PRIORITIZATION OF SUB-WATERSHEDS OF SHIPRA BASIN BASED ON LINER AND SHAPE PARAMETER USING ArcGIS

A PROJECT REPORT

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CANDIDATE'S DECLARATION

I, YOGESH. 2K14/HFE/18 student of M.Tech (Hydraulics And Water Resource Engineering), hereby declare that the project dissertation titled "PRIORITIZATION OF SUB-WATERSHEDS OF SHIPRA BASIN BASED ON LINER AND SHAPE PARAMETER USING ArcGIS" which is submitted by me to the Department of Civil Engineering , Delhi Technological University Delhi, in partial fulfillment of the requirement for the award of the degree of Master of Technology , is original and not copied from any other source without proper citation. This work has been previously formed the basis for the award of any degree, diploma,association, fellowship or other similar title or recognition.

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Date: 30 November 2018

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CERTIFICATE

I hereby certify that the project dissertation titled "**PRIORITIZATION OF SUB-WATERSHEDS OF SHIPRA BASIN BASED ON LINER AND SHAPE PARAMETER USING ArcGIS"** which is submitted by Yogesh, Roll No 2k14/HFE department of civil engineering , Delhi Technological University, Delhi, in partial fulfillment of the requirement for the award of the degree of Master of Technology, is a record of project work carried out by student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any degree or diploma to this university or elsewhere.

Place: Delhi (**DR. S. ANBUKUMAR)**

Date: 30 November 2018 **SUPERVISIOR**

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The quantitative analysis of morphometric parameters is found to be of immense utility in watershed prioritization for soil and water conservation and natural resources management at micro level. The present work is an attempt to carry out a detailed study of linear and shape morphometric parameters in twenty-five sub-watersheds of Shipra Basin and their prioritization for soil and water resource management. Shipra watershed has an area of 1075 km^2 and lies between latitudes 22°27'29'' to 23°56'40''N and longitudes 75°25'04'' to 76°13'19''E. Quantitative description of basin geometry i.e. morphometric analysis was done to find out the drainage characteristics of Shipra River basin located in Madhya Pradesh of Central India using SRTM imageries and GIS techniques. Following Strahler's stream ordering scheme, it has been found that in Shipra Catchment the total number of streams is 7069 belonging to different stream orders with the highest order of 6. The prioritization was carried out by assigning ranks to the individual indicators and a compound value (Cp) was calculated. Watersheds with highest Cp were of low priority while those with lowest Cp were of high priority. Thus an index of high, medium and low priority was produced. The highest priority zone consists of seven watersheds, medium of eleven and low of seven watersheds. High priority indicates that these watersheds are susceptible to greater degree of erosion and application of soil conservation measures becomes inevitable to preserve the land from further erosion and to alleviate natural hazards.

Keywords: Morphometric analysis, Soil erosion susceptibility, Prioritization, GIS.

CHAPTER 1

INTRODUCTION

1.1 General

The essential components of stream water environments functioning at the watershed scale are geology, relief & climate. Water is one of the main natural resource without which the possibility of life doesn’t exist. But the water requirement increases as world population is increases day by day. As a result, it becomes important to keep a check on conservation of water in proficient way. Watershed is a fundamental unit for the proper management of natural assets. Management of watershed also helps in achieving economic and long lasting development of land and water assets. Physiography of surface, seepage design, geomorphology of streams, soil attributes, land use pattern of basin region and accessible water assets so forth are essential factors in development of watershed. For setting a comprehensive watershed improvement plan, it is important to comprehend the topography, soil erosion and seepage pattern of the basin. Remote sensing and GIS are technological tools for setting up an arrangement for watershed advancement. Many studies have been carried out in past few years and they have demonstrated great outcome. Watershed management likewise facilitates in prioritization of sub-catchments by giving the rank to singular sub watershed as indicated by its soil degradation status. Morphometric investigation could be utilized for prioritization of sub-watersheds by concentrate distinctive direct and shape parameters of the watershed even without the accessibility of soil maps. "Morphometric examination is alludes as the quantitative assessment of frame attributes of the earth surface and any landform unit". In this examination work Shipra watershed is utilized as remote investigation site.

1.2 Watershed

V.T Chow explained about watershed in his book “Handbook of Applied Hydrology” that the term 'watershed' is characterized as a normally existing geo-hydrological unit discharging to a typical point by an arrangement of common stream or drains. A Watershed involves a basin zone i.e. recharge region, a concerned region and a discharge region. Subsequently watershed is the region encompassing the basin, command and delta region of a stream. The highest land portion of the watershed is known as the water divide or ridge and a locus of line joining the ridge points along the limit of the watershed is known as a "water divide line". A watershed is subsequently an applied unit for arranging ideal advancement of its dirt, water and vegetation assets. Administration of a watershed to soil use and water expects land to be "utilized inside its capacities and treated by its needs"

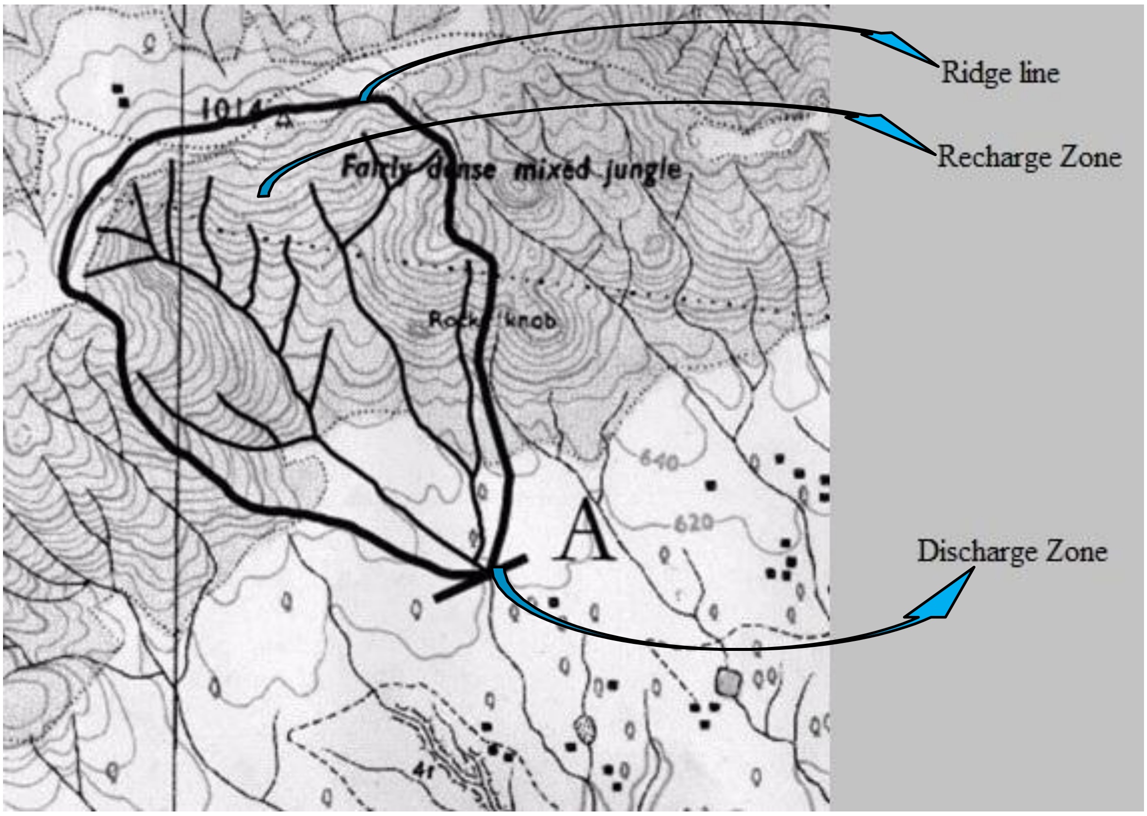

Figure 1.1 Watershed (Source: BACPE, 2007)

The terms, for example, watershed, catchment, basin and so forth are broadly used to indicate hydrological units. The Size of a catchment is represented by the measuring number of stream involved by it, which is of reasonable significance in watershed improvement projects. For instance, the size of a particular irrigation based hydel power project has its basin area up to few thousand of square kilometers, on the contrary, the size of a household pond used for local irrigation and other purposes may have size of few hectares. In deserts and level territories with minimal nascent seepage, it might be hard to portray little estimated watersheds while in undulating and uneven landscapes littler measured watersheds could be more effortlessly delineated. Consequently the areal degree of basins change generally relying on the geography, atmosphere, general ecosystem, inclination, structure, land use pattern and so on.

Watersheds would be categorized on different parameters, for example, shape and size of the basin, discharge of the basin, land cover and land use pattern. The classification could likewise be founded on the course of the stream or waterway, the purpose of interference of the stream or the waterway and the drainage density and its pattern in particular area. All

India Soil and Land Use Survey in 1990 have built up a framework for precisely representing the watershed like catchment boundary, basin and sub-basins, water resources area. National remote sensing agency has additionally grouped watershed into various sub watershed (30-50 km^2), smaller than usual mini-watershed (10-30 km^2) and miniaturized scale micro-watershed (5-10 km^2)

1.3 Watershed Management

Watershed administration is an all encompassing methodology which characterizes between connections between land utilization, soil erosion and water resources. Soil and water protection are the most important issues in watershed administration which has been managed by different specialists as far as administrations of land and water assets. Watershed administration has gained huge significance in the ongoing past and includes advancement and preservation of natural assets with dynamic interest of the neighborhood individuals. It has risen as another worldview for arranging, advancement and administration of land, water and biomass assets with an emphasis on social and ecological perspectives following a participatory methodology. Watershed administration could maybe be all the more precisely characterized as asset administration with watershed as the fundamental sorting out unit. It includes wise utilization of regular asset with dynamic support of foundations, associations and nearby individuals in congruity with the environment. Neighborhood Landowners Environmental pros, arrive utilize offices, storm water administration specialists, water utilize surveyors and networks all have a vital impact in the administration of a watershed. Watershed administration is a key component in making and executing designs, projects, and undertakings to support and helps in improving watershed works that influence the plant, creature, and human networks inside a basin limit. Its point is to assist and improve watershed works that give the merchandise, administrations and qualities wanted by the network influenced by conditions inside a watershed limit.

1.4 Remote Sensing and GIS Studies in Watershed Management

Remote detecting and Geographic Information System (GIS) is broadly utilized in watershed administration, which includes mapping of shifted arrive shapes and forms, soil erosion, drainage characteristics, linear and shape feature, basic components, and landscape attributes. Administration of expansive region watershed is exceptionally troublesome when done on the field. Remote detecting and GIS is extremely reasonable alternative to do administration of a vast watershed without going nearby. A few examinations have been completed for watershed administration in different parts of world and furthermore India. These all examinations demonstrate the significances of remote detecting and GIS in watershed administration. The aftereffect of these examinations likewise confirms the on location estimations and forecast of soil disintegration tempted area.

Names of few researchers and year of their study are: (Zahoor-ul-Hassan *et al*. in 2012; Ramu *et al*. in 2013; Nageswara Rao.K *et al*. in 2010; Scott D. Bryant in 2010; Preeti C. Solanke, Rajeev Srivastava *et al.* in 2005; P T Aravinda *et al*. in 2009; Raju and Nagesh Kumar in 2012; V. B. Rekha in 2012; Yassir Arafat M.N., in 2010; Kuldeep Pareta *et al.* in 2011.

1.5 Objectives of the thesis:

The objectives of analysis –

1. Division of Large watershed into small watersheds.
2. Study of linear and shape parameters for different sub watersheds.
3. Morphological analysis of sub watersheds.
4. Prioritization of sub-watersheds.

1.6 Overview of Thesis

This dissertation comprises of six chapters. Chapter 1 is Introduction, which gives general introduction of the subject followed by objectives of the analysis and basic layout of the dissertation. Chapter 2 titled Literature Review summarizes literature regarding the geo-morphological analysis, erosion study with the assistance of remote sensing and GIS technology. Chapter 3 of my report is about Study Area and Data used. Chapter 4 contains Methodology in which procedure adopted for processing the data for the study carried out is elaborated. Chapter 5 is Results and Discussions. This chapter includes discussion of the detailed results based on the methodology underlined in Chapter 4 and Conclusions of the study are given in chapter 6.

CHAPTER 2

LITERATURE REVIEW

Zahoor-ul-Hassan *et al.* in 2012 did morphometric examination and prioritization of watersheds for soil conservation and water asset management in Wular watershed utilizing geo-spatial techniques. Their examination has been separated into three segments, the primary segment manages validity of Horton's laws of stream numbers and stream lengths in the investigation region. The second area manages the different straight and shape morphometric physical terms and the prioritization of sub basins is done in next segment based on linear parameters and shape morphometric parameters. They inferred that watershed prioritization is a standout amongst the most critical parts of making arrangements for execution of its improvement and the board programs. The investigation shows the value of GIS for morphometric investigation and prioritization of the watersheds of Wular watershed. The morphometric qualities of various watersheds demonstrate their relative attributes regarding hydrologic reaction of the watershed.

Ramu *et al.* in July 2013 did Morphometric Analysis of Tungabhadra Drainage catchment in Karnataka utilizing Geographical information System. Their examination depends on the SRTM information. The Shuttle Radar Topographic Mission information has been downloaded from Global Land Cover Facility site. The ArcGIS programming has been utilized to break down the stream request of watershed. It also included the setting up of contour map from the downloaded topographic rise information. The investigation of morphometric examination of Tungabhadra utilizing, Geographical Information System was push found to the specialists in investigation of the watershed effectively and precisely.

Nageswara Rao.K *et al.* in 2010 has done Morphometric Analysis of Gostani stream catchment in Andhra Pradesh region, India Using Spatial Information innovation. Six SOI toposheets on 1:50000 surveying scale in paper arrange were utilized. The advanced information organize from Indian Remote detecting Satellite (IRS 1D) of LISS III with 23.5

m spatial goals with four otherworldly grounds i.e. B2: 0.520.59 (Green), B3:0.620.68 (Red), B4:0.770.86 (Near infrared), B5:1.551.70 (Short wave infrared) was utilized to meet the prerequisite of zone under investigation. They reasoned that the quantitative investigation of morphometric parameters is observed to be of massive utility in waterway bowl assessment, watershed prioritization for soil and water preservation, and common assets the board at small scale level. The morphometric investigation did in the lower Gostani stream bowl demonstrates that the bowl is having low alleviation of the landscape and prolonged in shape. Waste system of the bowl shows as primarily dendritic sort which demonstrates the homogeneity in surface and absence of auxiliary control.

Scott D. Bryant PE describe GIS techniques for proactive urban watershed the board in his paper which gives a review of the City's Storm Water Management Program with an emphasis on a joining of intuitive hydrologic, pressure driven, and water quality models with a powerful GIS database to make an instrument that gives a sound specialized premise to educated watershed-based administration and rebuilding choices by neighborhood authorities. A fundamental part of the City's program incorporates on-going partner and network contribution as staff endeavor to offset science and designing with nearby qualities identified with regular assets and urban watershed the executives. When lawful necessities are fulfilled for assigned water assets, network esteems give an extreme proportion of accomplishment for nearby precipitation water and watershed the executives programs.

Preeti C. Solanke, Rajeev Srivastava *et al*. (2005) in their research clarify the use of remote sensing and GIS in watershed portrayal and the board. This paper examines the use of high goals IRS-IC Pan combined LISS III information and GIS in portrayal of land assets and to get ready maps of land irrigability, cotton appropriateness and move plan for making suitable soil preservation and the executives measures for ideal usage of the assets in Ganeshpur small scale catchment in Nagpur, Maharashtra

P.T. Aravinda *et al.* have done morphometric investigation of Vrishabhavathi watershed utilizing remote detecting and GIS. Vrishabhavathi watershed is a constituent of Arkavathi waterway bowl, some piece of which lies between Bangalore urban territory and Ramanagara region. The advanced rise show (DEM) of the investigation region is created utilizing ArcGIS programming. This aides in illustration the correct limit line of the investigation region. The base guide is readied utilizing SOI toposheet number 57H/5, 57H/6, 57H/9 and 57G/12 on 1:50,000 scale. The topomaps are examined and anticipated for outlining the required highlights. The digitized maps are refreshed with the assistance of satellite symbolism utilizing QGIS and ArcGIS programming. It comprises of different highlights like the street organize, settlements, water bodies, Vrishabhavathi River, waterways and so forth. Morphometric investigation for the examination is gathered into three classes, for example, direct angles, areal perspectives and help viewpoints. The morphometric examination results in Dimensionless parameters for the watershed. This contrasts the watershed and the neighboring watersheds and to settle on choice for developing pressure driven structures to battle disintegration.

Raju and Nagesh Kumar in 2012 have done Prioritization of small scale catchments in the Kherthal catchment in Rajasthan dependent on morphology. They considered an arrangement of seven geomorphologic parameters to organize the small scale catchments in the Kherthal watershed for the watershed preservation and the executives rehearses. Morphologic parameters considered are Drainage thickness (Dd), Bifurcation proportion (Rb), Stream recurrence (Fu), Texture proportion (T), Form factor (Rf), Elongation proportion (Re), Circulatory proportion (Rc). These morphologic parameters were ascertained for all the miniaturized scale catchments by utilizing IRS LISS-III pictures and Survey of India topographic sheets of 1:50,000 scale. From the investigation, examination of the geomorphologic parameters was observed to be extremely successful in surveying the geo-morphological and hydrological attributes of the small scale basins.

V. B. Rekha in 2012 carried out Morphometric investigation and Micro-watershed Prioritization of Peruvanthanam sub-catchments, the Manimala River catchment, in Kerala, south India. She computed various the linear paramter and shape parameters and inferred that seepage morphometry of a sub-watershed reflects hydro-geologic development of that stream. Satellite remote detecting has the capacity of acquiring the synoptic perspective of a region at one time, which is extremely valuable in studying the seepage morphometry.

Yassir Arafat M.N., in 2010 h has done Basin Management for Asifabad and Wankadi Taluks, Adilabad area utilizing GIS technology. The targets of the examination were to think about the accessible water assets and assess the regular assets utilizing remote detecting information for the extraction of plausibility condition for its improvement, to consider the geology by translating RADAR information and extricating layers which can be utilized for the present investigation i.e. slant, DEM for 3D investigation and so on., to delineate the topical data by translating the satellite symbolisms and furthermore from SOI toposheets, GSI

Maps for the creation of topical maps through Arc/Info programming. The topical data incorporates Land utilize/Land cover charaterstics, Hydro Geomorphology, Drainage organize, Lineaments, Soil, Geology, highway. This topical data was utilized to set up the activity plan maps i.e. arrive assets advancement and water asset improvement by incorporating the data acquired from the investigation. Programming utilized in this investigation were ERDAS 9.1, ArcInfo 9.2, MS Office Package. Information Used LISS III Multispectral Data, SRTM RADAR Data, SOI toposheets, GSI Maps.

Kuldeep Pareta *et al*. in 2011 carrid out quantitative morphometric investigation of a watershed of Yamuna bowl, India utilizing ASTER (DEM) information and GIS. They have examined the nitty gritty morphometric qualities of Karawan watershed in Dhasan bowl, which itself is a piece of the mega Yamuna bowl in Sagar locale, Madhya Pradesh. For nitty gritty examination, they utilized ASTER information for planning computerized height show (DEM). Land data framework (GIS) was utilized in assessment of direct, areal and alleviation parts of morphometric parameters. Watershed limit, stream collection, stream heading, stream length, stream requesting have been readied utilizing ArcHydro Tool; and shape, incline angle, slope shade have been readied utilizing Surface Tool in ArcGIS-10 programming, and ASTER (DEM). Diverse topical maps i.e. drainage thickness, slant, radial relief, superimposed profile, and longitudinal profiles have been set up by utilizing ArcGIS programming. They figured more than 85 morphometric parameter everything being equal. In light of all morphometric parameters examination; that the erosional improvement of the zone by the streams has advanced well past development and that lithology has had an impact in the waste advancement. This examination was exceptionally helpful for arranging water reaping and catchment management.

CHAPTER 3

STUDY AREA AND DATA USED

3.1 Study Area of project

The study area is a watershed near river Shipra. This area collects water from different natural sources and the drainage is common for this area to river Shipra, i.e. this is a watershed of river Shipra. This area is named as Shipra watershed in this study work. The Shipra River initiate from the Vindhya Range and streams in a northerly course over the Malwa tableland to converge in the Chambal River. Study region has a catchment region of 1075 km2 and lies between scopes 22°27'29'' to 23°56'40''N and longitudes 75°25'04'' to 76°13'19''E. The mean reduce level of the catchment is around 500 meter above mean seal level. The atmosphere of the concerned zone is semi-arid and gets a normal yearly precipitation of around 1400 mm. About 90% of yearly precipitation of Shipra catchment happens amid the southwest and upper east storm season spreading over June to December. The normal most extreme and least month to month temperatures of the bowl are 37° and 24°C, separately. The soil of the region are dark, black and gravelly in nature. Figure 2.1 beneath demonstrates the area guide of the examination zone. In Figure 2.1 there are two pictures- image (a) and image(b). Picture (a) demonstrating the Google outline of India. Picture (b) demonstrating the Google delineate of the investigation region.

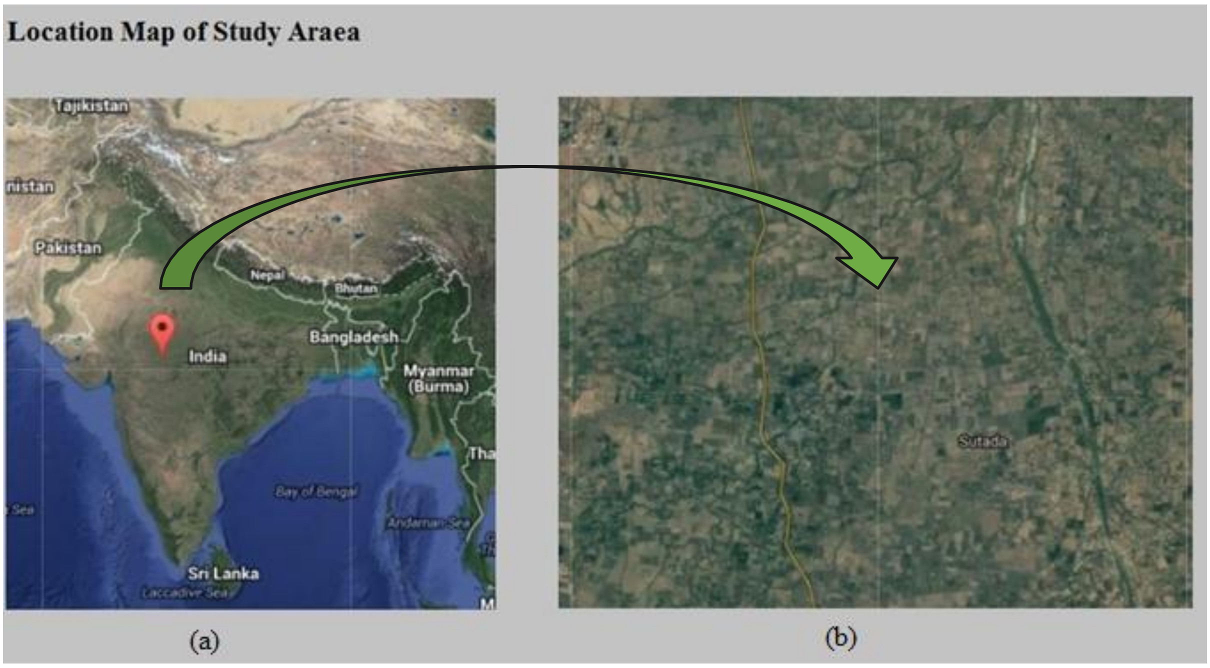

Figure 2.1 location map of study area.

