ANALYSIS OF MEENACIL WATERSHED USING FOSS GIS TOOLS

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PROJECT REPORT

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BACHELOR OF TECHNOLOGY
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KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
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2012

DECLARATION

We hereby declare that this project report entitled "**ANALYSIS OF MEENACIL WATERSHED USING FOSS GIS TOOLS"** is a *bonafide* record of project work done by us during the course of academic programme in the Kerala Agricultural University and that the report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship or other similar title of any other university or society.

RAHUL, B.T.
(2008-02-025)

SUMIT KUMAR JHA
(2008-02-034)

Dated:

Kelappaji College of Agricultural Engineering and Technology
Tavanur

CERTIFICATE

Certified that this project report entitled **“ANALYSIS OF MEENACIL WATERSHED USING FOSS GIS TOOLS”** is a bonafide record of project work jointly done by Rahul, B.T. (Admission No. 2008-02-025) and Sumit Kumar Jha (Admission No 2008-02-034) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship, associateship, or other similar title of any other University or Society to them.

Place: **Tavanur**

Date:

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SUMIT KUMAR JHA

Dedicated to
The Almighty,
Loving Parents
And
Community of
Agricultural Engineering

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SYMBOLS AND ABBREVIATIONS

AISLUS	All India Soil and Land Use Survey
API	Application programming interface
ASCII	American Standard Code for Information Interchange
ASTER	Advanced Space borne Thermal Emission and Reflection Radiometer
cm.	Centimetre(s)
Dbf	Data base file
Dec.	December
DEM	Digital Elevation Model
Geo tiff	Geostationary Earth Orbit Tagged Image File Format
FCC	False Colour Composite
GEODATA	Geographical Data
GIS	Geographical Information System
GRASS	Geographic Resource Analysis and Support System
E	East
EGM	Earth Gravitational Model
EIMU	Erosion intensity mapping units
EOS	Earth Observing System
ESRI	Environmental Systems Research Institute
Et. al.	And others
ILWIS	Integrated Land and Water Information System
InSAR	Interferometric synthetic aperture radar
IRS	Indian Remote Sensing
Km^2	square kilometre(s)
KCAET	Kelappaji College of Agricultural Engineering and Technology
L	Length of slope Factor
LANDSAT	Land Remote-Sensing Satellite

LIDAR	Light Detection and Ranging
LISS	Linear Imaging Self Scanning
LS	Topographic Factor
Mham	Million hectare meter(s)
Mkm^3	Million cubic meter(s)
MSS	Multi spectral Scanner
N	North
NASA	National Aeronautics and Space Administration
Nov.	November
PAN	Panchromatic
RS	Remote sensing
Sep.	September
SPOT	Systeme Pour l'Observation de la Terre
SRTM	Shuttle Radar Topographic Mission
TauDEM	Terrain Analysis Using Digital Elevation Models
USA	United States of America
USA-CERL	U.S. Army-Construction Engineering Research Laboratory
USGS	United States Geological Survey
USU	Utah State University
WGS	World Geodetic System

INTRODUCTION

Chapter 1

INTRODUCTION

Rivers play a major role in integrating and organizing the landscape, and moulding the ecological setting of a basin. They are the prime agents controlling the global water cycle and in the hydrologic cycle, they perform the most dynamic modes of transport. Rivers carry elements, in suspended or in dissolved form, from their source and deposit them sequentially based on their physico-chemical nature at different locations. And it is this life-giving liquid treasured in these rivers enables sustenance of life on earth. Rapid increase in demand of water in agriculture, industry and domestic uses, to meet the requirements of exploding population has forced man to develop new management and conservation techniques for river systems.

Out of world's total available water, 1400Mkm^3, about 95% is contained in oceans as saline water and 4% is in the form of snow and ice. Thus, the fresh and unfrozen water is only 1% of the total availability, out of which 99% is ground water and only 1% is present as surface water in lakes, rivers, soil and atmosphere. The cumulative requirement of water by different sectors by 2025 is estimated to be105Mham and the demand of water for agriculture is estimated to increase from 50Mham to 70Mham and this can be met if proper watershed management principles are applied. Watershed is an ideal unit for carrying out scientific resource management for ensuring continuous benefits on sustainable basis. Watershed analysis is very effective tool for planning watershed development activities to gain better understanding of hydrologic phenomena operating within the watershed area and how changes in watershed may affect these phenomena.

Kerala state is agro-climatically situated on the south-west corner of India receiving about 300cm of average rainfall and 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. Still the state experience severe shortage of water during the summer months. The rivers hardly contain any water during 6 months in a year. Compared to national average, Kerala receives 2.78 times more rainfall, but due to steep slopping and undulating topography rain water is not much retained on land. At the same time, unit land of Kerala has to support 3.6 times more population when compared to national level scenario. Hence for self sufficiency unit land of Kerala has to meet 3.6 times drinking water, food biomass and associated water requirement compared to national average. Proper management of water resource of Kerala would certainly make situation more comfortable.

Identification of suitable land for development is one of the critical issues of regional planning. The suitability of the land for development, as well as, for ground water occurrence is influenced by climate, physiography, drainage, geology, degree of weathering, etc. The various parameter characteristics of a watershed behave in more or less perceptible manner. India is a country that has enormous biological and cultural diversity, supporting some 81,000 recorded animals and 45,000 plant species. As the population continues to grow at a rate of 1.7 percent annually, various concerns will need to be addressed; among these most prominent are land and water resources. Land and Water are the most important natural resource on the planet, as it sustains all aspects of life in a way that no other resource can. Due to the importance of this resource, it is likely that water will be one of the most critical resource issues of the 21st century both in terms of quantity and quality.

One of the main issues facing water resources management in India is the uneven distribution of water throughout the country. This is due to the natural patterns of precipitation, which varies widely in time and space. A proper watershed planning can be done by using GIS based technologies for sustainable management of land and water resources. While remote sensing can provide a variety of latest and updated information on natural resources, GIS has the capability for captures, storage, manipulation, analysis, retrieval of multiple layer resource information occurring both in spatial and aspatial forms. Watershed delineation is an important tool for land and water resource management by considering different variables eg. Morphometric characteristics, Landuse / land cover, hydrogeomorphology, elevation and slope of watershed by integration of remote sensing and GIS. There is an urgent need to adopt modern technology of remote sensing and GIS, offering possibilities of generating various options, thereby optimizing the whole planning process. If watersheds are not managed in an integrated sustainable manner, then not only the water resources but also other resources such as vegetation, fertile soil, fauna and flora get depleted.

1.1 Watershed

Watershed is a basin like landform defined by high points and ridge lines that descending to lower elevations, valleys and streams. 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. It is a spatial unit within which hydrologic principles must hold and therefore all hydrologic analysis must be validated within this unit.

Watersheds are those areas from which runoff resulting from precipitation, flows past a single point into a large stream a river, lake or an ocean. Watershed is an ideal multidisciplinary approach to the resources management for ensuring continuous benefit on sustainable basis. Integrated watershed management is a prerequisite for land and water management for degraded areas but also for conservation of protection areas.

Watershed is topographically delineated area that is drained by stream system, i.e. the total land area that is drained to some point on a stream or river. In other words watershed can be defined as an area from which runoff resulting from precipitation flows past a single point into a stream, river, lake or an ocean.

1.2 Geographic Information System

Use of GIS is gaining more importance these days because it plays an important role in resource management, environment monitoring and land use planning activities. A Geographic Information System (GIS) can be defined as a computerized data base system for the capture, storage, retrieval, analysis and display of tabular and spatial data. GIS can provide a great deal of more problem- solving capabilities than using a simple mapping program or adding data to an online mapping tool. It is one of the most important tools for watershed analysis related study.

1.3 Remote Sensing

Remote Sensing technology has been playing an important role in effective and timely mapping of geo resources. It is generally understood to imply the acquisition of information about an object or phenomenon on earth surface by scientific means or devices called sensors without being in any physical contact between the object and sensing device. This is done by sensing and recording reflected or emitted electromagnetic energy and processing, analyzing and applying that information. Aircrafts and satellites are the common platforms for remote sensing observation. Remote sensing data having high resolution available from IRS, LANDSAT and SPOT have been improved and computer based image processing system have become comparatively less expensive and more effective.

1.4 Application of GIS in Watershed Analysis

Application of Geographic Information Systems (GIS) is gaining more importance in watershed analysis. The Geographic Information Systems can capture, store, manipulate, analyze and visualize diverse set of geo referenced data. The GIS can help in design, calibration, modification and a comparison of watershed models. The GIS technology is suitable for efficient management of large and complex data base. Spatial statistics and grid design capabilities of GIS can improve the effectiveness of watershed analysis. GIS data base for watershed analysis comprises details on Landuse, soils, hydrologic characteristics, drainage network, water use etc. A digital representation of watershed characteristics in GIS format is used in watershed analysis. Watershed analysis using GIS is only possible with the availability of digital database of watershed, mainly DEM.

1.5 DEM (Digital Elevation Model)

DEM (Digital Elevation Model) is a digital model or 3-D representation of a terrain's surface created from terrain elevation data. In other words Digital Elevation Models (DEMs) represent the terrain elevation in discrete form in three-dimensional space. Digital elevation models (DEMs) are increasingly used for visual and mathematical analysis of topography, landscapes and landforms, as well as modeling of surface processes. A DEM offers the most common method for extracting vital topographic information and even enables the modelling of flow across topography, a controlling factor in distributed models of landform processes DEMs can be generated from stereo satellite data derived from electro-optic scanners such as ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer) or SRTM (Shuttle Radar Topography Mission).

1.6 Watershed delineation

Watershed delineation is process of identifying drainage area of a point or set of points. This can be done manually or automatically. Manual delineation involves drawing lines on a topographic map, and connecting the slope or ridge tops. Assuming the water will drain away from those points, the watershed is delineated by enclosing a polygon.

The automated process involves some technical skills with GIS databases. Automated delineation involves obtaining a Digital Elevation Model (DEM), obtaining a stream network, and identifying stream outlets. The DEM and stream outlets can either be downloaded or constructed.

DEMs are used in water resources projects to identify drainage features such as ridges, valley bottoms, channel networks, surface drainage patterns, and to quantify sub catchment and channel properties such as size, length, and slope. The accuracy of this topographic information is a function both of the quality and resolution of the DEM, and of the DEM processing algorithms used to extract this information.

Watershed delineation is one of the most commonly performed activities in hydrologic analyses. Digital elevation models (DEMs) provide good terrain representation from which watersheds can be derived automatically using GIS technology.

1.7 Overview of ILWIS

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, Enscheda, the Netherlands. As an Integrated GIS and Remote Sensing package, ILWIS allows generating information on the spatial and temporal patterns and processes on the earth surface and this information can be analyzed on GIS platform

1.8 Overview of Mapwindow

Mapwindow GIS is an open source GIS. It is an extensible geographic information system. Mapwindow GIS includes standard GIS data visualization features as well as DBF attribute table editing, shapefile editing, and data converters. Dozens of standard GIS formats are supported, including Shapefiles, GeoTIFF, ESRI Arc Info ASCII and binary grids. Mapwindow GIS is an open source "Programmable Geographic Information System" that supports manipulation, analysis, and viewing of geospatial data and associated attribute data in several standard GIS data formats. Mapwindow GIS is a mapping tool, a GIS modelling system and a GIS application programming interface (API) all in one convenient redistributable open source solution.

1.9 Overview of TauDEM

TauDEM (Terrain Analysis Using Digital Elevation Models) is a set of Digital Elevation Model (DEM) tools for the extraction and analysis of hydrologic information from topography as represented by a DEM. This is software developed at Utah State University (USU) for hydrologic digital elevation model analysis and watershed delineation.

1.10 Overview of GRASS

GRASS is acronym of "Geographic Resource Analysis and Support System". This is free Geographic Information System (GIS) software used for geospatial data management and analysis, image processing, graphics/maps production, spatial modelling, and visualization. GRASS is currently used in academic and commercial settings around the world, as well as by many governmental agencies and environmental consulting companies

1.11 Meenachil at a glance

Meenachil watershed lies between 9°25’to 9°55’ N latitudes and 76°20’ to 76°55’E longitudes and it is located in the Alappuzha and Kottayam dist and along the western boundary of Idukki dist of Kerala state. It is bounded by Vaikom and Meenachil taluks of Kottayam district and Thodupuzha taluk of Idukki dist in the north, Changanassery and Kanjirapally taluks of Kottayam dist and Kuttanad taluk of Alappuzha dist in the south, Peerumedu and Thodupuzha taluks of Idukki dist in the east and shertallai taluk of Alappuzha dist in the west .Total area of 1208.11 km^2 covering 52 villages spread over 59 Panchayats, 18 blocks and three district. Meenachil River is formed by several streams originating from Western Ghats.

The general elevation ranges from 77 m to 1156 m in the high lands and less than 2 m in the lowlands and 8 to 68 m in the midlands. The river has a total annual yield of 2,349 million cubic metres and an annual utilizable yield of 1110 million cubic metres. The river has 38 tributaries including major and minor ones. The river has 47 sub watersheds and 114 micro watersheds.

1.11 The Objectives

1. Delineation of watershed.
2. Extraction of sub-watersheds using DEM
3. Extraction of drainage networks
4. Generation of L and LS map for use in soil erosion studies.
5. Comparison of two globally accepted digital elevation models, i.e. SRTM DEM and ASTER DEM.

REVIEW OF LITERATURE

Chapter 2

REVIEW OF LITERATURE

2.1 GIS and RS in Watershed Analysis

Geographic Information System(GIS) is defined as an information system that is used to input, store, retrieve, manipulate, analyze and output geographically referenced data or geospatial data, in order to support decision making for planning and management of Landuse, natural resources, environment, transportation, urban facilities, and other administrative records. The efficiency of GIS is in the integration of data set from various sources to analyze it as a whole and implement it for critical decision making in planning and management options.

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, analyzing, and applying that information. Remote sensing provides a means of identifying and presenting planimetric data in convenient media and efficient manner. Imagery is available in varying scales to meet the requirements of many different users.

Muessig et al. (1983) found that a tactical GIS approach was used to identify critical small areas rather than using a general statistical approach which could define only critically important counties.

Maeder ans Tessar (1988) found that potential problems areas in watershed were defined by correlating water quality records with geographical characteristics of minor drainage basins and it is very important for watershed analysis.

Kioshi Honda et al. (1994) conducted a study on remote sensing and GIS technologies for denudation in a Siwalik watershed of Nepal. The study was made as an attempt to use remote sensing to identify the land degradation in Ratu watershed in the central Siwalik area, and established a method to estimate the rate of denudation in this perspective, LANDSAT data procured for a period of 20 years from 1973-1993 were analyzed for the change of forest cover in the watershed and topographical parameters were used in a model to estimate the probable annual soil loss. Model was further improved for flood event soil yield estimation using factors that have identified in the field as main causes for intensive erosion during a heavy rainy season.

Teeter et al. (2000) have focused their studies on the use of remote sensing and GIS in watershed level analyses of non-point source pollution problems. Basin characteristics such as land use/land cover, slope, and soil attributes affect water quality by regulating sediment and chemical concentration. Among these characteristics, land use/land cover can be manipulated to gain improvements in water quality. These land use/land cover types can serve as nutrient detention media or as nutrient transformers as dissolved or suspended nutrients move towards the stream. This study examines a methodology to determine nitrate pollution 'contributing zones' within a given basin based on basin characteristics. In this process, land use/land cover types were classified and basins and 'contributing zones' were delineated using geographic information system (GIS) and remote sensing (RS) analysis tools. A 'land use/land cover-nutrient-linkage-model' was developed which suggests that forests act as a sink, and as the proportion of forest inside a contributing zone increases (or agricultural land decreases), nitrate levels will decrease in downstream. In the model, the residential/urban/built-up areas have been identified as strong contributors of nitrate. Other contributors were orchards; and row crops and other agricultural activities.

Garbrecht et al. (2001) described GIS and distributed watershed models which addresses selected spatial data issue, data structures and projections, data sources, and information on data solution and uncertainties. Spatial data that are covered include digital elevation data, steam and drainage data, soil data, remotely sensed data and radar precipitation data.

Sharma et al. (2001) conducted a study on micro-watershed development plans using Remote Sensing and GIS for a part of Shetrunji river basin, Bhavnagar district, Gujarat. Here an approach using remote Sensing and GIS has been applied to identify the natural resources problems and to generate local specific microwatershed development plans for a part of Shetrunji river basin. Study of the multidate satellite data has revealed that the main land use or land cover in the area is rainfed agriculture, waste land with or without scrubs in the plains and undulating land and scrub forest with forest blanks on the hills. The depleting vegetation cover has resulted in excessive soil erosion exposing barren rocky waste.

ChattoPadhyay and Sujith Choudhury (2005) conducted study on application of GIS and Remote Sensing for watershed development projects. GIS is a very powerful tool for development of watershed area with all natural and socio economic facts for better planning, execution and monitoring of the project .GIS based model help to plan the infra structure development needed such as connecting market with local place.

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-watersheds. Initially, polarization of watershed was mainly done with the help of aerial photographs and FCC. Then with progressing remote sensing and availability of data, work was carried out with visual interpretation techniques like 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 using GIS to arrive quantitative estimation of soil loss.

Selvi et al. (2007) studied on digital micro watershed atlas which is a tool for watershed development planning. The soil and Landuse survey of India (SLUSI) prepared digital data base through rapid reconnaissance survey on watershed prioritization using GIS and updated certain data set with remotely sensed data. They developed digital layers of drainage, micro watershed and EIMU (erosion intensity mapping units) and integration of these layers were done with the help of GIS. Finally they made spatial distribution of different priority and categories of micro watershed using sediment yield index model.

