Runoff Estimation In ArcGIS Using NRSC Curve Number Method

Tutorial

Developed by

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Rainfall Runoff Modelling Using NRCS-CN Method

Key Words: Rainfall-runoff, NRSC-CN, Modelling, Hydrology, GIS, Remote Sensing

Problem: You have to estimate surface runoff using NRCS-CN method for Ajmer Area. You have been provided with DEM, Soil map, LULC map, Rainfall map and watershed map.

Curve Number Method for Runoff Generation

The Stream flow which is measured in a river consists of 3 components namely the surface runoff, sub-surface and ground water (base flow) components Fig 1. Mathematically it is possible to quantify these components individually. But remote sensing and GIS play a prominent role in quantifying only the surface runoff. Runoff is computed indirectly using the soil type, land cover, and its hydrologic condition, in a model, of course with rainfall data also. The Natural Resources Conservation Service Curve Number (NRCS-CN) formerly known as Soil Conservation Service Curve Number (SCS-CN) method, developed by the USDA-Soil Conservation Service (SCS, 1972), is widely used for the estimation of direct runoff for a given rainfall event from small agricultural watersheds as it takes into account most of the watershed's runoff producing characteristics such as soil type, landuse, hydrologic condition and antecedent moisture condition. The thematic maps corresponding to each parameter may be generated and stored in the common spatial geo-database created in a GIS with the help of remote sensing data.

Natural Resources Conservation Service Curve Number (NRCS-CN) method is an experimentally derived method to determine rainfall excess using information about soils, vegetative cover, hydrologic condition and antecedent moisture conditions .

The NRCS-CN method is based on a water balance and two fundamental hypotheses which can be expressed, respectively, as follows (SCS, 1972):

$$P = Ia + F + Q \quad (1)$$

where, P is the precipitation (mm), I_a is the initial abstraction (mm), F is the cumulative infiltration excluding I_a, Q is the direct runoff (mm).

Let I_a be the initial quantity of interception, depression storage and infiltration that must be satisfied by any rainfall before runoff can occur. It is based on the hypothesis that ration of runoff (Q) to maximum potential runoff ($P-I_a$) and cumulative infiltration (F) to maximum possible infiltration i.e., Retention 'S' is equal, as mentioned below-

$$\frac{Q}{P - Ia} = \frac{F}{S} \quad (2)$$

I_a is assumed to be a fraction of S.

$$Ia = \lambda S \quad (3)$$

S is the potential maximum retention after beginning of the runoff (mm) and *λ* is the initial abstraction ratio. Knowing P and S the value of Q can be calculated. Q has the same units of P. On combining (1), (2) and (3), it gives an expression for *Q*:

$$Q = \frac{(P - Ia)^2}{P + S - Ia} \tag{4}$$

Eq. (4) is valid for $P > Ia$, otherwise, $Q = 0$. The parameter S in Eq. (4) is defined as

$$S = \frac{25400}{CN} - 254 \tag{5}$$

where, CN is the runoff curve number of hydrologic soil cover, which is a function of soil type, land cover and varies with one of three antecedent soil moisture conditions (AMC): AMC-I, AMC-II and AMC-III. Fig. 1 shows flow chart for NRSC-CN methodology adopting remotes sensing data integrated with GIS.

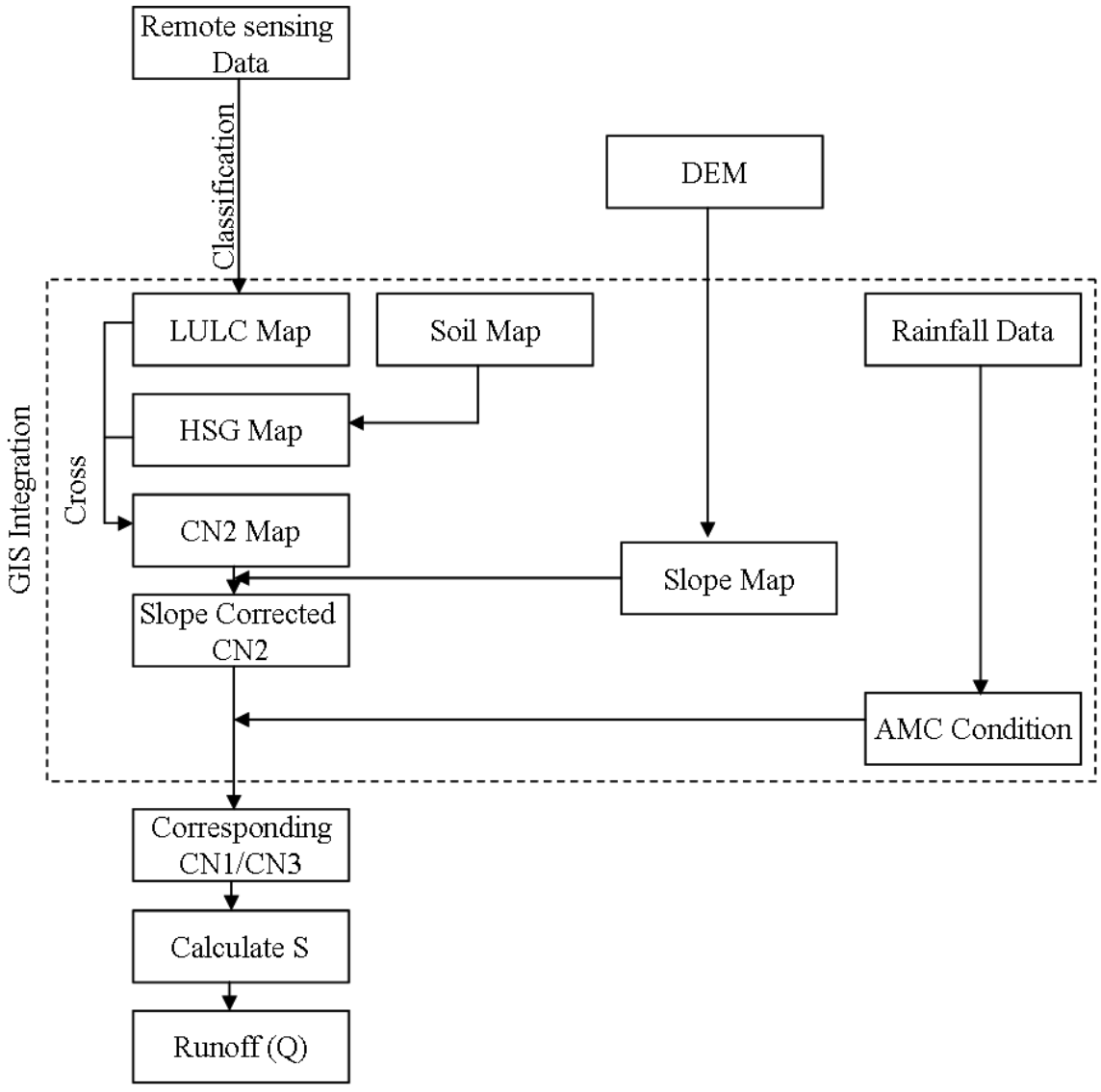


Fig. 1: Flow Chart Runoff Estimation Using NRCS-CN Integrating RS and GIS

In practice, curve numbers are first calculated for AMC-II and then adjusted to AMC-I or AMC-III depending on the 5-day antecedent rainfall depth that depends on whether the crop is in the dormant or growing season as depicted in Table 1. The values of CN_2 correspond to AMC-II for different landuse against different hydrologic condition of soil group can be found in SCS handbook (SCS, 1972) or standard hydrology textbooks and large number of literature. The values of CN range from 0 to 100. The sample table for CN_2 values corresponds to fallow, row crops, forest, pasture and water body is given in Table 2. CN_2 can be determined by 2 dimensional table or crossing LULC map and hydrological soil group map using cross function of GIS. The LULC map can easily be prepared from satellite data using classification technique based on extensive ground truth. Whereas the detailed soil map can be obtained from the ground truth or made by interpretation of physiographic units and field survey. The National Bureau of Soil Survey & Land Use Planning soil maps are also available with hydrological soil group identified for each soil type for every state.

Table 1: AMC for Determining the Value of CN

AMC class	**5-day antecedent rainfall (cm)**	
	Non-monsoon period	**Monsoon period**
I. Optimum soil condition from plastic limit to wilting point	Less than 1.25	Less than 3.5
II. Average value for annual floods	1.25 to 2.75	3.5 to 5.25
III. Heavy rainfall or low rainfall and low temperature during five days preceding the storm	Over 2.75	Over 5.25

(Source:- Chow, 1988)

Table 2: Curve Number Table

Land Use/HSG	**A**	**B**	**C**	**D**
Fallow	77	86	91	94
Row crops	67	78	85	89
Forest	45	66	77	83
Pasture	49	69	79	84
Water body	100	100	100	100

The daily rainfall data can be procured from any meteorological department, even, spatial rainfall products (like TRMM, CPC, Aphrodite data) of remote sensing data available freely on internet can be utilized. The point data procured from meteorological department can be interpolated using spatial interpolation tools available in GIS. The estimate average weighted rain in each watershed from interpolated rainfall data using zonal statistics tool of Arc GIS. Since the procedure of

estimating weighted average rainfall in all sub-watershed for all rainy days is repetitive work, so a customized model can be build in GIS environment.

