map is shown in fig. 4.7. Erosion value ranges from 0 to 4371.7 ton/ha/year.

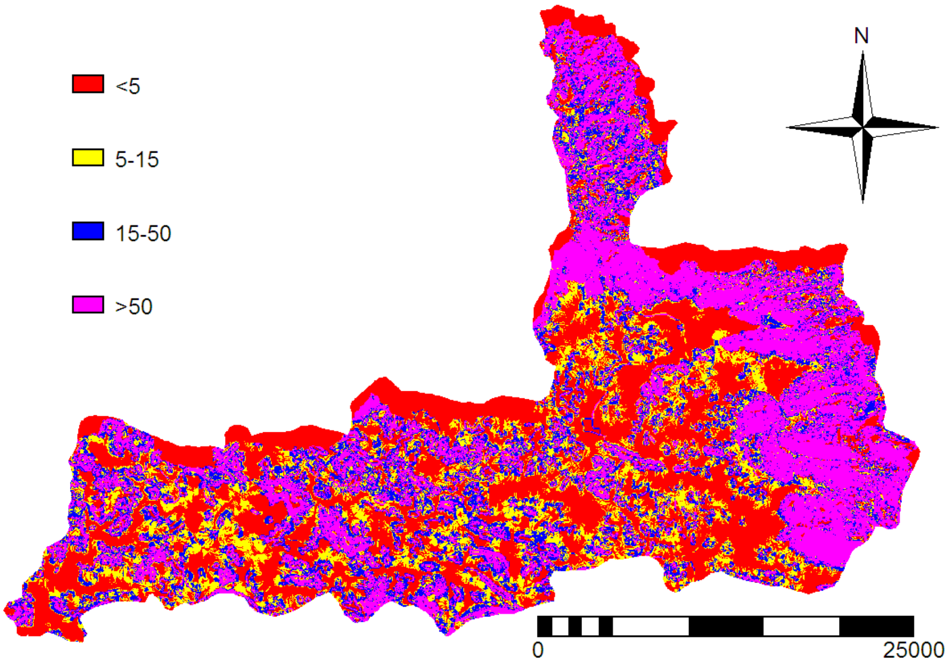


Figure 4.7: USLE map of Kunthipuzha river basin

4.8. Watershed delineation

Delineation of Kunthipuzha watershed is made using SWAT software.108 sub watersheds are delineated from DEM of the watershed. Map showing different sub watershed is shown in fig. 4.8.

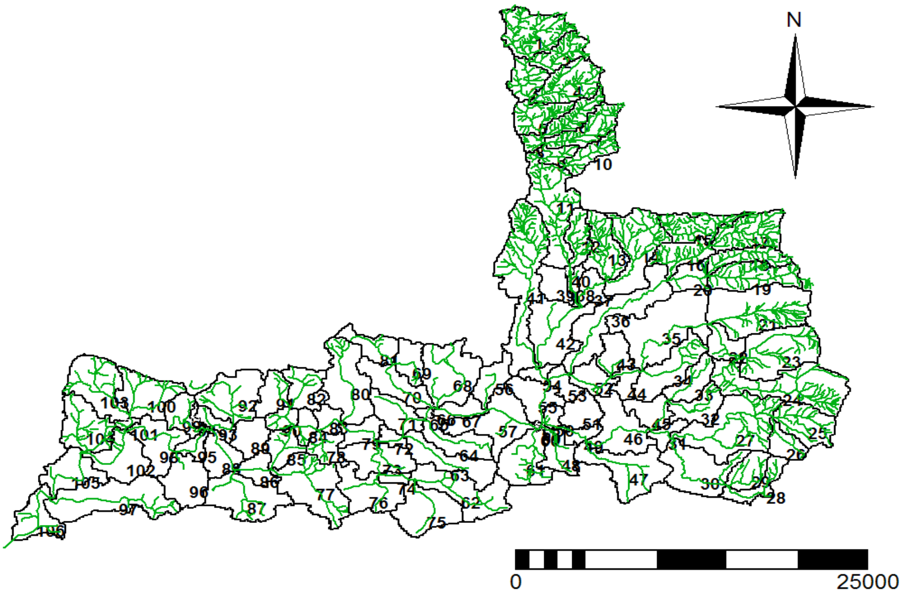


Figure 4.8.1: Sub watershed map of Kunthipuzha river basin

4.9 Sub watershed erosion estimation

After crossing the USLE map and delineated sub watershed map erosion status of different sub watershed is analyzed. It is found that rate of erosion varies greatly between sub watersheds, i.e. from 2 to 335 tons/ha/year.

Table 8 shows erosion status of different sub watersheds of Kunthipuzha.

Table 8:

Sub watershed no.	Sub watershed area ,ha	Soil loss rate (t/ha)	Sub watershed no.	Sub watershed area ,ha	Soil loss rate (t/ha)
1	3.6	2	45	647.9	37.7
2	11.7	2.2	46	1234.1	38.7
3	18.5	2.8	47	554.8	39.5
4	602.5	10.9	48	922.6	39.9
5	351.3	11.1	49	1660.7	39.9
6	300.5	12.6	50	674.2	40.6
7	678	12.8	51	790.1	41.2
8	1736.8	13.8	52	2797.7	42.9
9	244.2	15.4	53	116.1	43.6
10	14.3	16.6	54	1491.2	43.8
11	1724.2	16.7	55	691.5	44
12	370.3	16.9	56	1056.9	45.4
13	764.3	16.9	57	438.3	46.4
14	499.3	17.2	58	502.9	46.7
15	1.2	17.9	59	1765.1	48.2
16	355.3	18.4	60	1087.3	50.6
17	1664.4	18.4	61	1351.5	51.2
18	264.3	18.5	62	1610	55.2
19	1138.4	18.7	63	532.8	55.2
20	211.8	19.4	64	878.2	56.5
21	607.7	19.9	65	650.3	57.1
22	1502.6	20.7	66	654.6	57.4
23	508.2	21.1	67	380.6	57.8
24	252.8	22.6	68	1286.9	58.6
25	940.1	23.2	69	1843.3	60.8
26	1325	23.3	70	1728.5	61.5
27	762.4	23.5	71	988.4	62.4
28	412.2	24.6	72	1481	63.4
29	1012.5	25.8	73	686.2	63.6
30	677.1	26	74	981.1	65.4
31	1146.1	26.6	75	2000.4	67.4
32	1.2	27	76	386.6	72.2
33	1173.2	27.2	77	383.2	72.7
34	663.5	28	78	762.9	76.8z
35	708.3	28.7	79	736	76.8
36	1790.4	32.1	80	593.9	77.9
37	106.1	32.1	81	286.6	78.2
38	684.9	32.3	82	1276.8	80.3
39	2058.3	32.4	83	1407.3	83.1
40	2288.7	34.1	84	1332.7	85.1
41	40.2	34.3	85	898.5	100.9
42	1222.1	34.3	86	1473.9	103.8
43	99.3	34.4	87	1930.4	112
44	1309.9	37.7	88	810.4	114.7

89	789.1	136.5
90	795.7	140.2
91	219.1	140.8
92	856.7	144
93	3192.2	153.3
94	1352.4	165
95	628.6	178
96	2737.2	185.5
97	606	187.4
98	1189.1	193.8
99	2120.7	200.7
100	2660.7	207.1
101	1251.1	245.5
102	893.7	246.4
103	2256.3	289.6
104	671.7	293.6
105	718.2	313.9
106	2649.8	316.6
107	620	334.2
108	734.2	335.6

4.10 Watershed Prioritization

Based on amount of soil erosion in different sub watersheds, sub watersheds were grouped into low priority, moderate priority, high priority and very high priority areas.

Very high priority: >50 tons/ha/year

High priority: 15 to 50 tons/ha/year

Moderate Priority: 5 to 15 tons/ha/year

Low priority: < 5 tons/ha/year

Table 9:

Category	Number of sub watersheds	Cumulative area of sub watersheds, ha	Percentage of total watershed area
Very high	49	57362.8	61
High	51	43888.9	47
Moderate	5	3669.1	3.9
Low	3	33.8	0.04

61% of total catchment area of Kunthipuzha lies in very high priority category,47% of area falls under high priority, 3.9% of area with moderate priority and 0.04% are lies under lower priority.

Summary and Conclusion

Chapter 5

Summary and Conclusions

A study has been carried out on Kunthipuzha sub basin of Bharathapuzha river basin to estimate the erosion from individual sub watersheds and their by to prioritize them. The study used ILWIS as a GIS and Remote sensing software and SWAT as the watershed model. All the GIS thematic layers such as DEM , dranage net work, landuse and soil have been prepared in ILWIS.SWAT has been used for the delineation of main watershed and sub watershed boundaries.

USLE has been used for estimating erosion from the watershed. Digital USLE factors have been generated using ILWIS and finally the USLE map has been obtained through the map multiplication function of the software. Amount of erosion in individual sub watershed has been obtained through overlay operation. 108 sub watersheds have been generated in the Kunthipuzha sub basin. Erosion in individual sub watershed show great variability between them.49 sub watersheds were having very high erosion status (>50 tons/ha/year) with a total geographical occupancy of 61%. 51sub watersheds belonged to high erosion group(15 to 50 tons/ha/year) and their geographical occupancy in the entire basin was 47%.There were only 5 sub watersheds in the moderate priority group(5 to 15 tons/ha/year) with a geographical coverage of 3.9% and only 3 sub watersheds remains in the low priority (<5ton/ha/year) group.

The study showed that the rate of erosion from different sub watershed showed very high variability in erosion rate (2 to 335 ton/ha/year). This point to the necessity and importance of prioritization of sub watersheds in watershed development programme. It can also be concluded that this kind of erosion can be carried out only with the help of GIS and remote sensing techniques.

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PRIORITIZATION OF SUB WATERSHEDS OF A RIVER BASIN USING GEOGRAPHIC INFORMATION SYSTEM

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PROJECT REPORT

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In

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2012

Abstract

A sub watershed prioritization exercise has been carried out on Kunthipuzha sub basin of Bharathapuzha river basin, one of the major rivers in Kerala. Total catchment area of the Kunthipuzha basin comprises 940 sq.km. ILWIS and SWAT have been used for the study to make the sub watershed delineation and erosion estimation much easier than conventional procedures.

Soil erosion has been evaluated from each of the 108 sub watersheds of Kunthipuzha catchment. Erosion rates in different sub watersheds of the river basin are ranging from 2 tons/ha /year to 335.6 tons/ha/year. Out of 108 sub watershed 3 sub watersheds have low erosion rate (<5 tons/ha) and hence included in low priority class. 5 sub watersheds have resulted in medium rate of erosion (5-15 tons/ha) and are put under medium priority class. 51 sub watersheds have high rate of erosion (15-50 tons/ha).and is categorized into high priority class. 49 sub watersheds have very high rate of erosion (> 50 tons/ha), hence very high priority has given to them. From the study, it is concluded that 61% of total catchment of Kunthipuzha has very high priority,47% of area high priority,3.9% of area moderate priority and 0.036% low priority.