2.2 DEM as Heart for Watershed Analysis using GIS

DEM (Digital Elevation Model) is a digital model or 3-D representation of a terrain's surface created from terrain elevation data. In other words Digital Elevation Models (DEMs) represent the terrain elevation in discrete form in three-dimensional space. Digital elevation models (DEMs) are increasingly used for visual and mathematical analysis of topography, landscapes and landforms, as well as modeling of surface processes. Each and every watershed analysis is done with the help of DEM only by using GIS. DEM can be prepared by topographic survey or by using remote sensing techniques. Global elevation data sets are available freely without any inconvenience of complex surveys for any type of terrain. DEMs can be generated from stereo satellite data derived from electro-optic scanners such as ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer) or SRTM (Shuttle Radar Topography Mission).

Clarke et.al. (1982) described after their study that the most of the parts of earth's surface, elevation data exist in analogue form as contour maps. These contour maps are converted into digital contour files and spatial interpolation procedures are applied to interpolate elevation values from irregularly spaced points to regular grid points As a result, elevations are available as a matrix of points equally spaced in horizontal and vertical directions and is called as digital elevation model.

Dietrich et al. (1993) found that the a DEM offers the most common method for extracting vital topographic information and even enables the modelling of flow across topography, a controlling factor in distributed models of landform processes.

Shortridge and Goodchild (1999) after their research found that the vast majority of social and environmental processes are global in scope; therefore the study of such processes requires global datasets. Global elevation datasets are inevitably subjected to errors, mainly due to the methodology followed to extract elevation information and the various processing steps the models have undergone.

Maidment (2002) conducted a study and found that the value of the DEM in hydrologic applications is growing with an accurate representation of a surface; hydrologic characteristics can be derived from that surface. DEMs are raster models representing 3-dimensional land surfaces. DEMs are preferred over triangulated irregular networks (TIN) for hydrographic modelling due to the characteristics of more accurately representing land surfaces and the ease with which they are electronically delineated due to a uniform cell structure

C. Hirt et.al. (2003) conducted a study on Comparison and validation of the recent freely-available ASTER GDEM, SRTM and GEODATA DEM and found that digital elevation models over Australia DEMs have become an important data source for a range of applications in Earth and environmental sciences. Examples of applications for elevation data are numerous, such as 38 gravity field modelling, hydrological studies, topographic cartography, and orthorectification of aerial imagery, flood simulation and many more. Generally, DEM data sets can be obtained from a range of techniques, such as ground survey, airborne photogrammetric imagery and airborne laser scanning (LIDAR), radar altimetry and interferometric synthetic aperture radar (InSAR). Quite often, DEMs are constructed from data sourced from several of these methods and are thus of variable quality.

Hirano, et.al. (2003) made studies on ASTER DEM and found that the ASTER is an imaging instrument aboard the Earth Observing System (EOS) Terra Satellite which is operated jointly by NASA and Japan’s Ministry of International Trade and Industry. The sensor collects both emitted and optical reflected energy. Near-infrared stereo imagery is collected simultaneously at both nadir and off-nadir angles with along-track alignment. This stereo imagery is then utilized to develop a DEM through stereo correlation technologies.

Lee et al. (2003) made a study on DEM generation and found that the automatic DEM generation has become an important part of international research in the last 10 years as a result of the existence of many satellite sensors that can provide stereo pairs. Many new algorithms have been developed, the performances of which have been assessed and reported in the literature

Guth, (2006) after his study in USA concluded that the SRTM DEM data is produced via the use of interferometric synthetic aperture radar (INSAR) system. The

SRTM mission was obtained on the space shuttle Endeavour in February 2000. The SRTM DEM dataset was generated through the use of stereoscopy by measuring the amplitude of the return phase of INSAR microwave frequencies. SRTM data is offered in 3 arcsecond resolution for all extents of global coverage and 1 arcsecond for the U.S. and U.S. Territories. SRTM DEM data is referenced horizontally to the WGS84 ellipsoid and vertically to the EGM96 geoid orthometric heights.

Dinesh (2008) after a study found that the hydrologic features produced from DEMs include drainage channel networks and channel characteristics, watershed divides and low lying areas and it is very important in efficient watershed analysis.

Hoffman and Winde (2010) concluded after a study that the availability of more accurate and higher resolution DEMs with broader global coverage, the utility of DEMs in hydrologic modelling is increasing.

USGS (2010) stated that errors in elevation models are likely to have a more pronounced impact on delineations in low relief terrain due to being exaggerated where slope values are relatively small or are spaced far apart. The occurrence of pits can be greatly influenced by these factors and can present challenges to the process of hydrographic delineations. DEM pits, cells or groups of cells completely surrounded by cells of higher value, occur both as natural features of terrain and as spurious artifacts of DEM production.

2.3 Watershed delineation for Watershed analysis using GIS

Watershed delineation is process of identifying drainage area of a point or set of points. Therefore it is extremely important to use an integrated spatial approach for land and water resource management. In this work briefly the essential characteristics of GIS based watershed delineation is exposed and its potential of application in the scope of management of land and water resource is examined. The water and land management on watershed basis can be easily analyzed by watershed delineation tool and also have results in increasing the productivity, along with sustainable utilization of resources.

Jenson and Domingue (1988) found that the presence of pits or depressions, whether as real topographical features of terrain or errors resulting from the DEM creation processes, influence drainage network. Likewise, the omission or failure to recognize authentic pits can decrease the accuracy of drainage delineations. The impacts of DEM pits authentic to a landscape generally do not negatively impact delineation prediction accuracy whereas they represent natural topographical features. DEMs must be processed or "filled" to eliminate the premature termination of flow networks in pits just the way that in the natural world a lake would fill to capacity and then flow from an outlet downstream. Both the size and the abundance of pits can alter to varying degrees the accuracy of drainage network delineations.

Garbrecht and Martz,(1999) described that Watershed delineation is one of the most commonly performed activities in hydrologic analyses. Digital elevation models provide good terrain representation from which watersheds can be derived automatically using GIS technology. The techniques for automated watershed delineation have been implemented in various GIS systems and custom applications.

Ravinder Kaur *et al.* (2002) made a study on GIS based digital delineation of watershed and its advantage over conventional manual method in Hazaribagh and Bankura district of Jharkhand and West Bengal. Besides, benefits of digital delineation procedure over convention (AISLUS) manual methods have also been highlighted. The study indicated that the traditional manual delineation of watershed involves subjectivity in locating the ridge lines, which often leads to a slight change in actual watershed shape and thus area. Digital delineation of watershed boundaries avoids this subjectivity and thus gives more accurate shape and size of the delineated watershed.

Gaurav Savant et al. (2003) conducted a study on remote sensing and geospatial applications for watershed delineation and did the direct comparison of USGS topographical maps with software generated delineation maps and the comparison of river flow paths. Different terrain, source data accuracy, and source data resolution may affect the accuracy of the research. Comparison result has been showed the better and efficient watershed delineation.

The Federal Standard for Delineation of Hydrologic Unit Boundaries, United States Geological Survey (2004) defined delineation as "A hydrologic unit is a drainage area delineated to nest in a multi-level, hierarchical drainage system. Its boundaries are defined by hydrographic and topographic criteria that delineate an area of land upstream from a specific point on a river, stream or similar surface waters. A hydrologic unit can accept surface water directly from upstream drainage areas, and indirectly from associated surface areas such as remnant, non-contributing, and diversions to form a drainage area with single or multiple outlet points. Hydrologic units are only synonymous with classic watersheds when their boundaries include all the source area contributing surface water to a single defined outlet point."

Sampad Kumar Panda, B. Sukumar (2010) conducted a study on Delineation of Areas for Water Conservation in Peruvamba River basin, Kannur district, Kerala, Using Remote Sensing and GIS and found that the drainage pattern is of dendritic type. Stream ordering is done for delineation of watersheds from the study area. The drainage density (in terms of km/km2) indicates the closeness of spacing of channels. More the drainage density, higher would be the runoff, less percolation and infiltration. The whole catchment is divided into 5 sub catchments using drainage order and contour lines. Since watershed forms a basic unit of agriculture development, the watershed boundaries have been delineated. Total 25 watersheds have been delineated form the catchment area.

Maune et al. (2007) found that while watershed boundaries and drainage network delineations derived from DEM data in steep terrain can be accurate to within a scale comparable to horizontal resolution, hydrologic definition at the same scale in areas of low vertical relief are apt to be generalized. Higher resolution and accuracy of DEM data are required for hydrologic delineation in flat terrain.

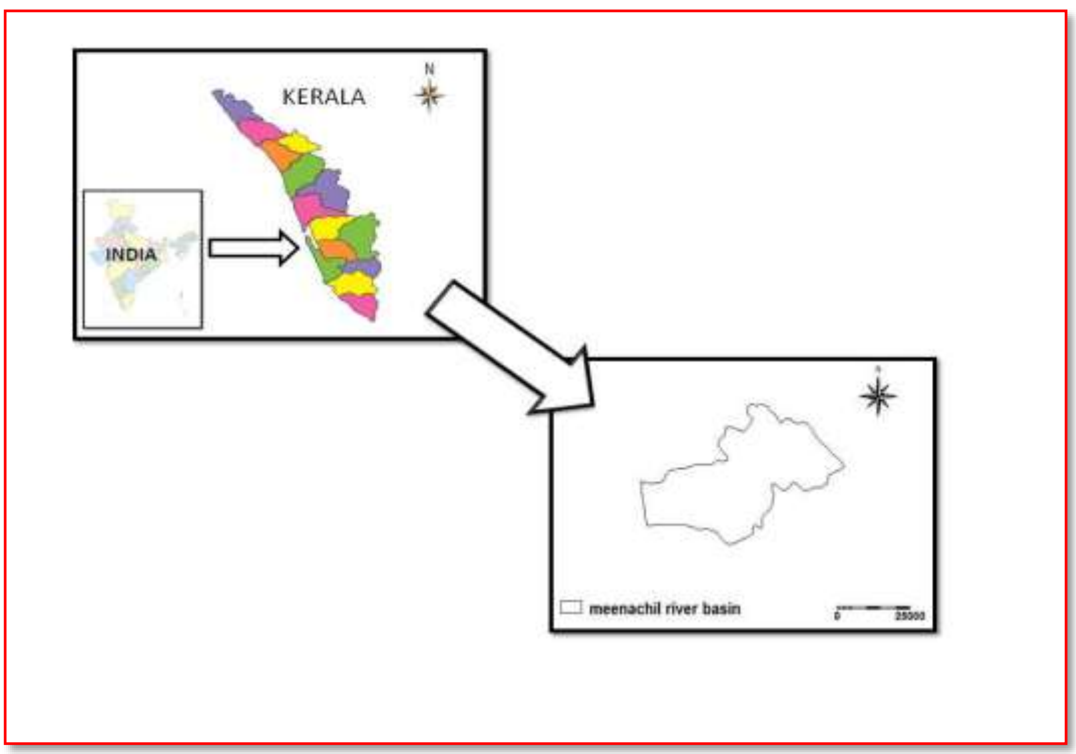
MATERIALS AND METHODS

Chapter 3

MATERIALS AND METHODS

3.1 Study Area

Meenachil watershed which lies between 9°25'to 9°55' N latitudes and 76°20' to 76°55'E longitudes and it is located in the Alappuzha and Kottayam dist and along the western boundary of Idukki dist of Kerala state has been taken for study. It is bounded by Vaikom and Meenachil taluks of Kottayam district and Thodupuzha taluk of Idukki dist in the north, Changanassery and Kanjirapally taluks of Kottayam dist and Kuttanad taluk of Alappuzha dist in the south, Peerumedu and Thodupuzha taluks of Idukki dist in the east and shertallai taluk of Alappuzha dist in the west .Total area of 1208.11 km² covering 52 villages spread over 59 panchayats, 18 blocks and three district. Meenachil River is formed by several streams originating from Western Ghats.



Map 1 Location Map of the Study Area

3.2 Basic Open Datasets Used

1. "Water Atlas of Kerala" map (Plate No.-49) published by CWRDM, Kozhikode.
2. SRTM (Shuttle Radar Topography Mission) DEM.
3. ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer) DEM.
4. Satellite imagery of MSS of LANDSAT 5 having four bands.

3.3 FOSS GIS Tools Used

1. MapWindow Open Source v. 4.6.602
2. ILWIS (Integrated land and water information system) v. 3.7.2 by 52^{O} north for generation of GIS maps.
3. TauDEM (Terrain analysis using digital elevation model) by Idaho State University
4. GRASS (Geographic Resources Analysis Support System) v. 6.4.0 by U.S. Army-Construction Engineering Research Laboratory (USA-CERL) for comparison of two major datasets, i.e. SRTM and ASTER datasets.

3.4 Georeferencing and Digitising the Map

A georeference defines the relation between rows and columns in a raster map and XY-coordinates. The location of pixels in a raster map is thus defined by a georeference. A georeference uses a coordinate system which may contain projection information. Polygon, segment and point maps merely use a coordinate system. A georeference is a service object, usually for several raster maps.

There are five main types of georeferences:-

1. **Georeference corners**: a North-oriented georeference to be used during rasterization of vector data or as the North-oriented georeference to which you want to resample maps;

2. **Georeference tiepoints**: a non-North-oriented georeference to add coordinates to a satellite image or to a scanned photograph, a scanned map, etc. without using a DTM;
3. **Georeference direct linear**: to add coordinates to a scanned photograph while using a DTM;
4. **Georeference orthophoto**: to add coordinates to a scanned aerial photograph while using a DTM and camera parameters;
5. **Georeference 3D**: to create a three dimensional view of maps.

In our study, maps were georeferenced by using "georeference tiepoints". Maps were digitized after Georeferencing the maps.

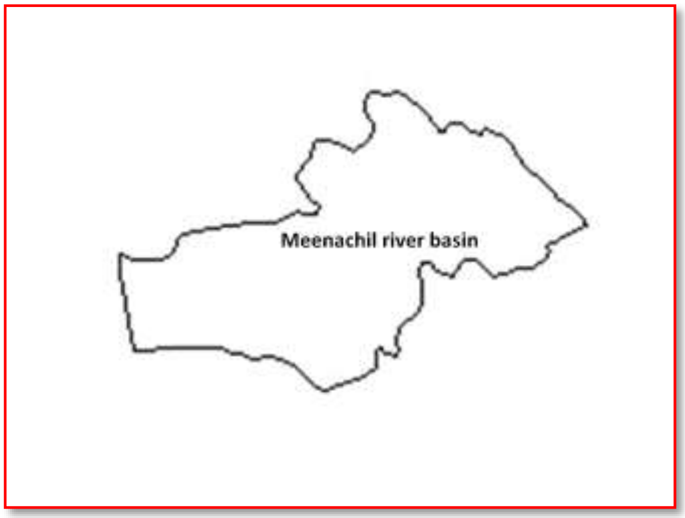
Key procedures involved in creation of a georeference-

1. Open the File menu of the Main window.
2. Then choose Create Georeference.
3. Then choose the type of georeference.
4. Select a coordinate system.
5. Select a background map.
6. Then add the tiepoints in georeference editor

3.5 Creation of Shapefile of Study Area

The ESRI Shapefile or simply a shapefile is a popular geospatial vector data format for geographic information systems software. A shapefile is a digital vector storage format for storing geometric location and associated attribute information. The main file (`.shp`) contains the primary geographic reference data in the shapefile. Shapefiles do not have the ability to store topological information. Shapefiles spatially describe geometries: points, lines, and polygons.

In our study, Shapefile is created for defining the exact boundary of the study area as polygon. Further shapefile can be utilized for clipping of DEM from global elevation datasets.



Map 2 Polygon Shapefile of Meenachil river basins.

3.6 Clipping of DEM

"Clipping of DEM" is operation of separating DEM of area of interest. Clipping of DEM has been done with the help of software (Mapwindow GIS) by using the shapefile of the study area. It has been done for getting the DEM of study area. DEM created after this operation is further used for watershed analysis of study area.

Clipping operation has been done on two global elevation dataset i.e. SRTM and ASTER dataset

3.7 DEM Hydro-processing / Digital Terrain Analysis

The process of quantitatively describing the terrain is known as digital terrain analysis (DTA). Common synonyms are hydro processing or geomorphological analysis. DEM can be used to derive topological attributes, geomorphometric parameters, morphometric variables or terrain information in general. Terrain processing uses DEM to satisfy the surface drainage pattern.

Processed DEM and its derivatives can be used for efficient watershed delineation and stream network generation.

All the steps in the Terrain Pre-processing menu should be performed in sequential order, from top to bottom. All of the pre-processing must be completed before watershed delineation processing functions have to be used.

Entire DEM Hydro-processing can be divided into two parts for watershed analysis and watershed delineation.

1. Flow determination
    1. Fill sinks
    2. Flow direction
    3. Flow accumulation
2. Drainage network and catchment extraction
    1. Drainage network extraction
    2. Drainage network ordering
    3. Catchment extraction
    4. Catchment merge

3.7.1.1 Fill Sink

The Fill sinks operation removes local depressions from a DEM by replacing these local depressions by flat areas in the output DEM. This function fills the sinks in a grid. If cells with higher elevation surround a cell, the water is trapped in that cell and cannot flow. The Fill Sinks function modifies the elevation value to eliminate these problems.

The Fill sinks operation will 'remove' the following from a Digital Elevation Model (DEM):

1. Depressions that consist of a single pixel, i.e. any pixel with a smaller height value than all of its 8 neighbouring pixels,
2. Depressions that consist of multiple pixels, i.e. any group of adjacent pixels where the pixels that have smaller height values than all pixels that surround such a depression.