Initially, CN_2 for each sub-watershed can be determined based on LULC, soil and hydrologic conditions using traditional NRCS-CN approach adopting corresponding values from Table 1 and Table 2. As, in the original NRCS-CN method the effect of slope has not been taken into account while calculating CN. Moreover, land slope parameter has been considered as an important factor in determining water movement (El-Hassanin et al., 1993; Barros et al., 1999; Ahmad, 2001; Haggard et al., 2002; Chaplot and Bissonnais, 2003; Huang et al., 2006). To overcome the problem of slope, Sharpley and Williams (1990), carried out some slope adjustment to CN_2 calculation as follows:

$$CN_{2\alpha} = \frac{1}{3}\left(CN_3 - CN_2\right)\left(1 - 2e^{-13.86\alpha}\right) + CN_2 \qquad (6)$$

Where, $CN_{2\cdot}$ is slope adjusted CN_2; · (m/m) is the slope. However, this approach has not been intensively verified in the field (Huang *et al.* 2006). Hence, Huang *et al.* (2006) adopted a simplified approach and proposed an equation for slope modified Curve Number ($CN_{2\cdot}$) for slope gradient range from 0.14 to 1.4 as follows:

$$CN_{2\alpha} = CN_2 \frac{322.79 + 15.63(\alpha)}{\alpha + 323.52} \qquad (7)$$

CN_2 and CN_3 in above formulae are the CN for AMC-II and AMC-III respectively. Here alpha is slope in meter per meter. Hope and Schulze (1981) questioned these AMC approach and highlighted three weaknesses in it such as the relationship between AMC and antecedent rainfall holds for discrete classes, rather than continuous; the use of 5-day antecedent rainfall is not based on physical reality, but on subjective judgment; and evapotranspiration and drainage are not considered in depletion of catchment storage. To convert CN_2 to CN_1 & CN_3; Sobhani (1975), Hawkins et al. (1985), Chow et al. (1988) and Neitsch et al. (2002); proposed mathematical expressions as presented in Table 3.

Table 3 CN Conversion Formulae

Method	**AMC – I**	**AMC - III**
Sobhani (1975)	$CN_1 = \frac{CN_2}{2.334 - 0.01334 CN_2}$	$CN_3 = \frac{CN_2}{0.4036 + 0.005964 CN_2}$
Hawkins et al. (1985)	$CN_1 = \frac{CN_2}{2.281 - 0.01281 CN_2}$	$CN_3 = \frac{CN_2}{0.427 + 0.00573 CN_2}$
Chow et al. (1988)	$CN_1 = \frac{4.2 CN_2}{10 - 0.058 CN_2}$	$CN_3 = \frac{23 CN_2}{10 - 0.013 CN_2}$

Neitsch et al. (2002)	$CN_1 = CN_2 - \frac{20(100 - CN_2)}{\{100 - CN_2 + \exp[2.533 - 0.0636(100 - CN_2)]\}}$	$CN_3 = CN_2 \exp\{0.00673(100 - CN_2)\}$

(Source:- Mishra *et al.,* 2008)

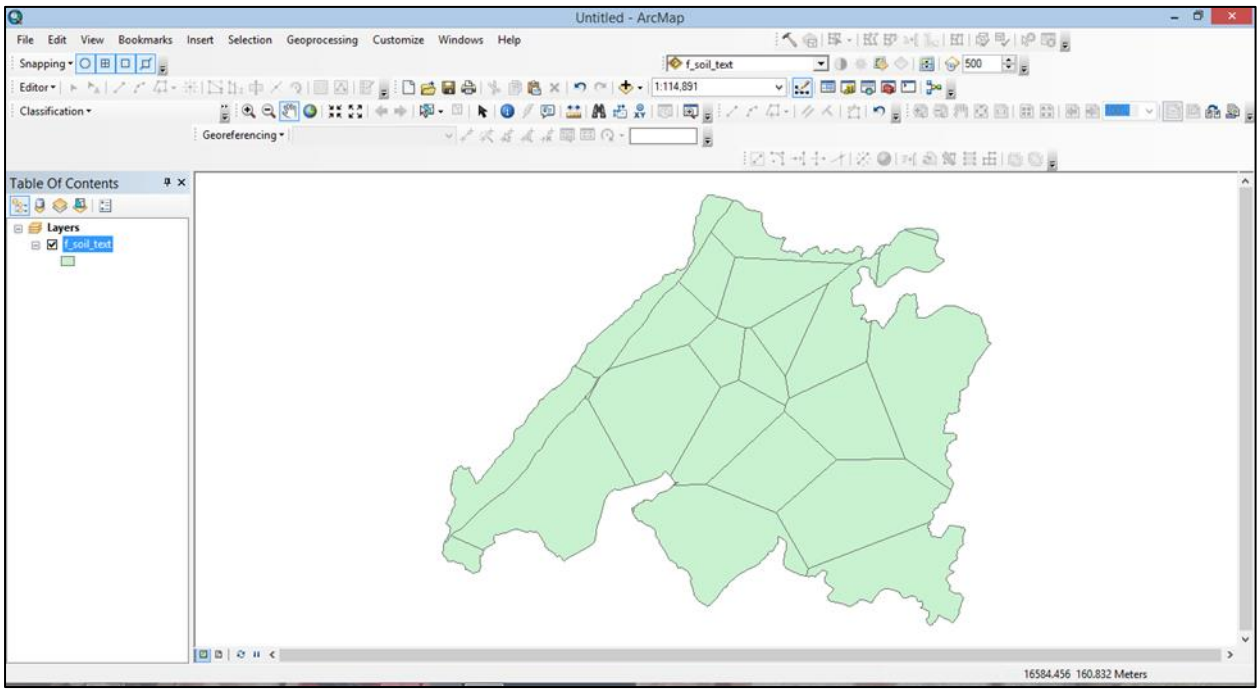
Mishra et al. (2008) compared these conversion formulae, as determining the CN is very sensitive to runoff calculation. It was suggested that the Sobhani (1975) formula is best for CN_1 conversion whereas the Hawkins et al. (1985) for CN_3 conversion. So, these conversion formulae can be used to calculate CN_1 and CN_3, respectively for the sub-watersheds falling in such categories.

The representative mean values of CN_2 and CN_{2s} for each sub-watersheds can be calculated using zonal attributes tool in Arc GIS. Similarly, the CN_1 & CN_3 for each sub-watershed can be obtained using above conversion formulae along with original NRCS-CN model table. Knowing the values of CN_2 or CN_{2s}, and their corresponding CN_1 and CN_3, the factor S (mm) has been determined for each sub-watershed accordingly. Then I_a has been estimated using the expression Eq. (3). Usually, λ has been assumed as 0.2 for a large number studies. Finally, the runoff depth in each sub-watershed for each rain event can be calculated adopting the Eq. (4).