3.2 Data Used:

The following sets of data have been used for the study:

Table2.1. Satellite dada used for study

DATA SATELLITES	SOURCE	RESOLUTION	YEAR	LAT. /LONG.
SRTM Void Filled	http://earthexplorer.usgs.gov/	90m	2016	Lat.-2°27'29'' to 23°56'40''N Long.-75°25'04'' to 76°13'19''E
ASTER Global DEM	http://earthexplorer.usgs.gov/	30m	2011	Lat.-2°27'29'' to 23°56'40''N Long.-75°25'04'' to 76°13'19''E
LANDSET ETM+	http://earthexplorer.usgs.gov/	30m	2015	Lat.-2°27'29'' to 23°56'40''N Long.-75°25'04'' to 76°13'19''E

Figure 2.2 shows the Shuttle Radar Topography Mission (SRTM) data of 90m resolution was extracted from the website link http://earthexplorer.usgs.gov/for generating Digital Elevation Model(DEM)

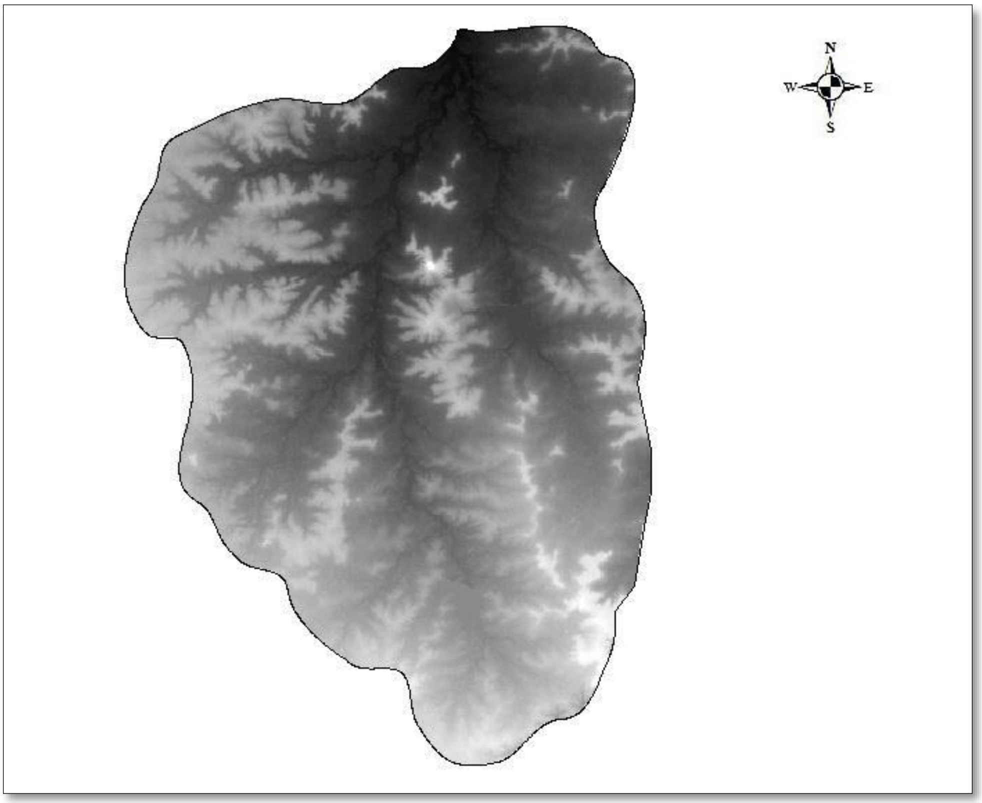

Figure 2.2 SRTM Image of study area

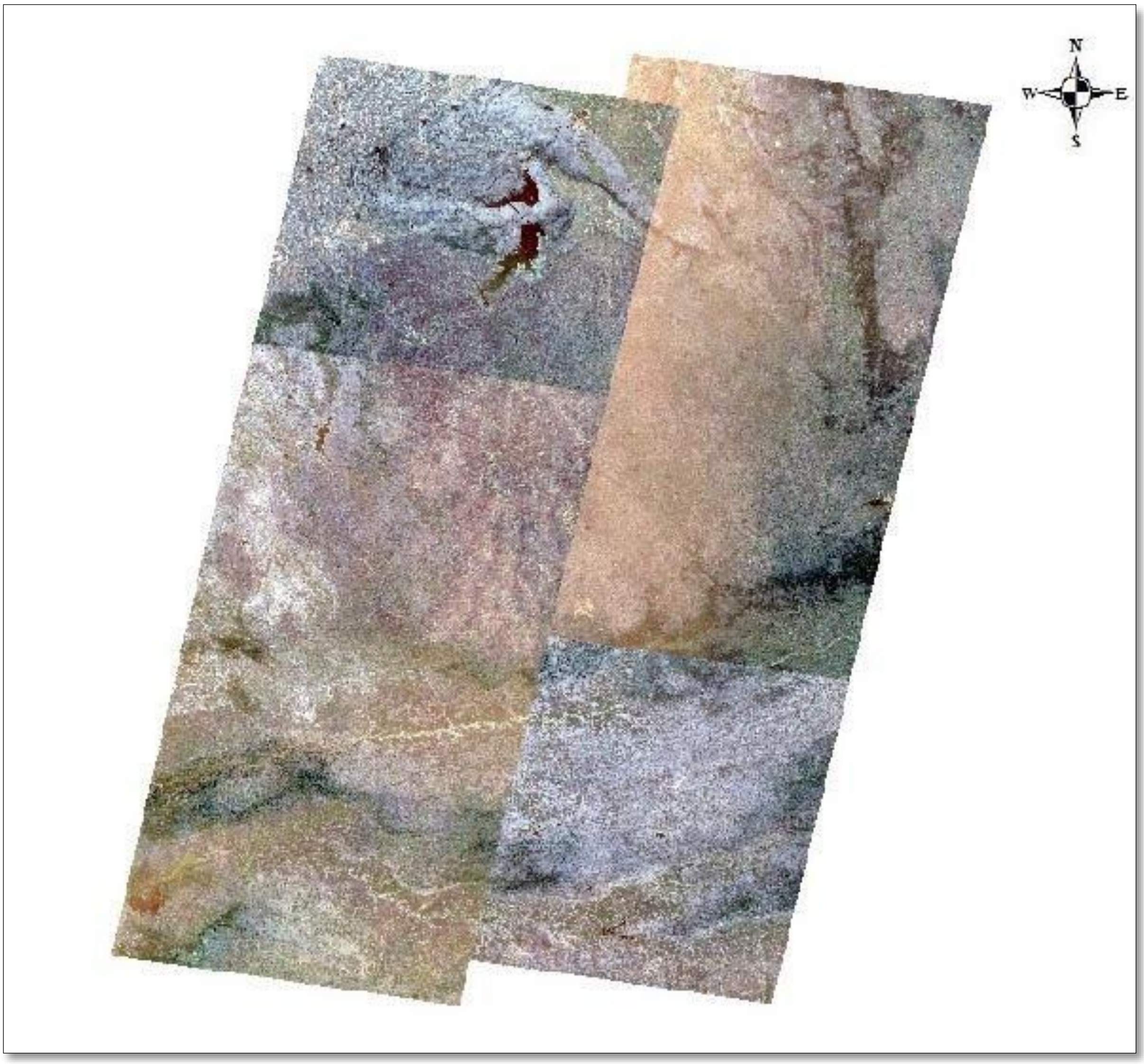

Figure 2.3 LandsatETM+ image of the whole study area bounded by Lat.- 22°27'29'' to 23°56'40''N and Long.- 75°25'04'' to 76°13'19''E

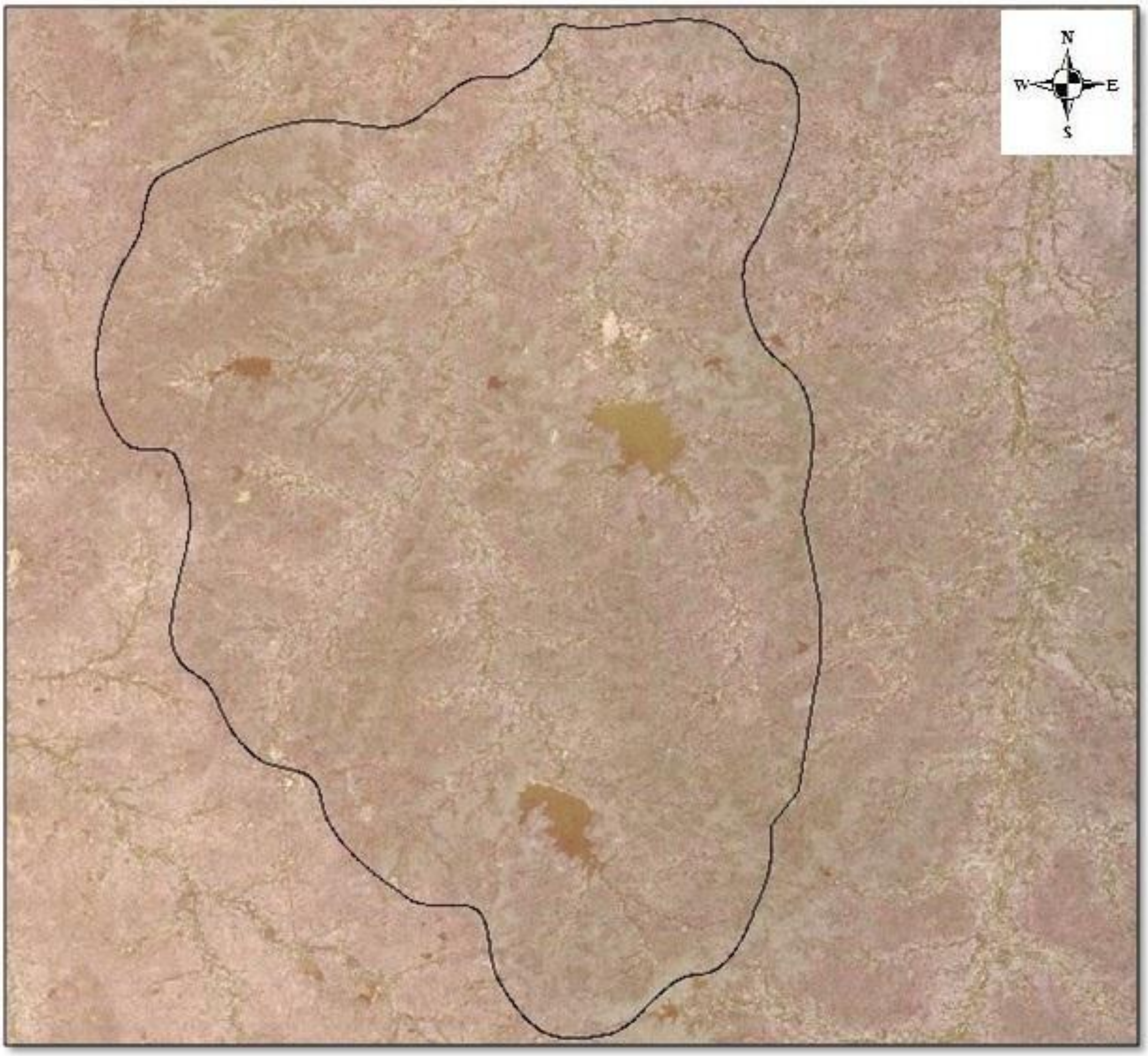

figure 2.4 LandsatETM+ image of the area selected for study work bounded by Lat.- 22°27'29'' to 23°56'40''N and Long.- 75°25'04'' to 76°13'19''E

Figure 2.4 shows only the area selected for study, Figure 2.3 shows the image of area which includes study area also. Fig. 2.3 is the mosaic image of downloaded data.

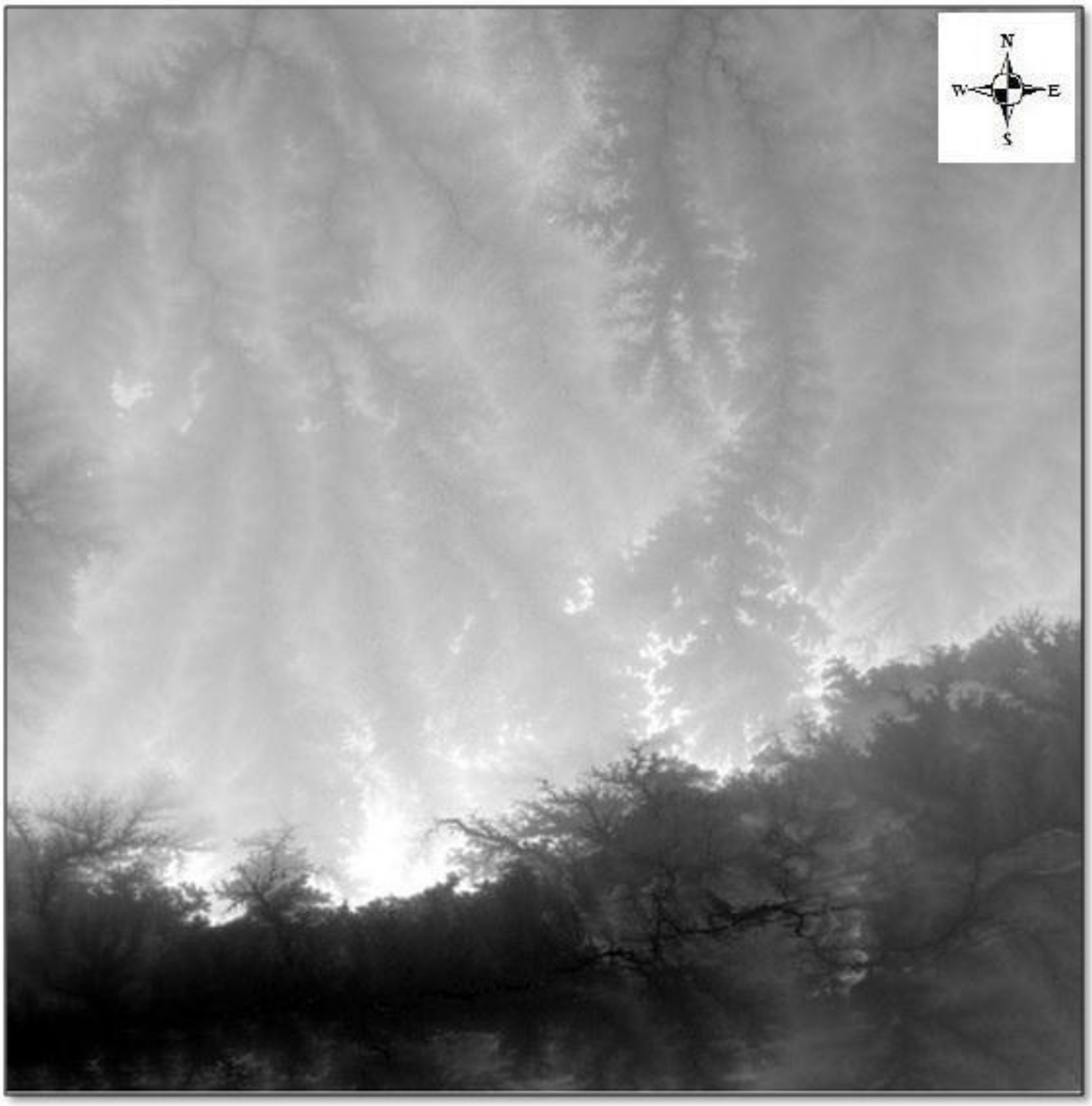

Figure 2.5 ASTER global DEM image of the study area bounded by Lat.- 22°27'29'' to 23°56'40''N and Long.- 75°25'04'' to 76°13'19''E

3.3 Data Characteristics:

3.3.1 SRTM Data: In USGS SRTM information, the landscape elevation information have been altered to depict water bodies that meet least capture limit. Sea, lake and waterway shorelines were distinguished and portrayed. Lake elevations were arranged at a steady value. Sea elevations were arranged at zero value. Waterways were ventured down monotonically to keep up appropriate stream. Subsequently this information is more appropriate to manage streams, watershed and water bodies related research work.

3.3.2 ASTER GDEM Data: ASTER is a progressed optical sensor involved 14 spectral channels running from the visible to thermal infrared range. It will offer logical and furthermore practical information with respect to different fields identified with the investigation of the earth. It is likewise useful for concentrate for water bodies qualities and examining morphometric examination of regions.

3.3.3 LANDSAT ETM+ data:

The Landsat provides a valuale set of collective information about the Earth's land surface. Major characteristics of variety to the land surface of the planet can be detected, measured, and analysed using Landsat data. The information obtainable from the historical and current Landsat data plays a key role in studying changes in the surfaces with passage of time. Therefore LANDSAT data does not play very significant role in studying morphological behaviour of water bodies but it plays a vital role in studying shifting of rivers or changes occurring due to hazards *etc.*

CHAPTER 4

METHODOLOGY

To accomplish the objectives of the present study, the methodology is broadly divided in three steps as given below and explained in Fig 4.1.

a.) Visual interpretation of satellite data

b.) Stream profile analysis

c.)Sub-watersheds analysis

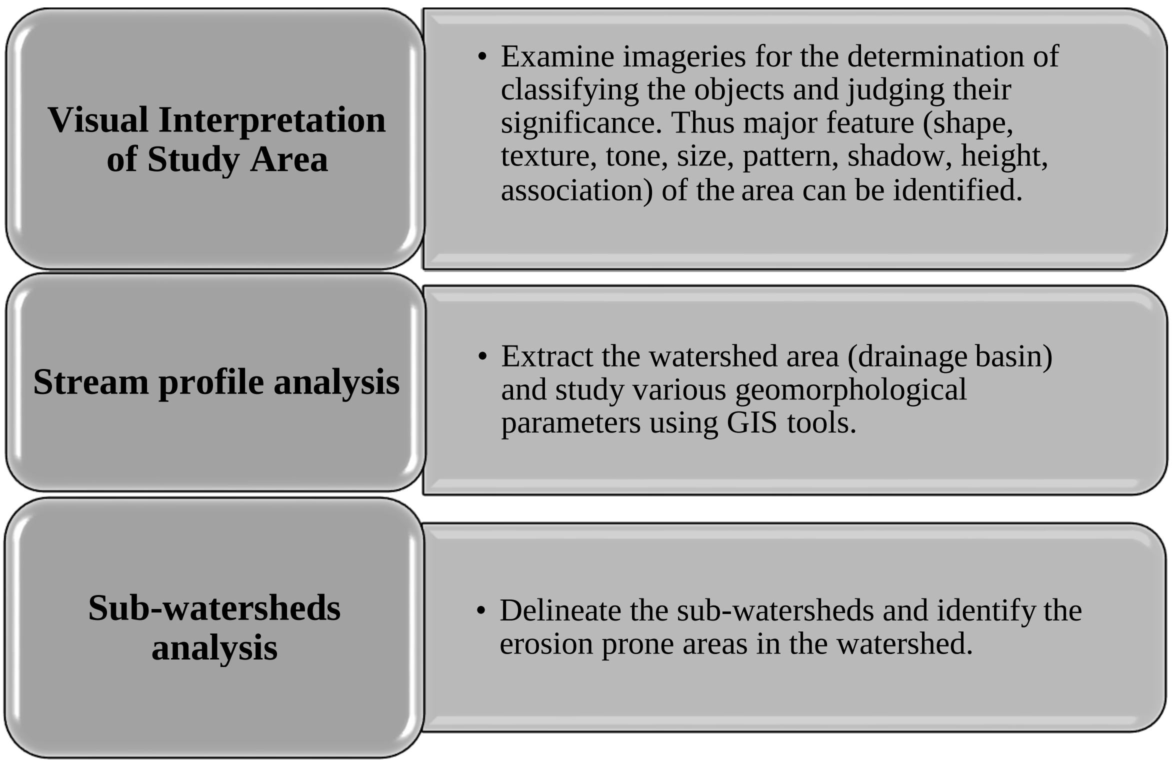

Fig. 4.1 Steps of methodology

4.1 Visual Interpretation of Study Area

Through visual interpretation, an object or phenomenon of an image can be analysed with the help of elements of photo-interpretation as explained in Fig 4.2

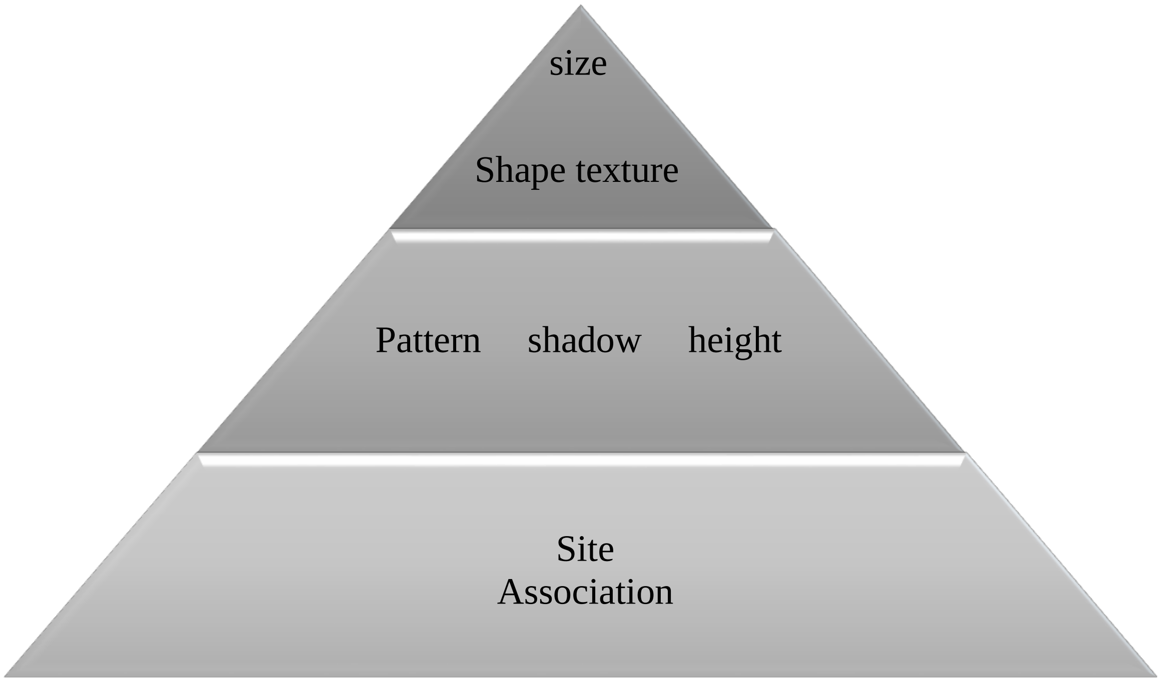

Fig 4.2 Order of implementation of element of photo-interpretation

Tone/Colour: The darker a target demonstrates the less light it reflects.

Size: The actual size of a target is one of the primary distinctive qualities and a standout amongst the most imperative components of elucidation. Most regularly, measurements, for example, length, width and edge are estimated. For doing this effectively, it is critical to know the size of the photograph. Estimating the size of a the target enables the interpreter to preclude different conceivable choices. It has ended up being especially useful to gauge the extent of understood articles to give an equality to the obscure target.

Shape: There are a vast number of exceptionally molded normal and man-made protests on the planet. for example, A couple of models of shape are the triangular state of fly flying machine and the state of a typical school building.

Texture: This is characterized as the "characteristic position and arrangement of reiterations of shading or tone in a picture." Adjectives frequently used to portray surface are smooth (uniform, homogeneous), middle of the road and harsh (coarse, heterogeneous). It is essential to bring up that texture is a result of scale.

Pattern: Pattern is kind of spatial arrangement of articles in the scene. The items might be organized methodically or unsystematically**.**

Height: Height and depth, otherwise called reduce level or elevation is a standout amongst the most essential indicative components of any image interperatation. This is on the grounds that any question, for example, a building or tower that ascents over the neighborhood scene will demonstrate some sort of radial relief. Likewise, objects that display this kind of radial relief will have a shadow that can likewise outfit vital data related to its elevation and height.

Shadow: Virtually all remotely detected information is gathered inside 2 hours of sun powered twelve to evade largely expanded shadows in the picture or photograph. This is on the grounds that shadows can obscure different articles that could have some way or another be distinguished. Then again, the shadow thrown by a target might be important information to the identification of an another article.

Site Association: Site has different physical qualities which may incorporate slope, land cover pattern like water body, soil surfaces, vegetation and grass. Site can likewise have financial qualities, for example, the estimation of specific land, the closeness to the principle roadway or the closeness to the water body like river or canal. Situation alludes to how the articles in the photograph or picture are arranged and sorted out in regard to one another. Association alludes to the way that when you locate a specific action inside a photograph or picture, you more often than not experience related or "related" highlights or exercises. Site, circumstance, and affiliation are only sometimes utilized autonomous of one another while breaking down a image**.**

4.2 Stream Profile Analysis:

SRTM DEM (Digital elevation model) of Shipra watershed for year 2016 obtained by USGS website http://earthexplorer.usgs.gov/.in is not projected on global XY coordinate system. So firstly the DEM procured were projected to WGS 1984 World Mercator, using Project Raster under data management in Arc Map 10. A mosaic of DEM has been prepared to cover the study region. The investigation area was extracted from the mosaic image file.

In order to escape depressions, the DEM was further conditioned to remove the pits and flat areas. From the corrected DEM, flow direction & flow accumulations are produced. With stream course outline, stream accumulations frameworks have been created as controlled by collecting the weight for all cells that stream into every downslope cell dependent on the stream bearing. The intersection point of two streams is taken as a pour point. *i.e.* outlet point and the stream profile is generated. The resulting drainage basin is used to compute stream order, no. of segment, basin area, perimeter, length needed for computation of geomorphological parameters like bifurcation ratio, form factor, elongation ratio, circulatory ratio and so on.

After this the complete basin is further classified into sub-watersheds using the location of the pour points. Area, perimeter, length, stream order and geomorphological parameters like bifurcation ratio, form factor, elongation ratio, circulatory ratio and so on are calculated from the maps made from the extracted Shipra watershed region and processed images. The flow chart of the process of stream profile analysis is shown in stream profile block of Fig 4.3.

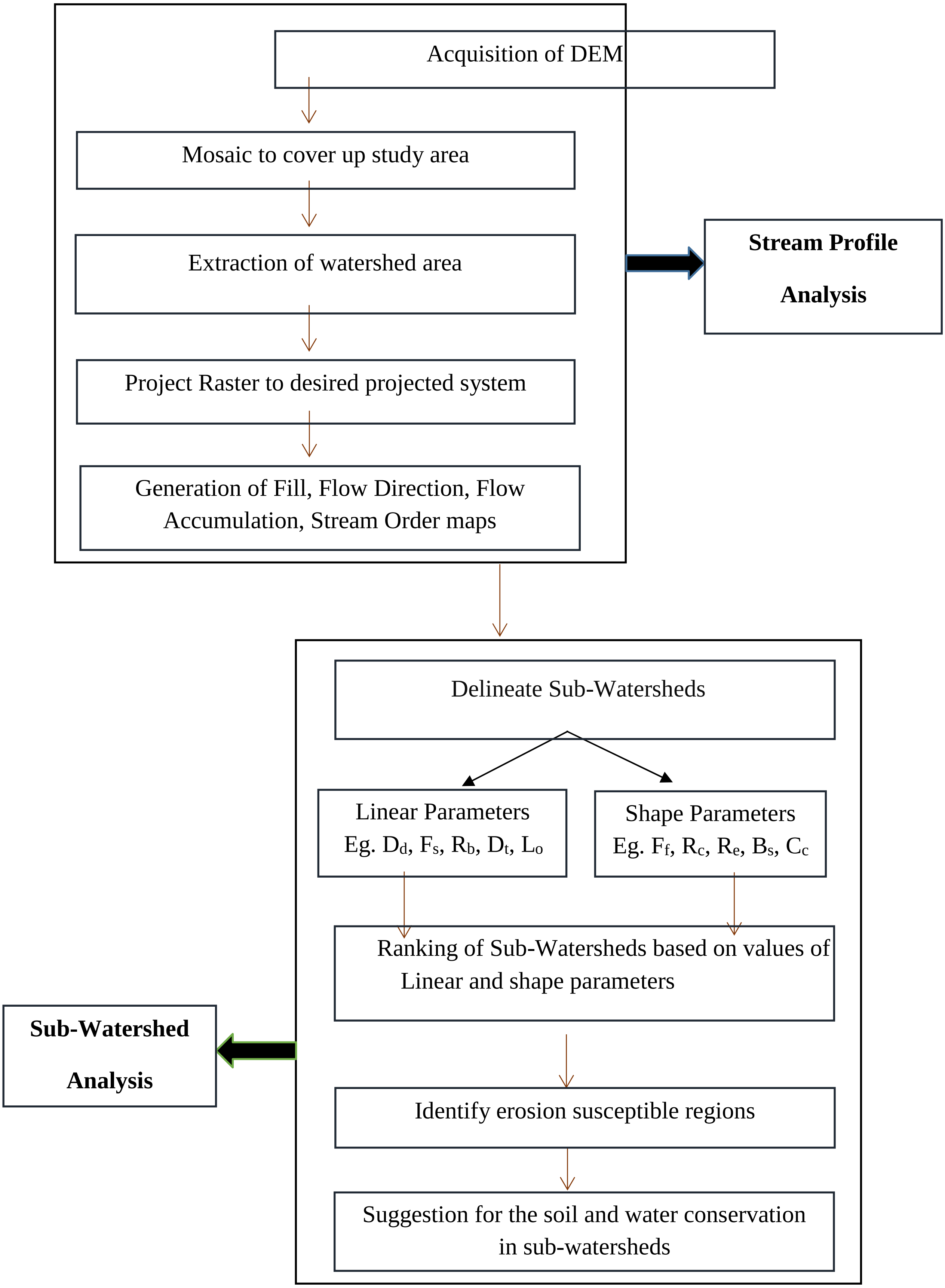

Fig 4.3 Flowchart showing methodology for stream profile and sub-watershed analysis

4.3 Sub-watersheds analysis

The watershed analysis is done after stream profile analysis. The whole Shipra basin divided into sub-watersheds, this dividing of whole watershed is also called as delineation of watershed boundary up to sub-watershed level. The numeric values of linear parameters and shape parameters are calculated for every sub-watershed. These values of all the linear parameters and shape parameters are used for prioritization of sub-watershed. These morphometric parameters are exceptionally useful in comprehension the hydrological conduct and soil errosion susceptible regions in Shipra watersheds. Morphometric parameters are calculated for every sub-watershed & depending upon their values, ranking has been done. Formulae for various linear and shape parameters considered in this study are concluded in table 4.1. the sub-basins are prioritized in such a manner lower the rank of watershed higher is the risk to erosion and vice versa. Sub-watershed analysis block of Fig 4.3 shows the flow chart of the steps of sub-watershed analysis.