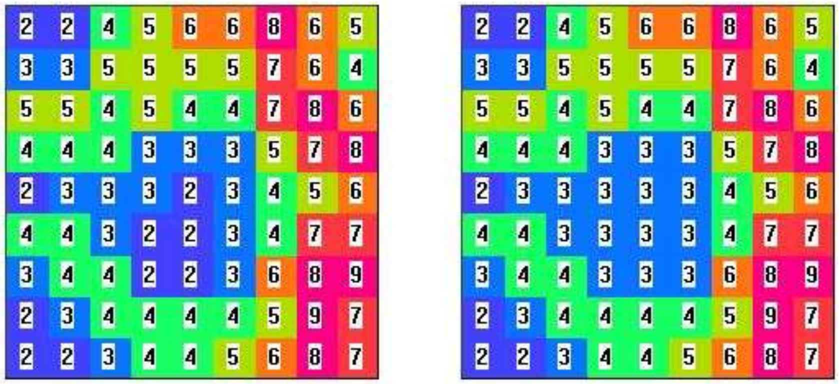
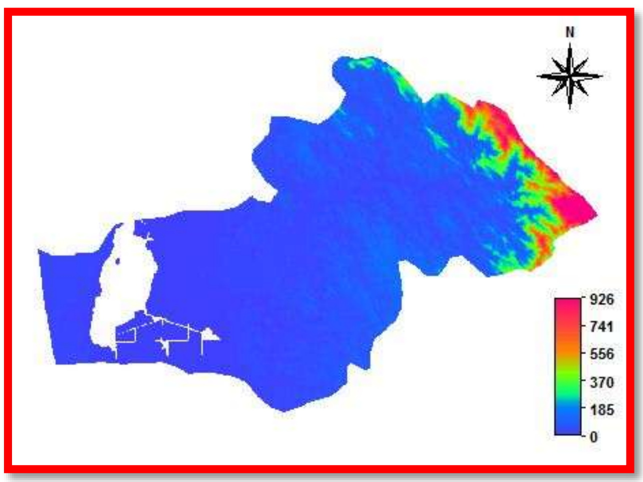
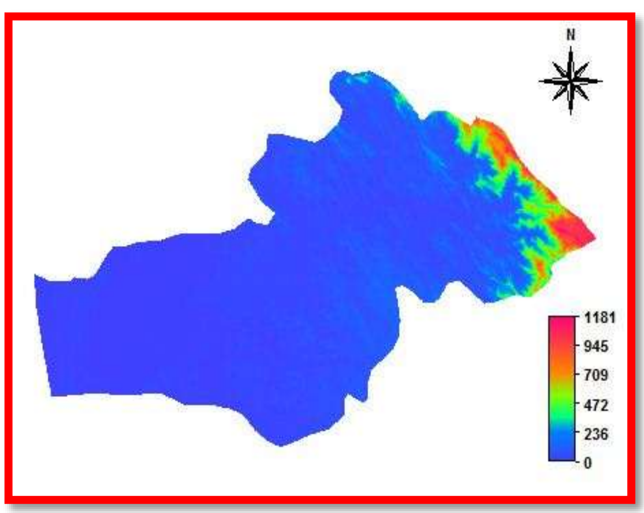


Figure 1 Input for fill sinks and output of fill sinks.



Map 3 (a) Sink Free SRTM DEM



Map 3(b) Sink Free ASTER DEM

3.7.1.2 Flow Direction

In a (sink-free) Digital Elevation Model (DEM), the Flow direction operation determines into which neighbouring pixel any water in a central pixel will flow naturally. Flow direction is calculated for every central pixel of input blocks of 3 by 3 pixels, each time comparing the value of the central pixel with the value of its 8 neighbours.

This function computes the flow direction for a given grid. The values in the cells of the flow direction grid indicate the direction of the steepest descent from that cell. For this study steepest slope method is used for flow direction determination.

For each block of 3x3 input pixels, height differences are calculated between the central pixel and the 8 neighbours.

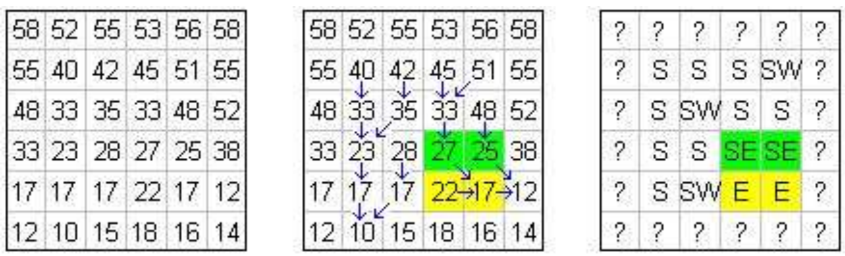
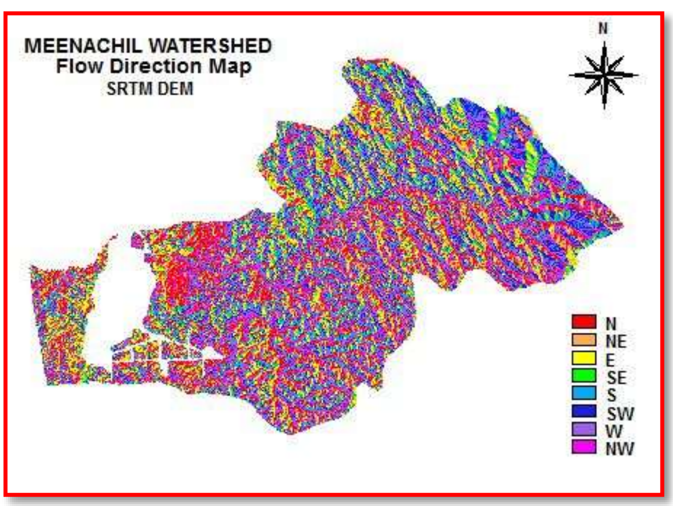
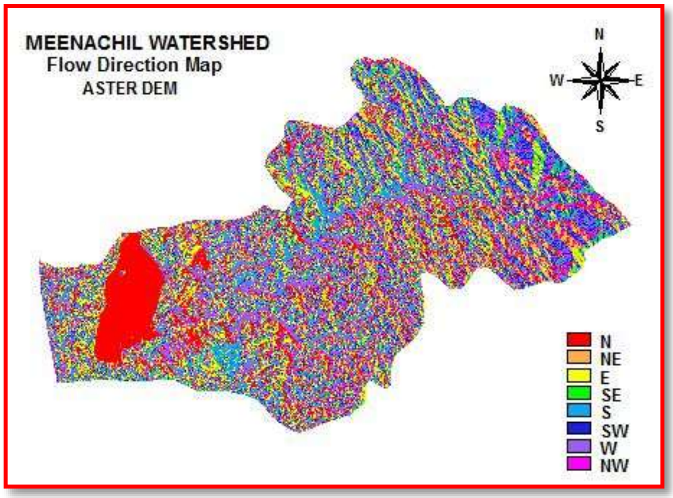


Figure 2 shows the input DEM, calculation of steepest slope and output map



Map 4(a) Flow Direction Map created from SRTM Dataset



Map 4(b) Flow Direction Map created from ASTER Dataset.

3.7.1.3 Flow Accumulation

The Flow accumulation operation performs a cumulative count of the number of pixels that naturally drain into outlets. The operation can be used to find the drainage pattern of a terrain. As input the operation uses the output map of the Flow direction operation.

This function computes the flow accumulation grid that contains the accumulated number of cells upstream of a cell, for each cell in the input grid.

The Flow direction operation determines the natural drainage direction for every pixel in a Digital Elevation Model (DEM). Based on the output Flow direction map, the Flow accumulation operation counts the total number of pixels that will drain into outlets.

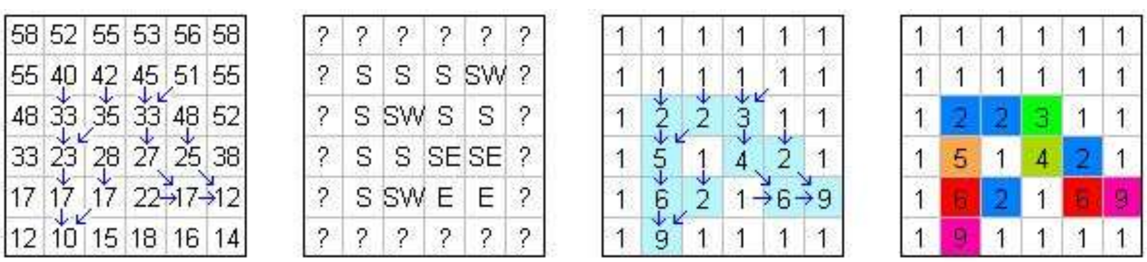
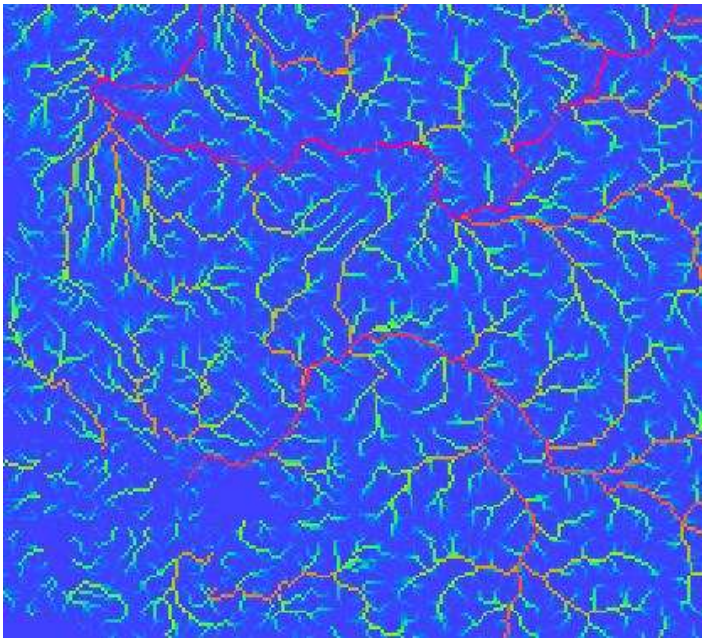
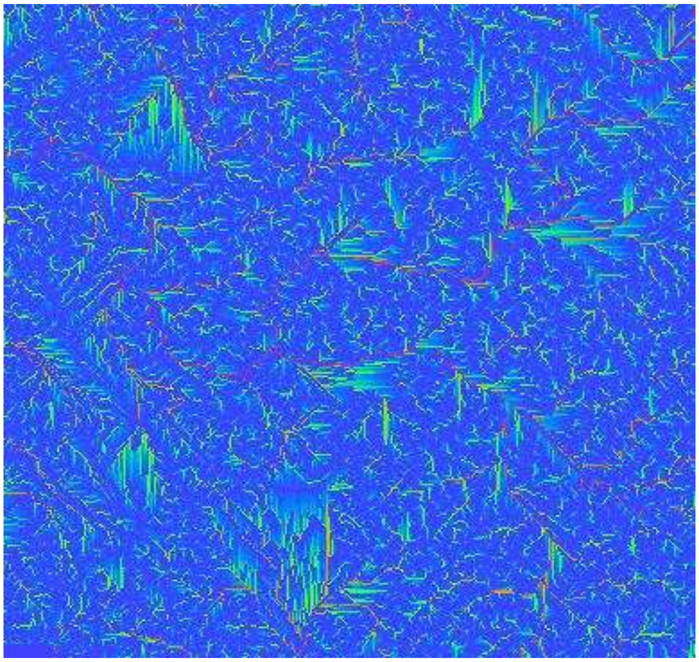


Figure 3 shows calculation of steepest slope, flow direction map, calculation of flow accumulation and output flow accumulation map.



Map 5(a) Flow Accumulation Map created from SRTM Dataset



Map 5(b) Flow Direction Map created from ASTER Dataset.

3.7.2.1 Drainage Network Extraction

The Drainage Network Extraction operation extracts a basic drainage network. The output raster map will show the basic drainage as pixels with value True, while other pixels have value false. The output raster map of the Flow Accumulation operation is required as input because this map contains a cumulative drainage count for each pixel. A threshold value has to be selected i.e. a value for the minimum number of pixels that are supposed to drain into a pixel to let this pixel remain as a drainage in the output map.

A smaller threshold will result in denser stream network and usually in a greater number of delineated catchment.

3.7.2.2 Drainage Network Ordering

The Drainage network ordering operation examines all drainage lines in the drainage network map, i.e. an output map from the Drainage network extraction operation, finds the nodes where two or more streams meet, and assigns a unique ID to each stream in between these nodes, as well as to the streams that only have a single node.

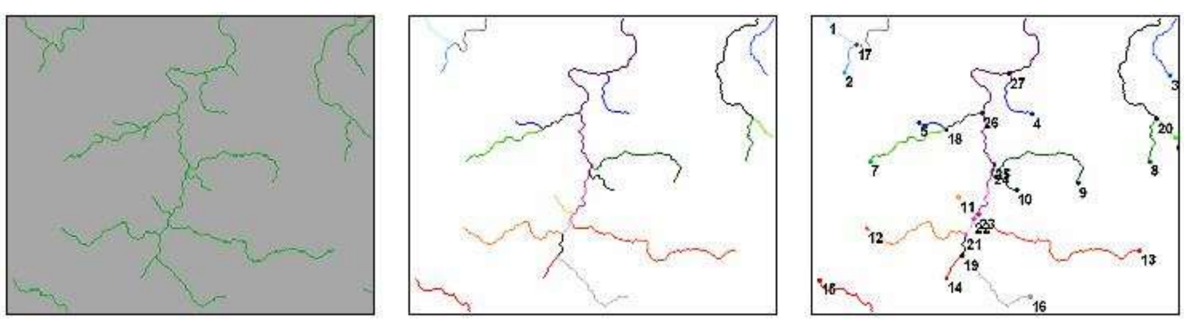
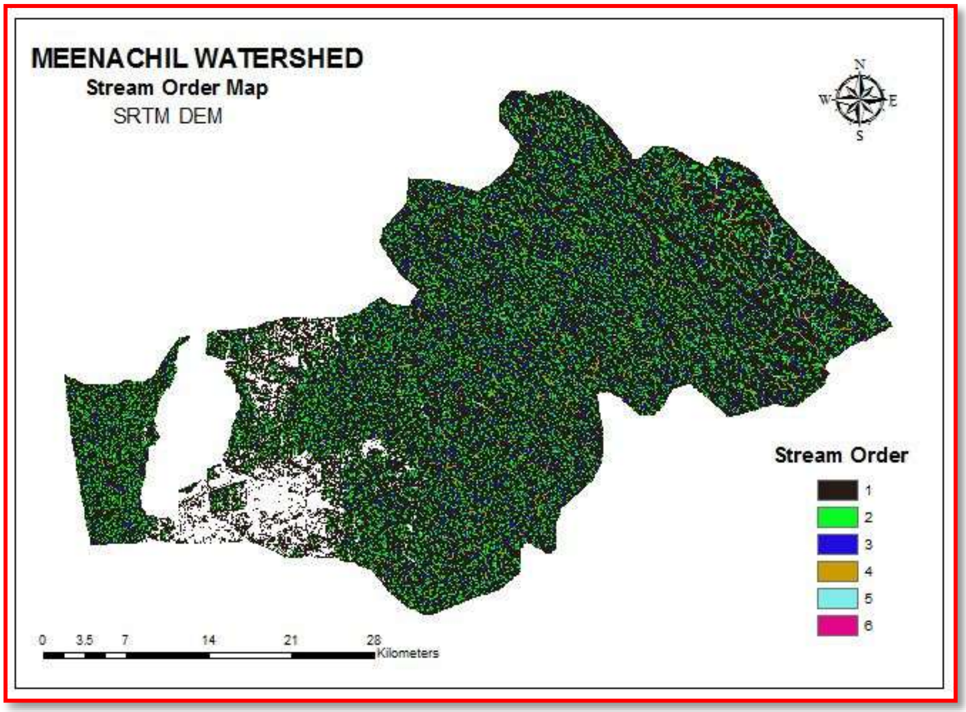
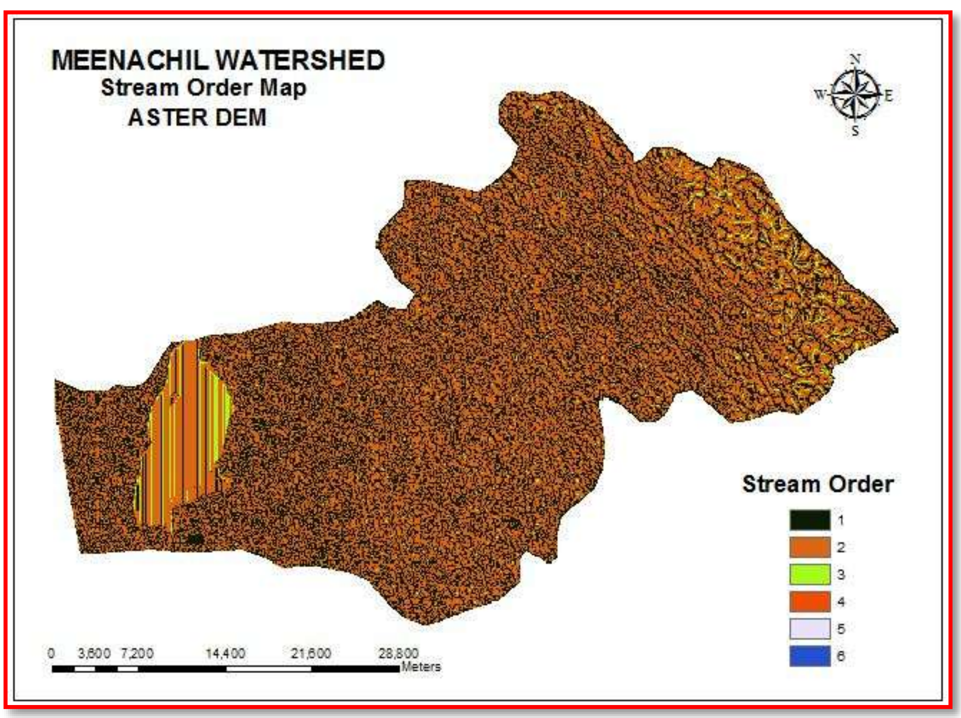


Figure 4 shows Input drainage map, Output drainage network ordering map and Output map including the IDs as point



Map 6(a) Drainage Networking Map created from SRTM DEM



Map 6(b) Drainage Networking Map created from ASTER DEM

3.7.2.3 Catchment Extraction

The Catchment extraction operation constructs catchments; a catchment will be calculated for each stream found in the output map of the Drainage network ordering operation. The operation uses a Flow direction map to determine the flow path of each stream.

Input required is –

1. The output raster map of the Drainage network ordering operation,
2. The output raster map of the Flow direction operation.