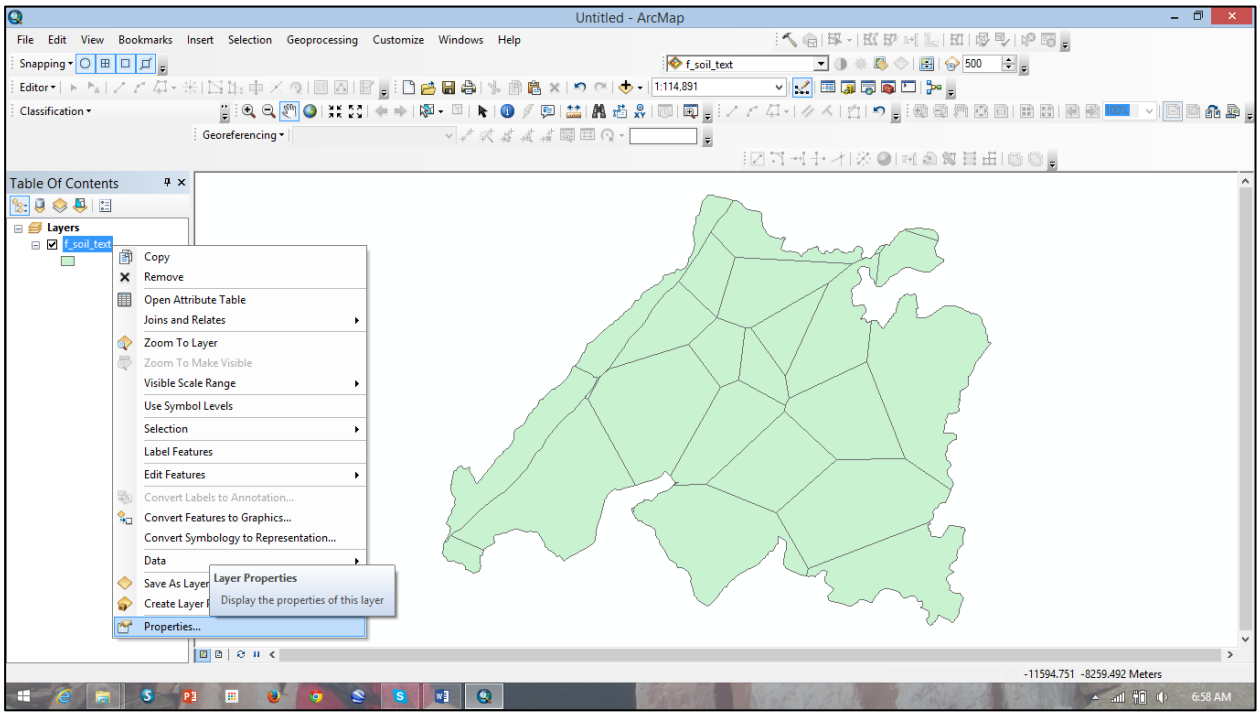
Tutorial

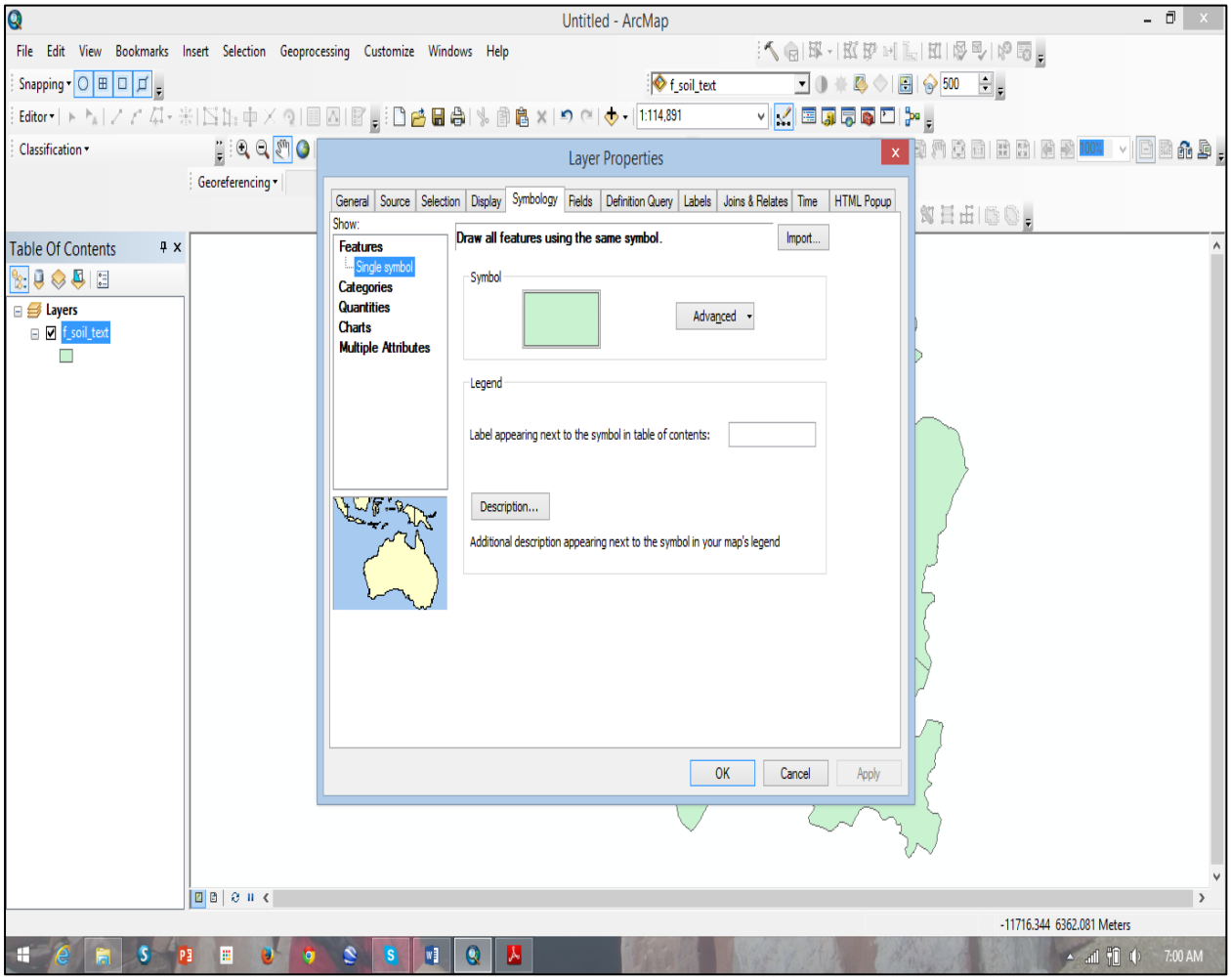
Find out the Hydrological Soil Group (HSG) for each pixel from the given soil map using following table. Open soil map in ArcGIS. You have been provided with DEM, Soil map, LULC map, Rainfall map and watershed boundary map.

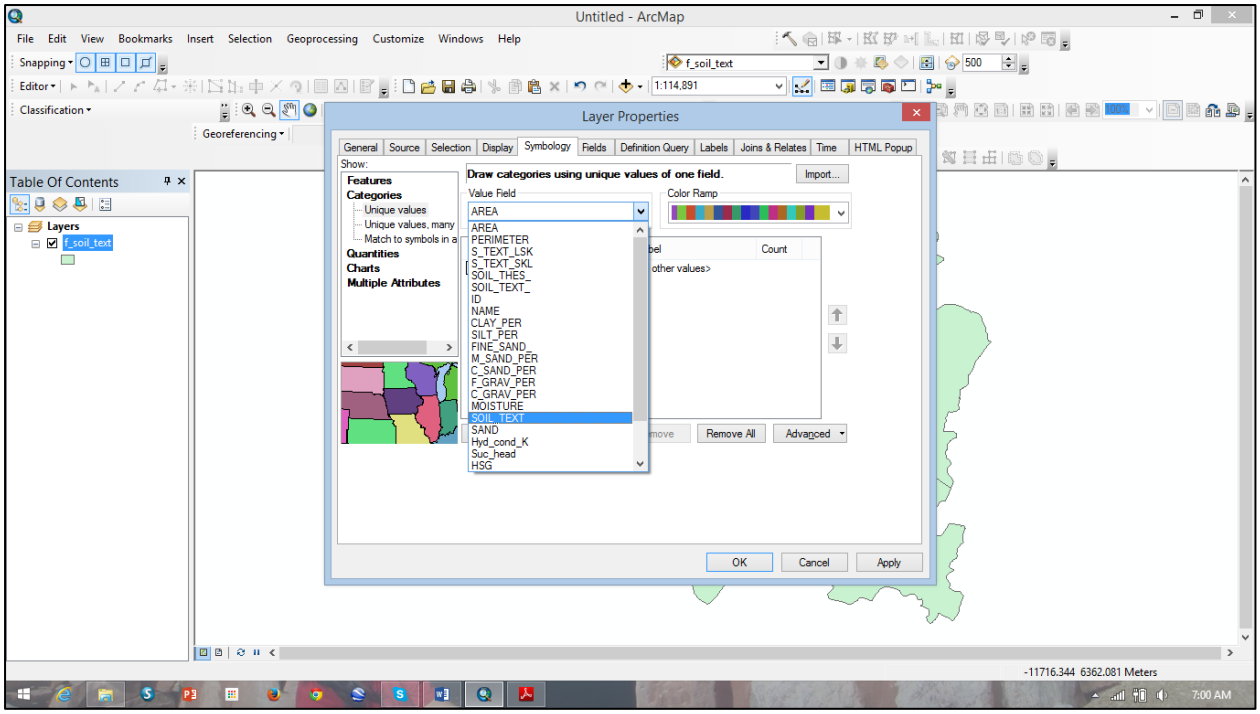
Open the given soil map (add layer f_soil_text.shp in the ArcMap) in ArcGIS, it will appears somewhat like this:

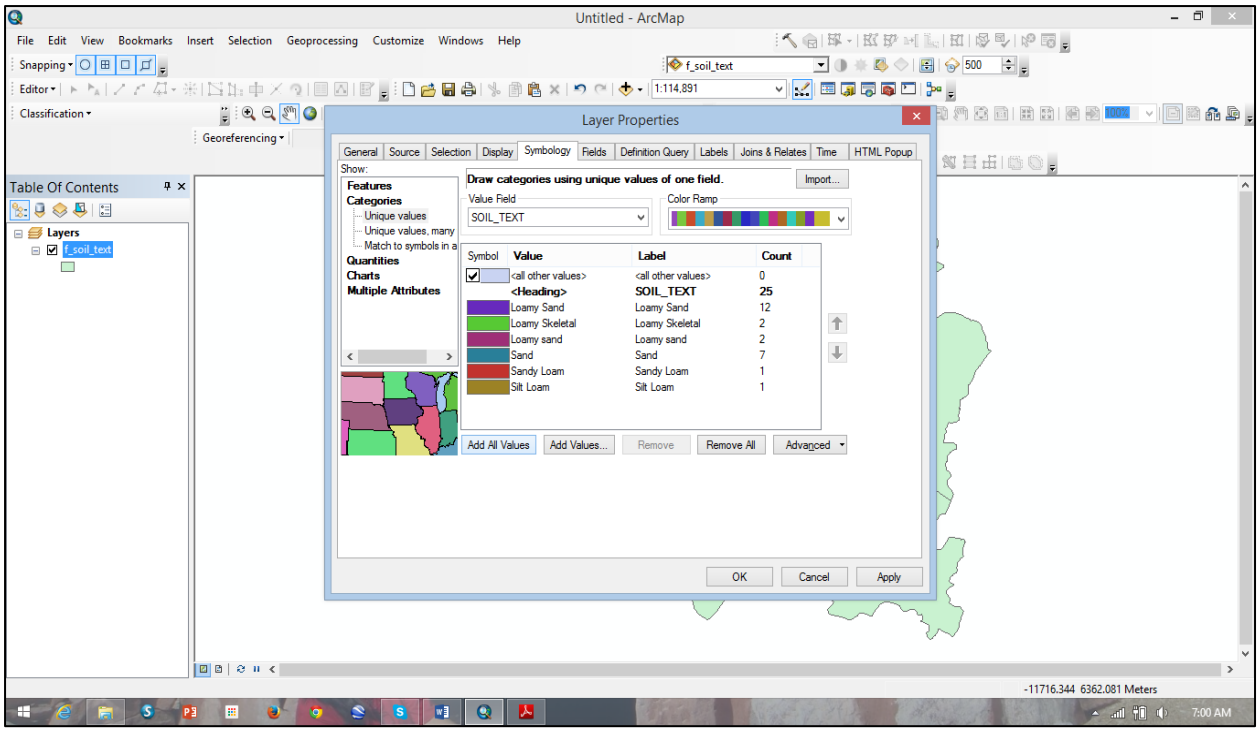


Now, to see its all soil texture classes, right click on f_soil_text.shp layer in Table of content and go to properties, in Symbology tab, select value field, Categories and then select the Soil_text and click "Add All Values" and then click "ok". We have selected soil texture classes for the display.