S. No.	Parameters	Formulae	References
1.	Drainage Density	Dd = Lu/A	Horton (1945)
2.	Stream Frequency	Fs = Nu/A	Horton (1945)
3.	Bifurcation Ratio	Rb = Nu/Nu+1	Schumm (1956)
4.	Drainage Texture	T = Dd * Fs	Smith (1950)
5.	Length of Overland flow	Lo = 1/2Dd	Horton (1945)
6.	Form Factor	$Ff = A/L^2$	Horton (1945)
7.	Elongation Ratio	Re = D/L = 1.128√(A/L)	Schumm (1956)
8.	Circulatory Ratio	Rc = 4πA/P2	Strahler (1964)
9.	Basin shape	Bs=L/A	
10.	Compactness Coefficient	Cc = .2821 P/√A	Strahler (1957)
11.	Basin length	$L=1.312A^{0.568}$	

Table 4.1 Formulae for Linear and Shape parameters with their references

4.4 Linear Parameters

4.4.1 Drainage Density (Dd):

Horton 1932 accounted the seepage density as the aggregate length of streams per unit area partitioned by the region of the watershed. In the region where the surface is very porous with thick vegetation and low relief, low drainage density existed.

Seepage basin with high Dd demonstrates that an huge extent of the precipitation changes into surface runoff. Then again, a lesser drainage density shows the most precipitation penetrates the surface and some channels are required to convey the overflow.

$$\mathbf{Dd = Lu/A} \qquad \text{........ (1)}$$

Where,

L_U is the total length of streams (km)

A is total area of watershed (km^2)

4.4.2 Stream Frequency (Fs):

Horton 1945 described the stream frequency (Fs) as a total number of stream segments of all various orders within a catchment and sub-catchment area.

Higher the range of F_s indicates huge number of streams are present in the region and the catchment will drain quickly after precipitation or storm *etc.* and vice versa for low value.

$$\mathbf{Fs = N/A} \qquad \text{........ (2)}$$

Where,
N is the total number of streams in watershed

A is total area of catchment (km^2)

4.4.3 Bifurcation Ratio (Rb) :

Bifurcation ratio is a dimensionless quantity and is defined as the ratio of the total accumulation of streams of any particular order (Nu) to the total accumulation in the next higher order (Nu+1) as defined by Horton (1945).

Higher the value of this parameter indicates alluvial region or structural disturbances. Lower the value of R_b shows comparatively plain area and less structural disturbances.

$$\mathbf{Rb = N_u/N_{u+1}} \quad \text{.................. (3)}$$

Where,

N_u is number of concerned order streams

N_{u+1} is number of higher order streams

4.4.4 Drainage Texture (Dt):

Drainage texture is defined as the total number of streams of all given order within the catchment per unit perimeter of the catchment area. It was defined by Smith (1950). it is a multiplied form of drainage frequency and drainage density.

$$\mathbf{D_t = D_d * F_s} \quad \text{.................(4)}$$

Where,

D_d is drainage density (km^{-1})

F_s is stream frequency (km^{-2})

Smith (1950) categorized drainage density in five class:

Very coarse drainage density	when $D_t < 2$,
Coarse drainage density	when $2 \leq D_t \leq 4$
Moderate drainage density	when $4 \leq D_t \leq 6$
Fine drainage density	when $6 \leq D_t \leq 8$
Very fine drainage density	when $D_t > 8$

Higher the drainage texture higher could be the dissection and causes more soil erosion.

4.4.5 Length of Overland Flow (Lo):

Length of overland flow as described by the Horton (1945) is the stream over the earth surface before it can be merge into a particular stream channel like catchment stream, lake or sea.

Length of overland flow is conversely related with the mean shape of the catchment zone and is relatively indistinguishable to the length of sheet flow at a greater scale.

Lesser the estimation of overland stream the speedier surface overflow will enter the streams leads to the formation of properly developed drainage network with higher inclination.

$$Lo = 1/2D_d \quad \text{..........(5)}$$

Where,

D_d is drainage density (km^{-1})

4.5 Shape Parameters

4.5.1 Form Factor (Ff):

As indicated by the Horton (1932) form factor is defined as the ratio of the catchment region (A) to the square of the largest catchment length (L). The estimation of form factor would dependably be under 0.7854 which shows a perfectly circular catchment. In this way this parameter recommends the shape of a catchment area. Lesser the range of form factor, large elongated would be catchment area. Those catchments which are having a large value of form factor, also have large peak flow of lesser duration, in the contrary, elongated drainage catchment with lesser value opf form factors have lesser peak flow of larger duration. The alluvial type catchment indicate lesser value of form factor shows the elongated nature of the catchment.

$$F_f = A/L^2 \quad \text{....... (6)}$$

Where,

A is total area of watershed (km^2)

L is maximum basin length (km)

4.5.2 Elongation Ratio (Re):

This parameter may be represented as the ratio of the diameters of a circle with the same area as that of the basin to the largest length of the basin (Schhumm,1956). Generally it varies from 0.6 to 1.5 over a large variety of of climatic and geological ecosystem. Elongation ratio shows circularity of the basin. Lower the number, more elongated will be the shape.

$$Re = D/L = 1.128\sqrt{(A/L)} \qquad \ldots\ldots\ldots(7)$$

Where,

D is diameter of the circle of same area as catchment (km)

A is total area of catchment (km^2)

L is largest length of catchment (km)

Elongation ratio	**shape of catchment**
0.60 - 0.70	Elongated
0.80 - 0.70	Less elongated
0.90 - 0.80	Oval
0.90 - 1.50	Circular

4.5.3 Circularity Ratio (Rc):

This parameter for any particular catchment may be described as the ratio of the catchment area to the area of circle which have circumference eual to the perimeter as the catchment (millers 1953); (strahler 1957). Circular number is nearly similar to the elongation ratio, which shows the shape of the catchment. The value of circularity ratio ranging from 0-1.0 shows a line and 1 shows circular shape.

$$\mathbf{Rc = 4\pi A/P^2} \qquad \ldots\ldots\ldots\ (8)$$

Where,

A is total area of watershed (km^2)

P is total perimeter of watershed (km)

4.5.4 Compactness Coefficient (Cc):

This parameter is used to estimate the relationship between hydrological catchments with that of a circular catchment having the same area as the concerned hydrological catchment. A circular type of catchment has the maximum risk from drainage perspective because it has very less time of concentration prior to the maximum or peak discharge attained in the catchment area.

$$Cc = 0.2821 P/\sqrt{A} \qquad \text{. . . . . (9)}$$

Where,

P is total perimeter of catchment (km)

A is total area of catchment (km^2).

4.5.5 Basin Shape (Bs):

The shape of the catchment primally controls the discharge rate at which water is draining to the main stream of the catchment. This parameter is described as the ratio of the square of the catchment length to the gross area of the catchment or sub-catchment.in order to estimate the catchment length, calculate the distance between drainage outlet point of the catchment and the farthest point in the basin from the drainage outlet. It can also be termed as shape factor.

Higher the value of B_s indicates higher the rate of water supply to main channel.

$$B_s = L^2/A \qquad \text{. . . . . (10)}$$

Where,

L is maximum basin length (km)

A is total area of watershed (km^2)

CHAPTER 5

RESULT AND DISCUSSION

5.1 General

The objectives of this study are to prioritize the Shipra watershed on the basis of morphometric analysis and assessment of regions susceptible to soil erosion. Suggestions for conservation of soil and water are also proposed after analyzing the result of this study. All the remote sensing and GIS data are studied thoroughly to find out the characteristics of the area. All the results with processed images are discussed in this chapter. This chapter is classified into two parts where first part is "stream profile analysis" and second is "morphometric behavior of the study area". First part covers the processing of images and study of the stream profiles. In the first part, delineation of sub watershed is also done. Second part covers study of morphometric parameters for each sub-watershed. Combination of first and second part of this chapter covers all the objectives of this study.

5.2 Stream Profile Analysis

5.2.1 Fill

Sinks are usually errors because of resolution of the information or may be rounding off the elevations values to the nearest possible integer. Peaks/sinks would be filled to ascertain appropriate delineation of catchment and streams. In order to create a continuous drainage network, sinks are supposed to be filed with pixels.

It is very necessary to locate and fill sinks for better and accurate results. In this process iterations on a pixel are done till when all the sinks or peaks under certain particular limits are filled. As sinks/peak are supposed to be filled during the process, others sinks may be developed at the limiting boundaries of the particularly filled catchment areas which are further supposed to be eliminated in the following iteration. Figure 5.1 shows the profile view of concept of working of Fill and Figure 5.2 shows Fill image of Shipra watershed.

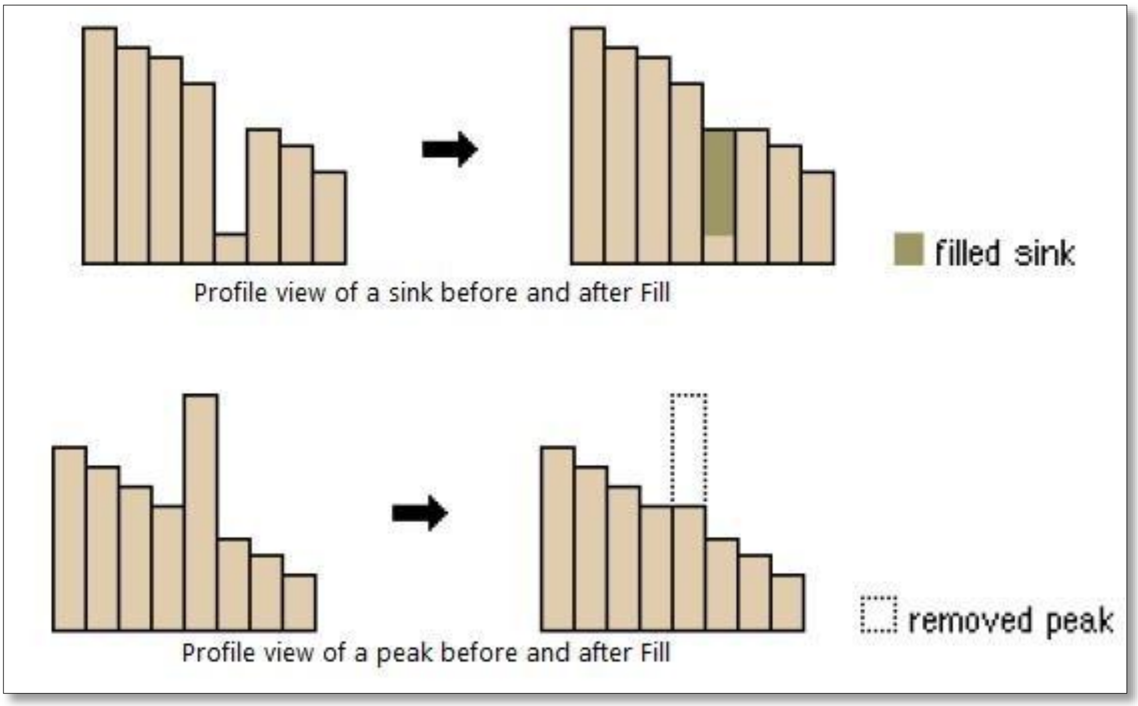

Fig 5.1 Profile pixels view before and after Fill

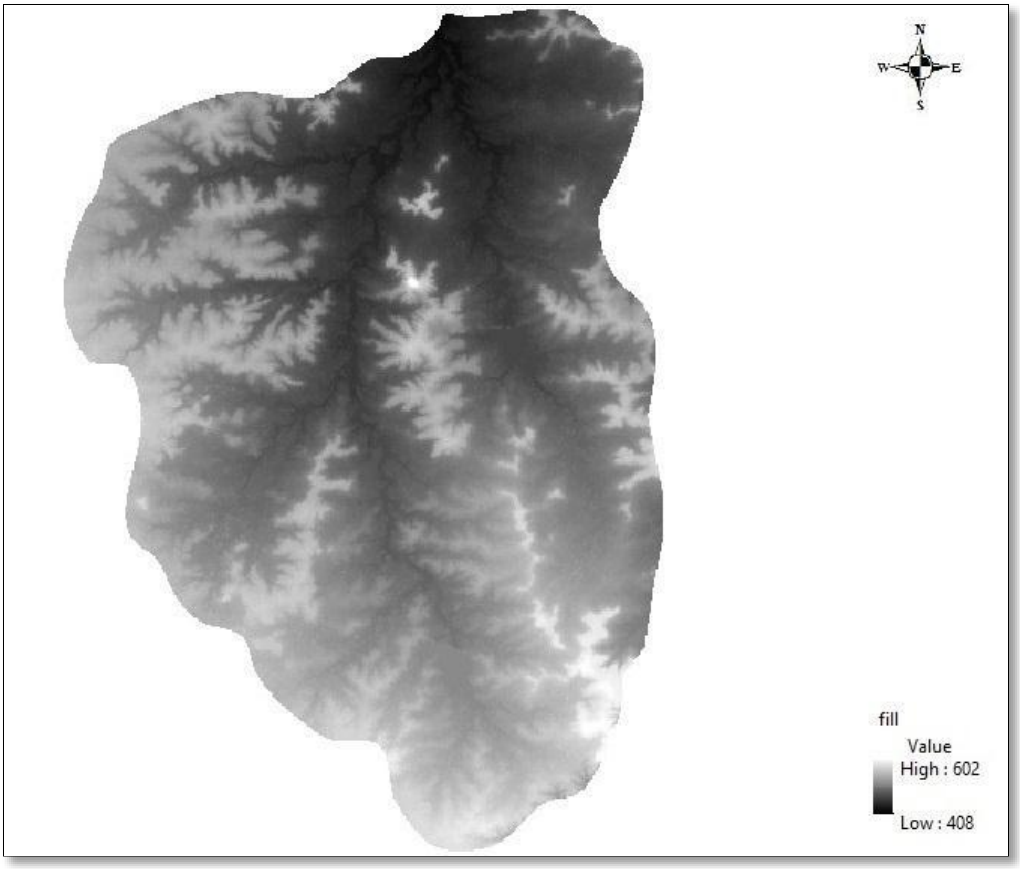

Figure. 5.2 Fill image of the Shipra watershed

5.2.2 Flow Direction

It is very important to develop a flow direction map for study area. Flow direction shows the direction of every stream to its steepest adjacent down slope neighbor. This helps in obtaining results with minimum error. Flow direction helps to calculate accumulated flow at each cell in the area. Cell is an area which has same direction of flow. Flow direction, as shown in Figure 5.3, depends on fill sinks by which the neighborhood terrain is leveled. Values from 1 to 128 show the direction of flow.

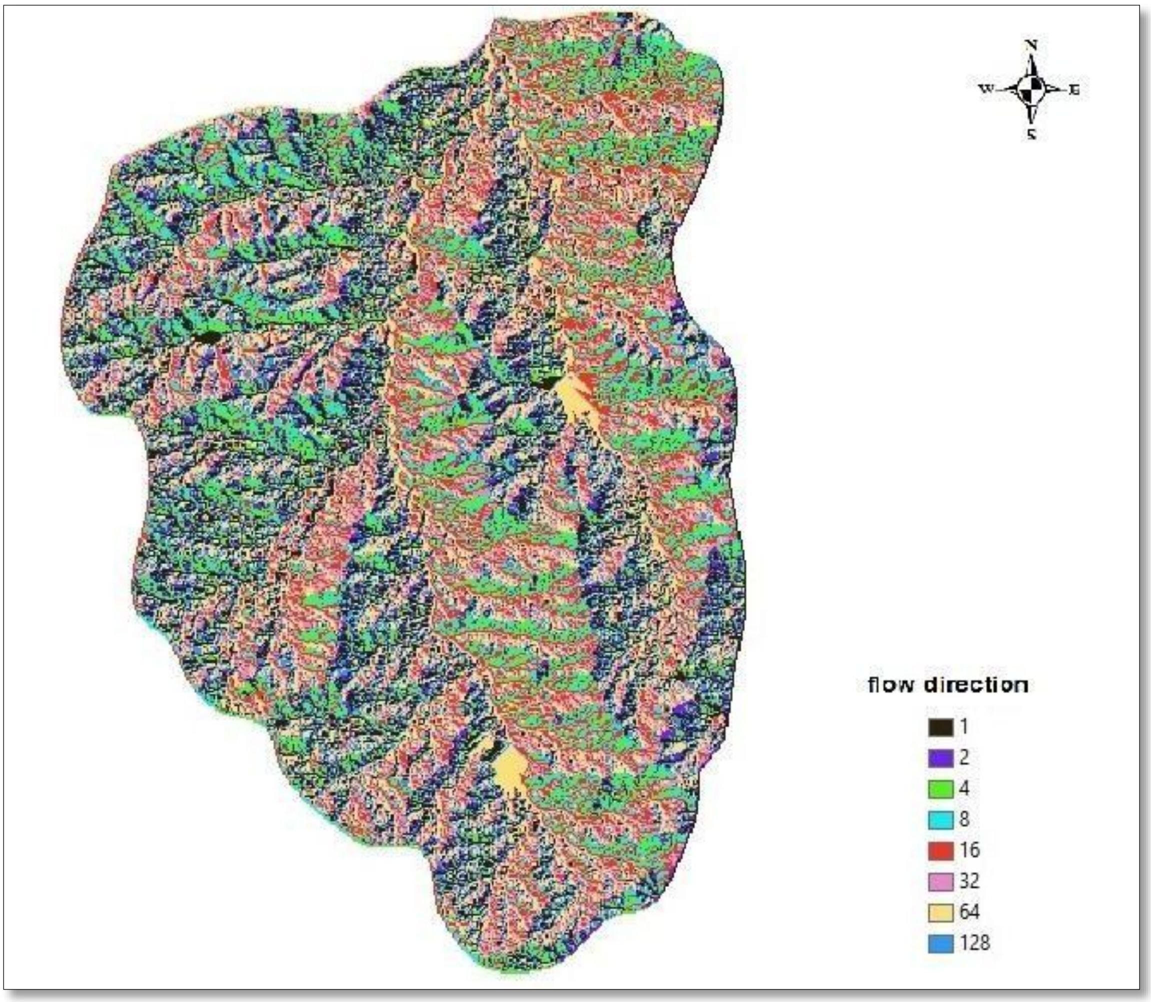

Fig 5.3 Flow Driection map of shipra watershed

5.2.3 Flow Accumulation

The Flow Accumulation is the cumulative weightage of all cells streaming into each down inclination cell in the raster. On the off chance that no weight raster is given, a weight of 1 is connected to every cell, and the estimation of cells in the yield raster is the quantity of cells that stream into every cell.

In Fig 5.4 underneath, the left picture demonstrates the course of movement from every cell and the correct one demonstrates the quantity of cells that stream into every cell. Deciding the collection of stream Cells with a high stream amassing are territories of concentrated stream and might be utilized to distinguish stream channels. Cells with a stream collection of 0 are nearby topographic highs and might be utilized to recognize edges.

In Fig 5.4 there are two images 1 and 2. 1 shows the direction of flow and image 2 shows the accumulation of flow. Cell (x, y) of image Z is represented as Z(a, b) in description of the flow accumulation mapping concept. In 1(1,1) the direction of the flow is towards 1(2,2), 1(1,1) is the only cell which gives flow to the 1(2,2). Therefore in 2(2, 2) the value assigned is 1 and 2(1, 1) is 0 because no flow is drain in this cell.
In cell 2(3,2) value assigned is 3, the reason is cell 1(2,1), 1(3,1) and 1(4,1) has flow towards 1(3,2). Therefore the accumulated vale is 3 which are assigned to 2(3, 2).

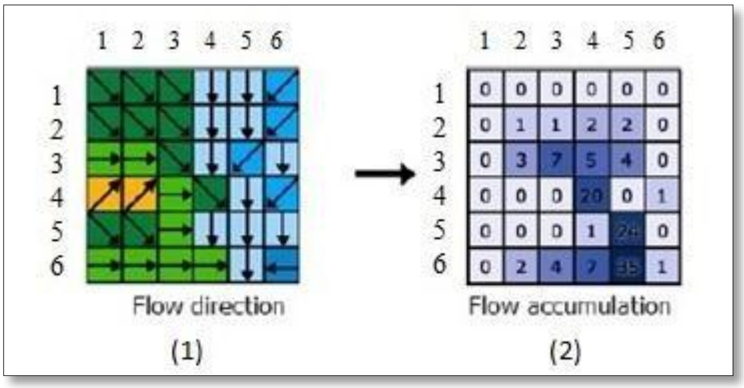

Fig 5.4 Flow accumulation mapping concept

Stream begins to form, as water flows downstream. Flow accumulation addresses the cell by accounting the total number of upstream cells which flow to a given cell. Figure 5.5 represent the flow accumulation map of Shipra Basin.

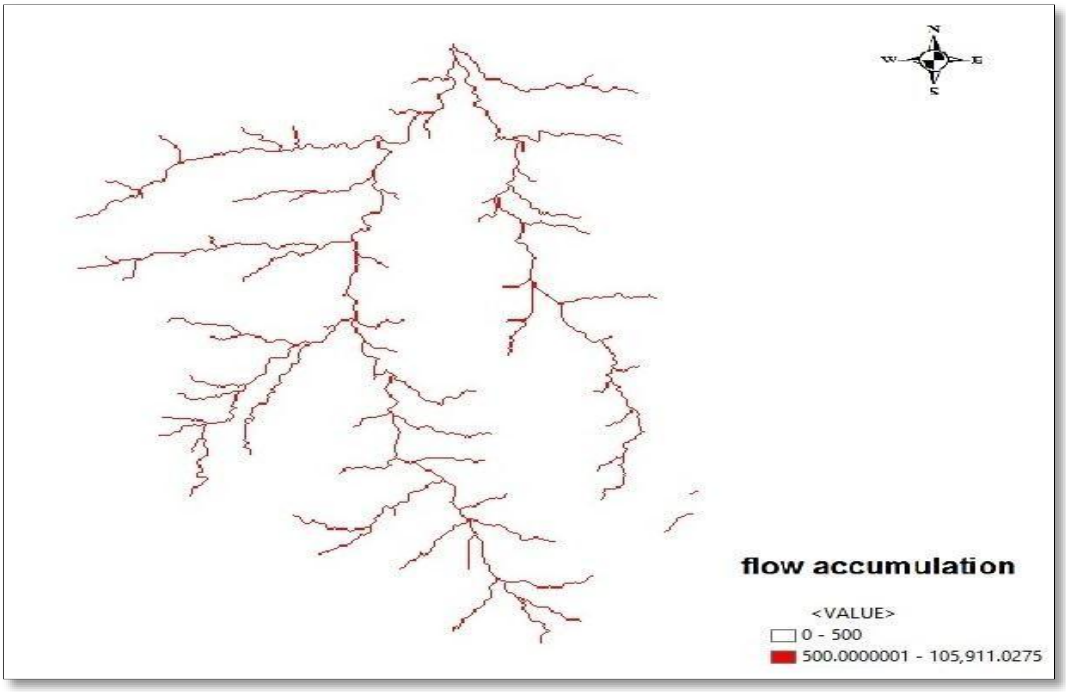

Fig 5.5 Flow Accumulation map of shipra Basin

5.2.4 Stream Network

Stream network map is made by assigning different values to the concerned portion of a linear network between various intersections. Input stream raster for making stream link map is output map of flow accumulation raster. Links are the portions of a stream channel interfacing two progressive intersections, a intersection & a outlet, or a intersection & the catchment divide. Junction is the point of merging of two or more streams. Figure 5.6 shows the concept of links and junction.

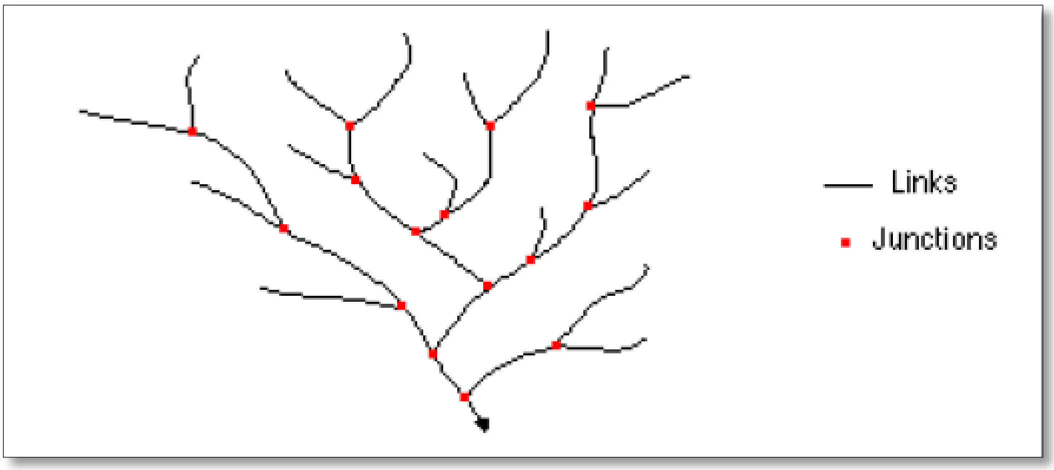

Fig 5.6 Links and Junctions

The stream raster linear network ought to be indicated as values greater than or equivalent to one on a foundation of No Data. Fig 5.7 shows the stream network in Shipra watershed in which value 1-2 represents the background data and 2-9 represents the streams.

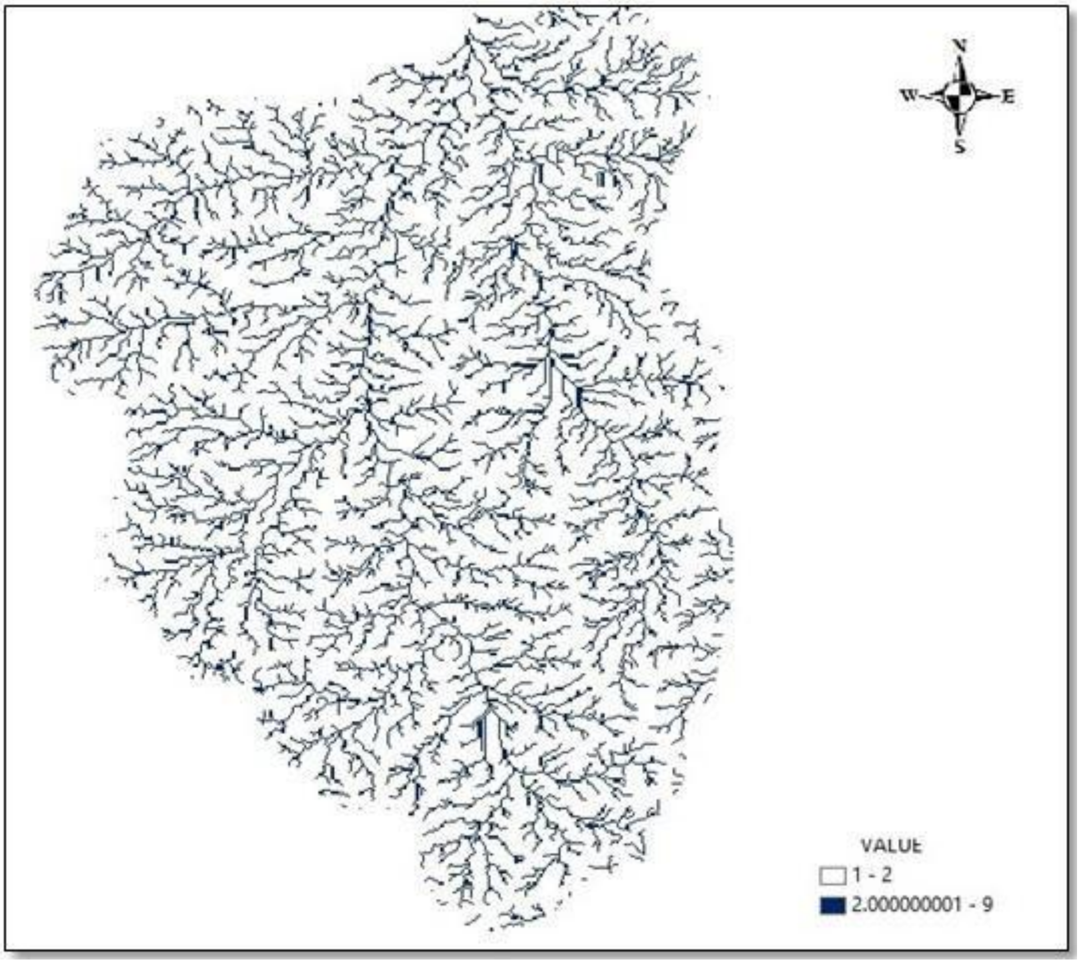

Fig 5.7 Stream network map of Shipra watershed

5.2.5. Stream Order

Stream ordering is a strategy of assigning a numeric request to joins in a stream arrange. This request is a strategy for perceiving and grouping kinds of streams dependent on their quantities of tributaries. A few attributes of streams can be closed by essentially knowing their order.