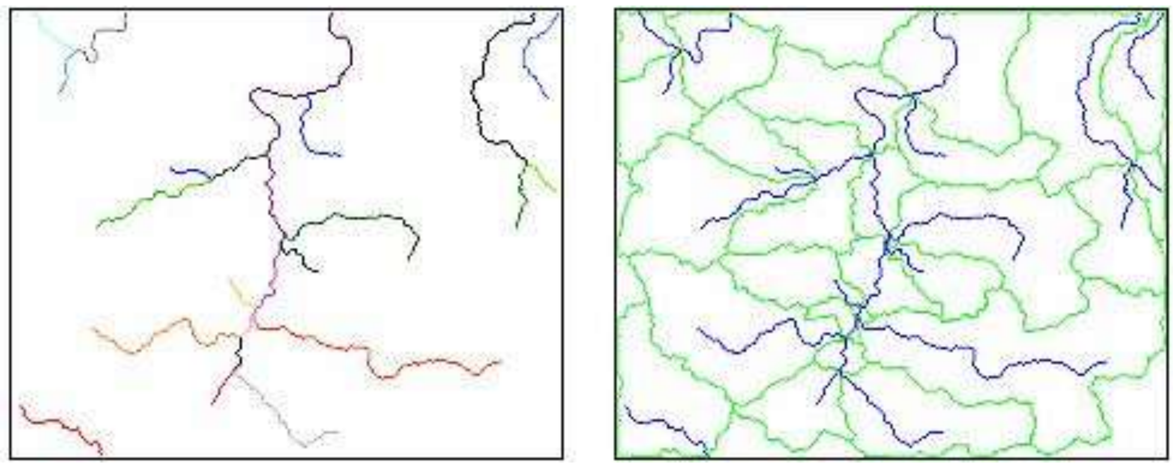


Figure 5 shows Input drainage network ordering map: Stream segments with unique IDs and Output catchment map, including input drainages: For each stream, a catchment is constructed; input streams in blue, output catchment polygon boundaries in green

3.7.2.4 Catchment Merge

The Catchment merge operation is able to merge adjacent catchments, as found by the Catchment extraction operation. In fact, new catchments will be created on the basis of the Drainage network ordering map and its attribute table.

Input required is output map and table of Drainage network ordering operation, the output map of Flow direction operation and the output map of Flow accumulation operation.

3.8 Watershed Analysis Using GRASS

GRASS is used for comparing the results by using ILWIS and also for developing L and LS map of USLE for further use in calculating surface runoff. GRASS has been also used for developing the contour map of study area at 10 m interval for watershed analysis work. GRASS is highly advanced GIS software used for variety of watershed applications. For our study it is mainly used for creation of sub basins extraction Map and River network extraction Map.

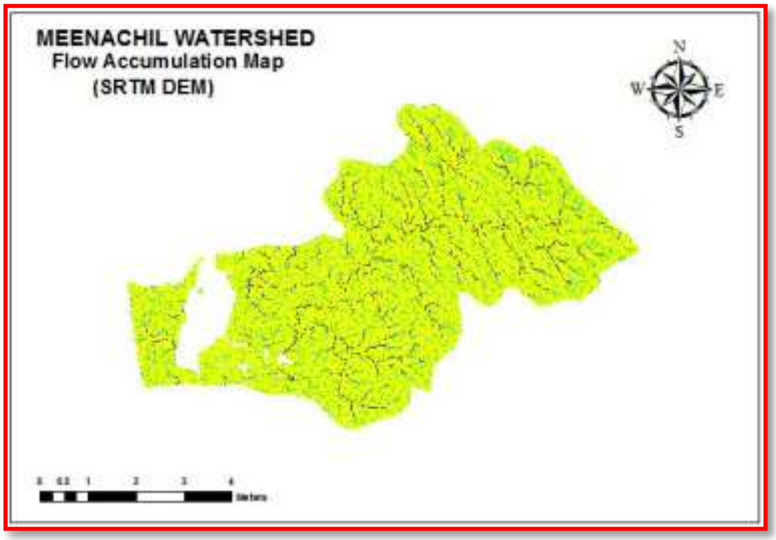
Sub basins Extraction-

GRASS displays the map *elevation.dem* (DEM). The area can be divided into a set of basins and sub basins. Operation can be performed automatically using the r.watershed (**Raster -> Hydrologic modelling -> Watershed analysis**) module to identify the entire basis with a minimum area of 1 square km. the following parameters must be provided:

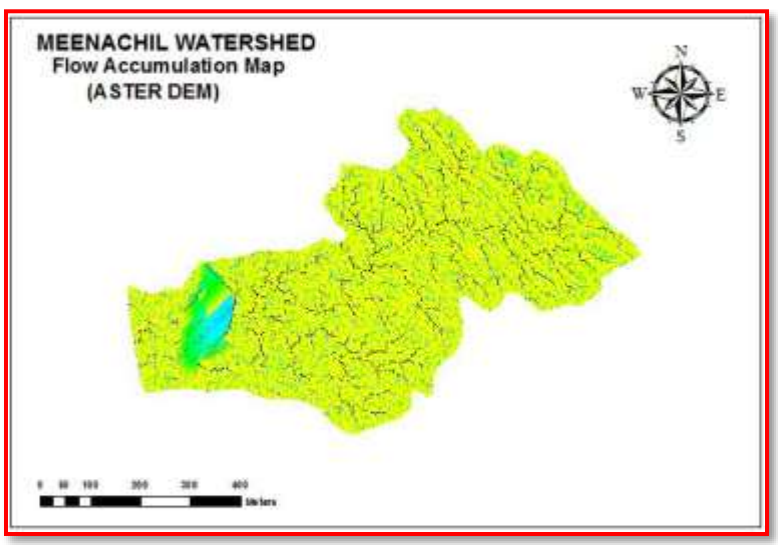
1. The name of the accumulation output map (Output map: number of cells that drain through each cell): *accumulation*;
2. The minimum area of a sub basin (Input value: minimum size of exterior watershed basin): insert *1000*;
3. The name of the output map containing the basins (Output map: unique label for each watershed basin): *basins*.
4. Generation of L Factor map of watershed area for further soil erosion studies by using USLE.
5. Generation of LS Factor map of watershed area for further soil erosion studies by using USLE.

Generation of Accumulation Map using GRASS

The Flow accumulation operation performs a cumulative count of the number of pixels that naturally drain into outlets. The operation can be used to find the drainage pattern of a terrain. As input the operation uses the output map of the Flow direction operation.



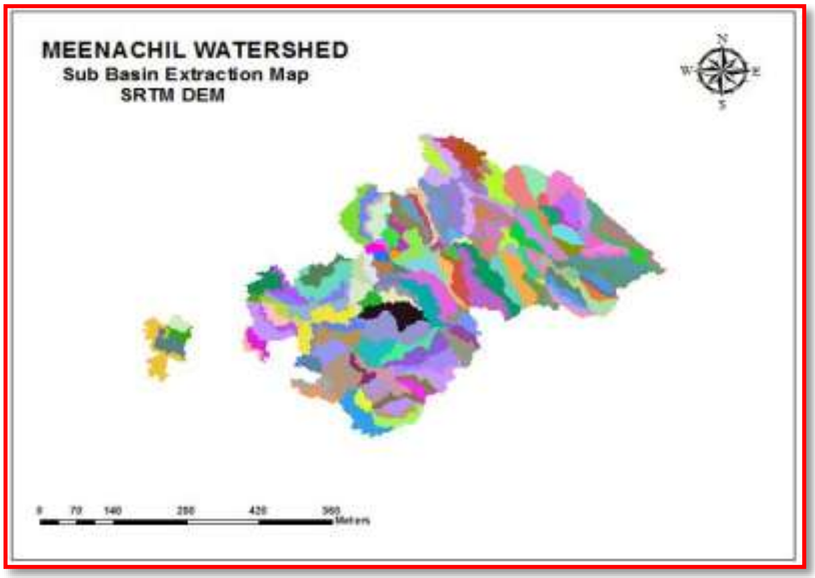
Map 7(a) Flow Accumulation Map created from SRTM Dataset in GRASS.



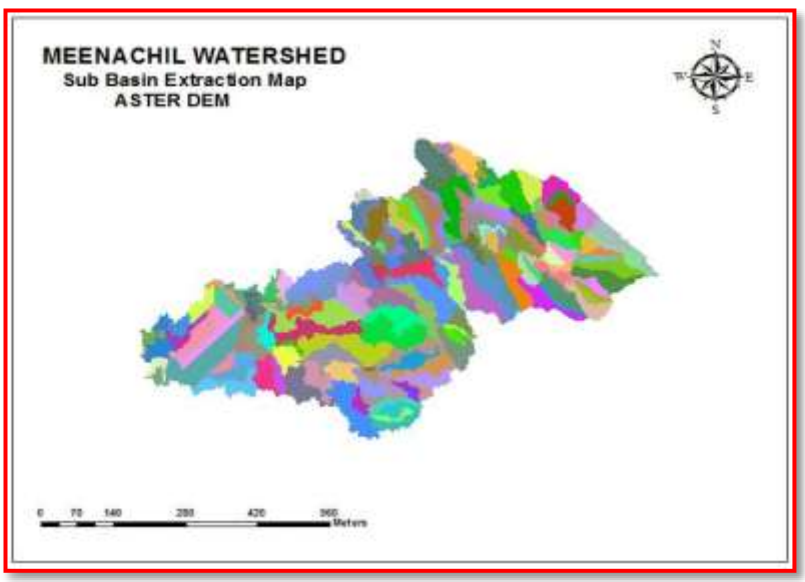
Map 7(b) Flow Accumulation Map created from ASTER Dataset in GRASS.

Generation of Sub Basin Map

A sub basin is basically a smaller watershed that makes up a piece of the large watershed. In this study it is done for delineation of micro watersheds of the study area by using GRASS GIS interface.



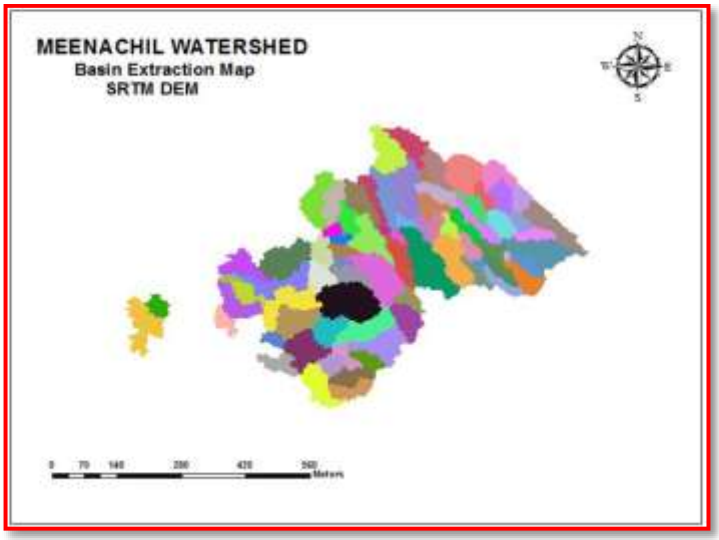
Map 8(a) Sub Basin Delineation from SRTM Dataset.



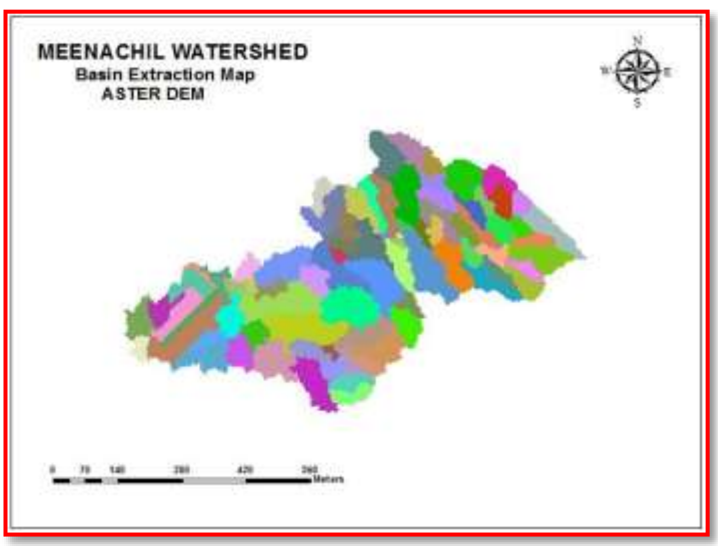
Map 8(b) Sub Basin Delineation from ASTER Dataset.

Generation of Basin Map

Basins have been delineated by using the watershed analysis tool of GRASS GIS interface. Delineated basins have been labeled by using a colour representation. In this study delineation has been done for two globally accepted digital elevation datasets. Further it is used for comparison study.



Map 9(a) Delineated Basin from SRTM Dataset



Map 9(b) Delineated Basin from ASTER Dataset

Generation of L Factor Map

The slope length (L) is defined as the distance of the point of origin of overland flow to the point where the slope decreases sufficiently for deposition to occur where runoff enters a defined channel. The slope length factor was defined as (Wischmeier and Smith, 1965),

$$L = (X/22.13)^{m}$$

Where, L= slope length factor

X= slope length (m)

m= an exponent

m depends upon the slope.

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%

L factor is further utilized for calculation of topographic factor LS. In general the input required for generation of L factor map is DEM of study area and slope map by using map calculation formula but in GRASS L map can be generation operation can be performed automatically using the r.watershed (**Raster -> Hydrologic modeling -> Watershed analysis**) module. For our study GRASS has been used for generating L factor map.

Generation of LS Factor Map

LS factor is also known as topographic factor. It is the combination of slope length factor (L) and steepness of slope factor (S). In general steepness of land slope directly influences runoff. It is defined as the ratio of soil loss from field having specific steepness and slope (i.e. 9 % slope and 22 m length) to the soil loss from a continuous fallow land. The topographic factor was defined as (Wischmeier and Smith, 1978),

$$LS = (X/22.13)^{m} (0.065+4.56 \sin\theta+65.41 \sin^2\theta)$$

Where L, X, m is same as in L factor.

θ= angle of slope and it is given by $\theta=\tan{-1} (s/22.13)^{m}$

Further LS factor can be utilized in estimation of soil loss by using USLE. USLE is the product of several factors. It can be written as –

$$A=R*K*LS*C*P$$

Where,

A= Mean annual soil loss (in ton per ha per year.)

R= Rainfall and Runoff Erosivity Index (in MJ/ha/mm/yr)

K= Slope and Length of Slope Factor

C= Cropping Management Factor

P= Erosion Control Practice Factor

With the help of rainfall data and soil data or soil map of the area soil erosion study can be done in future.

SNAPSHOTS OF OPERATIONS INVOLVED IN STUDY

1. Georeferencing and Digitizing

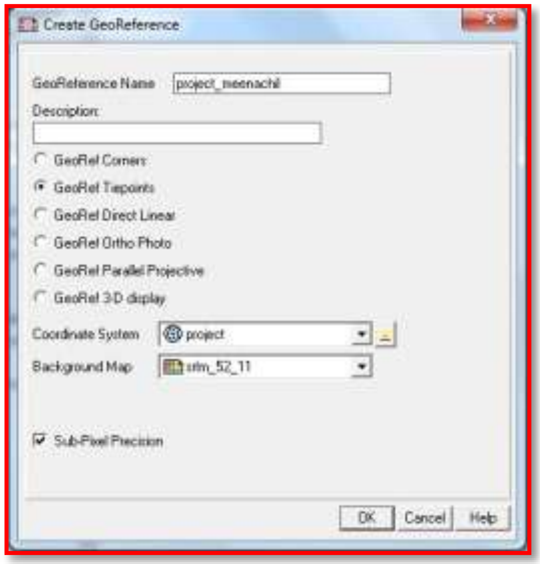


Figure 6 shows Snapshot of Creation of a Georeference.

Digitizing of map has been done by creating a segment map using already created georeferenced map and coordinate system.