Untitled - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Layer Properties
General Source Selection Display Symbology Fields Definition Query Labels Joins & Relates Time HTML Popup
Show:
Features
Categories
Unique values
Unique values, many
Match to symbols in a
Quantities
Charts
Multiple Attributes
Draw categories using unique values of one field.
Import...
Value Field
AREA
Color Ramp
AREA
PERIMETER
S_TEXT_LSK
S_TEXT_SKL
SOIL_THES_
SOIL_TEXT_
ID
NAME
CLAY_PER
SILT_PER
FINE_SAND_
M_SAND_PER
C_SAND_PER
F_GRAV_PER
C_GRAV_PER
MOISTURE
SOIL_TEXT
SAND
Hyd_cond_K
Suc_head
HSG
Count
Remove All
Advanced
OK
Cancel
Apply
Table Of Contents
Layers
f_soil_text
-11716.344 6362.081 Meters
7:00 AM


Untitled - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Layer Properties
General Source Selection Display Symbology Fields Definition Query Labels Joins & Relates Time HTML Popup
Show:
Features
Categories
Unique values
Unique values, many
Match to symbols in a
Quantities
Charts
Multiple Attributes
Draw categories using unique values of one field.
Import...
Value Field
SOIL_TEXT
Color Ramp
Symbol Value Label Count
<all other values> <all other values> 0
<Heading> SOIL_TEXT 25
Loamy Sand Loamy Sand 12
Loamy Skeletal Loamy Skeletal 2
Loamy sand Loamy sand 2
Sand Sand 7
Sandy Loam Sandy Loam 1
Silt Loam Silt Loam 1
Add All Values
Add Values...
Remove
Remove All
Advanced
OK
Cancel
Apply
Table Of Contents
Layers
f_soil_text
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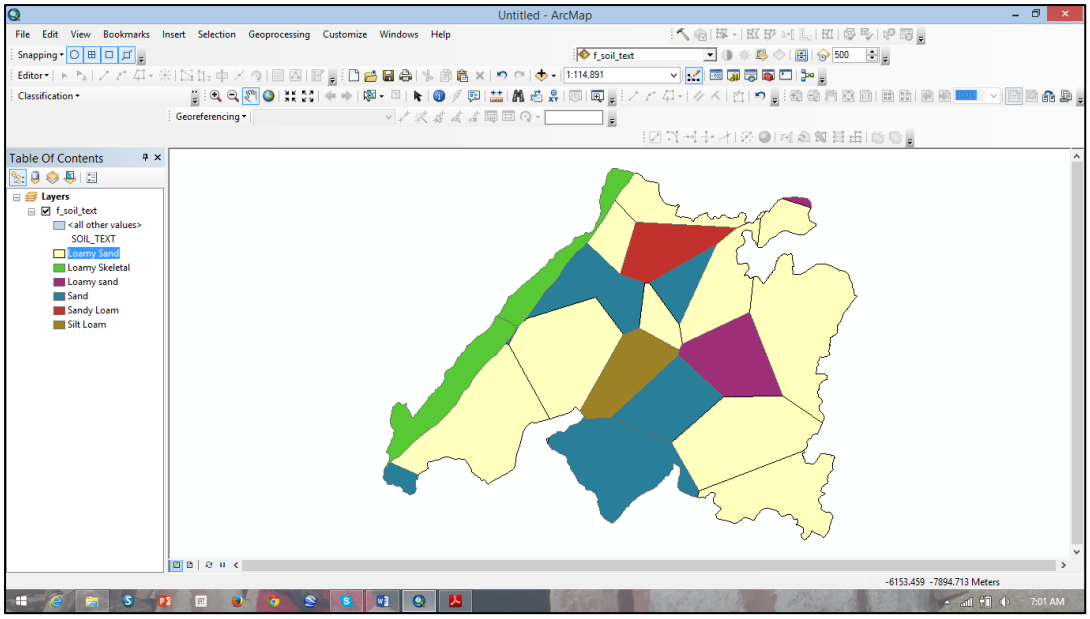
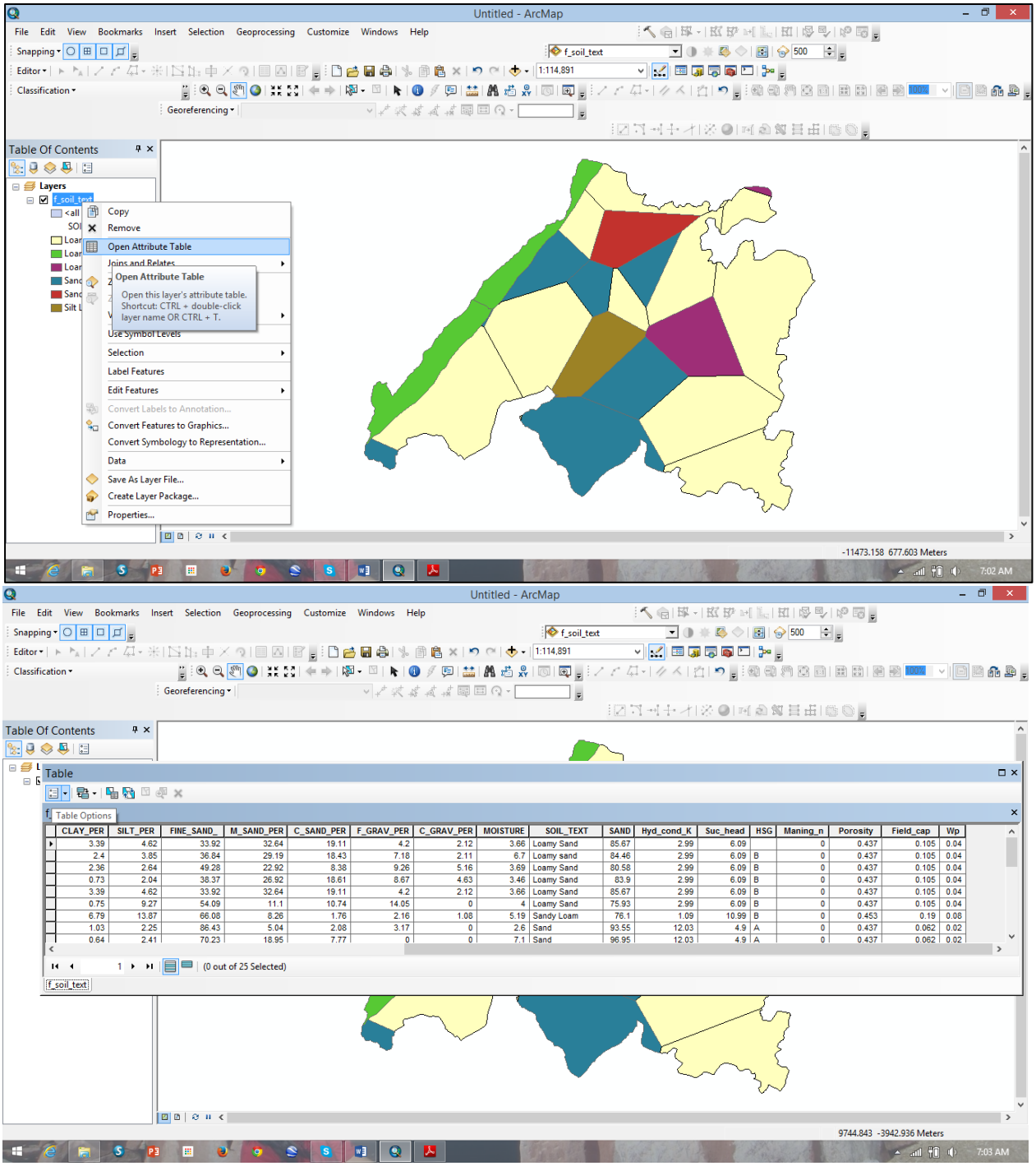


Soil Group	Description of the Hydrologic Soil group
A	Lowest runoff potential. Includes deep
	sand with very little clay and silt.
B	Moderately low runoff potential.
	Mostly sandy soil less deeper than A
C	Moderately high runoff potential.
	Comprises shallow soil of clay, colloids
D	Highest runoff potential. Includes mostly clay of high swelling percent, nearly impermeable soils.

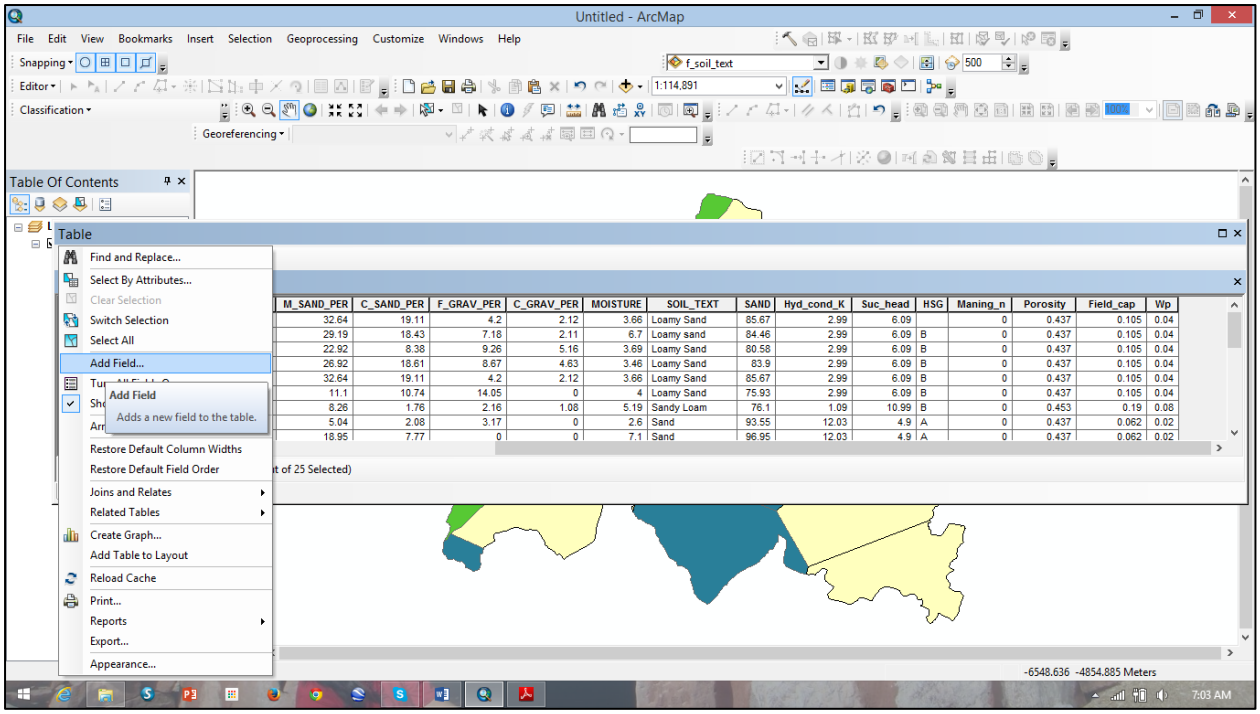
SOIL_TEXT	HSG
Loamy Sand	A
Loamy Skeletal	B
Sand	A
Sandy Loam	A
Silt Loam	C