For instance, first-order streams are commanded by overland stream of water; they have no upstream focused stream. Along these lines, they are to a great extent vulnerable to non-point source contamination issues and can get more profit by wide riparian cradles than different regions of the watershed. First-order streams are the first stream form by the overland flow.

When two or more first-order stream merges at a point, then the stream form is called second order stream. Higher order streams are form when two or more streams of lower order are merged. Fig 5.8 shows the stream order map of the Shipra watershed.

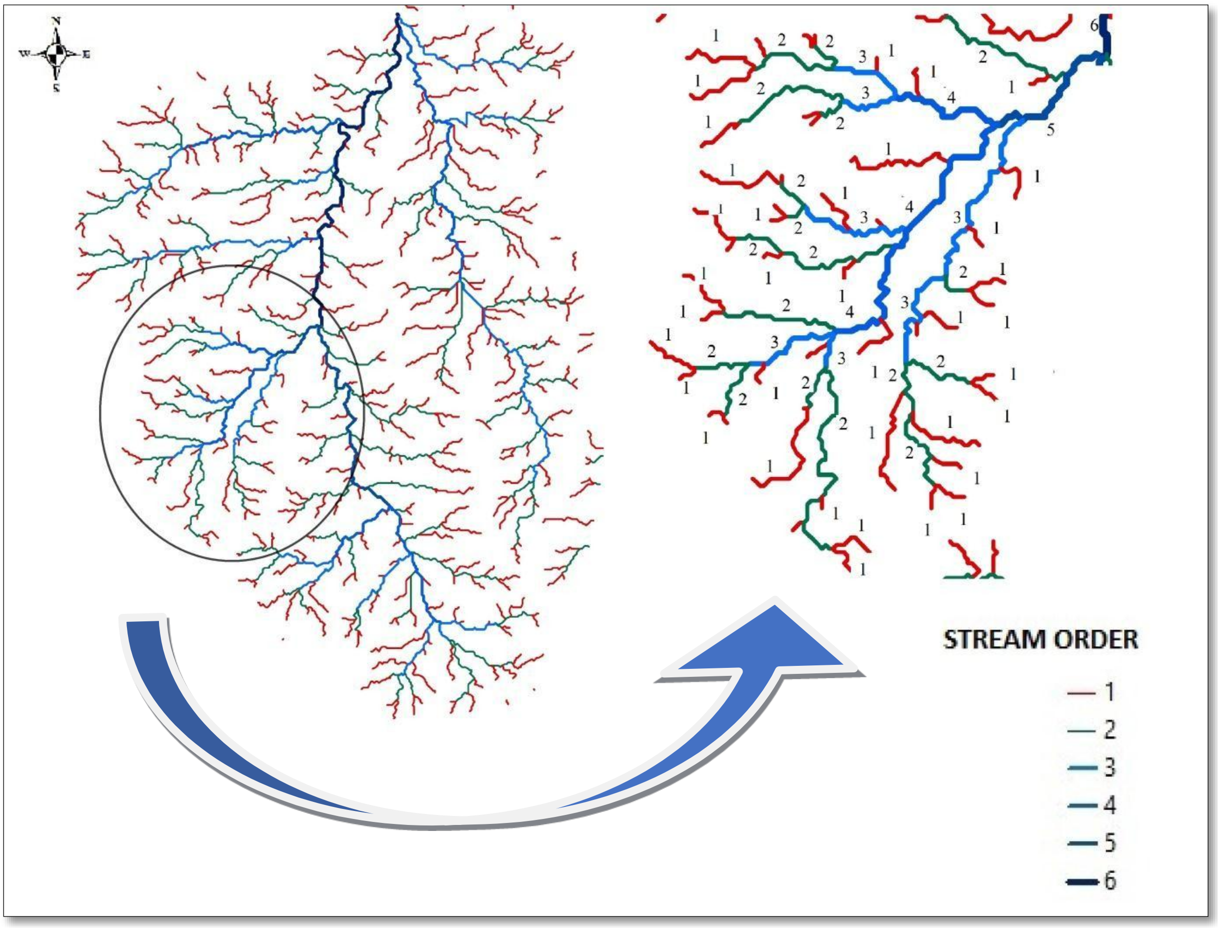

Figure 5.8 Stream orders of the streams in Shipra Watershed.

5.2.6 Sub-Watershed

Sub-Watersheds are delineated from DEM of the Shipra watershed by using flow direction map of the area. Flow accumulation threshold is also used to define pour points. These are the points of high accumulated flow in the area. Figure 5.9 shows the sub watersheds inside Sipra basin with their assigned numbers.

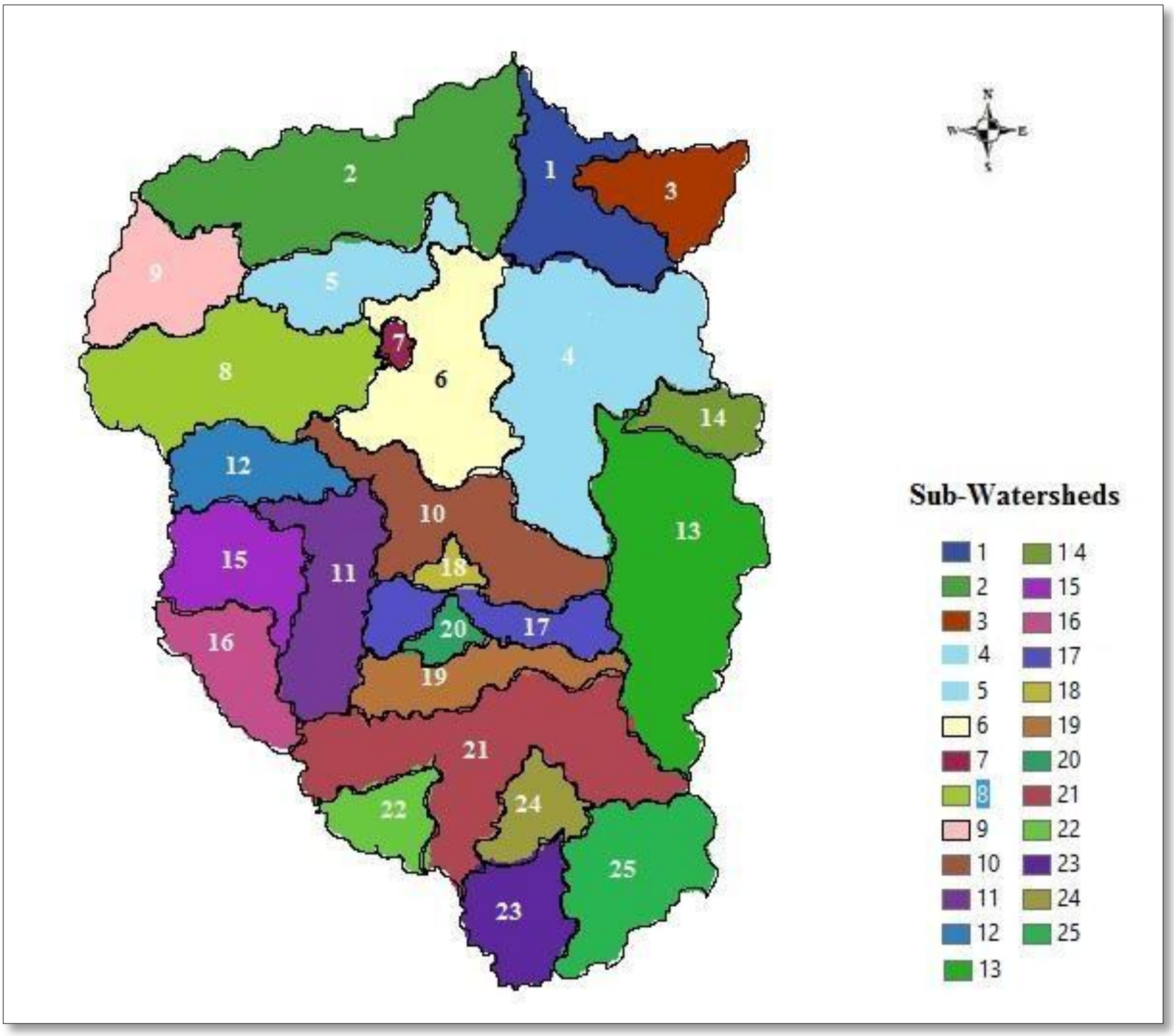

Fig 5.9 Sub-Watersheds within Shipra Watershed

5.3 Morphometric parameters of the investigated Area

5.3.1 Linear parameters

5.3.1.1 Drainage Density (Dd):

In this ongoing analysis the value of drainage density may vary between 0.81 to 1.24 km^{-1}. The largest vale of drainage density is founded in sub-watershed-3, and the lowest value observed in sub-watershed-20. The drainage density values for all the different sub-watersheds (twenty-five sub-watershed) is represented in table below intablee 5.1. Values lower than 1 indicates more run off, which may lead to more erosion in that area. [12]

5.3.1.2 Stream Frequency (Fs) :

Estimations of stream frequencies for every one of the twenty-five sub-watersheds given in table 5.1 demonstrates an expansive variety in stream recurrence esteems from 15.85 km^{-2} for sub-watershed-7 to 25.21 km^{-2} for sub-watershed-18. It shows that sub-watershed having lesser stream frequency range supposed to show low relief and porous surface while, sub-watersheds which are supposed to have large stream frequency range indicate high relief, light vegetation and grass cover and lesser conducting surface.

5.3.1.3 Bifurcation ratio (Rb):

Nag and Chakraborty (2003) described that Lesser ranges of this parameter existed in those area which accounted very low structural disturbances and in such regions drainage pattern is not been disturbed by the structural regularities.

Bifurcation ratio of the investigated region lies between 2.670-4.727, sub-watershed-24 shoe least value which represents the presence of a some lesser amunt of structural irregularity or disturbance. On the contrary, sub watershed number 7 shows the maximum value of this parameter which represents a properly managed and controlled drainage pattern structurally. Table 5.1 represents the bifurcation ratio estimates of different twenty-five sub-watersheds.

5.3.1.4 Length of Overland Flow (Lo):

The values of this parameter for all twenty-five sub-watershed lies between 0.403 km for sub-watershed-3 to 0.616 km for sub-watershed-20. Table5.1 represents the value of this parameter for all the sub-watershed. 0.403 shows quicker surface runoff. Value above 0.5 km shows water take long time to drain.

TABLE 5.1 Linear Parameters for Morphometric Analysis of Shipra Watershed

SUB-WATERSHEDS	D_d (km^{-1})	Fs (km^{-2})	R_b (km^{-1})	D_t (km^{-3})	L_o (km)
1	1.019543011	21.96324518	3.175270108	22.39247312	0.490415799
2	1.024276757	20.45813332	3.434645669	20.95479045	0.488149318
3	1.240547682	19.9442336	3.374757282	24.74177276	0.403047789
4	1.065466212	21.24721251	3.245604688	22.63818702	0.469278138
5	1.043249798	21.40643162	3.399698341	22.33225546	0.4792716
6	1.226224847	21.08342401	3.324027073	25.85301837	0.407755561
7	0.929671802	15.85014409	4.727272727	14.73543202	0.537824207
8	1.136844653	20.77692939	3.489751098	23.6201411	0.439813829
9	1.155919289	20.69091797	3.438053097	23.91703118	0.432556152
10	1.110117793	20.56231641	3.303206997	22.82659331	0.450402654
11	0.98748809	21.76065815	3.270711785	21.48839075	0.506335221
12	1.065568975	21.609538	3.226860254	23.02645326	0.469232881
13	1.074161755	21.01868714	3.328366446	22.57746988	0.465479242
14	0.964143426	21.62534435	3.426751592	20.8499336	0.518595041
15	1.019296898	20.04519996	3.375816993	20.43201015	0.490534211
16	1.030969462	20.53310012	3.416666667	21.16899918	0.484980418
17	1.152591838	22.50713396	3.189285714	25.94153889	0.433804911
18	1.034504005	25.21342069	2.763779528	26.08338468	0.483323407
19	1.071091021	21.48474966	3.3375	23.01212246	0.466813735
20	0.811450764	21.76933766	3.567375887	17.66474568	0.61618033
21	1.026079931	20.87741745	3.347083088	21.42189906	0.487291472
22	0.992244774	22.47053795	3.282608696	22.29627386	0.50390792
23	0.957619815	22.18657067	3.169312169	21.2462997	0.522127876
24	1.028935258	24.38426663	2.670854271	25.08983168	0.485939223
25	1.092927868	21.60921738	3.25	23.61731588	0.457486733

5.3.2 Shape Parameters

5.3.2.1 Form Factor (Ff):

Table 5.2 represent the range of form factor for twenty-five sub-watersheds which lies between 0.011 for subwatershed-2 to 0.311 for subwatershed-7. These values indicate nearly almost all sub-basins is more or less elongated type of watersheds, no watershed is perfectly circular.[12]

5.3.2.2 Elongation ratio (Re):

For the investigated area, range of elongation ratio is shown in table 5.2. Elongation ratio for twenty-five sub-watersheds ranges from 1.016 for sub-watershed-20 to 1.256 for sub-watershed-3.

Those area having low value of relief have elongation value about 1. Whereas those area having very steep surface inclinations and strong relief are having value in between 0.6 to 0.8. These values indicate that there is no sub-watershed which is having very steep surface slope. All the sub-watersheds lie in low relief region.[12]

5.3.2.3Circularity ratio (Rc):

For the concerned investigated area, the Value of this parameter lies between 0.197 for sub-watershed-21 to 0.509 for sub- watershed-7 as shown in Table 5.2. 0 shows line and 1 shows circle, it means no sub- watershed is perfectly circular in shape.[12]

5.3.2.4Compactness Coefficient (Cc):

For the concerned investigated area, the Value of this parameter lies between 1.40 to 2.247. A circular type of catchment has the maximum risk from drainage perspective because it has very less time of concentration prior to the maximum or peak discharge attained in the catchment area. C_c also shows the shape of the area 1 shows circle and value greater than 1 shows irregularity.[12]

5.3.2.5 Basin Shape (Bs):

Higher the value of B_s indicates higher the rate of water supply to main channel & vice-versa. In study area value of basin shape varies from 1.977 for sub-watershed-7 to 3.189 for sub-watershed-2.[12]

Table 5.2 Shape Parameters for Morphometric Analysis of Shipra Watershed

SUB-WATERSHEDS	F_f	R_c	R_e	B_s	C_c
1	0.02740707	0.248875426	1.138968926	2.822309678	2.004042363
2	0.011266932	0.314114832	1.141609985	3.189008015	1.783830907
3	0.059598736	0.470029917	1.256365003	2.678540968	1.458260645
4	0.012850412	0.373709618	1.164337649	3.166253948	1.635425512
5	0.035140454	0.305706006	1.152134693	2.745614047	1.808197732
6	0.026820316	0.294884803	1.24909122	2.976375023	1.841075972
7	0.311343537	0.509797947	1.087611845	1.977756028	1.400228345
8	0.019657709	0.396257423	1.202706509	3.041570586	1.58821466
9	0.040776044	0.472611297	1.212754389	2.766743264	1.454272717
10	0.024626052	0.22746947	1.188484799	2.930747235	2.096217529
11	0.024760245	0.317338048	1.12092107	2.836806192	1.774748561
12	0.044530443	0.368277906	1.164393797	2.673945196	1.647441771
13	0.013384026	0.363355693	1.169079224	3.155751699	1.658562803
14	0.064020148	0.4886377	1.107592285	2.476823901	1.430225182
15	0.034029877	0.440971557	1.138831447	2.740264283	1.505541104
16	0.040415911	0.453006926	1.145333597	2.685217111	1.485407064
17	0.053392868	0.228482633	1.211007602	2.665052048	2.091564722
18	0.212467448	0.465174089	1.14729523	2.144682734	1.465852081
19	0.044014425	0.227204978	1.167406989	2.681955214	2.097437287
20	0.101660081	0.446768068	1.016108739	2.21929237	1.495742533
21	0.012952611	0.197943018	1.142614409	3.13060561	2.247128004
22	0.060117829	0.453936462	1.123617539	2.517697459	1.483885434
23	0.035883382	0.488292838	1.103838815	2.67477159	1.430730149
24	0.06486385	0.419131065	1.144203111	2.516545859	1.544269097
25	0.028553122	0.45214769	1.179247189	2.86019516	1.486817785

5.4 Watershed Prioritization

Values of all linear parameters and shape parameters are determined, listed in Table 5.1 and Table 5.2.

5.4.1 Compound Value (C_p):

Compound value is the mean of all the linear and shape parameters for same watershed. Comparison of values of C_p has done to prioritize the watershed. On the basis of values of C_p rank is allotted to each sub-watershed. Lower the value of C_p less is the risk of erosion in a given watershed.

Table 5.3 shows the ranks of sub-watershed on the basis of values of Compound value of each watershed.

Sub watershed 15 gets the highest priority and sub watershed 9 gets the lowest priority. Soil erosion prone areas in the drainage basin area can be identified by using these priorities of the sub watersheds and suggestion to soil conservation structure is done according to the seriousness of erosion in the area.

Table 5.3 Morphometric Analysis Based Final Priority of Sub- Watersheds

SUB-WATERSHEDS	Shape Parameters					Linear Parameters					Cp	Final Priority
	F_f	R_e	C_c	R_c	B_s	D_t	F_s	R_b	D_d	L_o		
1	9	8	21	5	16	12	20	4	8	18	12.1	8
2	1	9	18	8	25	5	4	21	9	17	11.7	4
3	19	25	5	21	10	21	2	16	25	1	14.5	21
4	2	15	14	12	24	14	12	7	15	11	12.6	11
5	12	14	19	7	14	11	13	18	14	12	13.4	16
6	8	24	20	6	20	23	11	12	24	2	15	23
7	25	2	1	25	1	1	1	25	2	24	10.7	2
8	5	21	13	13	21	19	8	23	21	5	14.9	22
9	15	23	4	22	15	20	7	22	23	3	15.4	25
10	6	20	23	3	19	15	6	11	20	6	12.9	13
11	7	5	17	9	17	9	18	9	5	21	11.7	5
12	17	16	15	11	8	17	16	6	16	10	13.2	14
13	4	18	16	10	23	13	10	13	18	8	13.3	15
14	21	4	2	24	4	4	17	20	4	22	12.2	9
15	11	7	11	15	13	3	3	17	7	19	10.6	1
16	14	12	8	18	12	6	5	19	12	14	12.0	7
17	18	22	22	4	7	24	23	5	22	4	15.1	24
18	24	13	6	20	2	25	25	2	13	13	14.3	20
19	16	17	24	2	11	16	14	14	17	9	14.0	18
20	23	1	10	16	3	2	19	24	1	25	12.4	10
21	3	10	25	1	22	8	9	15	10	16	11.9	6
22	20	6	7	19	6	10	22	10	6	20	12.6	12
23	13	3	3	23	9	7	21	3	3	23	10.8	3
24	22	11	12	14	5	22	24	1	11	15	13.7	17
25	10	19	9	17	18	18	15	8	19	7	14.0	19

CHAPTER 6

CONCLUSIONS

- From Shipra watershed 25 sub-watersheds are delineated, this dividing of whole Shipra watershed into different sub-watersheds helps in study of small parts of very large area in accurate manner. All the linear parameter nad the shape parameters for all sub watershed is studied in this study.
- On the basis of linear parameters and shape parameters of each sub watershed, Final prioritization of sub watershed is done.
- For the morphometric investigation of Shipra catchment, assessment of drainage parameters and their effects on landforms and soil-erosion parameters is calculated by using the data obtained from remote sensing and GIS methodology. In this investigation it has been proved that Geomatics strategies are far more suitable than some other accessible regular conventional techniques.
- Quantitative morphometric investigation at sub-watershed level aides in building up the relationship among different parts of seepage attributes and furthermore valuable in discovering their impact on soil erosion. The findings of this investigation demonstrates that sub-watershed 15, 7, 23, 2, 11, 21 and 16 are inclined to generally higher land and soil disintegration or soil erosion. Based upon the compound value, seven sub-watersheds go under serious soil erosion affected, eleven goes under moderate affected, seven goes under less affected and seventeen sub-watersheds are not concerned with soil disintegration. This is comprehended by table 5.3.
- Those Sub-watersheds which are supposed to be extremely prone, appropriate soil erosion measure and water seepage controls measures can be given to control the disintegration and save the land from further disintegration and this should be possible by giving soil and water preservation structures, for example, Check Dam, Groynes, and Drop Structure. Thus, geomatics strategies can be successfully utilized for methodical examination of morphometric parameters and in water-land resources assessment.

Overall this study shows the importanc and application of remote sensing data in the study of geomorphology. It permits for the fast assessment of large as well as unreachable areas and for the monitoring of basins, erosion and management that would be difficult to do using field study alone. This study further shows that the GIS approach is useful in analysis of geo-spatial database, simplification of watershed mapping and its quantitative analysis.

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APPENDIX

SOFTWARE APPLICATION IN THIS STUDY

This software work is broadly divided into four parts:

A1: Mosaicing of data images.

A2: Creating shape file and extraction of selected study area.

A3: Image processing in ArcGIS.

A4: Sub-Watershed delineation in ArcGIS

<u>A1. Mosaicing of Data Images</u>

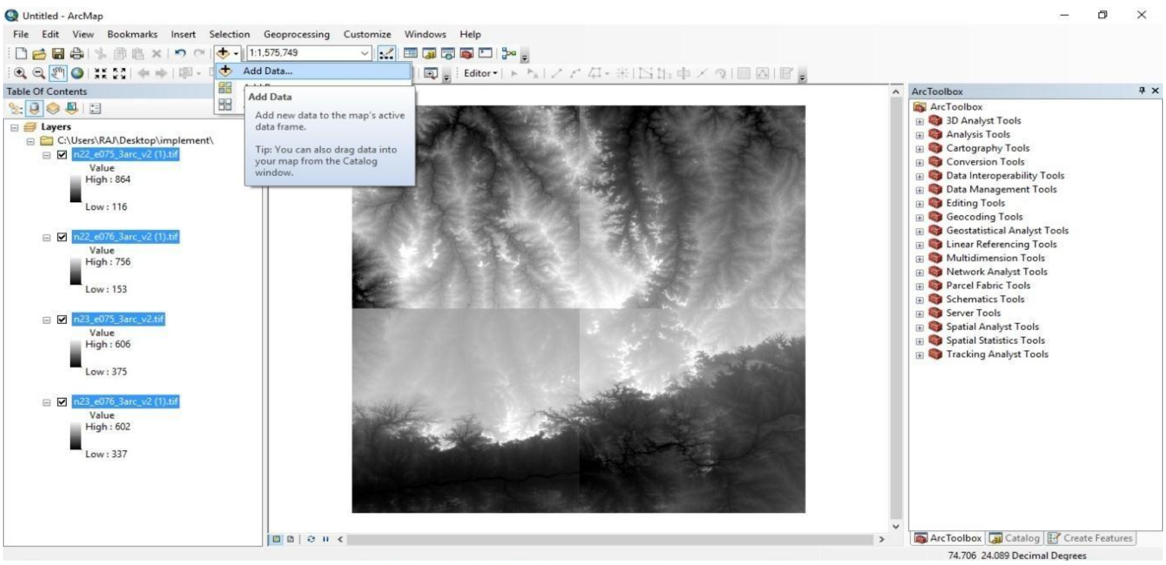


Image: A1

In this study Arc GIS is used for processing of images in this firstly “add data” tab is used to select image file of the study area. Image A1 shows the position of “add data” tab and added SRTM data.

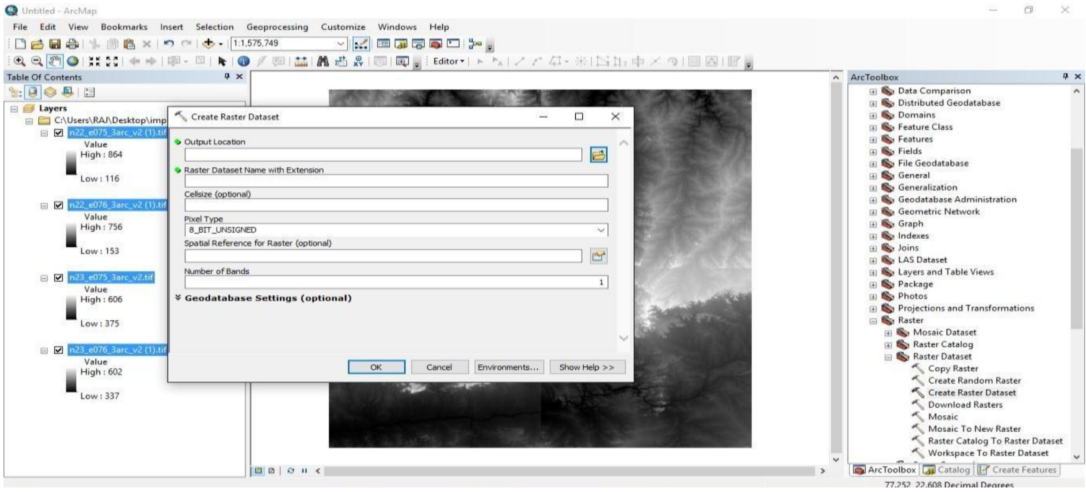


Image: A2

After adding data files, to mosaic all the images “arc toolbox” ->” Data management tool” -> “raster” -> “raster dataset” -> “create raster dataset” command is used to create raster dataset for mosaic file. Image A2 shows the “create raster dataset” pop up window. In this window output location, raster dataset file name is specified. In this study pixel type used is 12_BIT_UNSIGNED.