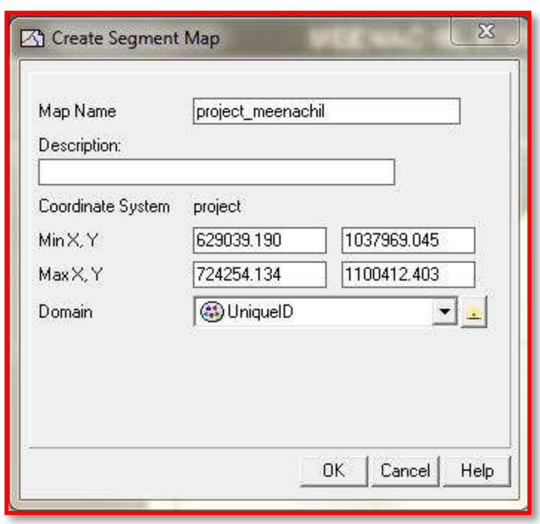


Figure 7 shows Snapshot of Creation of Segment Map of Study Area

2. Clipping operation -

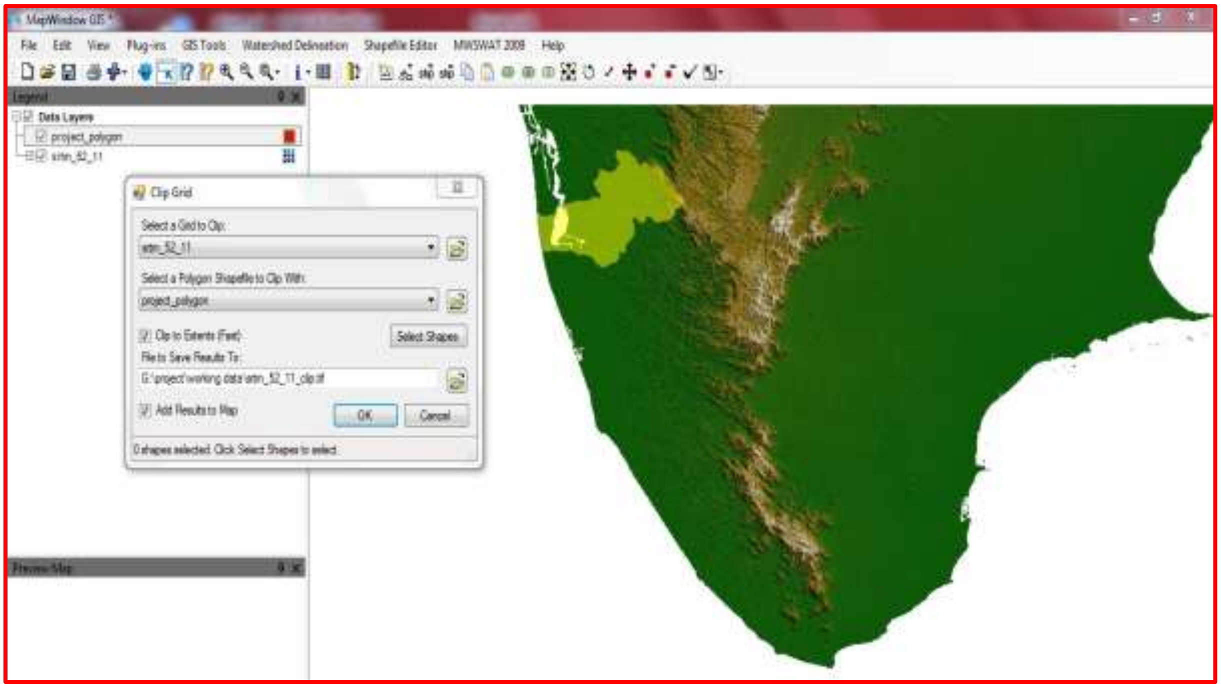


Figure 8 shows Snapshot of the clipping operation in MapWindow GIS

3. Filling Sinks of the DEM -

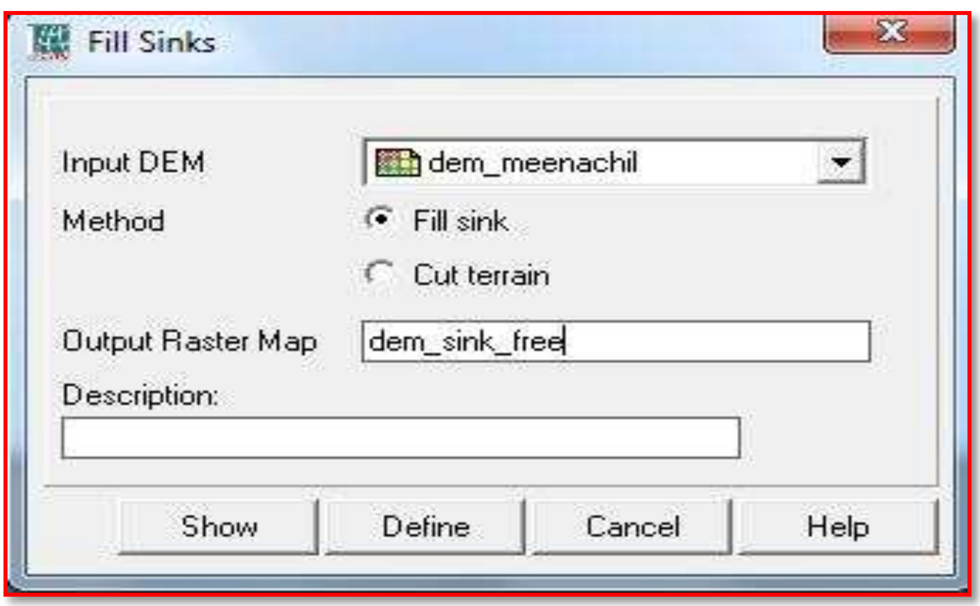


Figure 9 shows Snapshot of Fill sink operation in ILWIS 3.7

4. Creation of Flow direction Map-

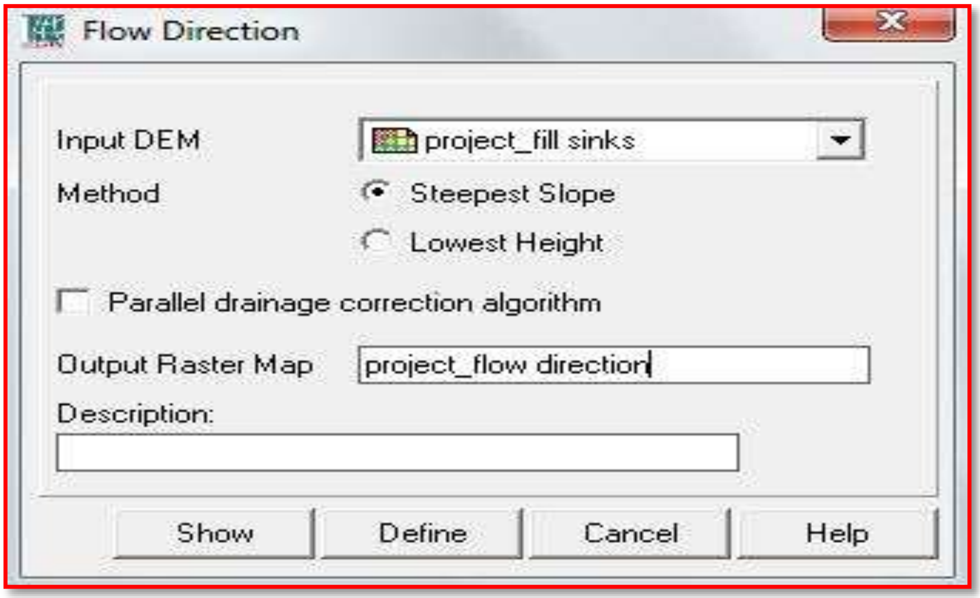


Figure 10 shows Snapshot creation of Flow Direction Map in ILWIS 3.7

5. Creation of Flow Accumulation Map

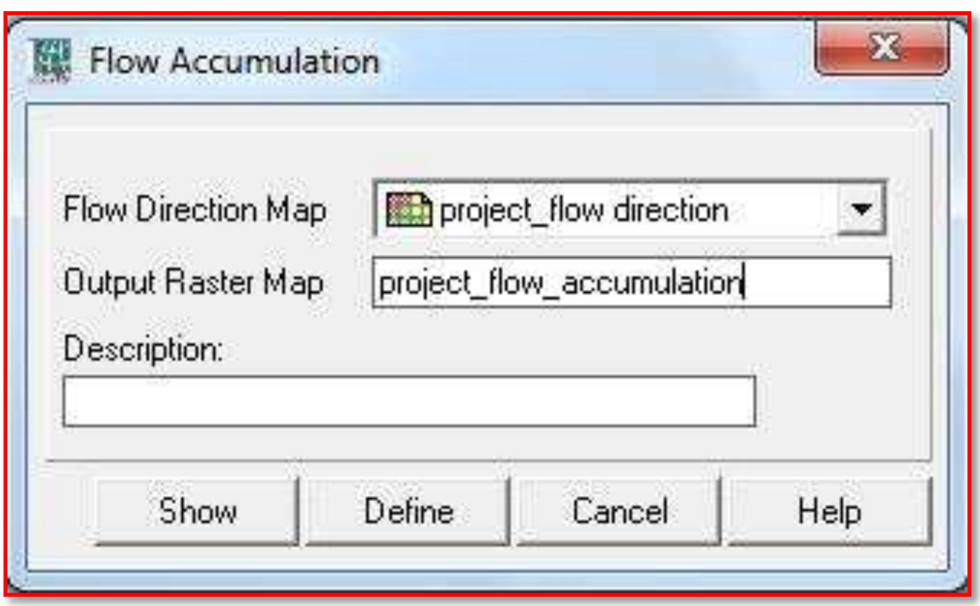


Figure 11 shows Snapshot Creation of Flow Accumulation Map in ILWIS 3.7

6. Creation of Drainage Extraction Map

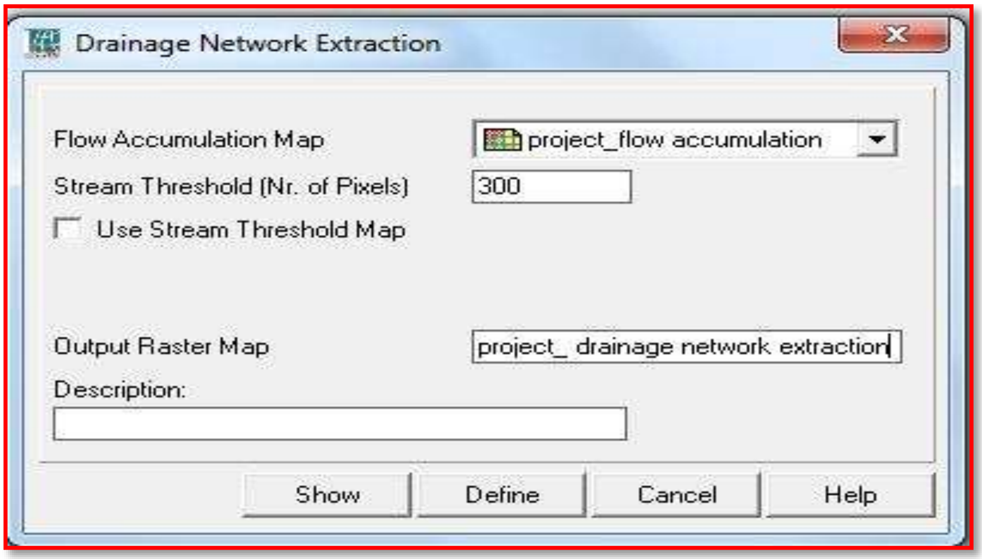


Fig12 shows Snapshot of Creation of Drainage Extraction Map in ILWIS 3.7

7. Creation of Drainage Network Ordering Map

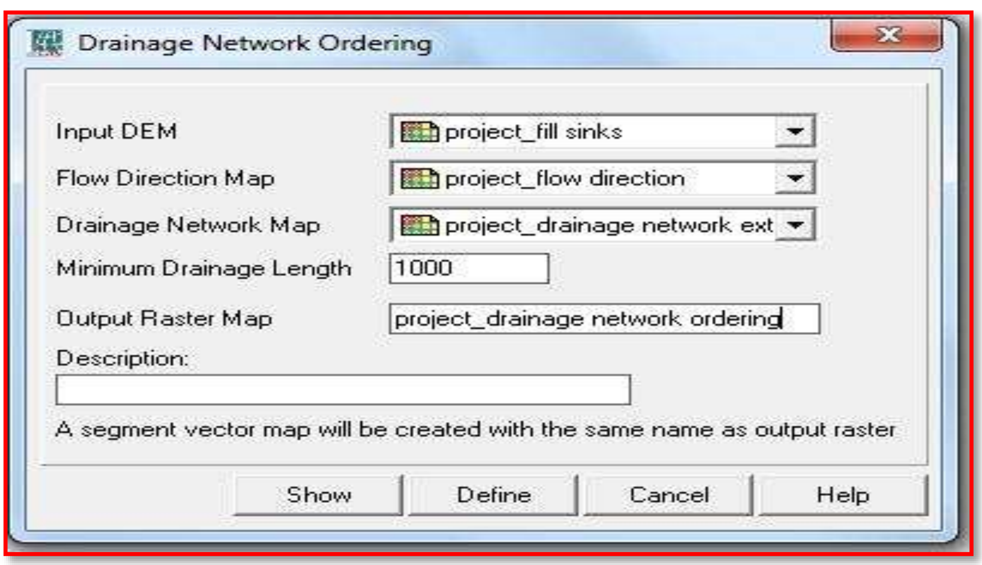


Figure 13 shows Snapshot of Creation of Drainage Network Ordering Map in ILWIS 3.7