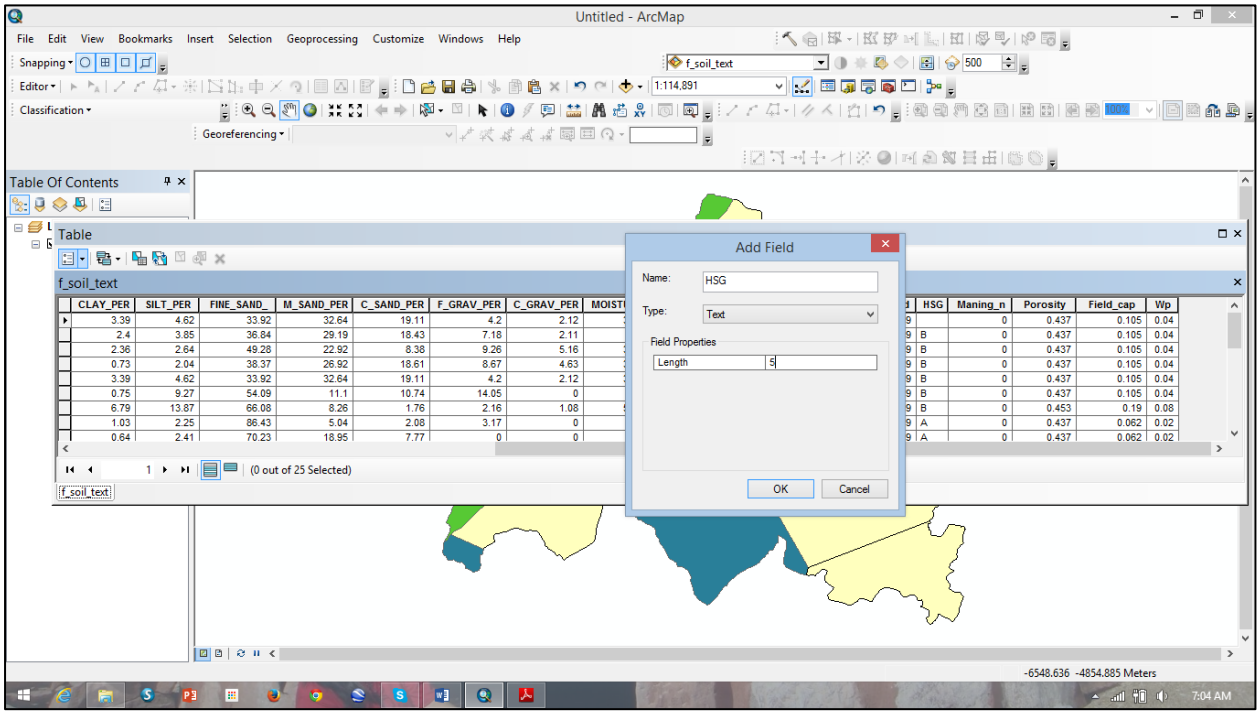
Now, open attribute table of soil map, you will find soil type correspond to each polygon for entire watershed.



Now we will assign Hydrological Soil Group category based on soil texture class.

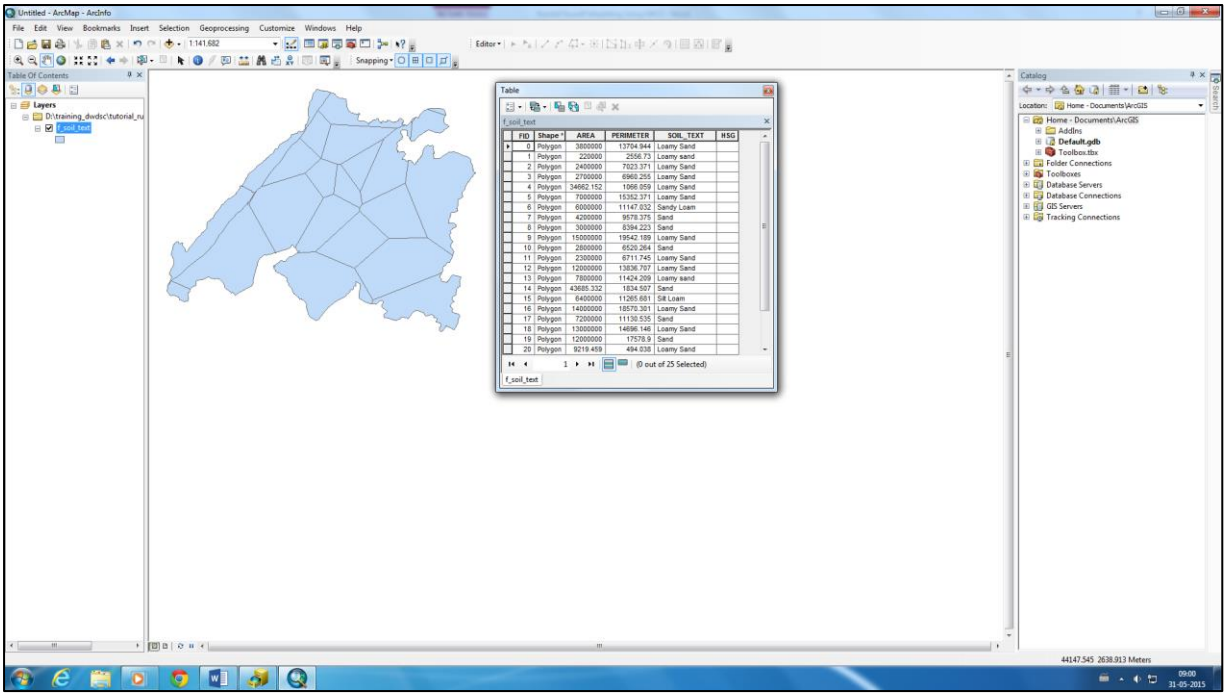
A new column will be added in the attribute table of Then go to Table Options and click on "Add Field" give Name as "HSG" and Type as "text" . Length you can give "5" as its just single letter (A, B, C, D). Then click "ok".

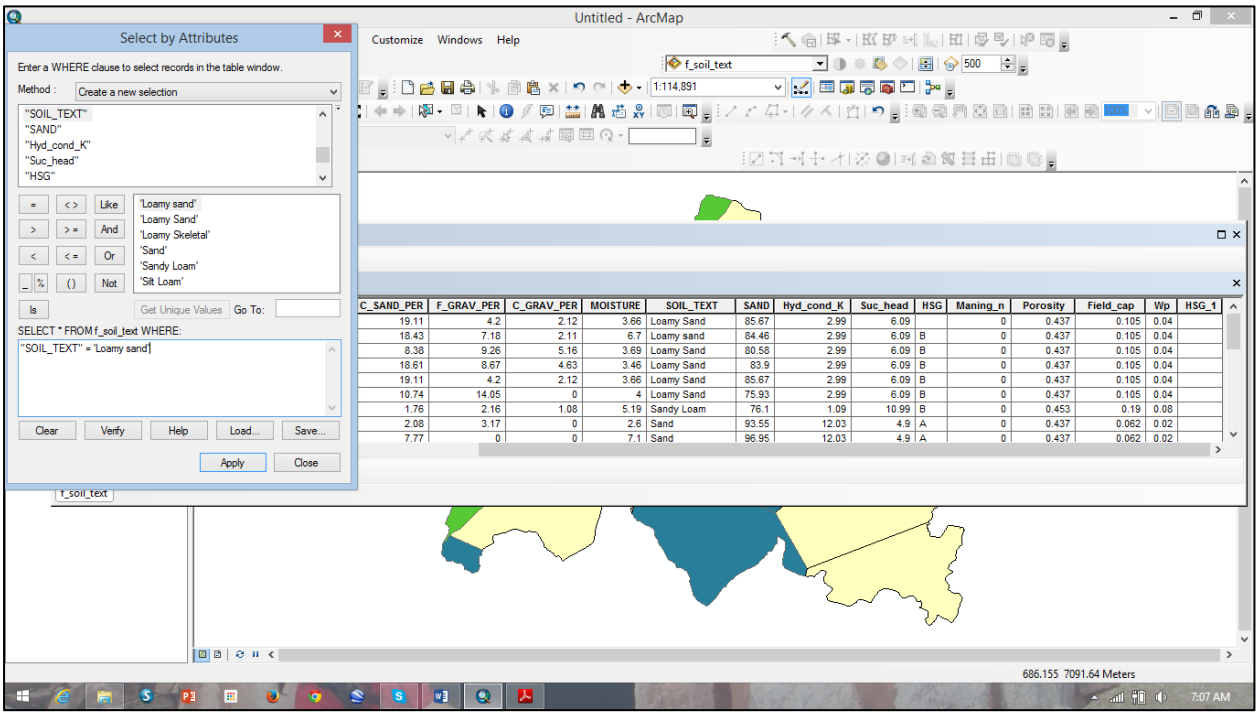




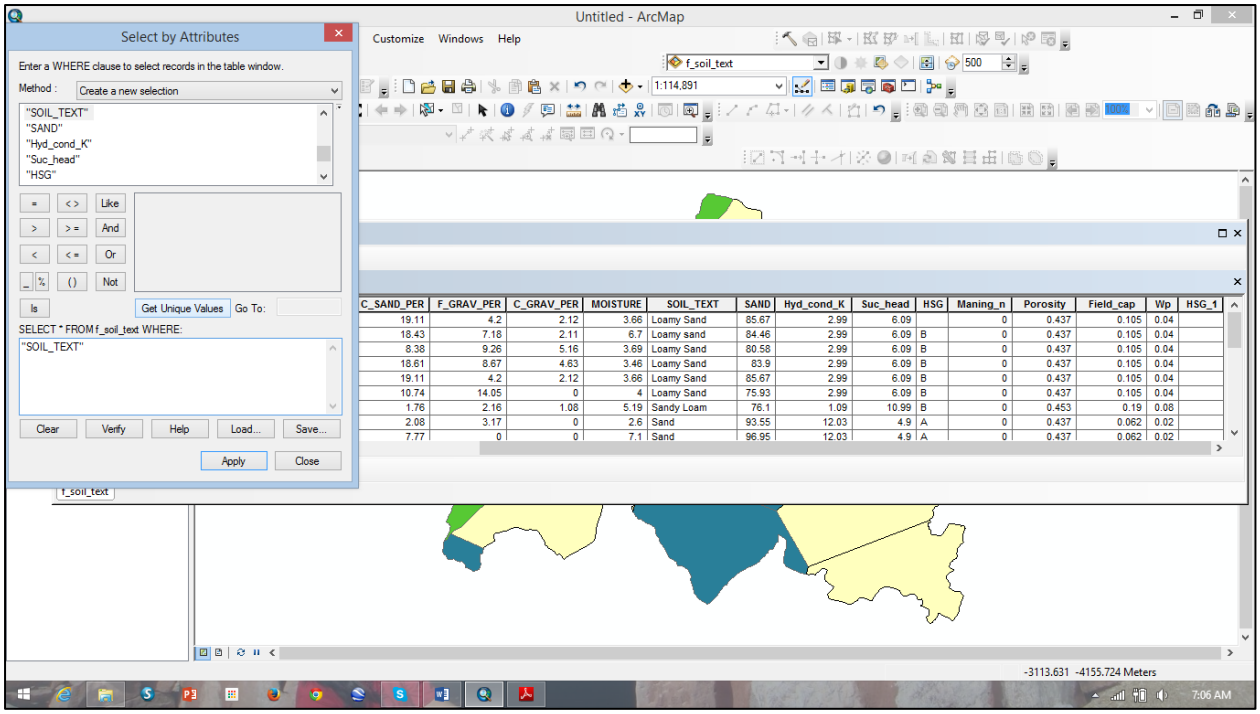
In given file we have created the HSG column for you.