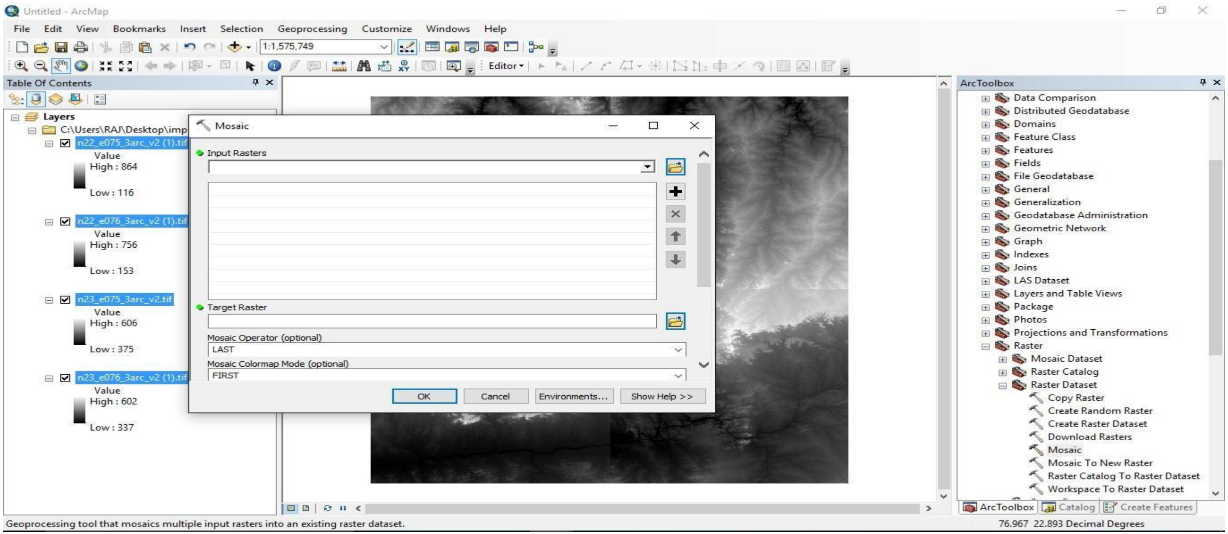


Image: A3

After creating raster dataset of the images “MOSAIC” command is used to create mosaic image of all the images. Image A3 shows the pop up window of the mosaic tool. In this all the images are added as “input raster” and previously created raster dataset is added to target raster. In mosaic operator “first” is selected and in mosaic colour map mode “last” is selected and in all other tabs “0” is assigned.

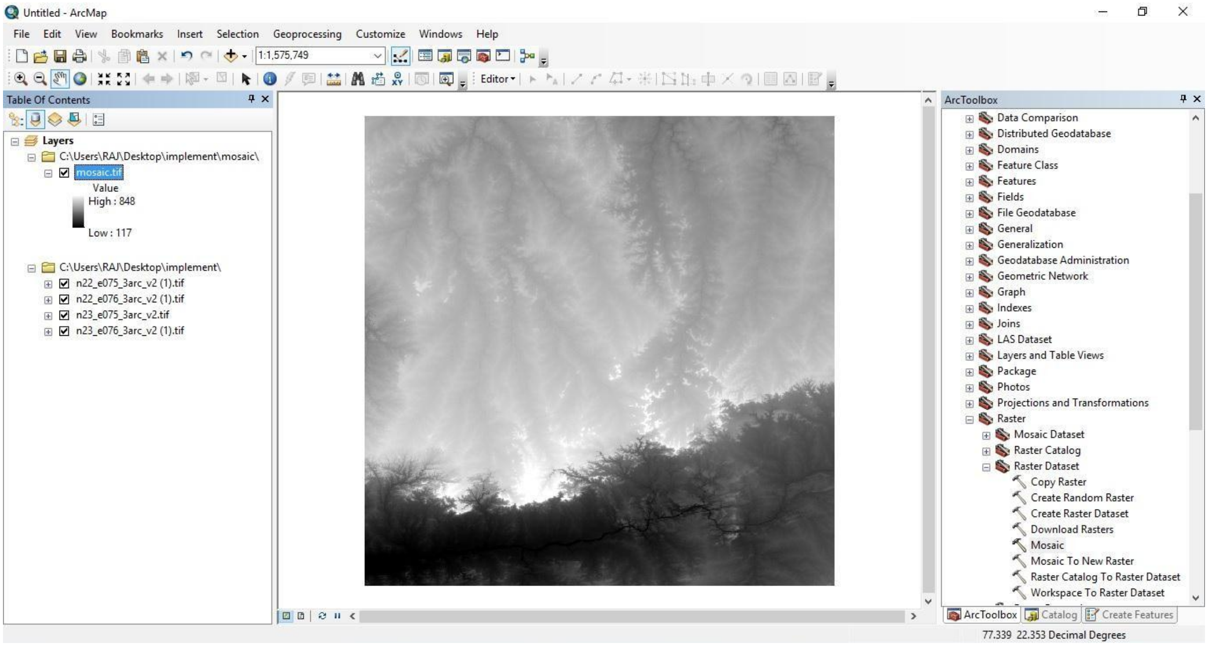


Image: A 4

Image A4 shows the mosaic image of all the images.

A2. Creating Shape File and Extraction Of Selected Study Area

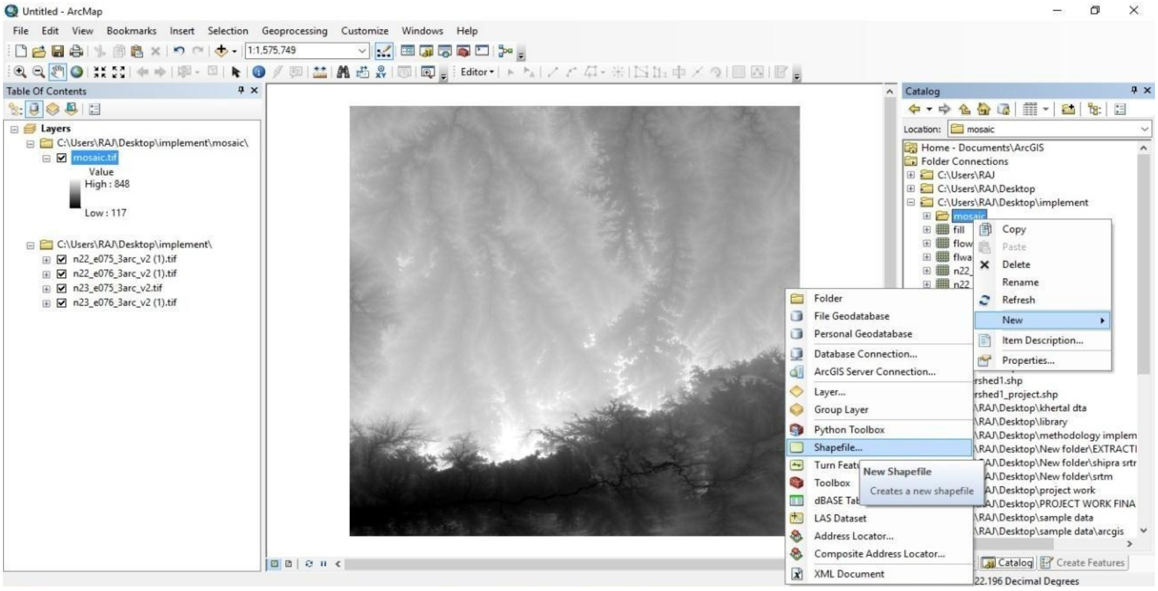


Image: A5

To create a shape file following successive commands are use:

"Catalog tab"-> right click on the folder containing data -> "new" -> "shapefile". Image A5 shows all commands used to create a shapefile.

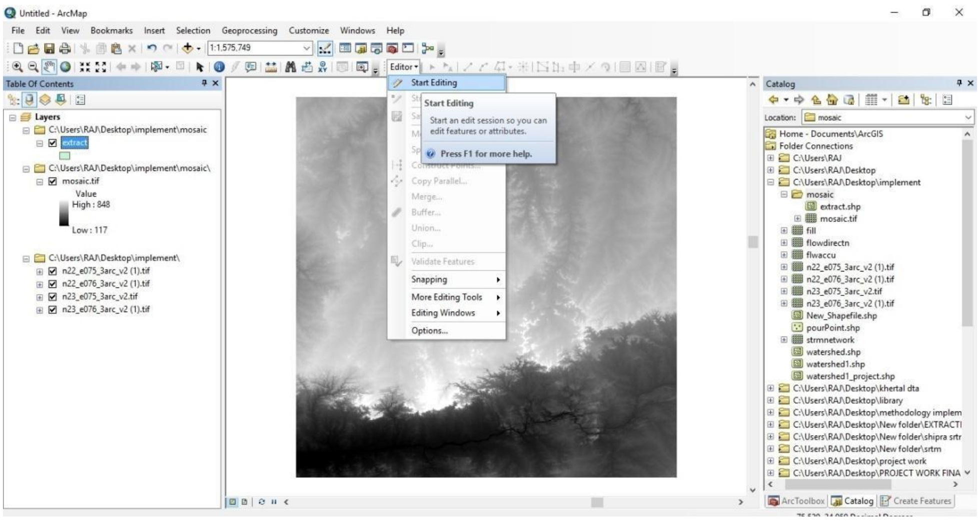


Image: A6

After creation of shape file "editor" tool is used to edit shape file. In this process "start editing" is used for start editing of shape file. Image A6 shows how editing of shape file was started.

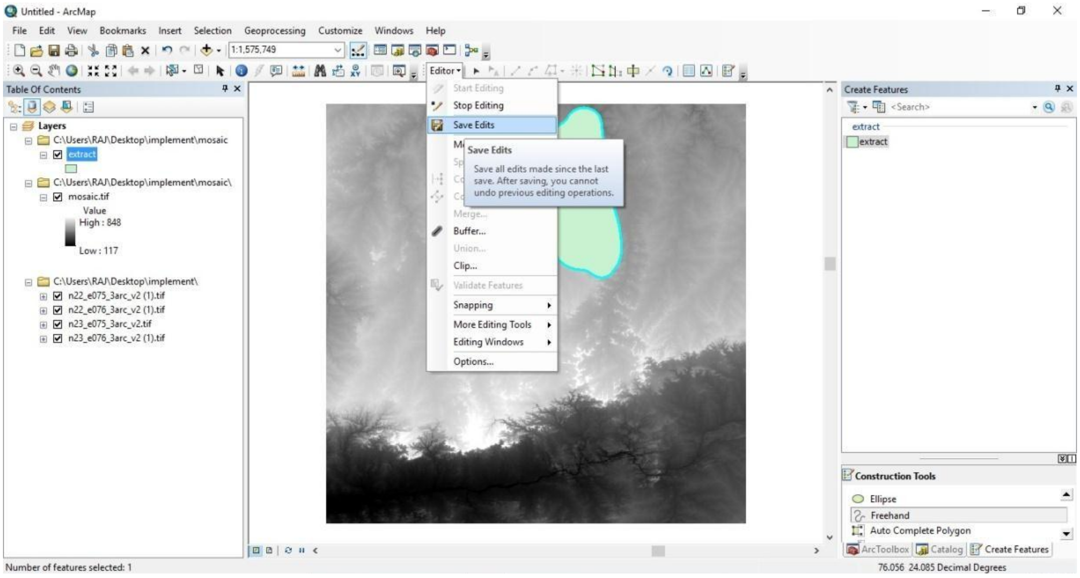


Image: A7

ImageA7 shows few steps are "create feature" -> "shape file(name)" "freehand" -> study area selection" -> "save edit" -> "stop edit".

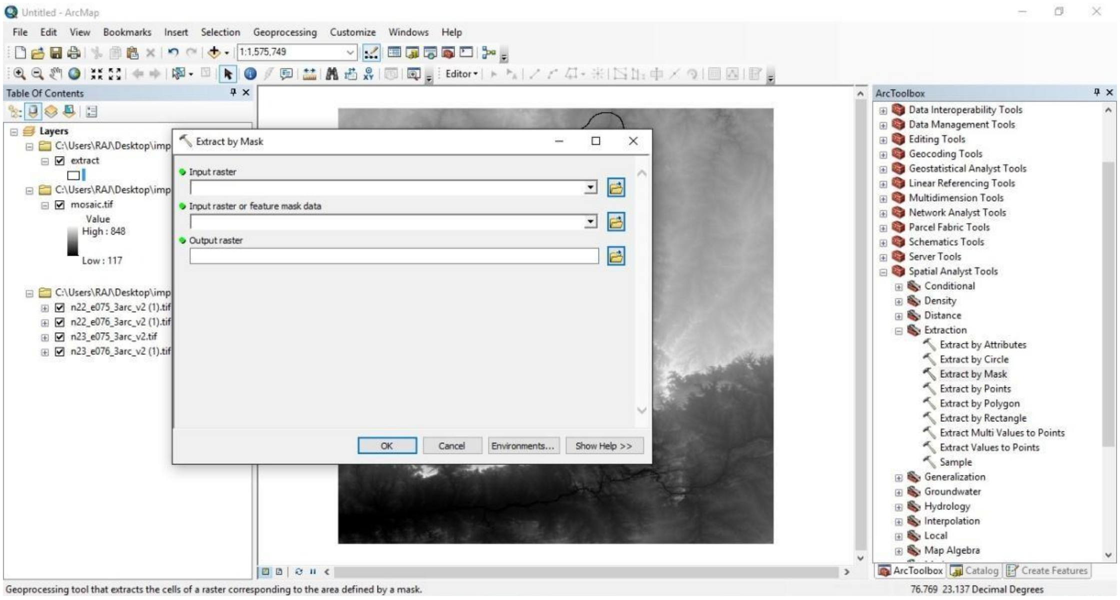


Image: A8

To extract the study area “spatial analyst tool” -> extraction” -> “extraction by mask” is used. Image A8 shows the pop up window of “extraction by mask” tool, in this mosaic file is added in input raster , shape file is added to input mask data.

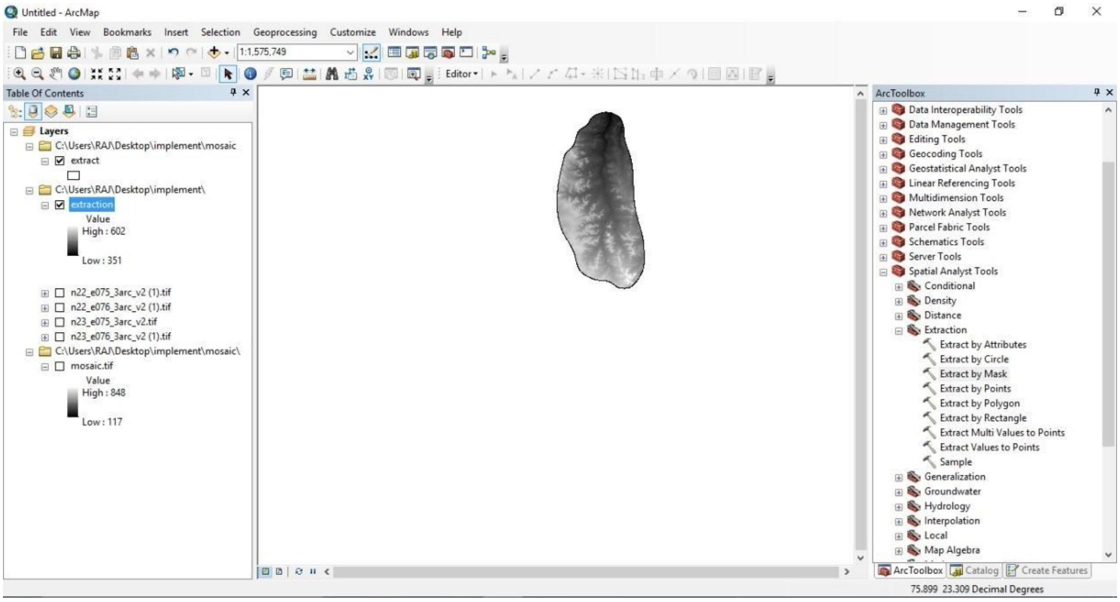


Image: A9

Image A9 shows the extracted image of study area from mosaic image.

A3. Image Processing in ArcGIS

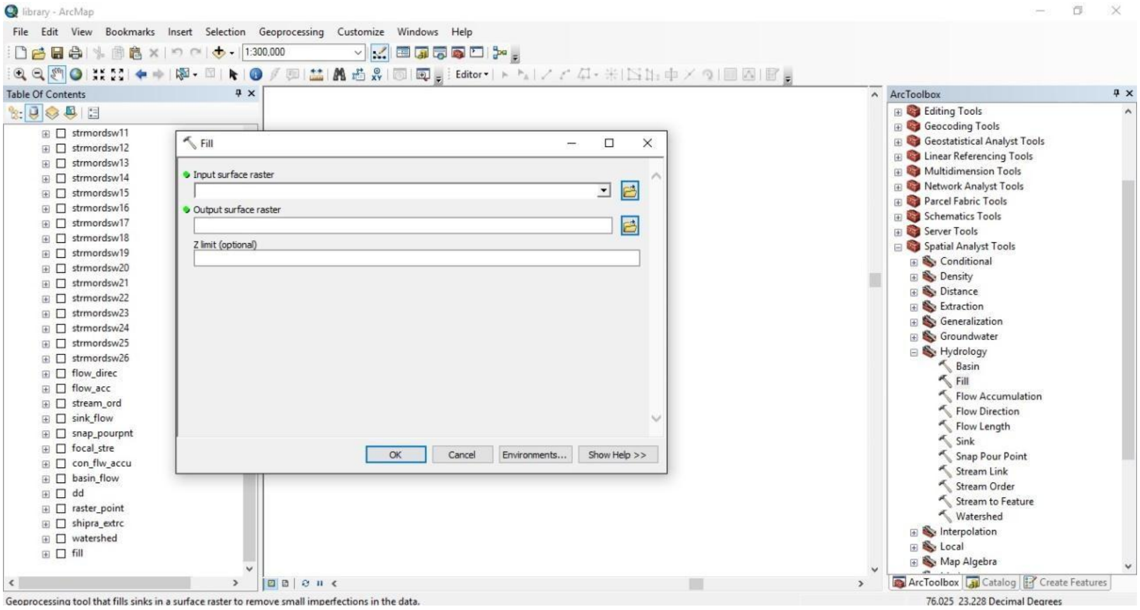


Image A10

In order to escape depressions, the DEM was further conditioned to remove the pits and flat areas using FILL. The steps of using fill command is “arc toolbox” -> “spatial analyst tool” -> “hydrology” -> “fill”. Image A10 shows the pop up window of fill command, in input raster tab extracted study area is inserted.

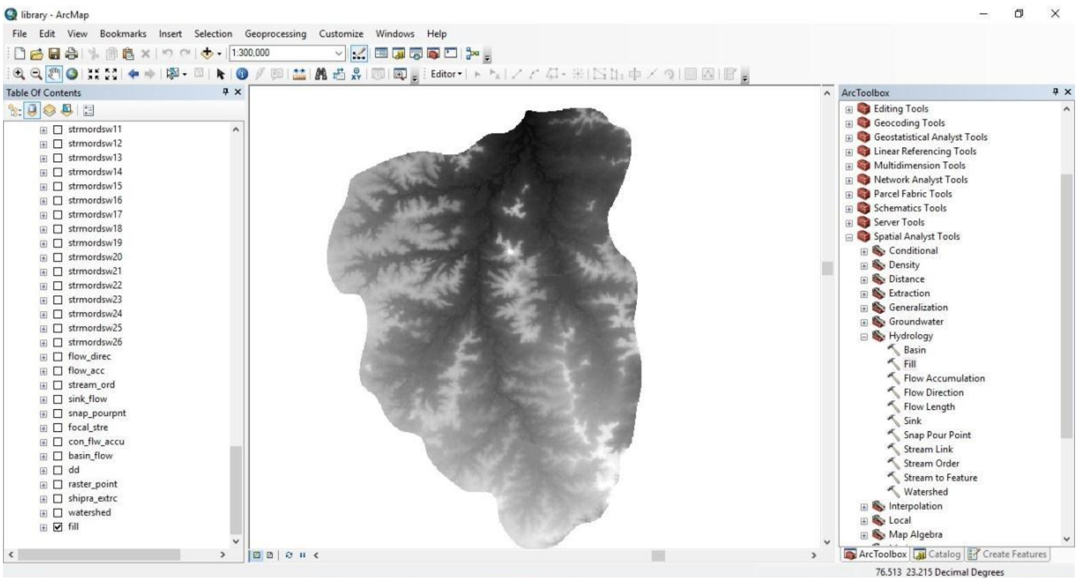


Image A11

Image A11 is showing filled image of the area. It is free from pits and flat areas.

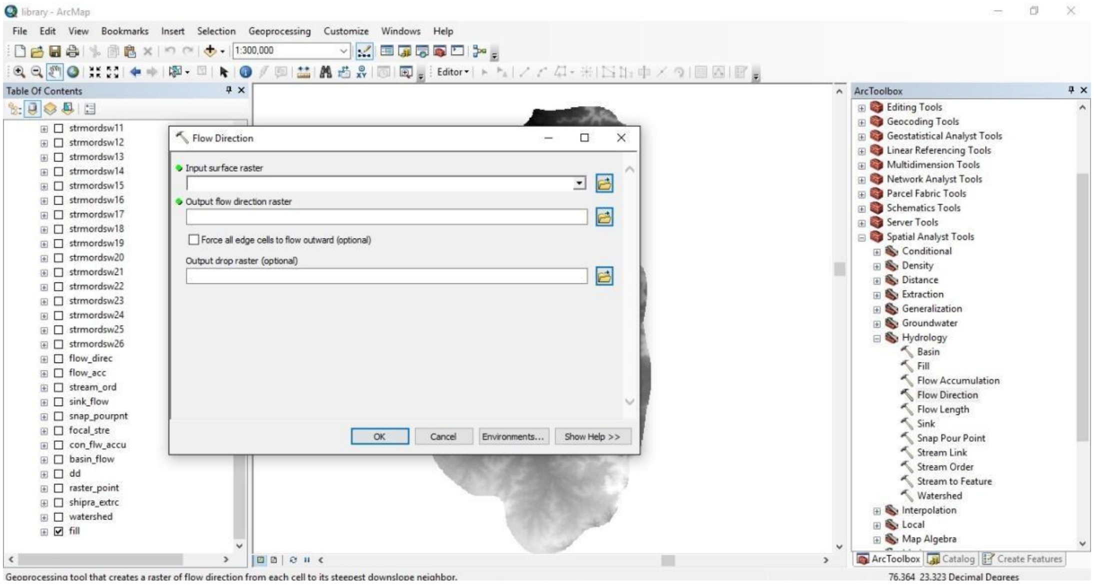


Image A12

To trace the direction of flow in each cell “flow direction” tool is used in the study. The order of command to find flow direction map is “arc toolbox” -> “spatial analyst tool” -> “hydrology” -> “flow direction”. Image A12 shows the pop up window of the flow direction tool.

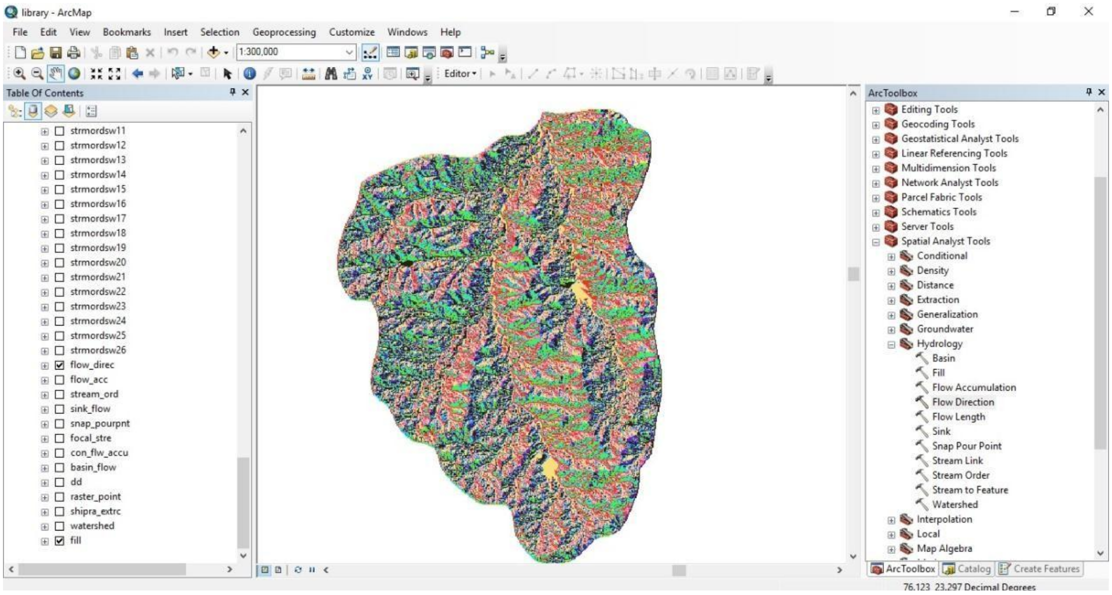


Image A13

Image A13 shows the flow direction map of the study area.

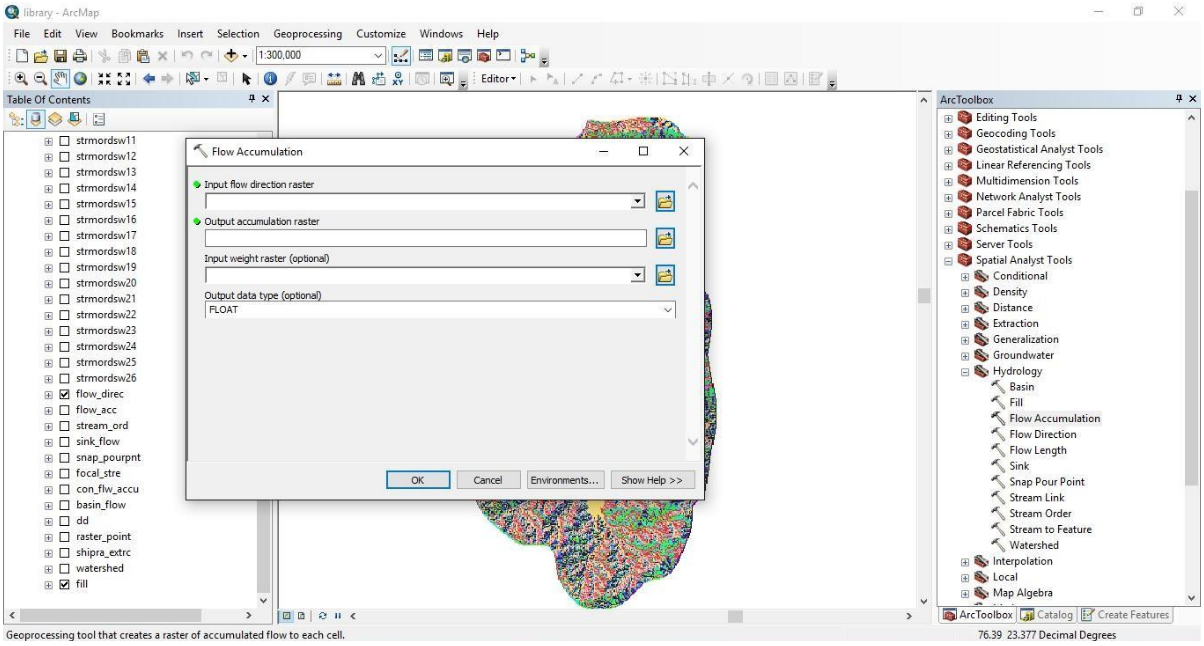


Image A14

After flow direction ,flow accumulation is the thing which has to be identify. In flow accumulation map the flow in the streams are accumulated and the path of the streams and bifurcation points are identified in flow accumulation map. To find the flow accumulation map these following command are used in the study is “arc toolbox” -> “spatial analyst tool” -> “hydrology” -> “flow accumulation”. Image A14 shows the pop up window of the flow accumulation tool.