8. Creation of Catchment Extraction Map

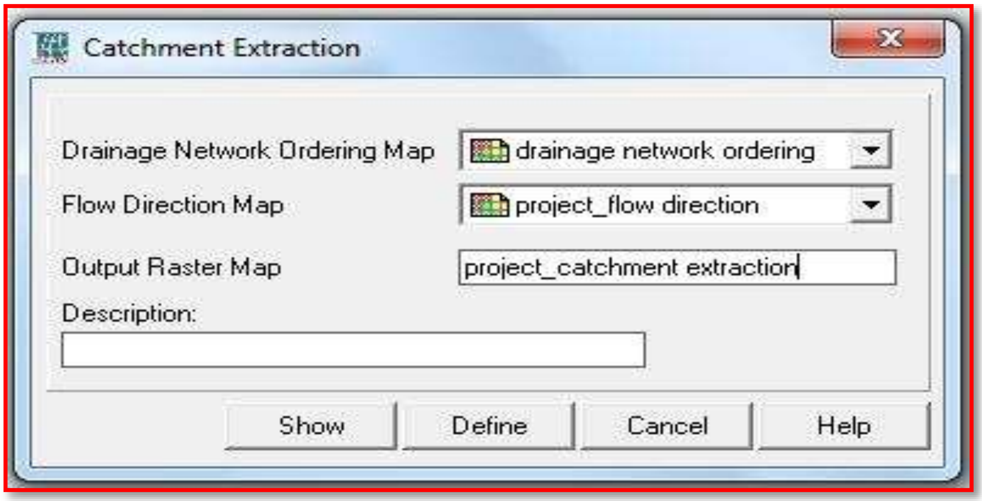


Figure 14 shows Snapshot of Creation of Catchment Extraction Map in ILWIS 3.7

9. Creation of Catchment Merging Map

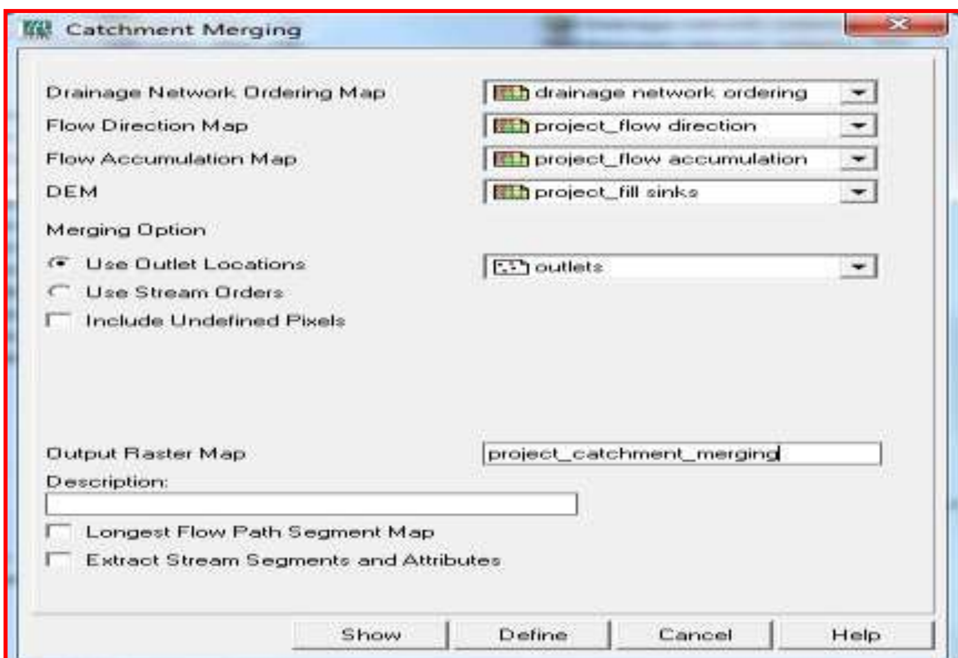


Figure 15 shows Snapshot of Creation of Catchment Merging Map in ILWIS 3.7

10. Watershed analysis tool of GRASS GIS

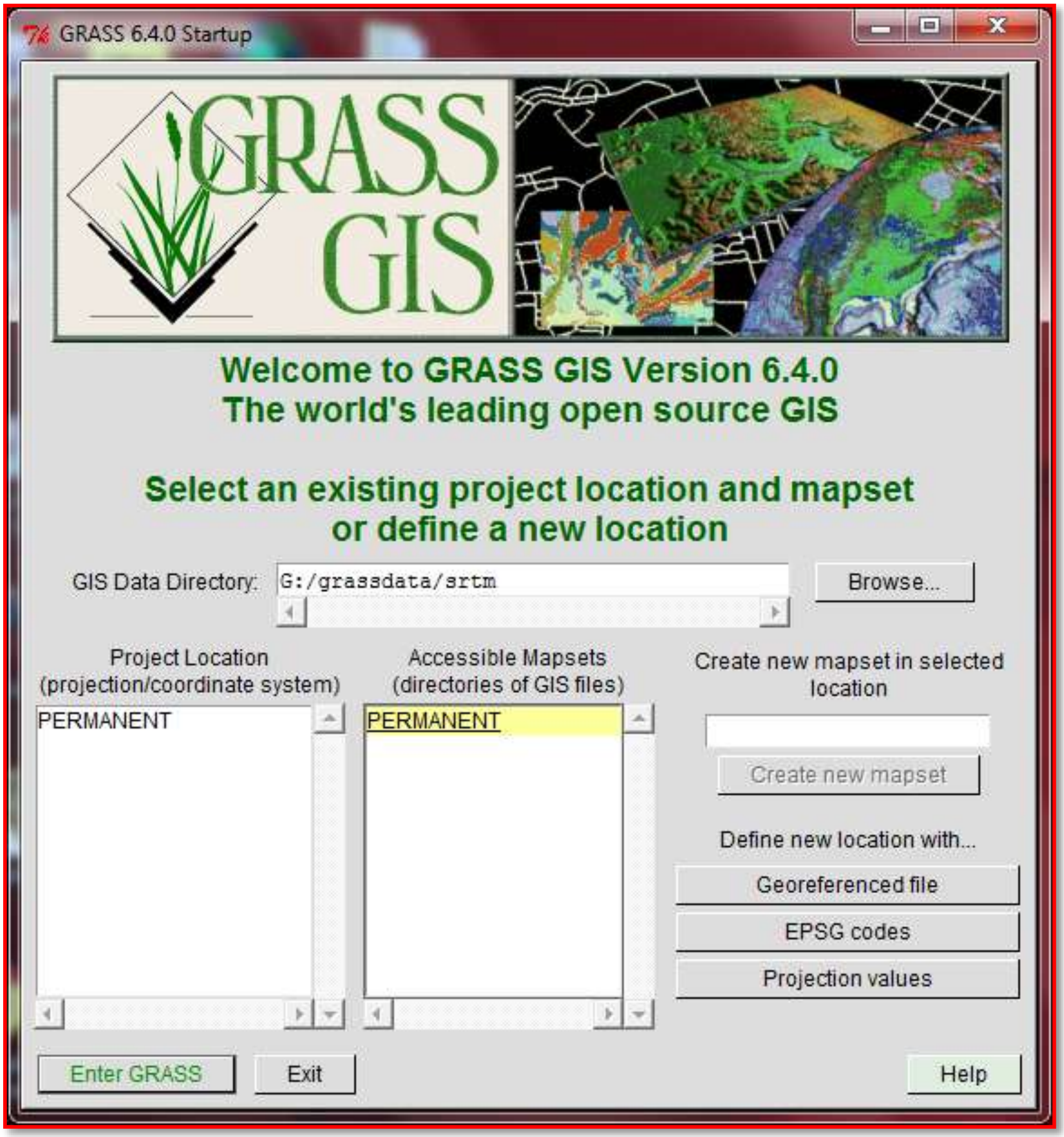


Figure 16 shows Snapshot of start up window of GRASS GIS

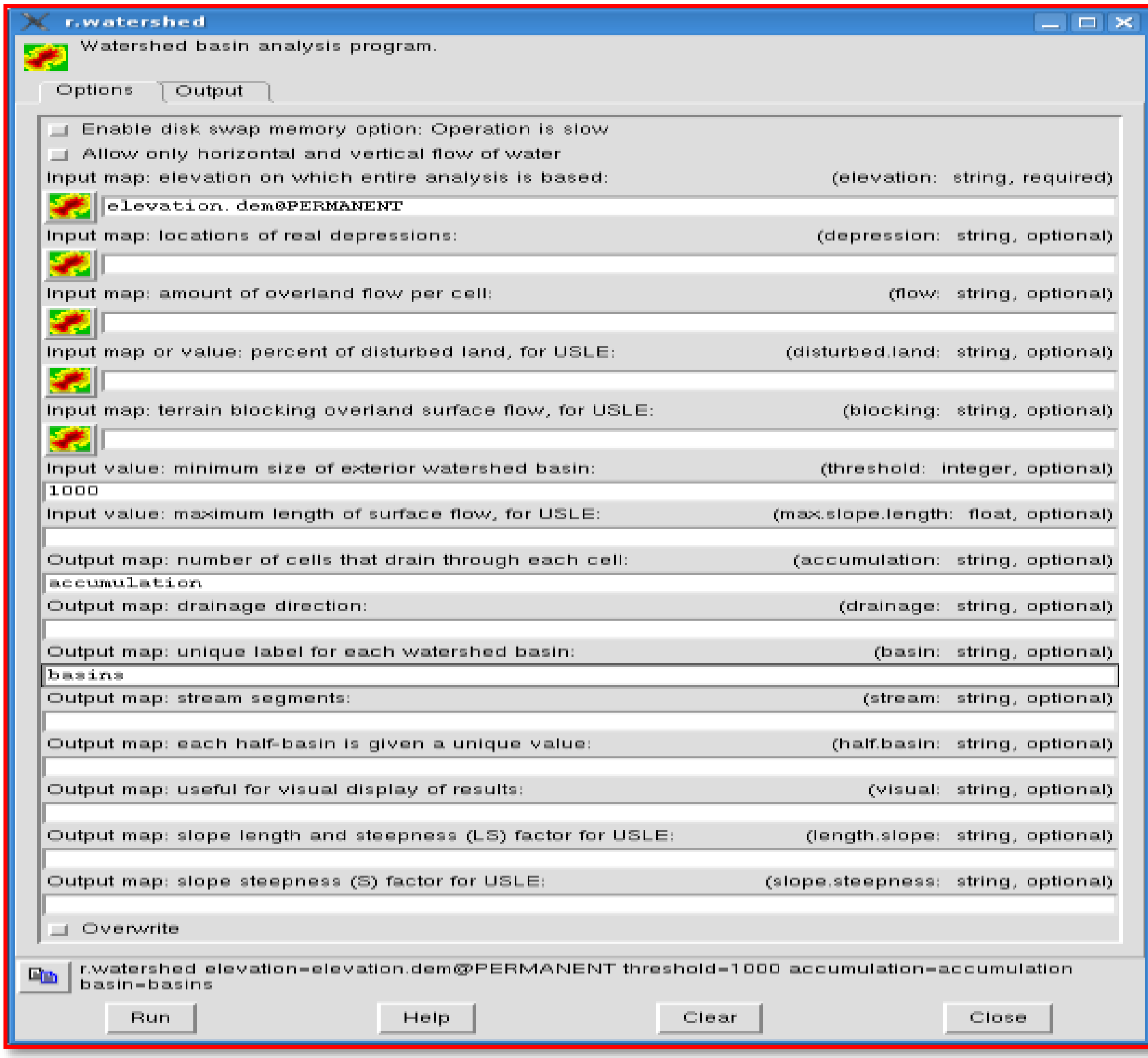


Figure 17 shows Snapshot of r.watershed module of GRASS GIS.

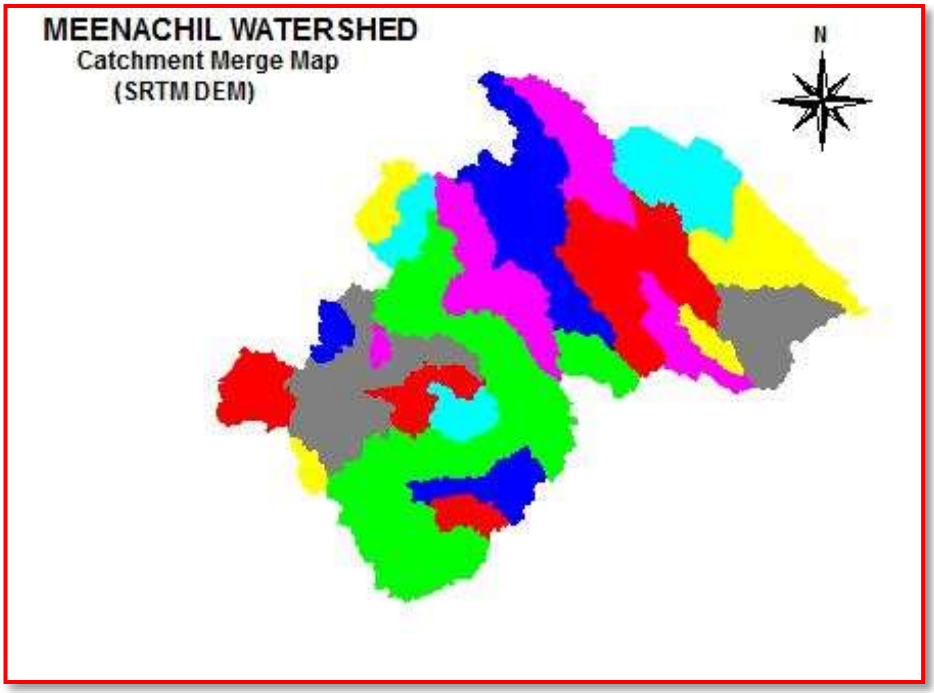
RESULTS AND DISCUSSION

Chapter 4
RESULTS AND DISCUSSION

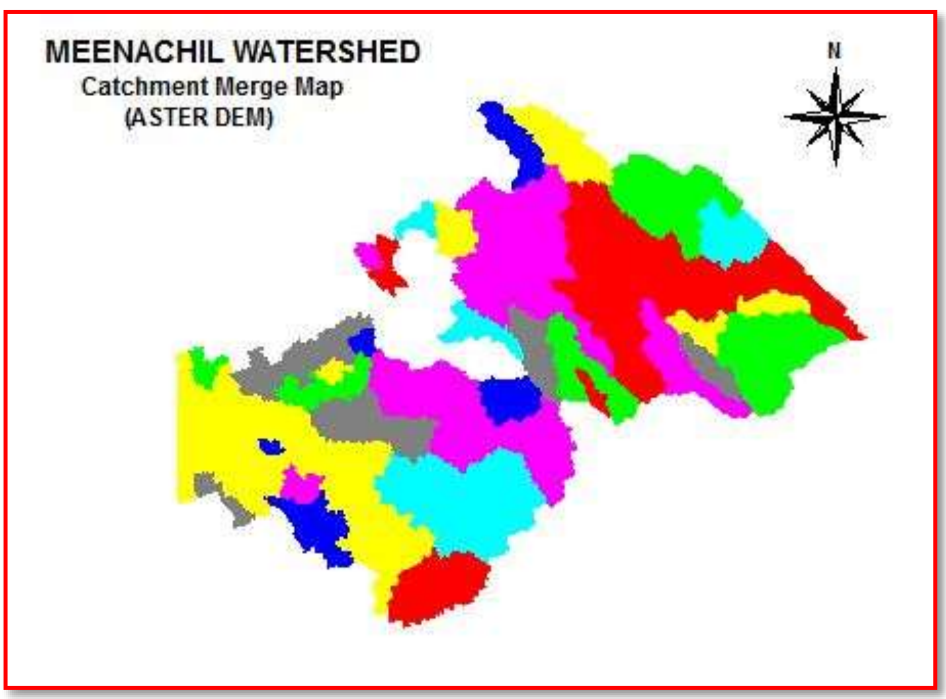
4.1 Delineation of watershed

Meenachil watershed has been delineated by using two FOSS GIS Tools and delineation has been done with the two globally accepted digital elevation datasets. The number of subwatersheds delineated when SRTM DEM is used as DEM has been found to be 28 and when ASTER DEM is used then number of delineated subwatersheds increased to 39. It is due to more spatial resolution of SRTM DEM as compare to ASTER DEM. SRTM DEM having high accuracy due to its way of acquisition. SRTM data is captured by using active remote sensing whereas ASTER data is captured using passive remote sensing. The sensor used for the acquisition was a C-band InSAR, which gives heights of the surface including topographic objects. The areas coming under water bodies are left same as it is whereas the rest of area has been delineated in SRTM DEM based delineation whereas in ASTER based delineation water bodies are also delineated as a part of subwatershed. Delineation of watershed using SRTM DEM is more accurate than using ASTER DEM.

Flow direction of water and outlet of water flow into drainage channels has been identified which can be helpful in soil and water conservation practices and finding the area of potential for construction of soil and water conservation structures. Watershed Delineation is a very important tool for any watershed development project for proper implementation of watershed based development plans. GIS based delineation should become mandatory in every watershed development project because it helps to take proper decision for implementation and also very important in watershed analysis study.



Map 10(a) Delineated watershed Map using SRTM DEM

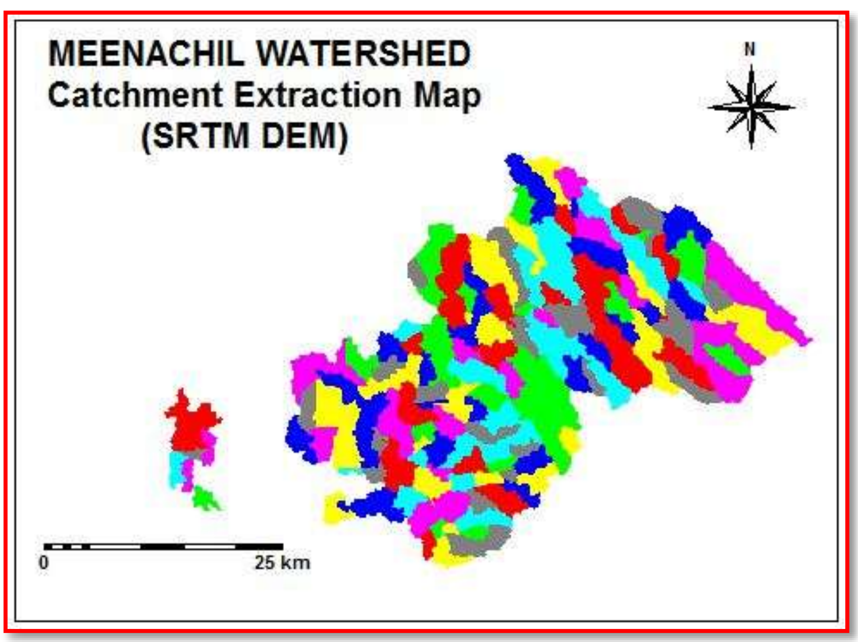


Map 10(b) Delineated watershed Map using ASTER DEM

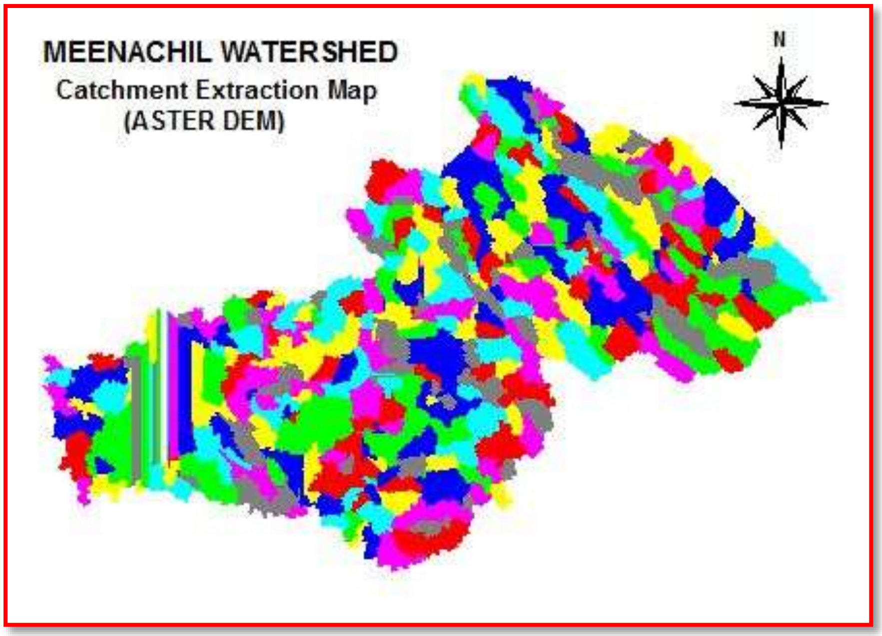
4.2 Extraction of Microwatershed using DEM

Microwatersheds were extracted using DEM using both the DEMs i.e. SRTM DEM and ASTER DEM. The number of microwatershed delineated is more in the case of ASTER DEM than that of SRTM DEM. The exact number of microwatershed delineated in case of ASTER DEM is 430 whereas in case of SRTM DEM is 186. The basic reason behind this is the high spatial resolution of SRTM DEM (90 m) compare to ASTER DEM (30m). The accuracy of microwatershed extraction based on SRTM DEM is more than ASTER DEM because water bodies are shown as delineated in ASTER DEM which is practically not possible.

Extraction of microwatershed has been done which is very important in watershed prioritization. It is compulsory for implementation of watershed development plan on a micro level. Projects can’t be implemented in a sub-watershed evenly, so there is a need of again dividing sub-watershed into micro-watershed for effective and efficient implementation of project.



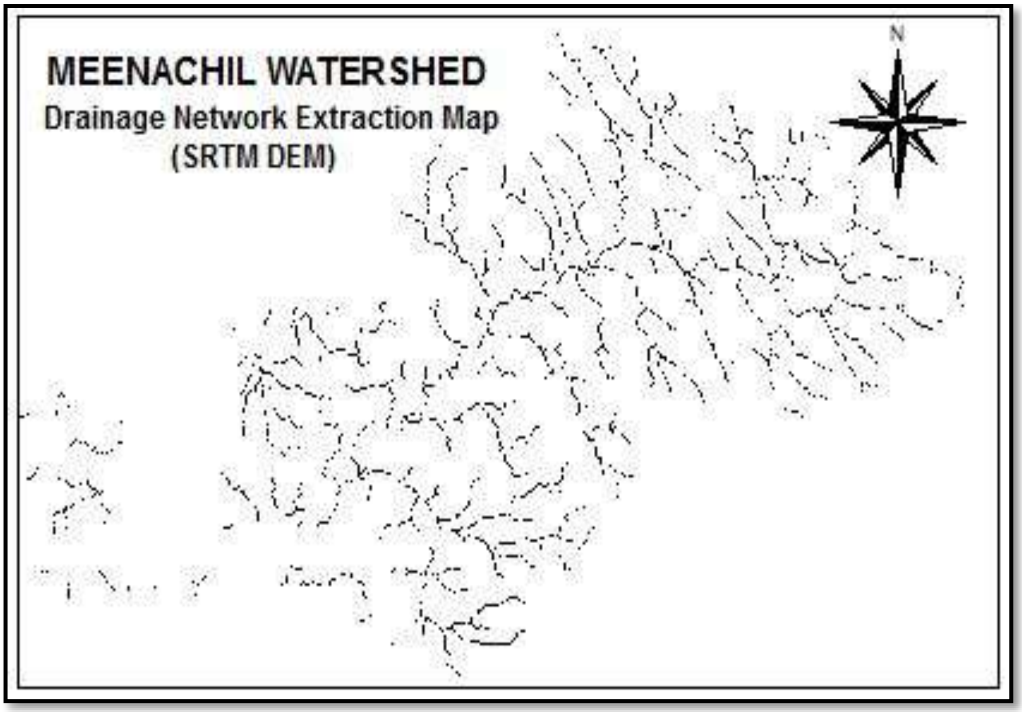
Map 11(a) Delineated Microwatershed Map using SRTM DEM