You will find HSG column has been added to your attribute table. Now, to assign corresponding HSG following steps has to be performed: Go again to Options at the bottom of the window, click "Select by attribute".

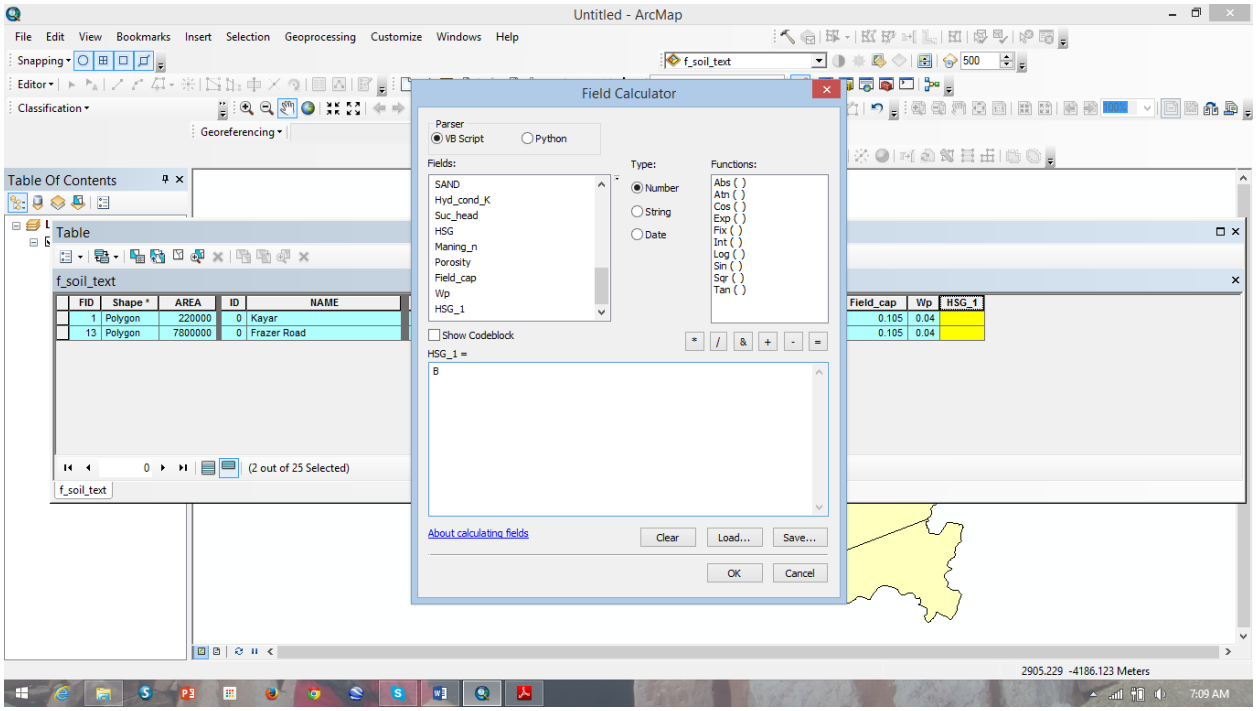


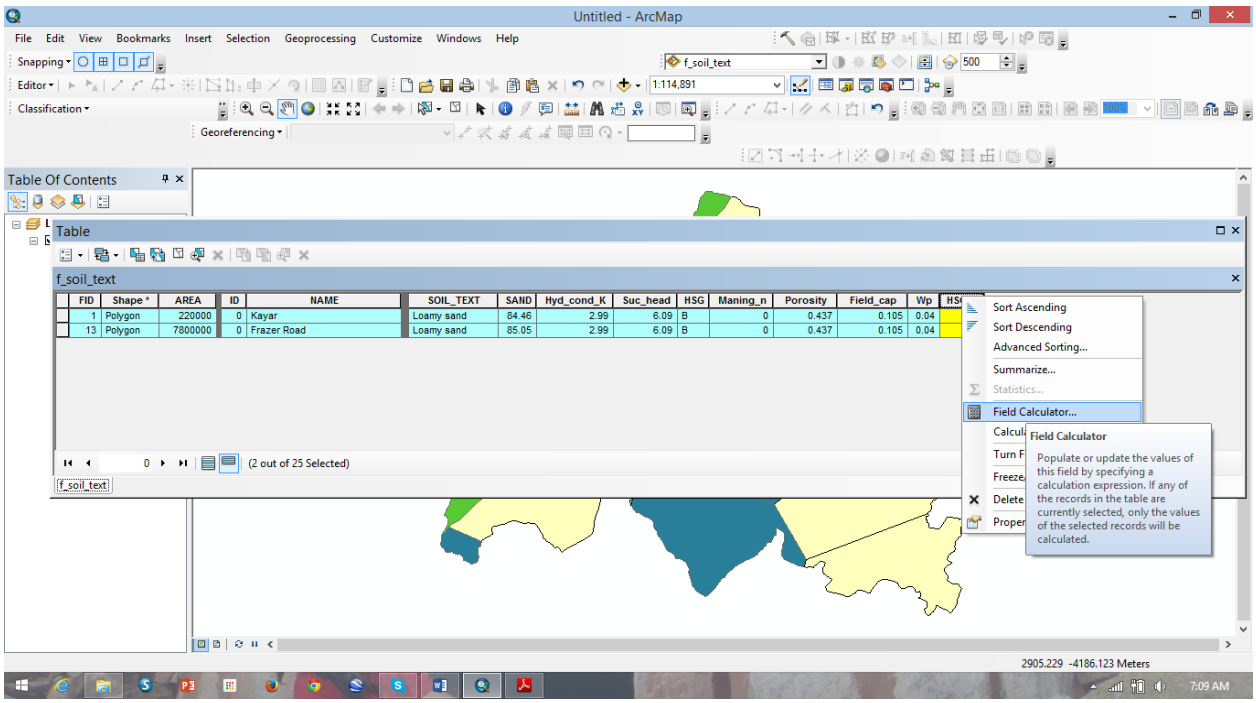


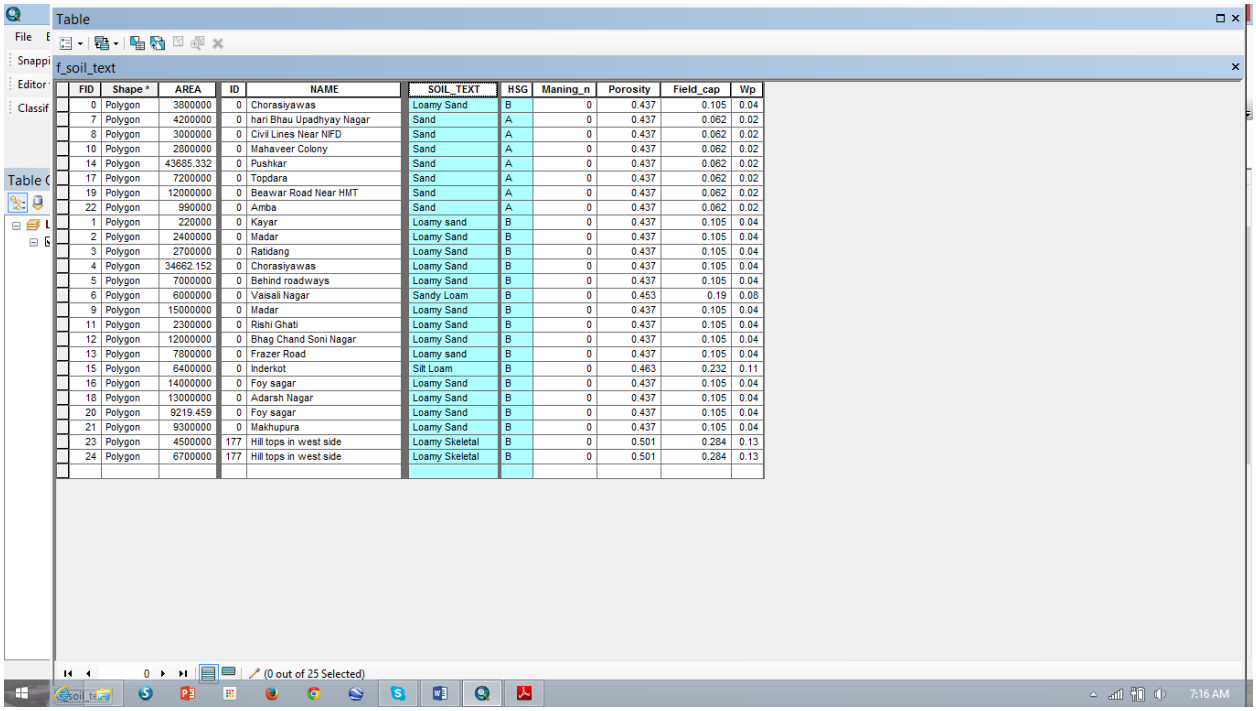
Now, double click on Soil_Text -> click = -> Get Unique Values -> double click “Loamy sand” -> Apply. It will select all polygons of “Loamy sand” class.