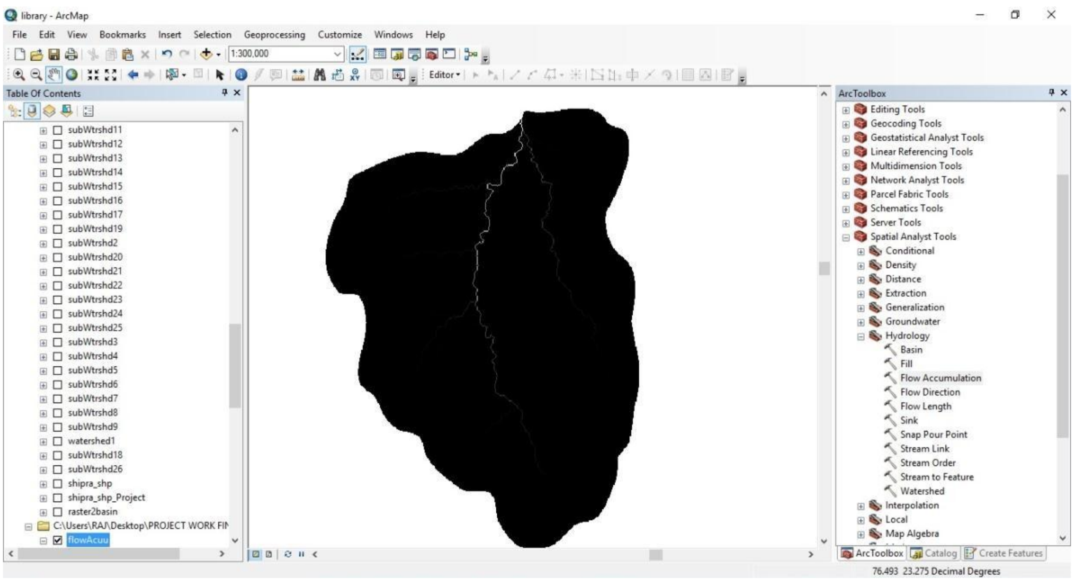
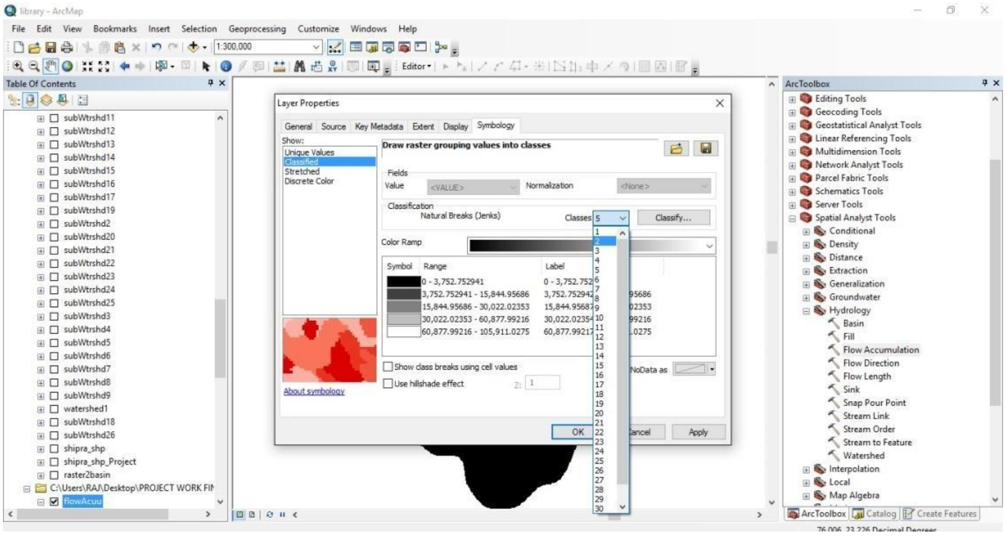


Image A15

Image A15 shows the flow accumulation map of the study area. But in this map very less streams are identified. To trace more stream flow different options are used in the below images.



ImageA16

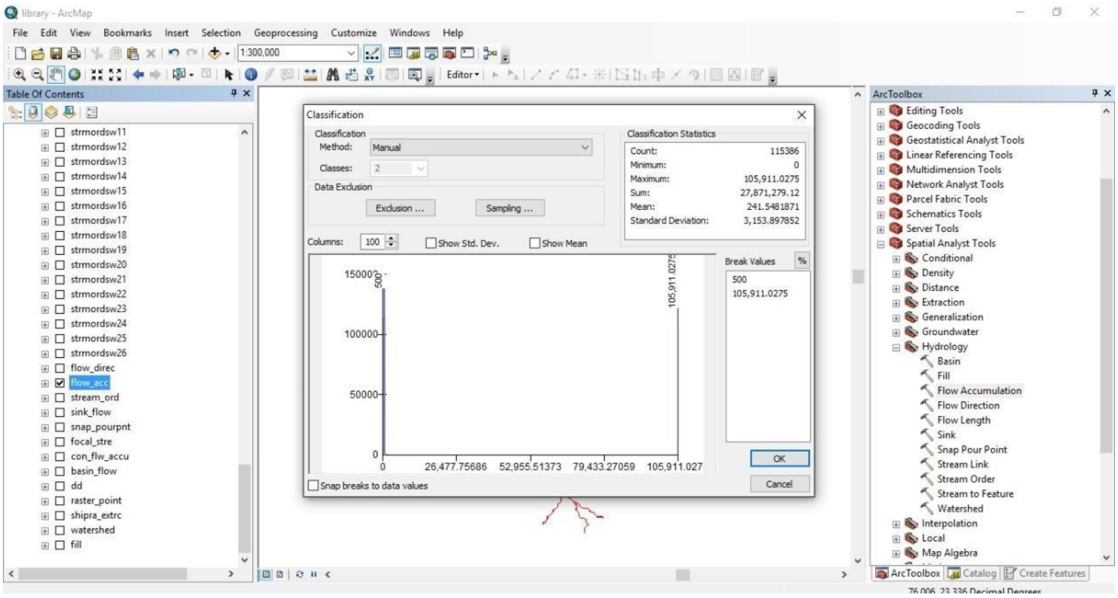


Image A17

Right click on the file of flow accumulation map -> properties -> classified. In this study only two classes are selected (image A16) i.e. for water and land only and break value 500 is in order to trace more water streams then previous map (imageA17).

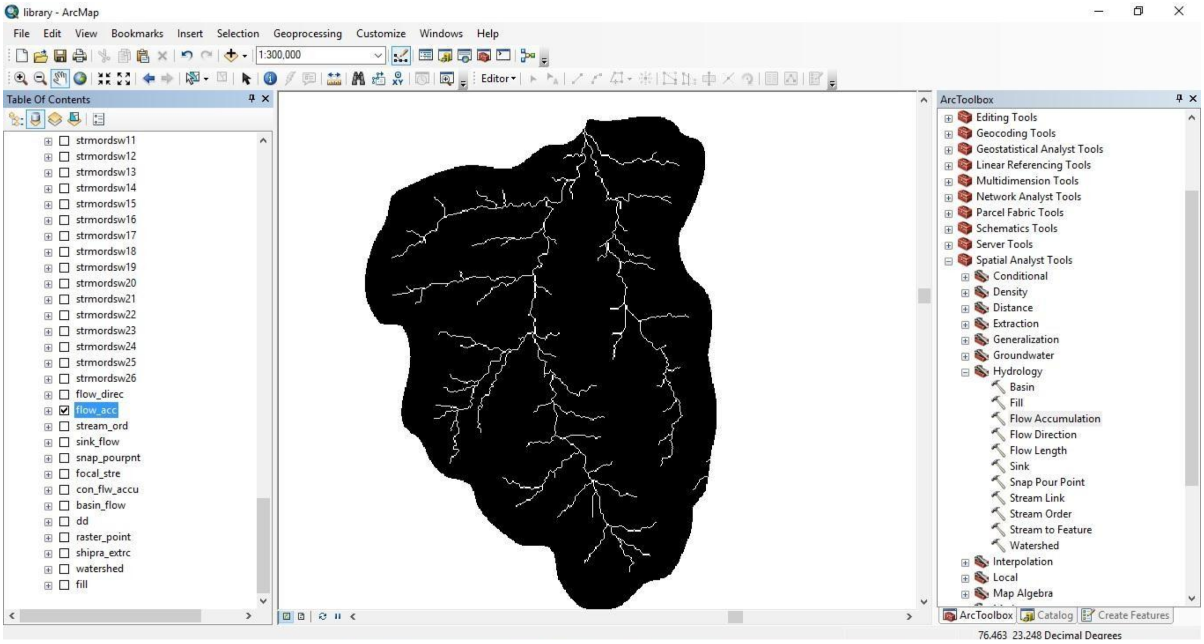


Image A18

Image A18 shows the flow accumulation map with traced streams.

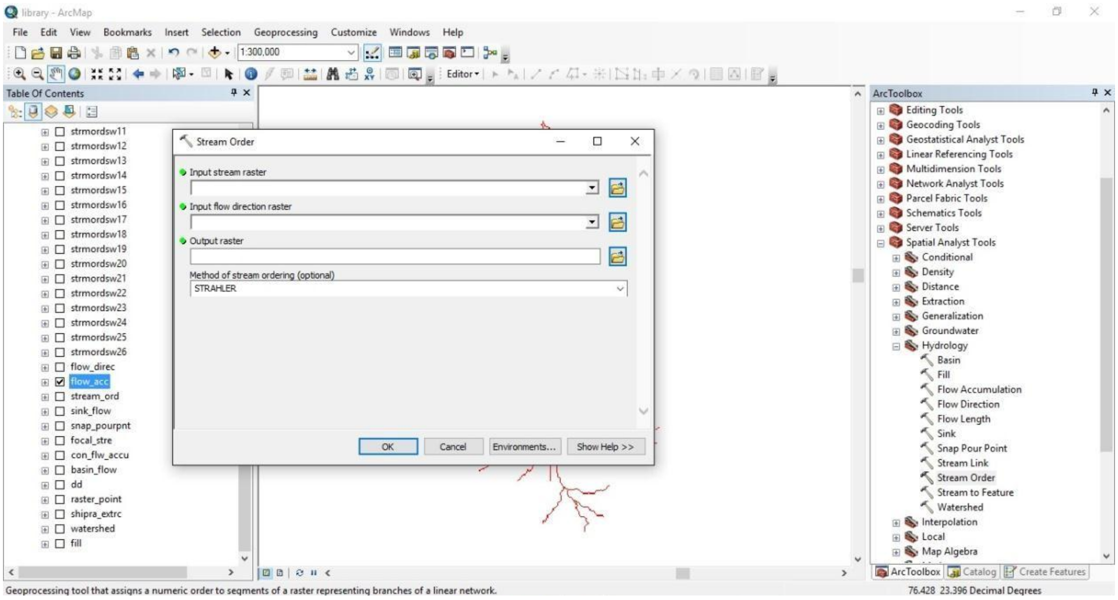


Image A19

In order to extract stream network in the study area stream order command is used. Image A19 shows the pop up window of the stream order tool.

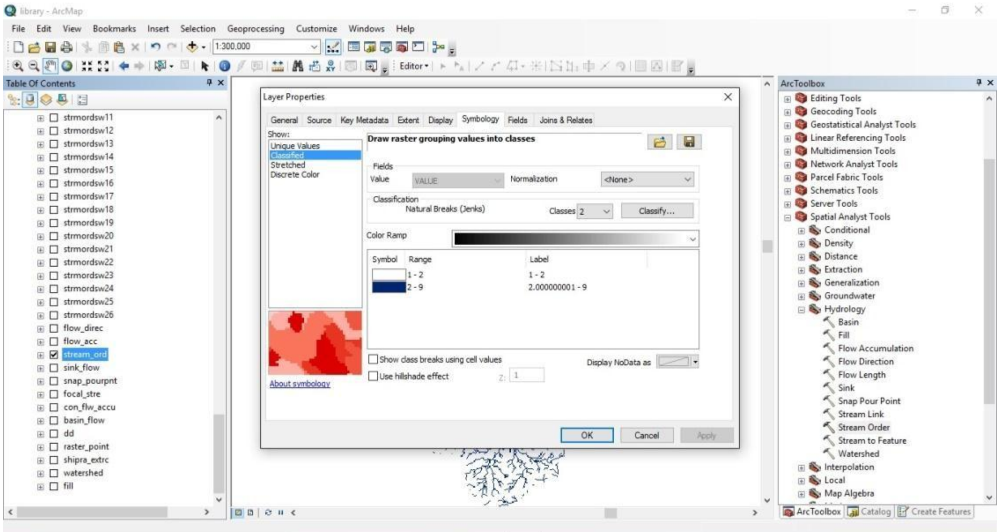


Image A20

In stream order map once again it is classified in two classes only i.e. land and water streams, to show best output image of stream network in the study area. Image A20 shows the snapshot of the pop up window of the properties tool of stream network map.

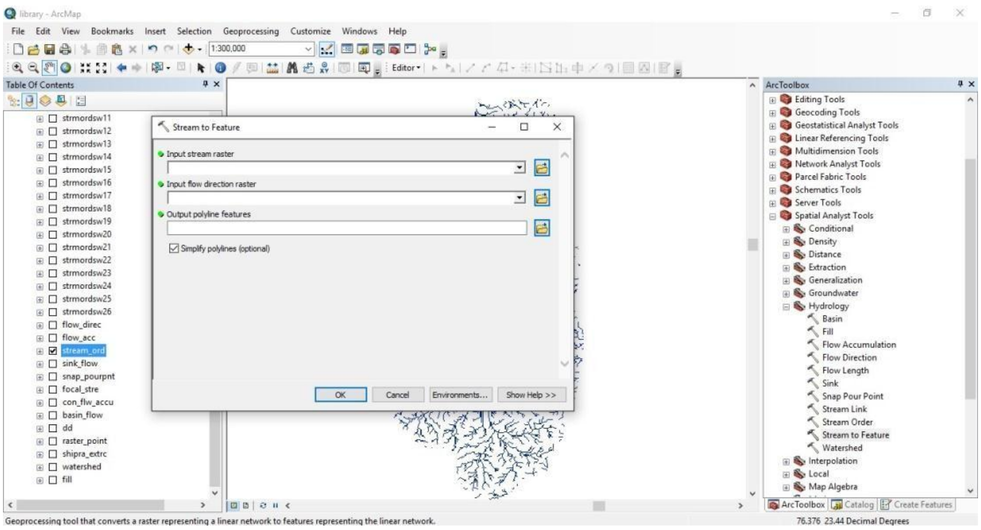


Image A21

It is very necessary to identify the order of the streams of the study area to do morphological study of the area. To find the order map of the streams "stream to feature" is used in the study. Image A21 shows the pop up window of the stream to feature tool.

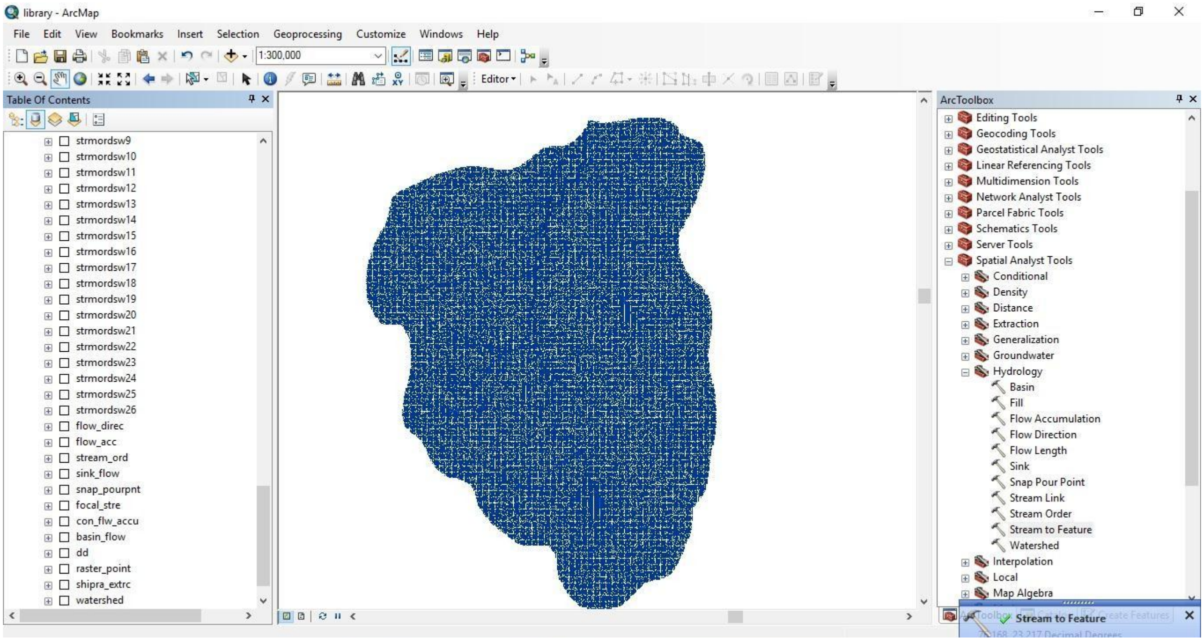
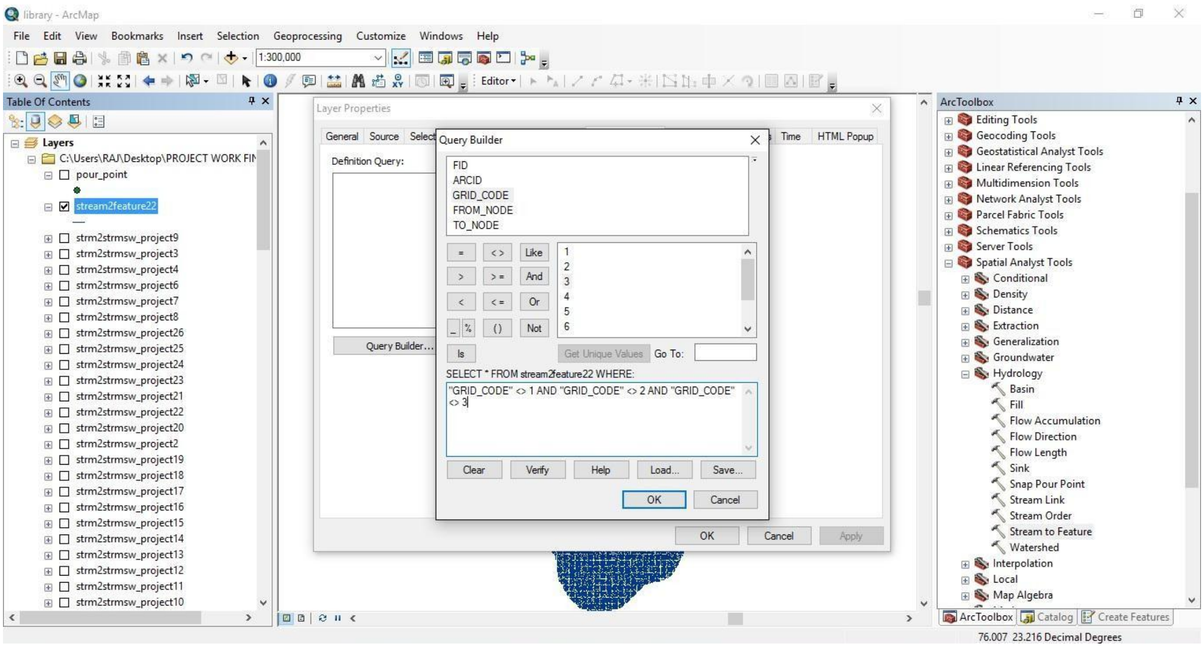
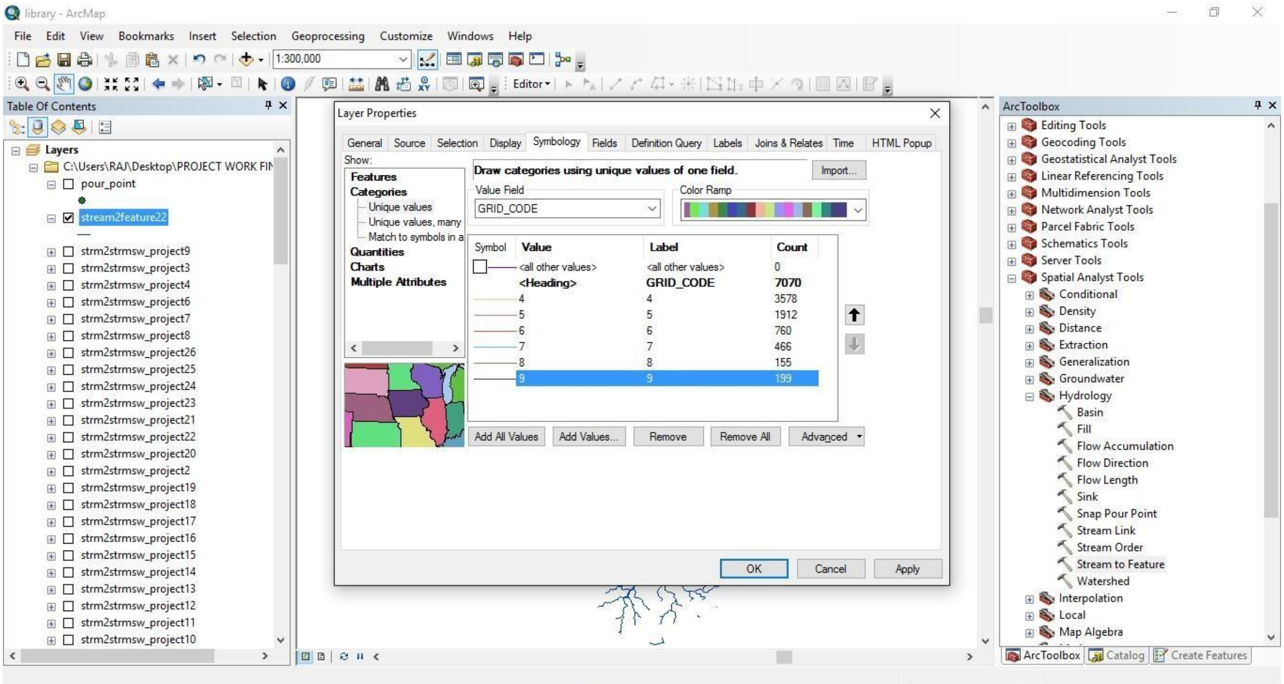


Image A22

Image A22 shows the stream to feature map of the study area. This map is almost unreadable, in order to make easy for study further changes area applied to this map which are explained below.



ImageA23



ImageA24

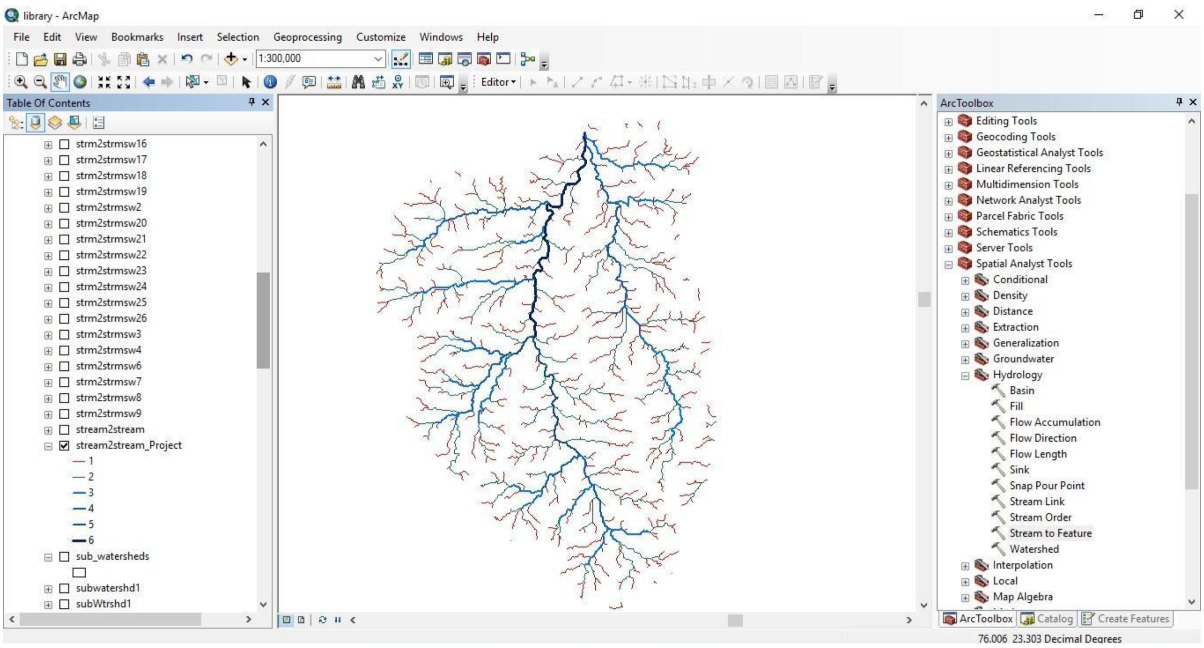


Image A25

To make stream to feature map readable few changes are made in the map to modify it. Steps are : right click on the map -> “layer properties” -> “definition query” -> query builder. In query builder type code “GRID_CODE <> 1 AND GRID_CODE <> 2 AND GRID_CODE <> 3”. This code is used to limit the stream order range of 4-6. Image A23 shows the window of the query builder. In the same section of layer properties select tab symbology. In this section different colour and thickness is given to the different order of streams in order to easily identify different order streams in the map (image A23 and image A25).