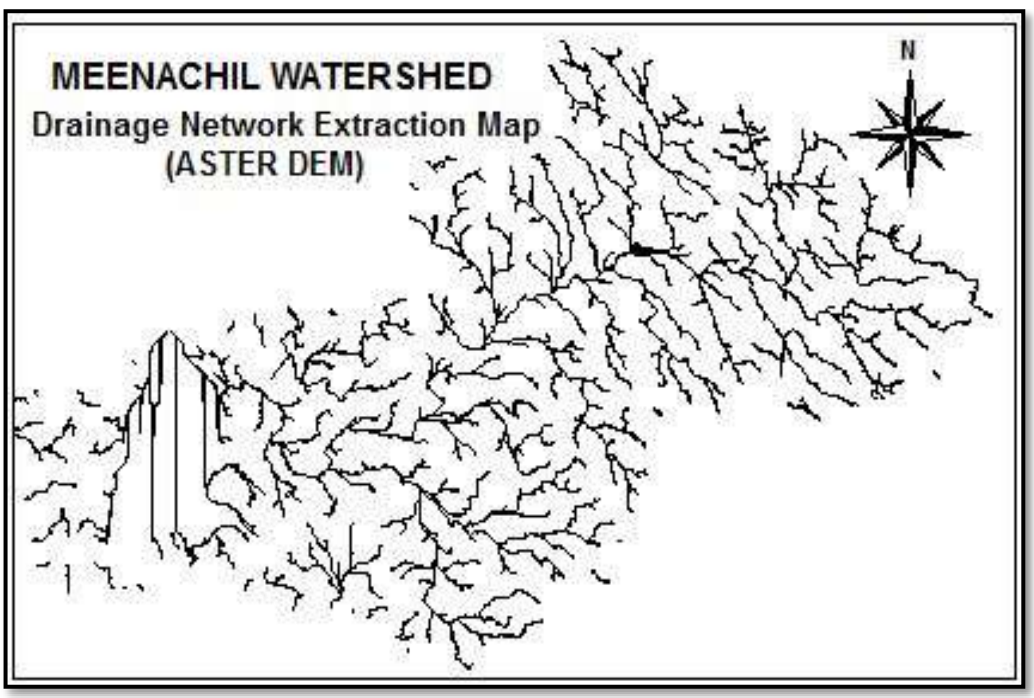
Map 11(b) Delineated Microwatershed Map using ASTER DEM

4.3 Extraction of drainage networks

Extraction of drainage networks has been done and it is compared with already extracted drainage network. Study of drainage extraction was done for identifying the potential zone for drainage problems and further can be utilized for adoption of proper agricultural practices. Drainage extraction has been done for different threshold number for both the DEMs and it is found that drainage network is dense in the case of less threshold value. Number of channels extracted from SRTM DEM is less as compare to ASTER DEM. In case of SRTM DEM channels extracted up to 6^{th} order whereas in case of ASTER DEM drainage channels extracted is up to 5^{th} order only. By comparing number of first order drainage channels in case of ASTER DEM is nearly 3.5 times than that of SRTM DEM. Drainage channels with high stream number in both the case is very less. Drainage network extracted from SRTM DEM closely resembles with the actual stream network of the study area derived by CWRDM.



Map 12(a) Drainage Extraction Map Generated from SRTM DEM



Map 12(b) Drainage Extraction Map Generated from ASTER DEM

Sl.No.	Stream Order	No. of drainage channels
1	1	115007
2	2	28923
3	3	10750
4	4	2253
5	5	206
6	6	28

Table 1- No. of drainage channel extracted with their stream order from SRTM DEM

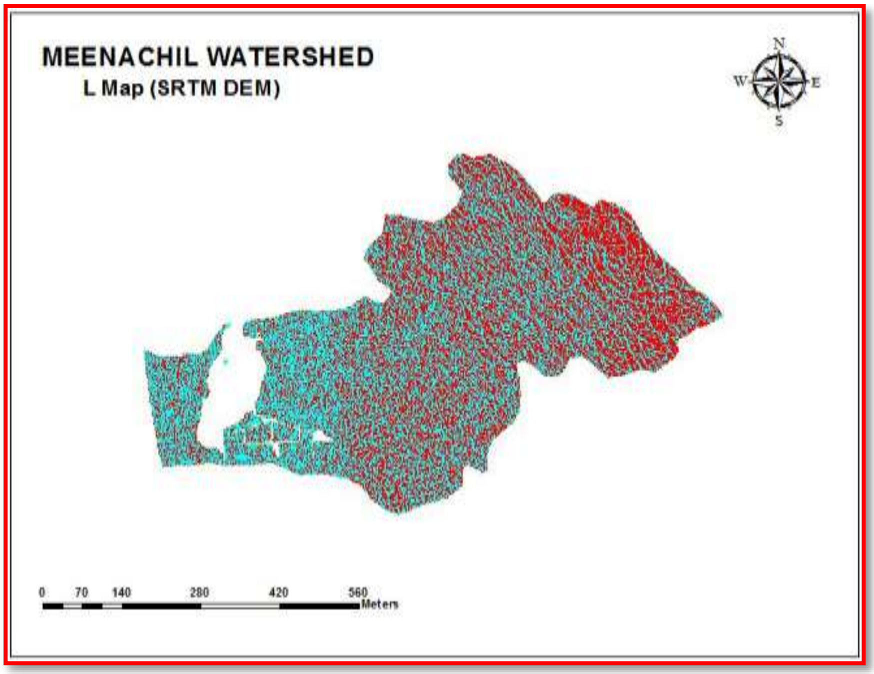
Sl.No.	Stream Order	No. of drainage channels
1	1	407719
2	2	45876
3	3	12569
4	4	1418
5	5	21

Table 2- No. of drainage channel extracted with their stream order from ASTER DEM

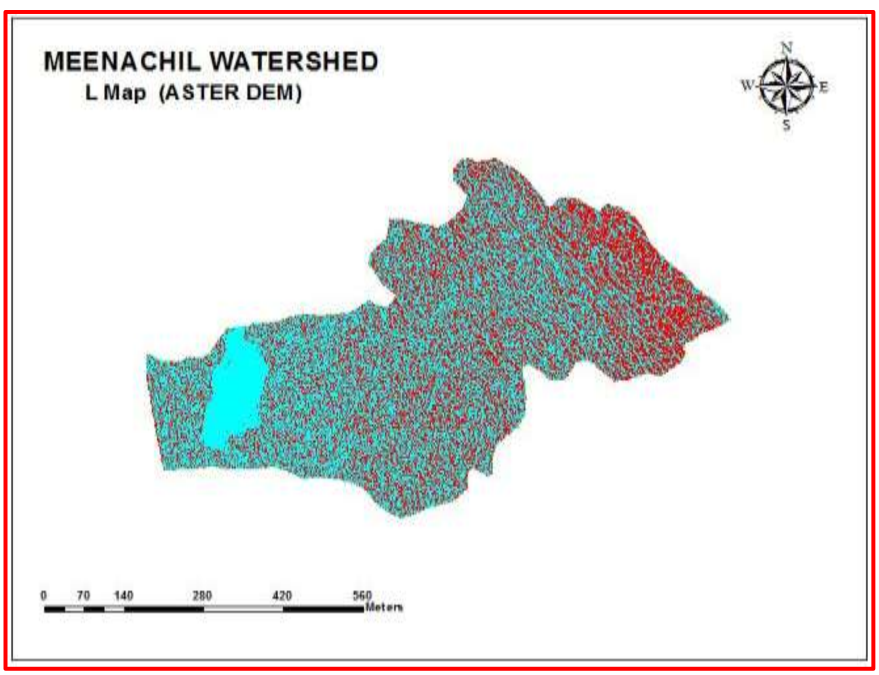
4.4 Generation of L and LS map has been done by using GRASS for further soil erosion studies by USLE.

L and LS factor has been prepared by using GRASS GIS. By using USLE soil loss estimation of the study area can be done in future. Due to unavailability of soil and rainfall data of study area, this could not become possible to estimate soil loss in our study.

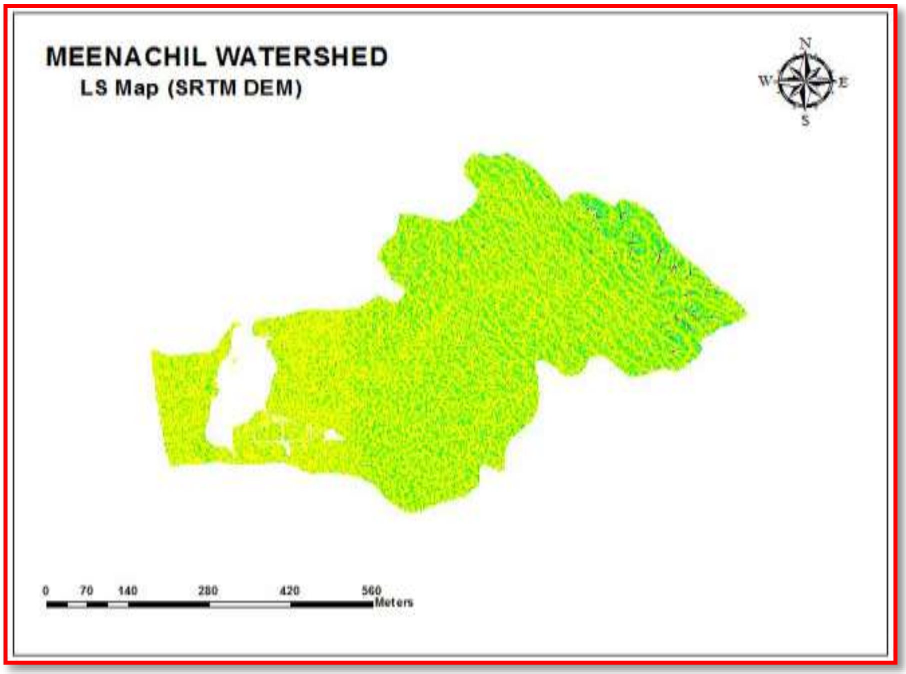
LS factor is topographic factor of watershed and it is very important for watershed analysis to understand the topography of the area. Area prone to surface runoff on the basis of topography can be easily identified because it makes a relation between slope and length of slope together.



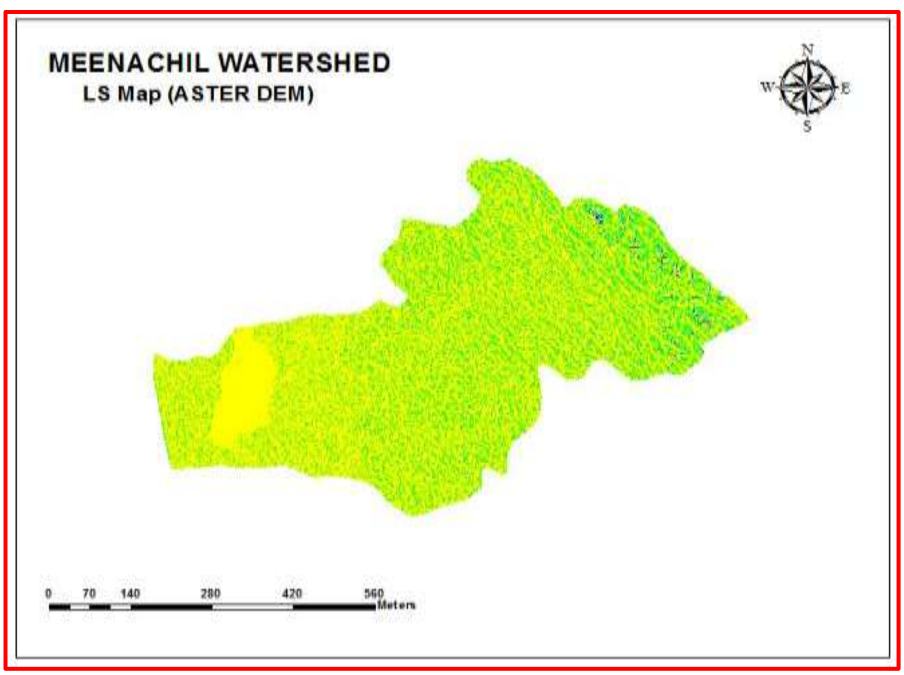
Map 13(a) L Factor Map Generated from SRTM DEM



Map 13(b) L Factor Map Generated from ASTER DEM



Map 14(a) LS Factor Map Generated from SRTM DEM



Map 14(b) LS Factor Map Generated from ASTER DEM

4.5 Comparison between two globally accepted digital elevation data models.

In this study a comparison between two globally accepted digital elevation data models i.e. SRTM & ASTER data models have been done. Both data models have been utilized in creating the Digital Elevation Model for watershed analysis of the study area. Use of these digital elevation data models found more relevant than the creation of DEM from Toposheet of study area by digitizing the contour line interpolation. Creation of DEM from Toposheet is time consuming process and accuracy is not that much as DEM generated from remote sensing techniques. SRTM digital data model is generated by using a high resolution imaging radar system i.e. where as ASTER digital data model is captured by an advanced multispectral imager i.e. Advanced Space borne Thermal Emission and Reflection Radiometer. The spatial resolution is 90 m and 30 m for SRTM and ASTER DEM respectively.

SRTM DEM is available for 80 % of earth's land area. Since the SRTM elevation data are unedited, they contain occasional voids, or gaps, where the terrain lay in the radar beam's shadow or in areas of extremely low radar backscatter, such as sea, dams, lakes and virtually any water-covered surface whereas ASTER consists of three separate instruments subsystems, each operating in a different spectral region, using separate optical system. The visible– near infrared system, which is used in DEM production, consists of two telescopes— one nadir looking with a three-band detector and the other backward looking (27.7u off-nadir) with a single band detector. The most important specifications of the ASTER stereo subsystem that govern the DEM generation capabilities include: stereo geometry; platform altitude of 705km and base-to-height ratio of 0.6.

In SRTM DEM Vembanad Lake which lies in the study area is shown as void with no elevation whereas in ASTER DEM same lake is provided with some elevation value. In general Water body shouldn't have any elevation value in DEM or it must be represented as unknown elevation or zero elevation value because surface contour won't lie inside the water body.

DEM hydro processing operations have been done on both the DEMs. Drainage network extracted from SRTM DEM resembles closely to the real drainage pattern of watershed where as drainage network extracted from ASTER DEM resulted in a very dense drainage network for same threshold value. The number of subwatersheds delineated from SRTM DEM is 28 whereas from ASTER DEM is 39. Similarly microwatersheds delineated from SRTM DEM is 186 whereas from ASTER DEM 430.

Watershed delineation has been done for both the DEMs, the number of subwatershed and microwatershed delineated in case of SRTM DEM is less as compare to ASTER DEM, it is due to high spatial resolution of SRTM DEM.

In brief Digital Elevation Model generated from Shuttle Radar Topography Mission (SRTM) is more accurate than DEM generated from the Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) because SRTM utilizes active remote sensing technique whereas ASTER is passive remote sensing technique. Active remote sensing gives accurate and reliable information than passive remote sensing.

	ASTER DEM	**SRTM DEM**
Data source	ASTER	Space shuttle radar
Generation and distribution	METI/NASA	NASA/USGS
Data acquisition period	2000 ~ ongoing	11 days (in 2000)
Posting interval	30m	90m
DEM accuracy (St.dev.)	7~14m	10m
DEM coverage	83 degrees north ~ 83 degrees south	60 degrees north ~ 56 degrees south
Area of missing data	Areas with no ASTER data due to constant cloud cover (supplied by other DEM)	Topographically steep area (due to radar characteristics)

Table 3- Comparison between SRTM and ASTER DEM

Operations involved in DEM generation process by remote sensing techniques (Both the DEMs i.e. ASTER and SRTM DEM)