Then go to HSG column, right click and then click on Field Calculator and then assign HSG = "B" and click ok. Follow same steps for other soil classes too and assign corresponding HSG group as mentioned table above.





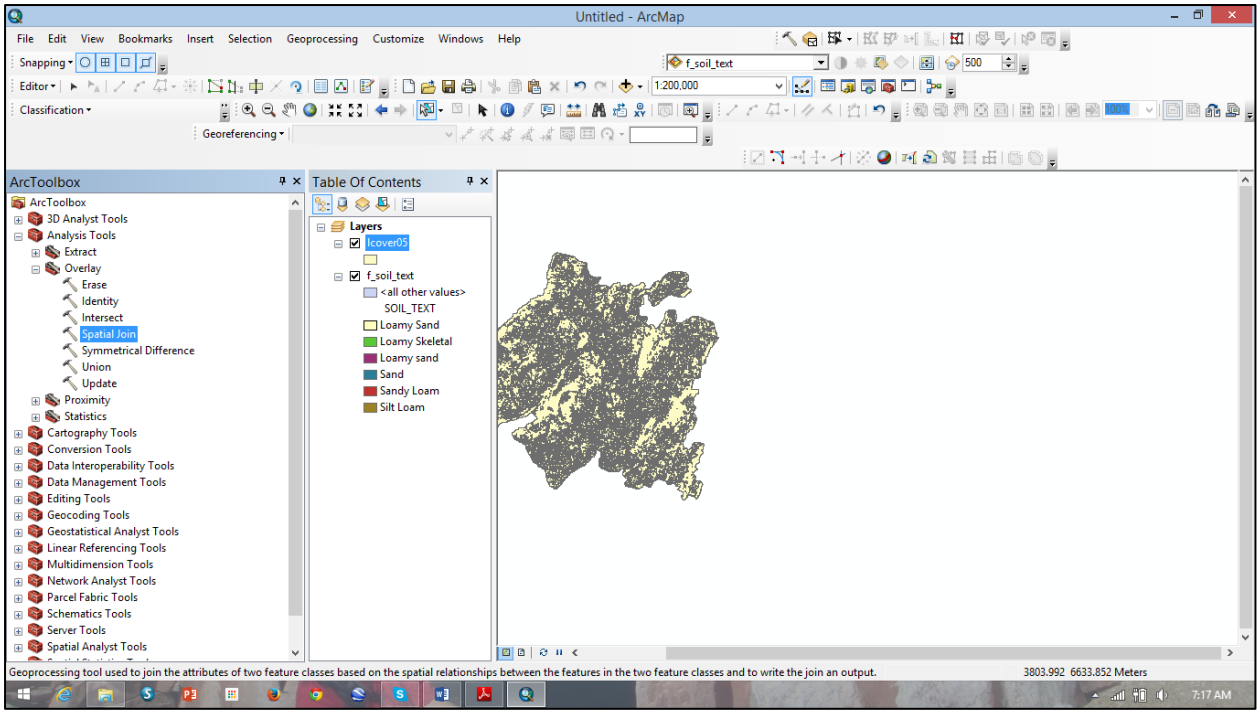


FID	Shape *	AREA	ID	NAME	SOIL_TEXT	HSG	Maning_n	Porosity	Field_cap	Wp
0	Polygon	3800000	0	Chorasiyawas	Loamy Sand	B	0	0.437	0.105	0.04
7	Polygon	4200000	0	hari Bhau Upadhyay Nagar	Sand	A	0	0.437	0.062	0.02
8	Polygon	3000000	0	Civil Lines Near NIFD	Sand	A	0	0.437	0.062	0.02
10	Polygon	2800000	0	Mahaveer Colony	Sand	A	0	0.437	0.062	0.02
14	Polygon	43685.332	0	Pushkar	Sand	A	0	0.437	0.062	0.02
17	Polygon	7200000	0	Topdara	Sand	A	0	0.437	0.062	0.02
19	Polygon	12000000	0	Beawar Road Near HMT	Sand	A	0	0.437	0.062	0.02
22	Polygon	990000	0	Amba	Sand	A	0	0.437	0.062	0.02
1	Polygon	220000	0	Kayar	Loamy sand	B	0	0.437	0.105	0.04
2	Polygon	2400000	0	Madar	Loamy Sand	B	0	0.437	0.105	0.04
3	Polygon	2700000	0	Ratidang	Loamy Sand	B	0	0.437	0.105	0.04
4	Polygon	34662.152	0	Chorasiyawas	Loamy Sand	B	0	0.437	0.105	0.04
5	Polygon	7000000	0	Behind roadways	Loamy Sand	B	0	0.437	0.105	0.04
6	Polygon	6000000	0	Vaisali Nagar	Sandy Loam	B	0	0.453	0.19	0.08
9	Polygon	15000000	0	Madar	Loamy Sand	B	0	0.437	0.105	0.04
11	Polygon	2300000	0	Rishi Ghati	Loamy Sand	B	0	0.437	0.105	0.04
12	Polygon	12000000	0	Bhag Chand Soni Nagar	Loamy Sand	B	0	0.437	0.105	0.04
13	Polygon	7800000	0	Frazer Road	Loamy sand	B	0	0.437	0.105	0.04
15	Polygon	6400000	0	Inderkot	Silt Loam	B	0	0.463	0.232	0.11
16	Polygon	14000000	0	Foy sagar	Loamy Sand	B	0	0.437	0.105	0.04
18	Polygon	13000000	0	Adarsh Nagar	Loamy Sand	B	0	0.437	0.105	0.04
20	Polygon	9219.459	0	Foy sagar	Loamy Sand	B	0	0.437	0.105	0.04
21	Polygon	9300000	0	Makhupura	Loamy Sand	B	0	0.437	0.105	0.04
23	Polygon	4500000	177	Hill tops in west side	Loamy Skeletal	B	0	0.501	0.284	0.13
24	Polygon	6700000	177	Hill tops in west side	Loamy Skeletal	B	0	0.501	0.284	0.13

Now we will calculate Curve Number (CN-II) corresponding to land use land cover and HSG Group.

Find out the CN-II for each pixel with the help of HSG derived from soil map and LULC map with the help of table provided below. Open the given LULC map in ArcGIS.

Here you have to use spatial Join tool to join attributes of both layers i.e., *f_soil_text and lcover05*. ArcGIS ToolBox -> Analysis Tools -> Overlay -> Spatial join.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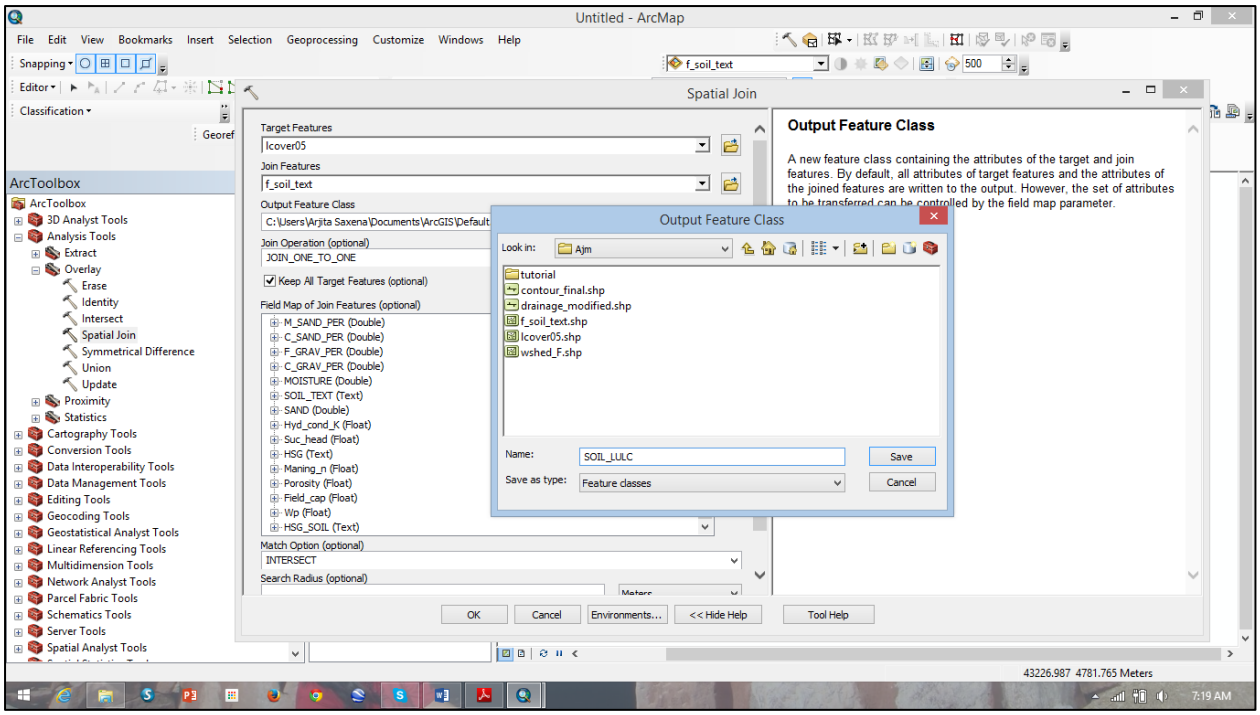
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
ArcToolbox
3D Analyst Tools
Analysis Tools
Extract
Overlay
Erase
Identity
Intersect
Spatial Join
Symmetrical Difference
Union
Update
Proximity
Statistics
Cartography Tools
Conversion Tools
Data Interoperability Tools
Data Management Tools
Editing Tools
Geocoding Tools
Geostatistical Analyst Tools
Linear Referencing Tools
Multidimension Tools
Network Analyst Tools
Parcel Fabric Tools
Schematics Tools
Server Tools
Spatial Analyst Tools
Table Of Contents
Layers
lcover05
f_soil_text
<all other values>
SOIL_TEXT
Loamy Sand
Loamy Skeletal
Loamy sand
Sand
Sandy Loam
Silt Loam
Geoprocessing tool used to join the attributes of two feature classes based on the spatial relationships between the features in the two feature classes and to write the join an output.
3803.992 6633.852 Meters
7:17 AM