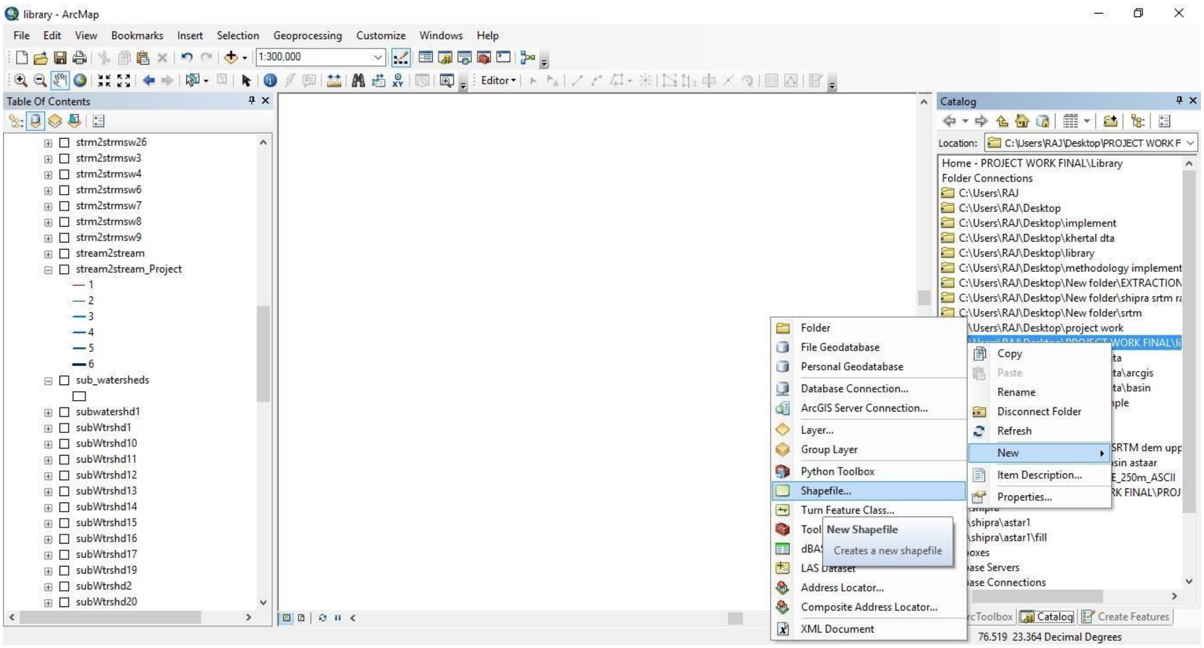
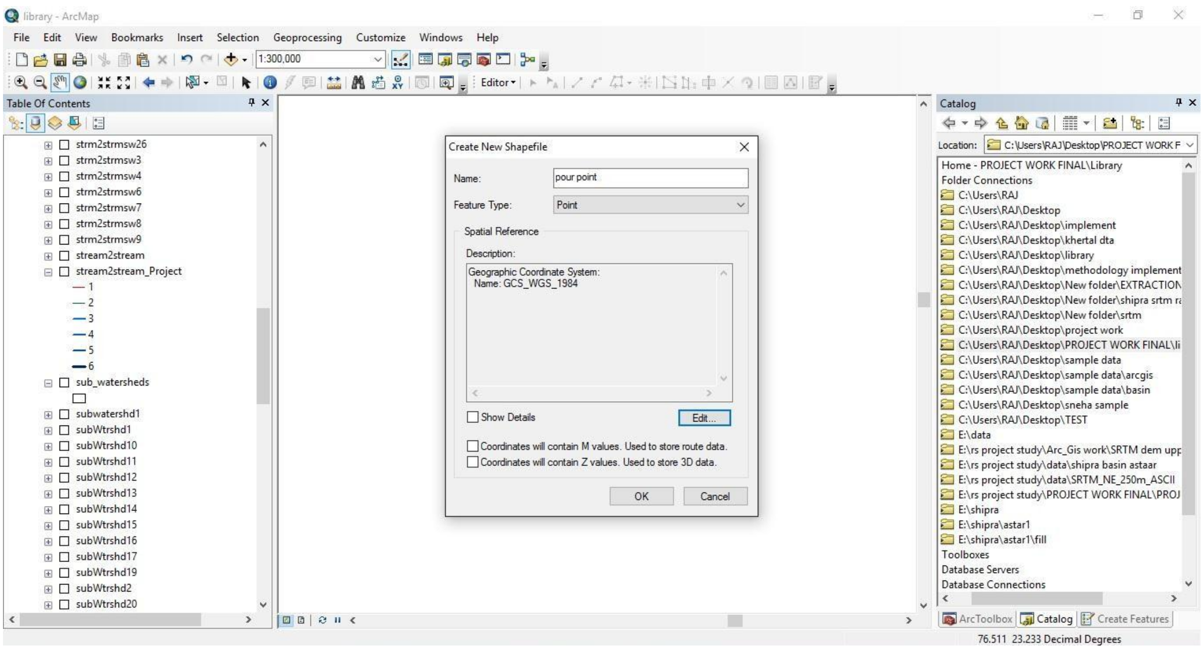
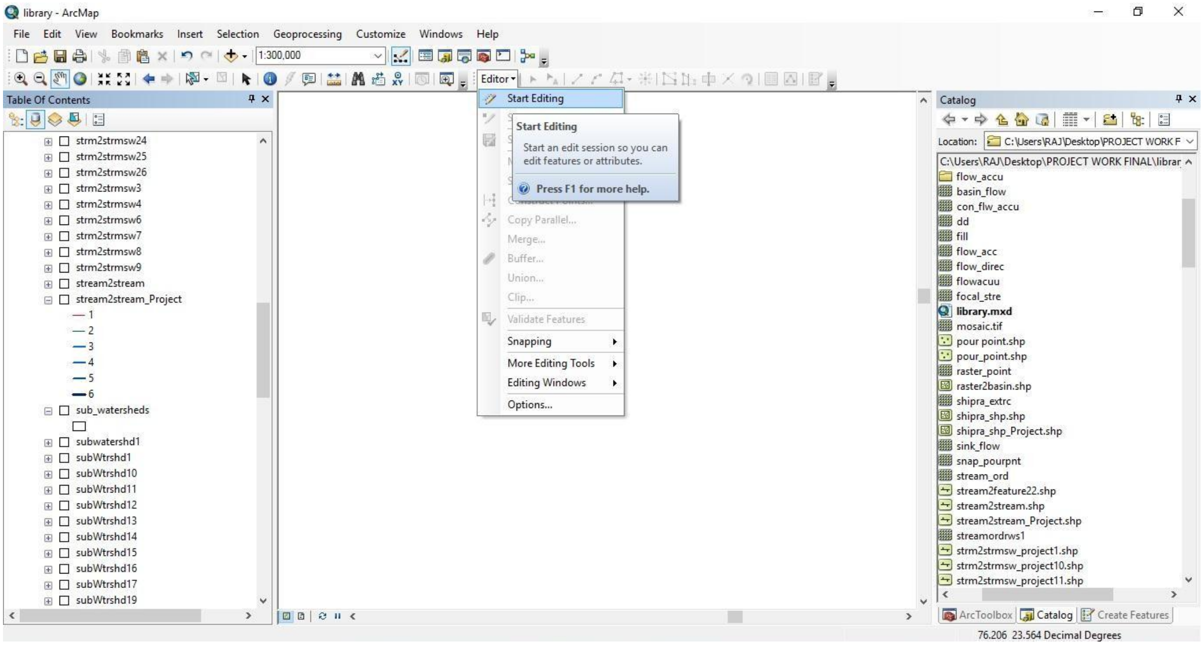


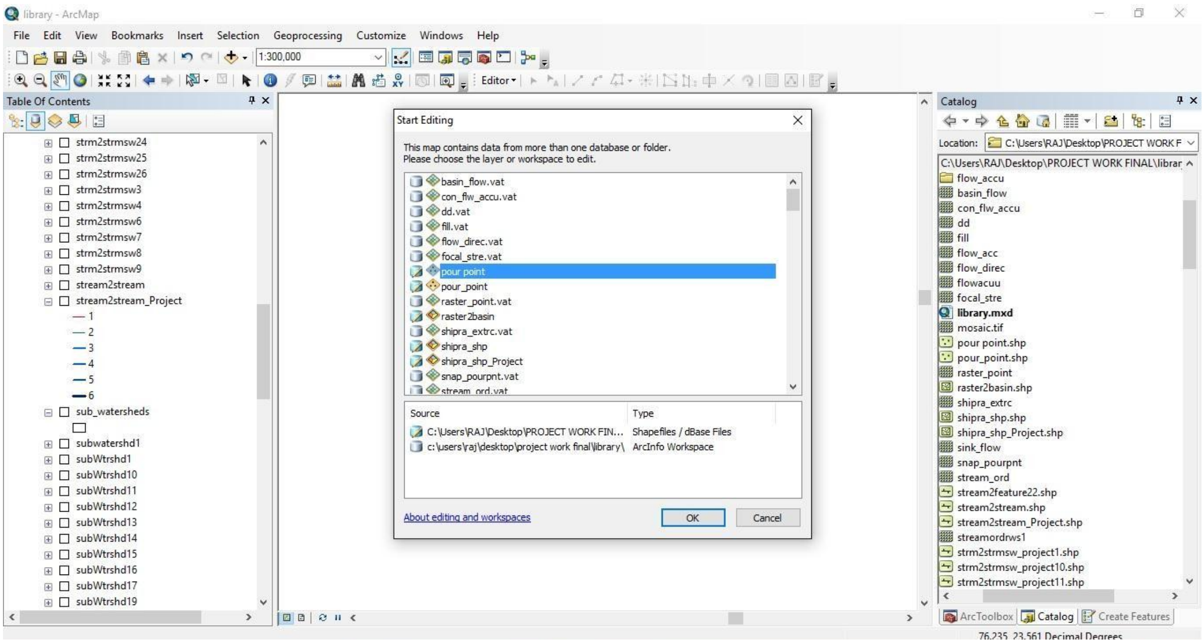
Image A26



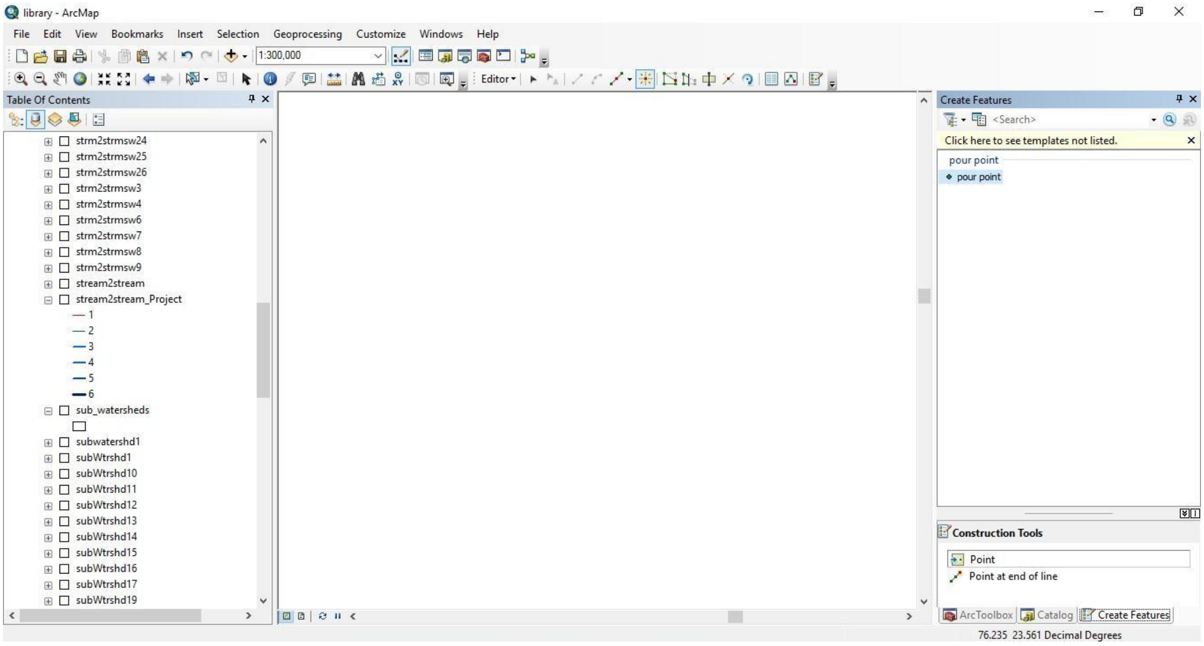
ImageA27



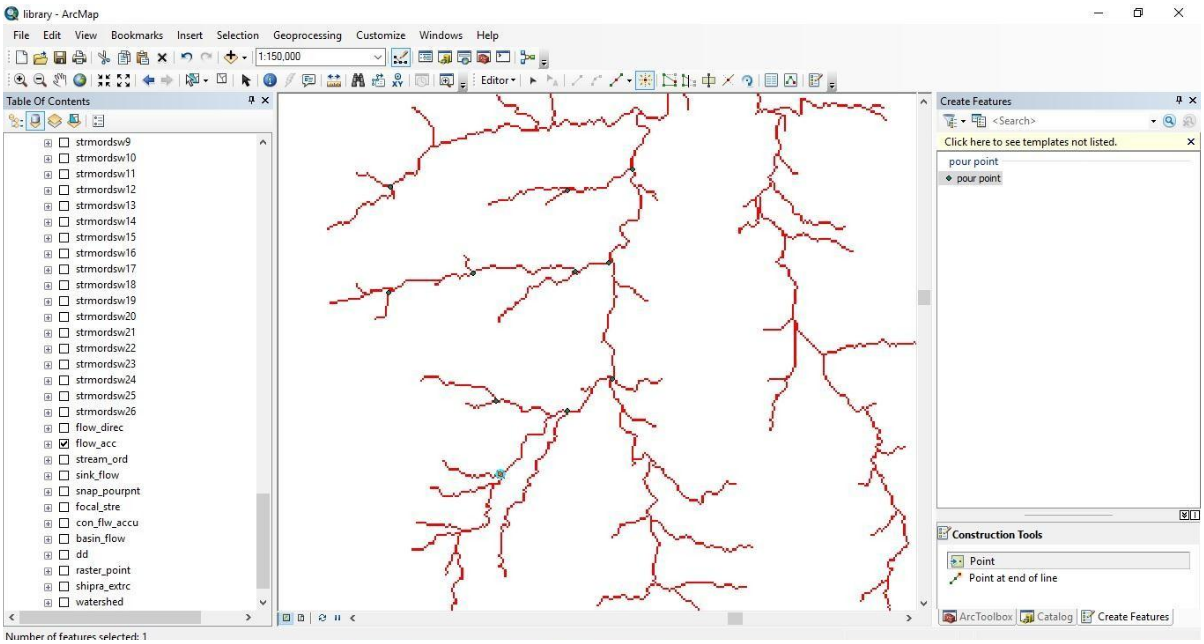
ImageA28



ImageA29



ImageA30



ImageA31

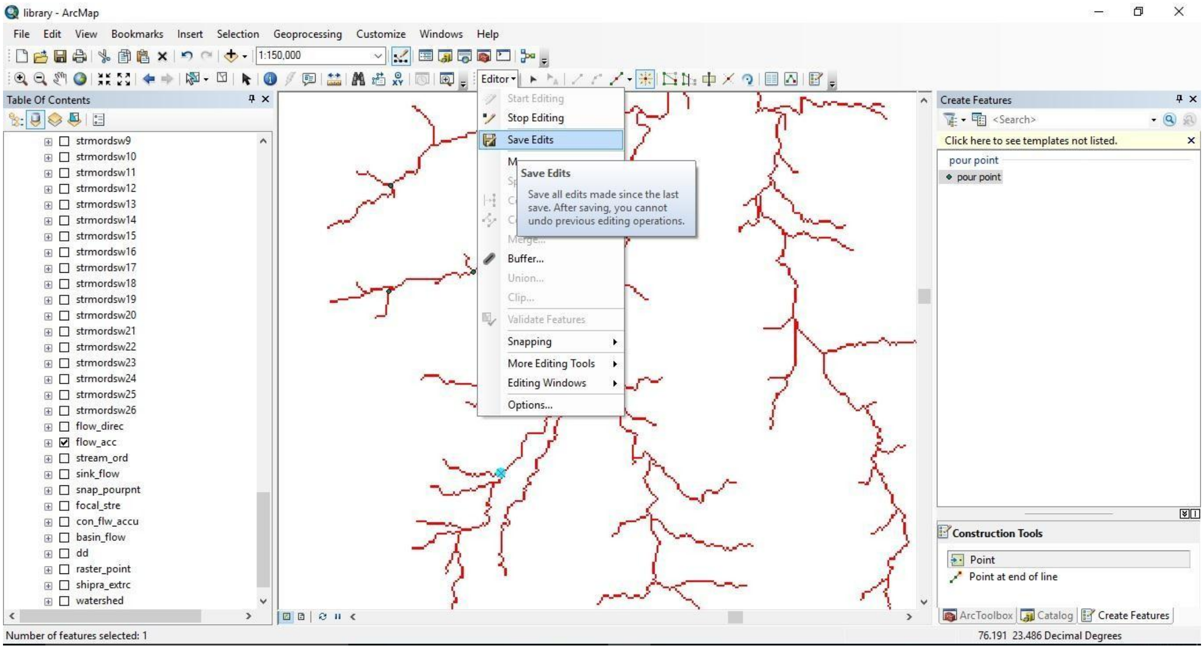


Image A32

After preparing all the maps it is required to give pour points to the flow accumulation map at all the pour points i.e. at all the bifurcation points of the streams. These pour points helps in delineating the sub watershed inside the study area. To mark these pour points point shape file is used in this study.

Steps for creating shape file are: catalog -> right click on the folder of study -> new shape file -> point. Image A26 to image A32 shows the software window of all the command included.

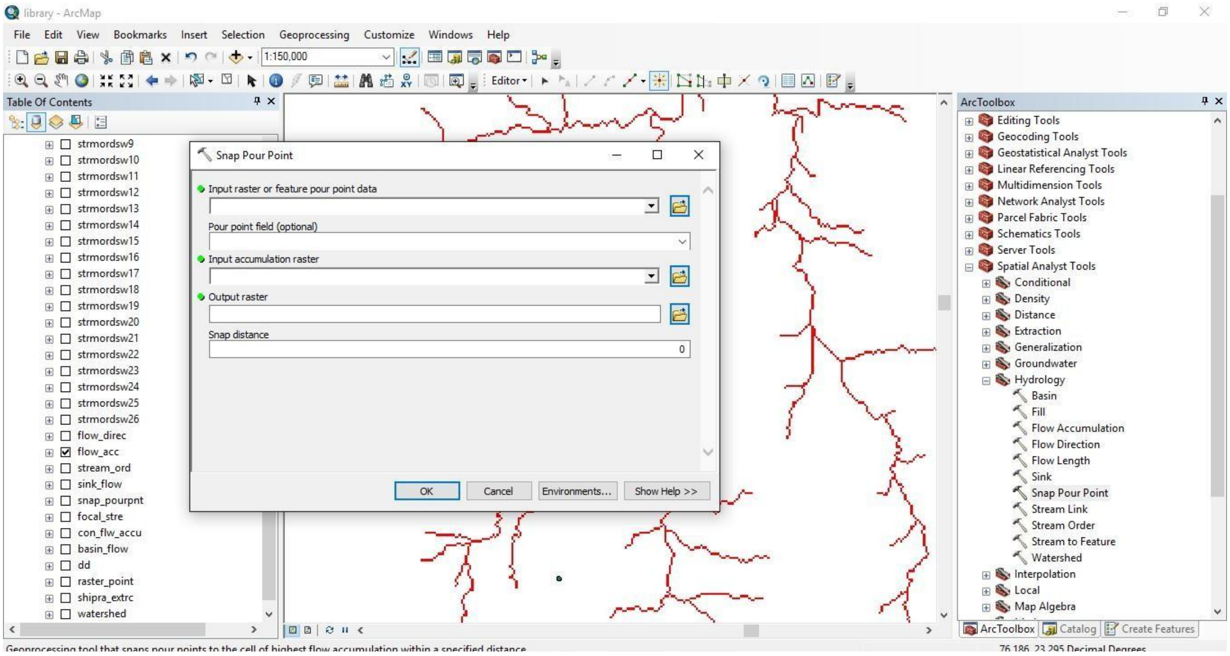


Image A33

Snap pour point tool is used to fix all the pour points by using shape file of pour points on flow accumulation map. The steps of command used are: “arc toolbox” -> “spatial analyst tool” -> “hydrology”-> “snap pour point”. Snap pour point file is used further to divide whole study area in different sub watersheds. Image A33 shows the pop up window of snap pour point tool.

A4: Sub Watershed Delineation in ArcGIS

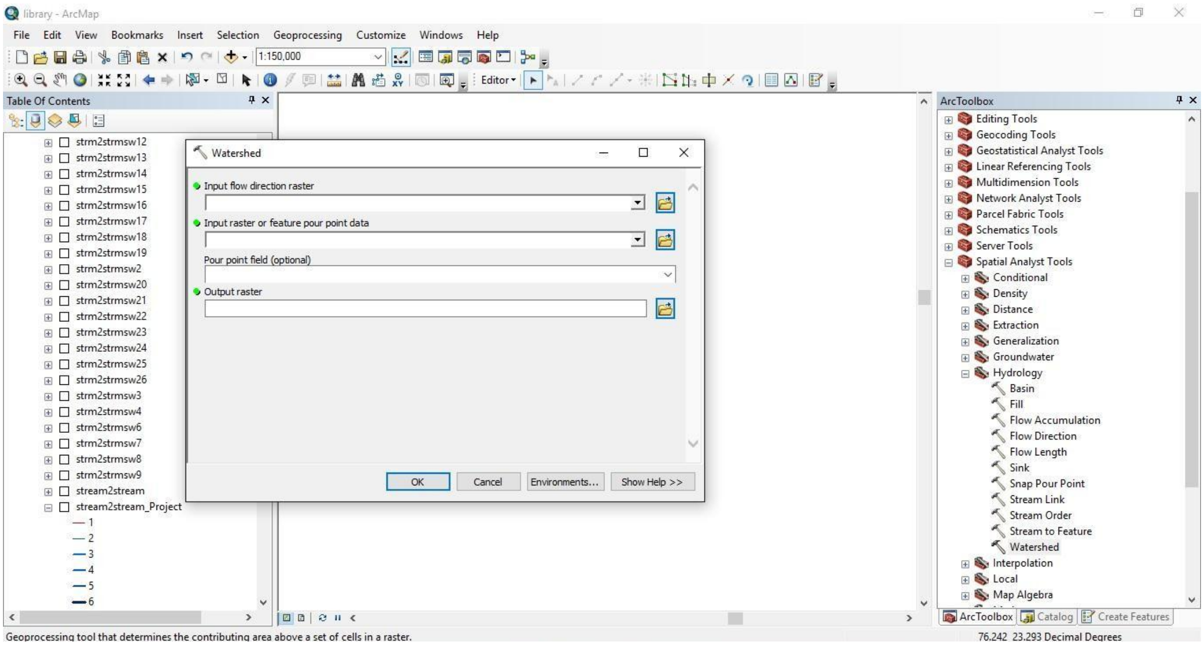


Image A34

To delineate sub watersheds from study area watershed tool is used in the study. Commands to use watershed tool are: “arc toolbox” -> “spatial analyst tool” -> “hydrology” -> “watershed”.

Image A34 shows the pop up window of the watershed tool. In this flow direction raster is inserted in first tab and snap pour point raster is taken as input in the second tab.

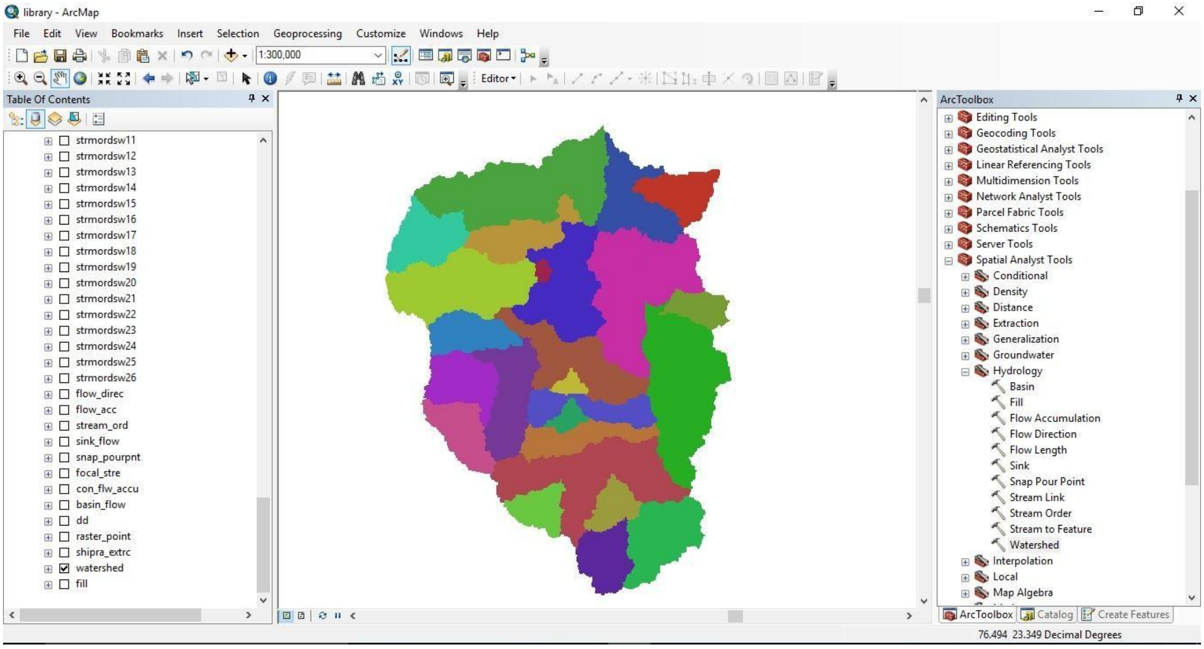


Image A35

Image A35 is showing the different sub watershed in the study area, delineated by using watershed tool.