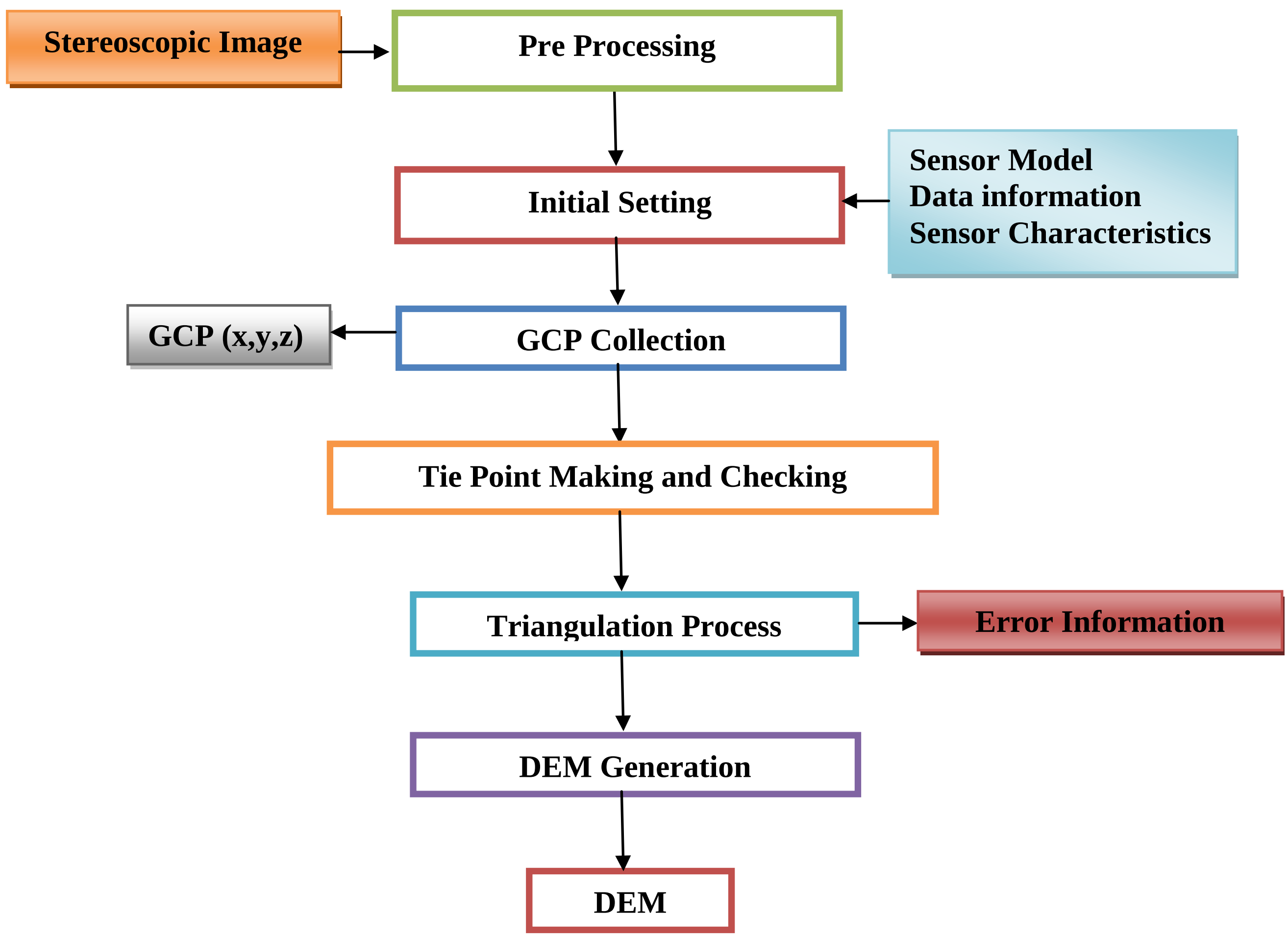
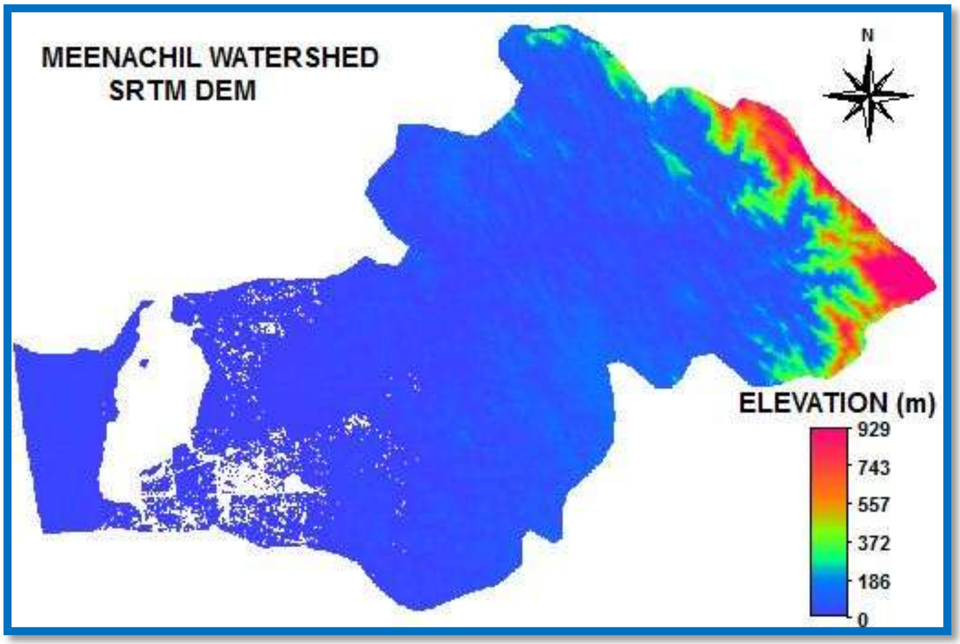
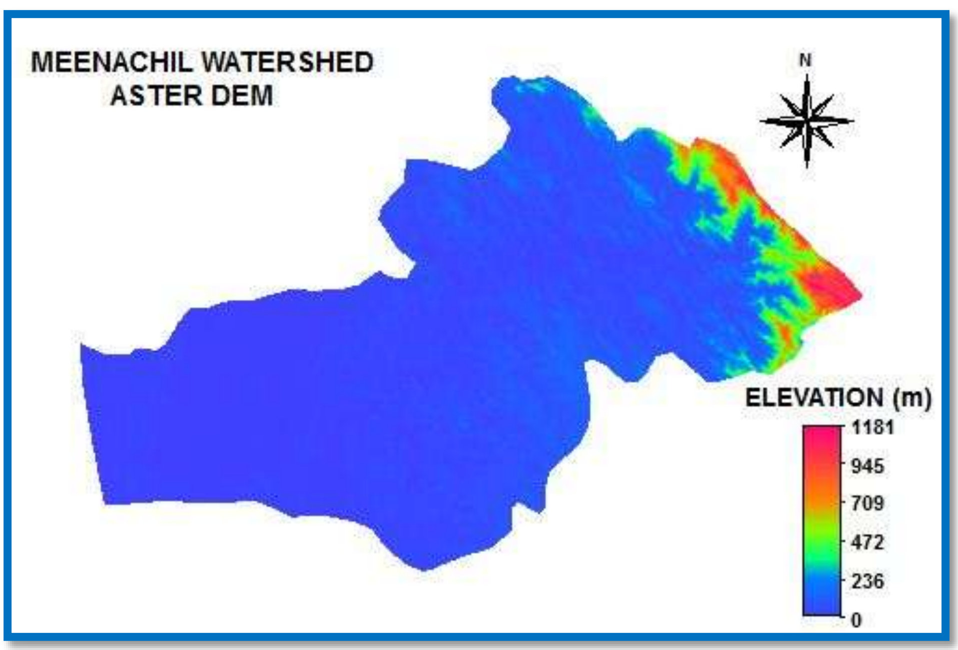


Figure 18 shows flow chart of DEM generation process

4.5.1 DEM generated from two different data sets.

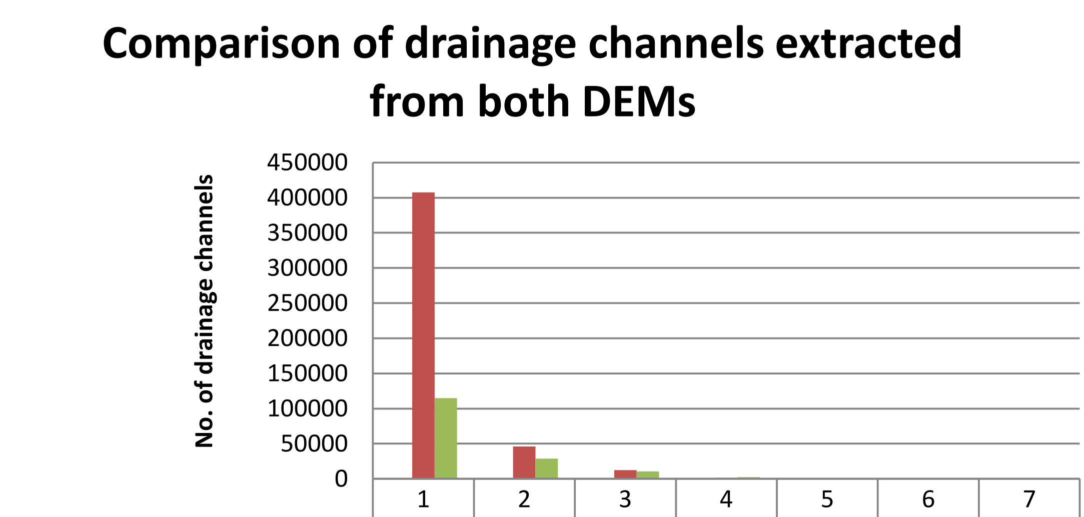


Map 15(a) SRTM DEM of Study Area



Map 15(b) ASTER DEM of Study Area

4.5.2 Comparison of drainage channels extracted from both the DEMs.



Stream Number	1	2	3	4	5	6	
No of Drainage Channel(ASTER DEM)	407719	45876	12569	1418	21	0	
No of Drainage Channel(SRTM DEM)	115007	28923	10750	2253	206	28	

Figure 19 shows the number of drainage channels extracted stream number

SUMMARY AND CONCLUSION

Chapter 5
SUMMARY AND CONCLUSION

Watershed analysis study has been conducted in the Meenachil river basin of Kerala state in India using FOSS GIS tools. The geological location of river basin lies between 9°25'to 9°55' N latitudes and 76°20' to 76°55' E longitudes and it is located in the Alappuzha and Kottayam and along the western boundary of Idukki district of Kerala state and the total area is 1208.11 km^2. The main objective of study to delineate the watershed, extraction of micro watershed using DEM, extraction of drainage network, Generation of L and LS map for use in soil erosion studies and to compare two globally accepted digital elevation models , i.e. SRTM DEM and ASTER DEM.

The elevation of watershed varies from 0 m to 1181 m (ASTER Dataset) and 0 m to 929 m (SRTM Dataset) as revealed by Digital Elevation Model (DEM). Watershed is delineated for both dataset and variance in above objective has been found. The number of subwatershed delineated is 28 in case of SRTM DEM whereas in ASTER DEM no of subwatershed delineated raised to 39. Again microwatershed has been delineated for both dataset and number of microwatershed found as 186 in case of SRTM Dataset and 430 in case of ASTER Dataset.

Drainage extraction has been done in for both the datasets and drainage channels in case of SRTM dataset is found less as compare to ASTER dataset for three different threshold number (1000,500 and 300) due to less spatial resolution. A smaller threshold will result in denser stream network and usually in a greater number of delineated catchment.

L and LS factor map has been generated for further soil erosion studies by using USLE. Due to unavailability of rainfall and soil data, erosion estimation hasn't been done for this study.

Two globally accepted digital elevation dataset has been compared through different DEM Hydro- processing operations by using two well known Free and Open GIS Tools (FOSS) and it is found that SRTM dataset is more accurate than ASTER dataset with less spatial resolution also because it is captured by using active remote sensing where as ASTER data sets are captured by passive remote sensing. SRTM DEM represents the terrain as it is where as in ASTER DEM water bodies are provided with some elevation values. SRTM represents undefined elevation values as voids whereas in ASTER DEM voids are not present.

Watershed analysis using FOSS GIS Tools are most appropriate for watershed analysis without incurring heavy expense on licence fees and free globally accepted data sets require consideration in this context.

Even though Kerala is having 3000 mm. of annual rainfall, it is facing water scarcity in summer; this is due to the peculiar topography and climatic condition of Kerala, which require proper analysis and management of the water resources to tide over the scarcity. Since watershed is the basic unit on which all development activities are based, Watershed analysis is the major element of watershed development plans. This study can be utilized in watershed development plan of study area.

REFERENCES

REFERENCES

Abrams, M. and Hook, S.J. (1995): Simulated ASTER data for geological studies. *IEEE Transactions on Geoscience and Remote Sensing*, 33: 692-699.

Aishwarya,K.P. et.al., (2010). Recommendations to Rejuvenate River Bharathapuzha using GIS and Watershed Simulation Model. B-Tech project report, KCAET Tavanur.

AMES, D. P., MICHAELIS, C. and DUNSFORD, T., 2007, Introducing the MapWindow GIS project. *OSGeo Journal*, **2**, September 2007.
Available at: *http://www.osgeo.org/journal [2011 Sep.15]*.

ASTER Validation Team 2009. ASTER global DEM validation summary report. Published by the ASTER GDEM Validation Team: METI, NASA and USGS in cooperation with NGA and other collaborators. June 2009, 28 pages.
Available at: *https://lpdaac.usgs.gov [2011 Dec. 28]*.

Buyuksalih,G.(2008). DEM Generation and Validation based on Optical Satellite Systems.
Available:http://www.earsel.org/workshops/3D-RS/Paper/Buyuksalih.pdf [2011Dec.15]

CGIAR-CSI 2009. SRTM Data Processing Methodology. *Web document.*
Available at: *http://srtm.csi.cgiar.org/SRTMdataProcessingMethodology.asp [2011 Dec. 28]*.

Daniel, P. Amesa, Eric B. Rafna, Robert Van Kirkb and Benjamin Crosbyc(2009). Estimation of stream channel geometry in Idaho using GIS derived watershed characteristics. 24(3):444-448.

Deshmukh,S.B , V. K. pandey and M.K.Jain.(2007). Integration of GIS with MUSLE in assessment of sediment yield. Indian Journal of Soil Conservation, 35 (1):1-5.

Divya Gopinath, Kripa I V, Pooja P and Shalini M Chandran. (2009). Watershed simulation using GIS Integrated Physically Based Model. B-Tech project report, KCAET Tavanur.

Dr. Ravat M.S.(1994). Water Resource Assessment and Management in Himalayan catchments through Remote Sensing and GIS Technology. Journal of Hydrology, 340(1-2): 261-270.

Garbrecht, J., Ogden, F.L., De Barry, P.A. and Maidment, D.R (2001). GIS and distributed watershed models I: Data coverages and sources. Journal of hydrologic engineering (6):506-513

ILWIS 3.7 help.

Jacobsen, K. 2001: New Developments in Digital Elevation Modeling, *Geoinformatics*, June 2001, pp 18 – 21

Jacobsen K., 2004. Analyses of Digital elevation Models based on Space Information: EARSEL Symposium, Dubrovnik, 2004.

Jacobsen K., 2005. Analysis of SRTM Elevation Models, EARSEL 3D- RS Workshop, Porto, 2005.

Jolma, A., Ames, D.P., Horning, N., Netelar, M., Racicot, A. and Sutton, T., 2006, Free and open source geospatial tools for environmental modelling and management. In *Proceedings of iEMSs 2006*, Burlington, VT, USA.
Available at: *http://www.iemss.org/iemss2006/papers/w13/pp.pdf [2012 Sep. 12]*.

Kioshi Honda, Lal Samarakon, Akichika Ishibashi, Yasushi Mabuchi and Shigechika Miyagima (1994). Remote sensing and GIS technologies for denudation in a Siwalik watershed of Nepal. Journal of water resource and hydrology.

Krzystek, P. (1995): New investigations into the practical performance of automatic DEM generation. *Proceedings, ACSM/ASPRS Annual Convention, Charlotte,* *North Carolina, American Society for Photogrammetry and Remote Sensing*, 2, pp. 488-500.

Murthi, V. V. N (2004). Land and Water Management Engineering. Noida: Kalyani publishers.

Millaresis, G.C. and Argialas, D.P. (2000): Extraction and delineation of alluvial fans from digital elevation models and Landsat Thematic Mapper images. *Photogrammetric Engineering and Remote Sensing*, 66: 1093-1101.

Nikolakopoulos K.G., Kamaratakis E.K., Chrysoulakis N. 2006. SRTM vs ASTER elevation products. Comparison for two regions in Crete, Greece. *International Journal of Remote Sensing* **27**(21), 4819–4838

Panda, S. K., & Sukumar, B. (2010). Delineation of Areas for Water Conservation in Peruvamba River basin using Remote Sensing and gis. *International Journal of Geomatics and Geosciences* , 76-83.

Rajashree, V. B., (1997). *Delineation of eco watersheds by integration of remote sensing and gis techniques for management of water and land resources.* Jodhpur: Regional remote sensing service centre. Jodhpur: Regional remote sensing service centre.

Sefercik U., Jacobsen K., 2006. *Analysis of SRTM Height Models*, Turkish-German Geodetic Days, Berlin 2006.

Sefercik U.G, 2006. *Accuracy Assessment of Digital Elevation Models Derived From Shuttle Radar Topography Mission (SRTM),* Master Thesis, Leibniz University of Hannover, Germany, 2006.

Sefercik, U. et.al, (2007). Comparison of SPOT, SRTM and ASTER DEMs. *Available:http://www.ipi.unihannover.de/uploads/tx_tkpublikationen/Sefercik_jac_oruc_maramgoz.pdf [2011 Nov. 11]*

Selvi, M. S. , Shialendra Kumar, Darshan Singh, Yadav, A. K. Munish Kumar,Saha, S. K.Lagathe. Sharma, R. K. Meena, R. L.Das, S. N (2007). Digital micro watershed atlas- A tool for watershed development planning. Journal of soil water conservation vol.7:39-43.

Sharma,A.K, Navalgund, R.R, Pandey, A.K and Rao,K.K(2001). Micro-watershed development plans using Remote Sensing and GIS for a part of Shetrunji river basin, Gujarat.

Singh, R. V. (2000). *watershed planning and management.* Bikaner: Yash publishing house.

Teeter,L.D, B. G. Lockaby and K. M. Flynn(2000). The use of remote sensing and GIS in watershed level analyses of non-point source pollution problems. Forest Ecology and Management.128 (1-2):65-73

Topan,H. et. al. (2006) Information Contents of High Resolution Satellite Images. Available:http://www.earsel.org/workshops/3D-RS/Paper/Topan.pdf[2011 Dec.15]

Welch, R., Jordan, T., Lang, H. and Murakami, H. (1998): ASTER as a source for topographic data in the late 1990's. *IEEE Transactions on Geoscience and Remote Sensing*, 36: 1282-1289.

ANALYSIS OF MEENACHIL WATERSHED USING FOSS GIS TOOLS

By

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SUMIT KUMAR JHA

PROJECT REPORT

Submitted in partial fulfilment of the requirement for the degree

Bachelor of Technology
In
Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Land and Water Resources and Conservation Engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR - 679 573, MALAPPURAM

KERALA, INDIA

2012

ABSTRACT

The 78 kilometre long Meenachil River is the holy river in Kottayam district is the lifeline of several millions of people in the state, but now facing tremendous pressure due to encroachments, sand and clay mining and illegal diversions of water. River is facing Water pollution due to disposal of urban and domestic waste into the river all through the banks of the river especially at urban centres like Erattupetta, Palai, Ettumanoor and Kottayam which is affecting the entire watershed in many different ways. Our study focusing on the watershed analysis of the Meenachil watershed using FOSS GIS tools with freely available remote sensing data. Watershed is an ideal unit for carrying out scientific resource management for ensuring continuous benefits on sustainable basis. GIS has become a useful and important tool for scientific study and management of water resources. Data required for analysis require money and time for its collection. Hence data derived using remote sensing are usually used. However most of the commercial GIS packages are very expensive. Use of FOSS (Free and Open Source Software) GIS tools makes watershed analysis possible without incurring heavy expense on licence fees. In this study watershed has been delineated and drainage network has been extracted by using two globally accepted digital elevation data models. So use of FOSS–GIS tools and free globally accepted data sets require consideration in this context. Based on entire analysis and accuracy of results FOSS-GIS tools and freely available remote sensing data are recommended for watershed analysis.