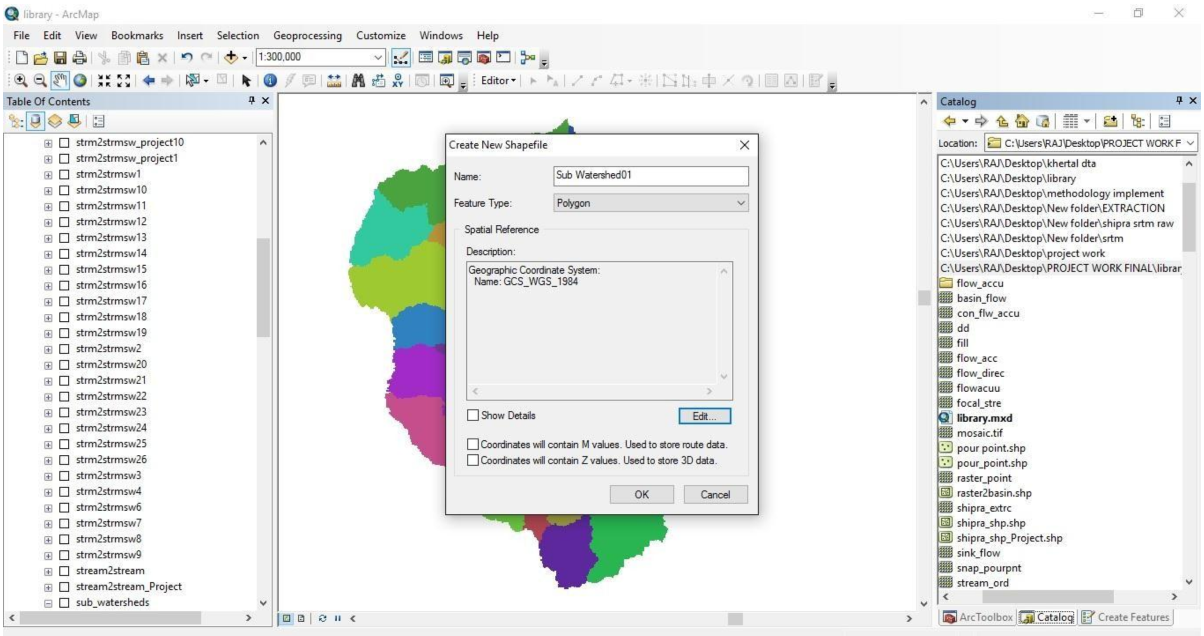


Image A36

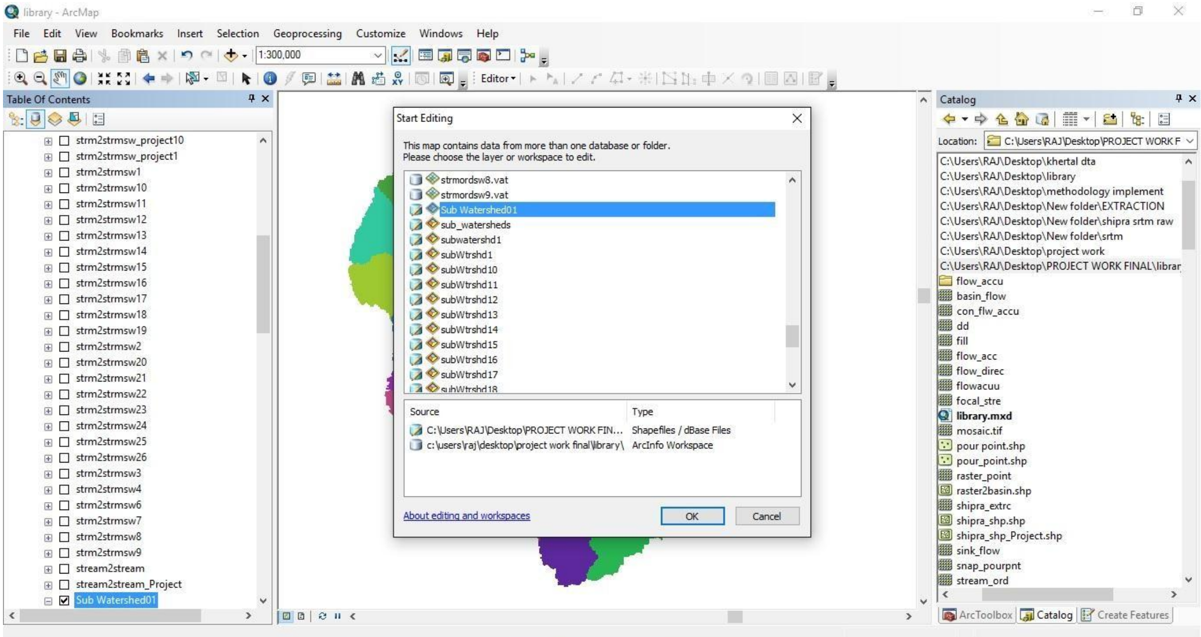


Image A37

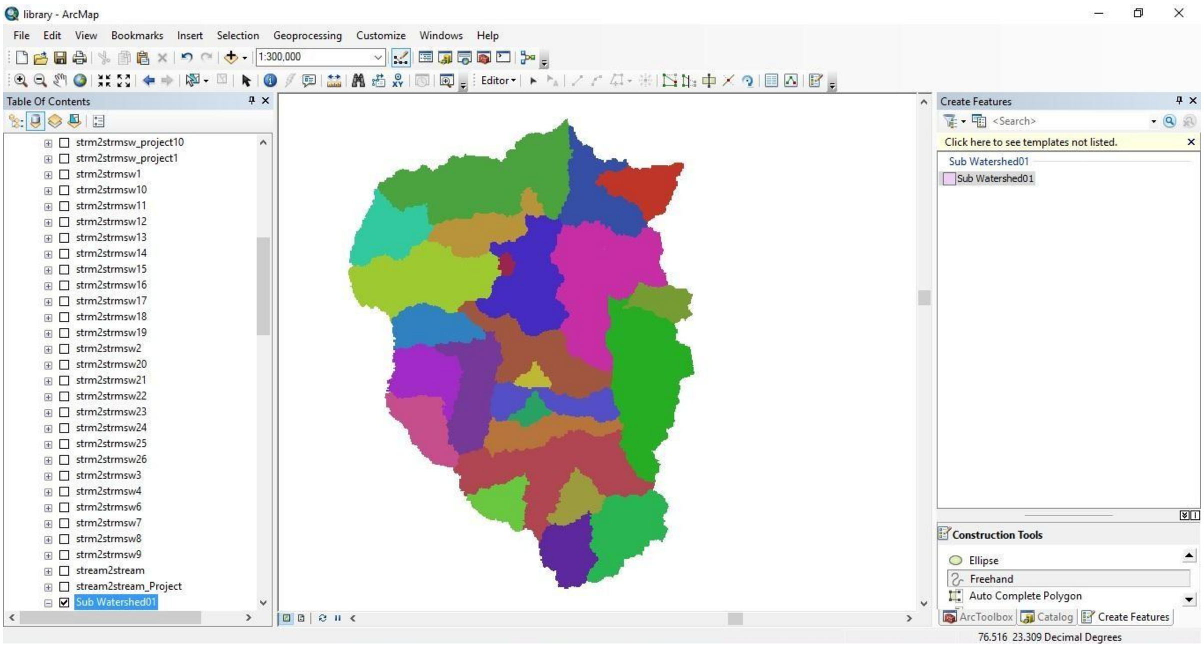


Image A38

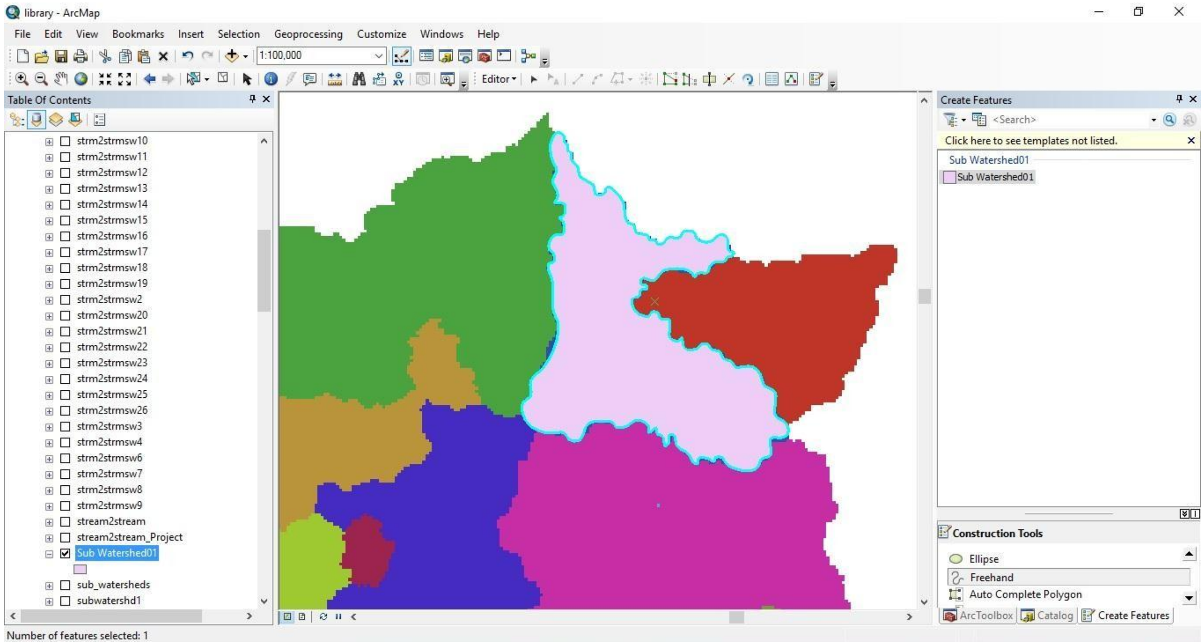


Image A39

To calculate all the morphological parameters and basic parameters for each sub watershed, one sub watershed is taken to demonstrate the method used in ArcGIS in appendix. Firstly shape file is created for one sub watershed. Image A36 to image A39 shows the pop up windows of all the step of shape file creation of selected sample sub watershed.

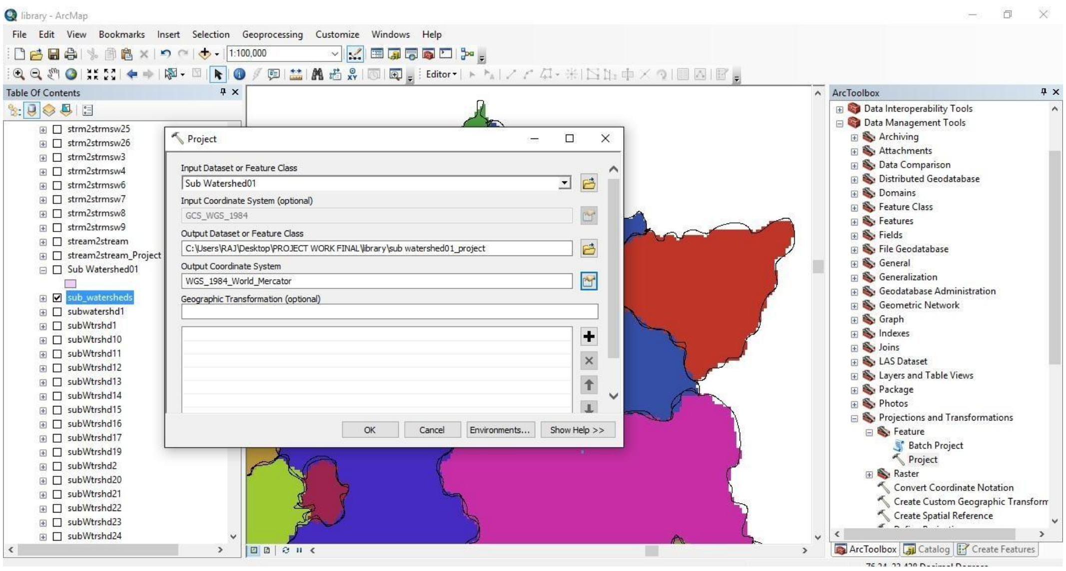


Image A40

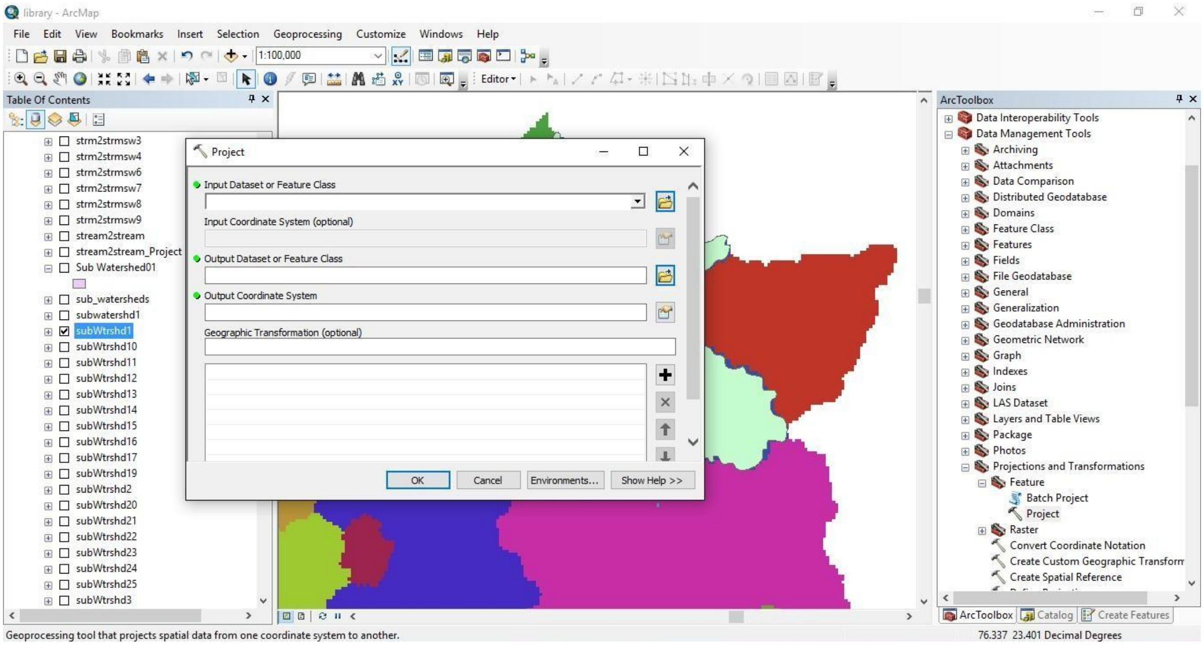


Image A41

All the images was in GCS_WGS_1984 coordinate system, but this coordinate system do not support mathematical calculation. To find all the parameters from the processed images these images are projected to WGS_1984_WORLD_MERCATOR coordinate system. Successive commands used in this process are “arc toolbox” -> “data management tool” -> “projection and transformations” -> “feature” -> “project”.

Image A40 and image A41 shows the pop up window of the “project” tool.

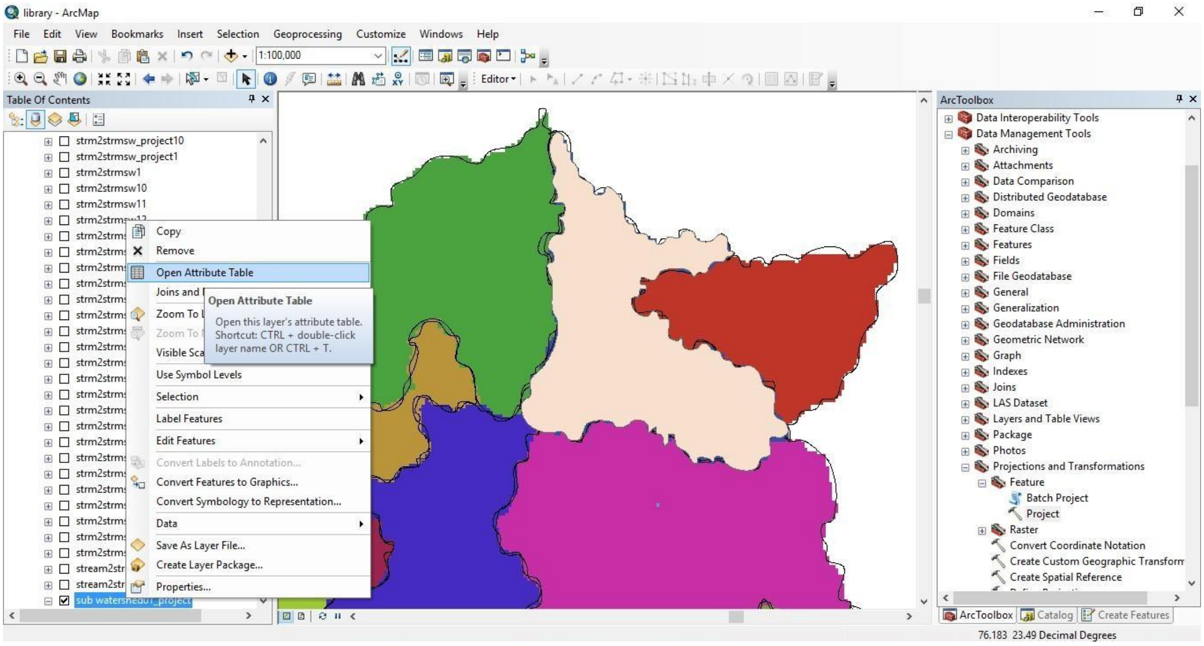


Image A42

Image A43

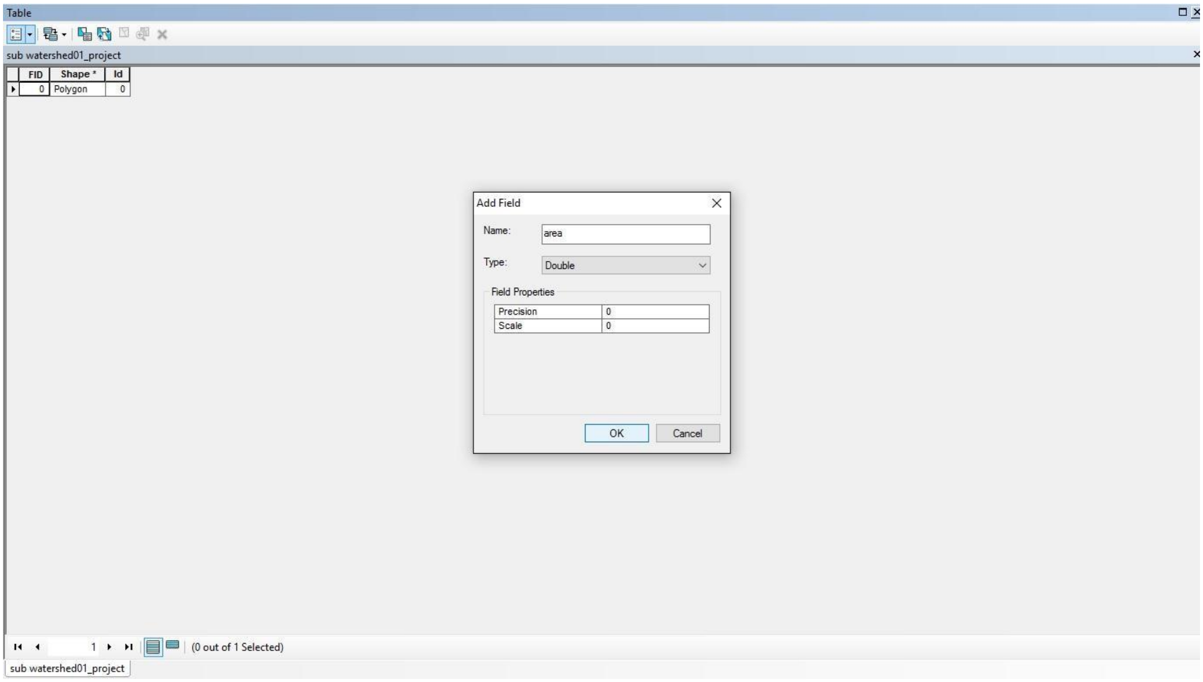


Image A44

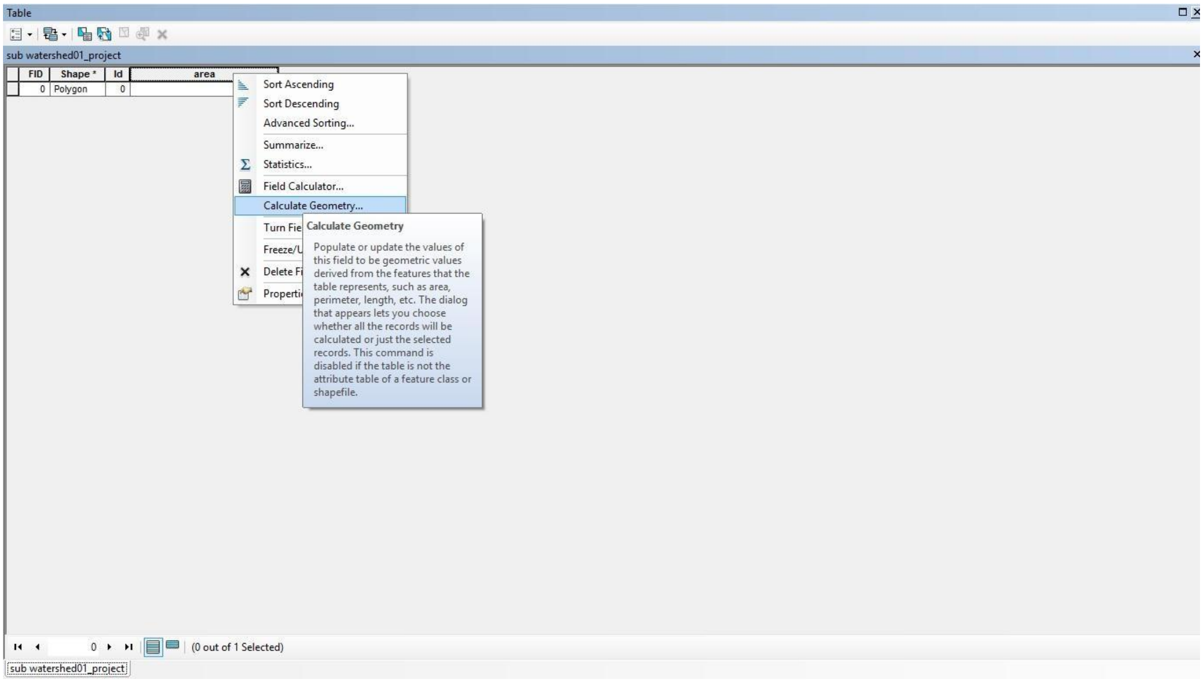


Image A45

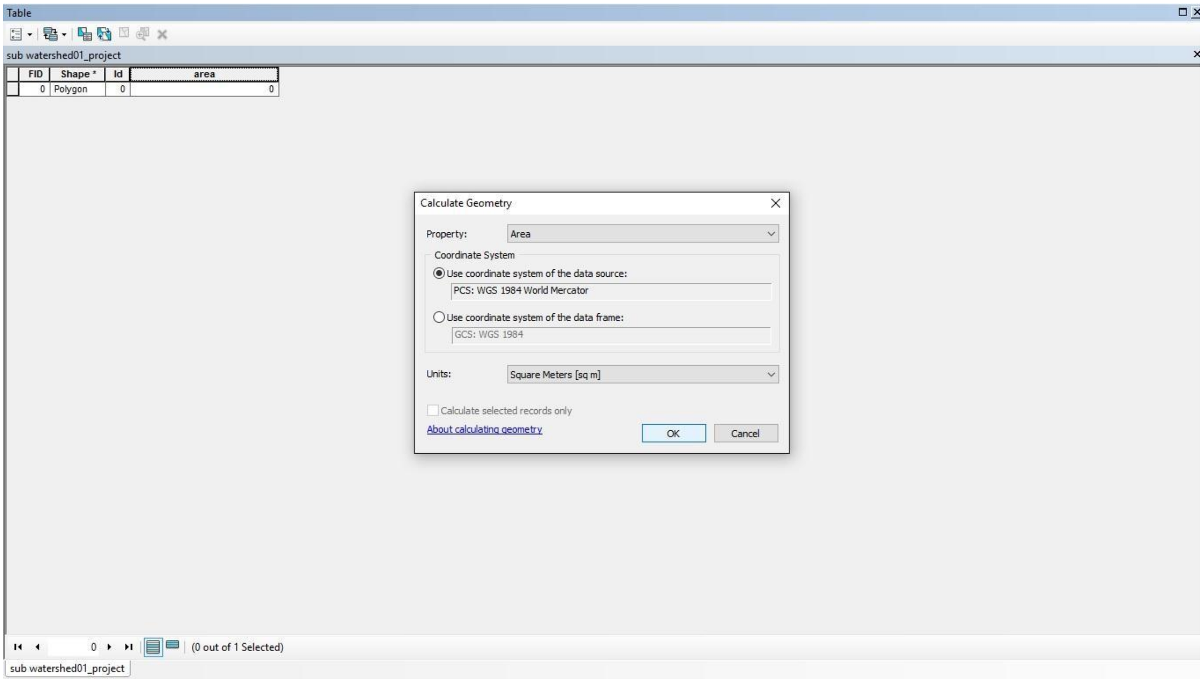


Image A46

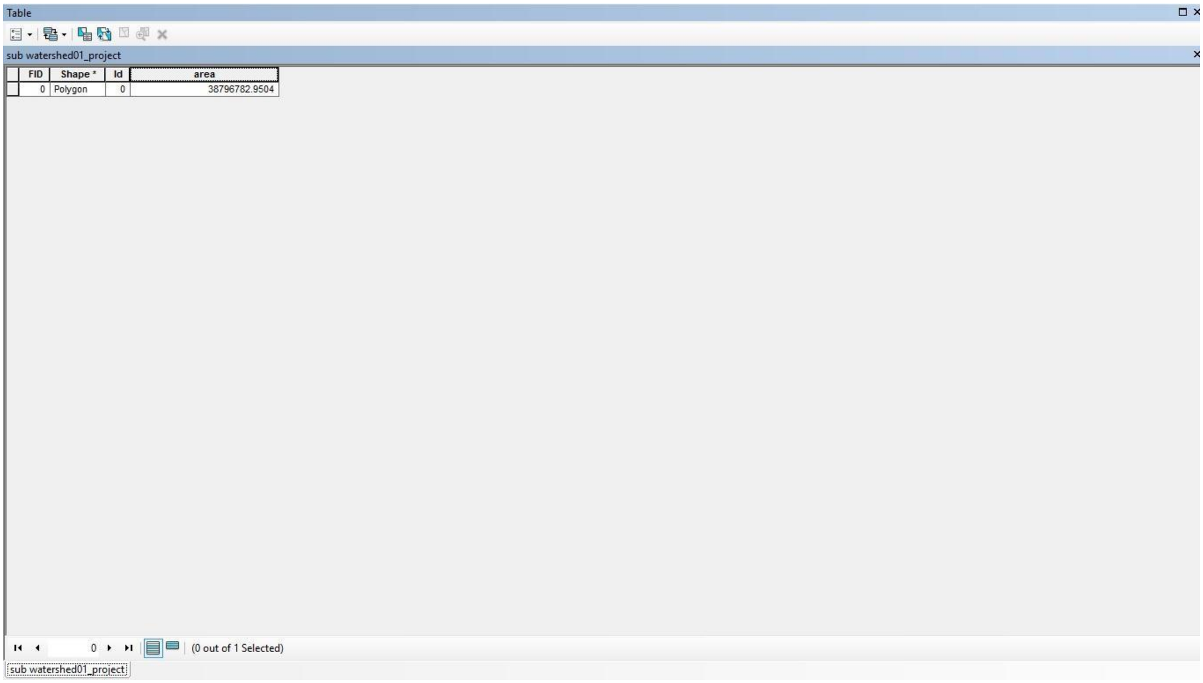
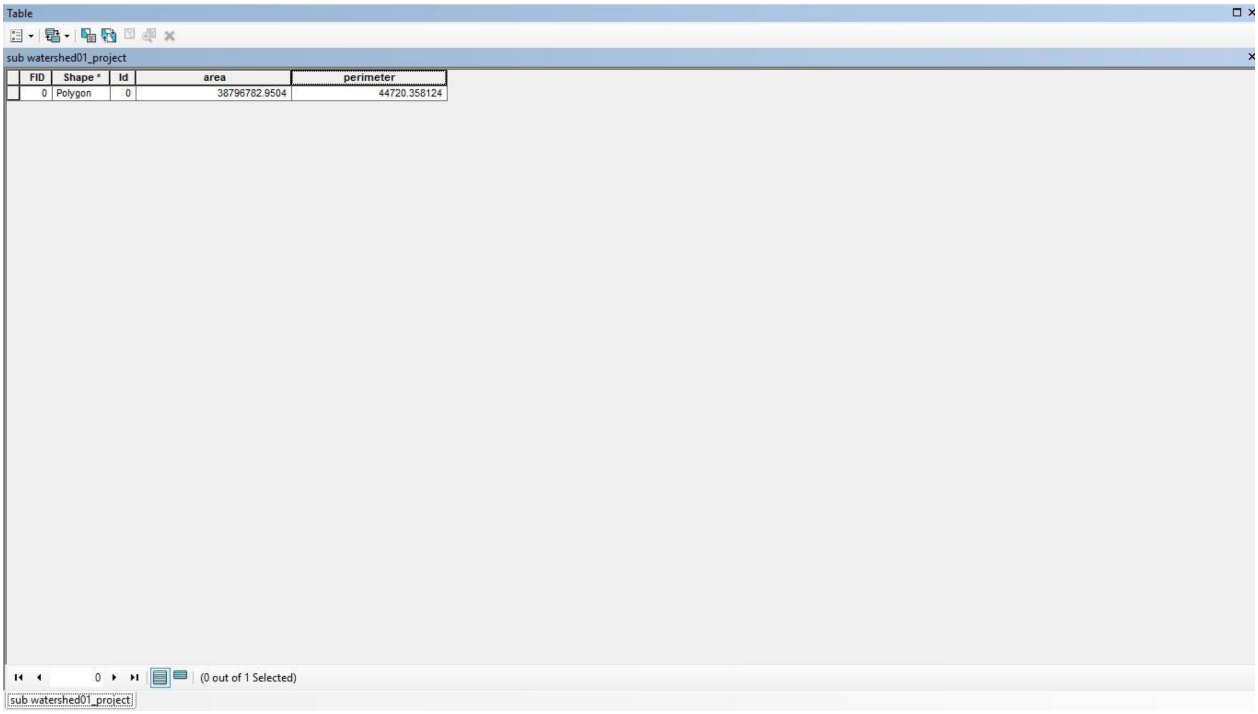


Image A47



FID	Shape *	Id	area	perimeter
0	Polygon	0	38796782.9504	44720.358124

Image A48

Image A42 to image A48 is showing how the total area and total perimeter of the sub watershed is calculated in the study.

By using this process all the basic perimeters are calculated for each sub watershed. And by using these basic parameters all the morphometric parameters are worked out using relation earlier explained in table 4.1.

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