Untitled - ArcMap
Spatial Join
Target Features
lcover05
Join Features
f_soil_text
Output Feature Class
C:\Users\Arjita Saxena\Documents\ArcGIS\Default
Join Operation (optional)
JOIN_ONE_TO_ONE
Keep All Target Features (optional)
Field Map of Join Features (optional)
M_SAND_PER (Double)
C_SAND_PER (Double)
F_GRAV_PER (Double)
C_GRAV_PER (Double)
MOISTURE (Double)
SOIL_TEXT (Text)
SAND (Double)
Hyd_cond_K (Float)
Suc_head (Float)
HSG (Text)
Maning_n (Float)
Porosity (Float)
Field_cap (Float)
Wp (Float)
HSG_SOIL (Text)
Match Option (optional)
INTERSECT
Search Radius (optional)
Output Feature Class
A new feature class containing the attributes of the target and join features. By default, all attributes of target features and the attributes of the joined features are written to the output. However, the set of attributes to be transferred can be controlled by the field map parameter.
Output Feature Class
Look in:
Ajm
tutorial
contour_final.shp
drainage_modified.shp
f_soil_text.shp
lcover05.shp
wshed_F.shp
Name:
SOIL_LULC
Save as type:
Feature classes
Save
Cancel
OK
Cancel
Environments...
<< Hide Help
Tool Help
43226.987 4781.765 Meters
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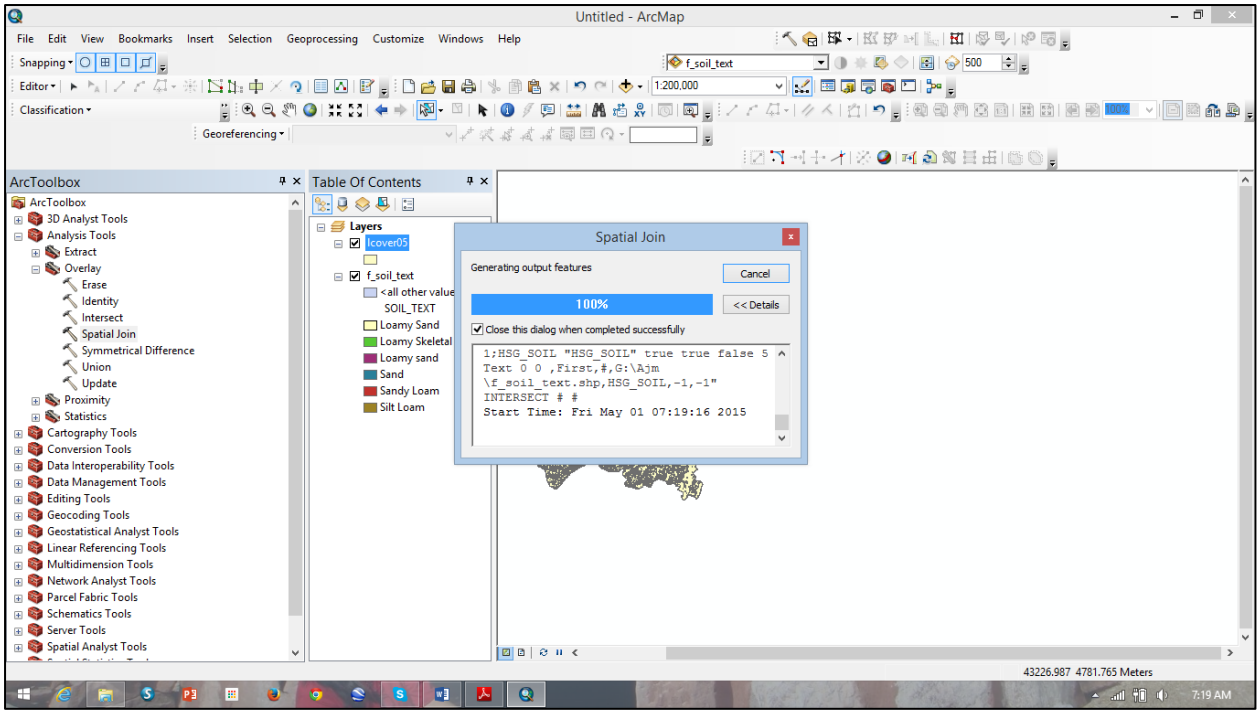
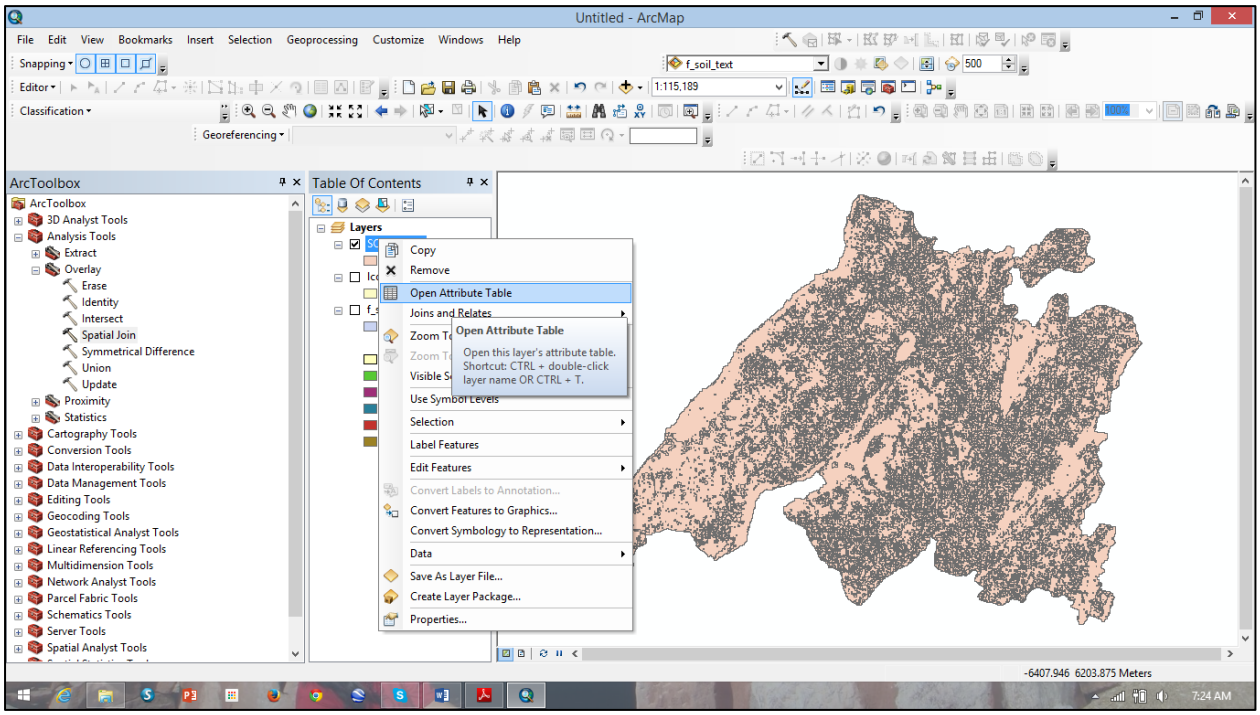
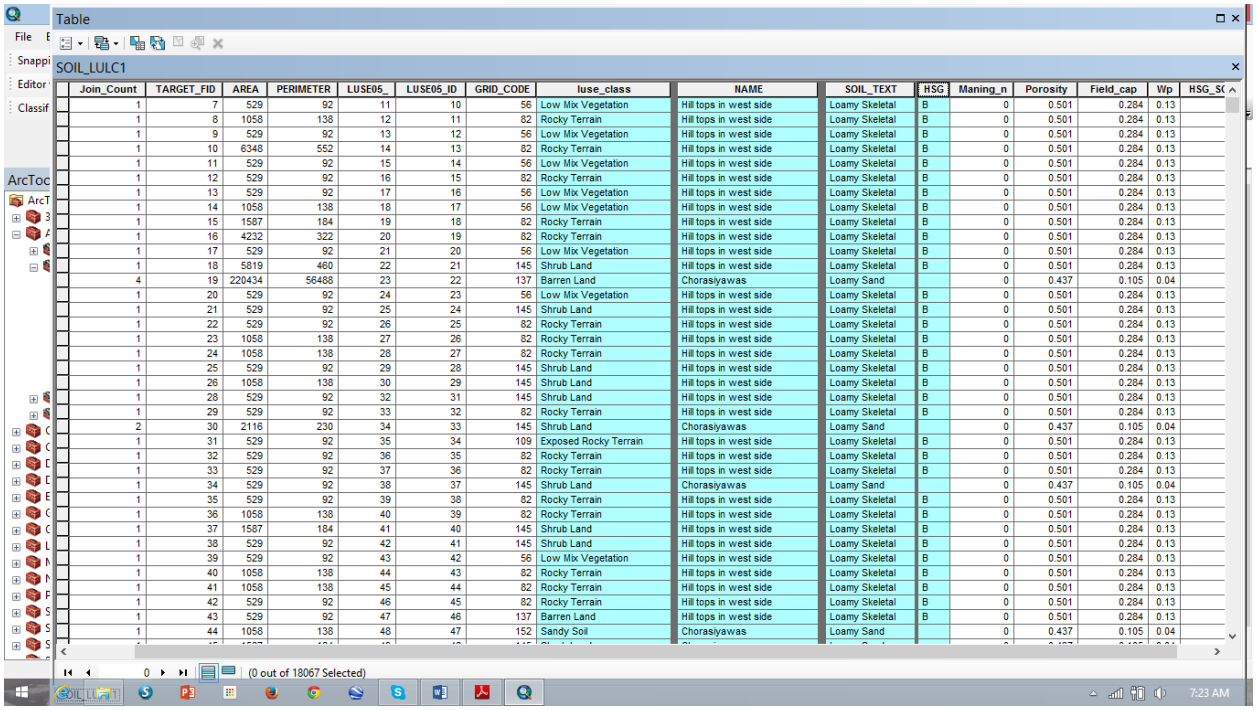
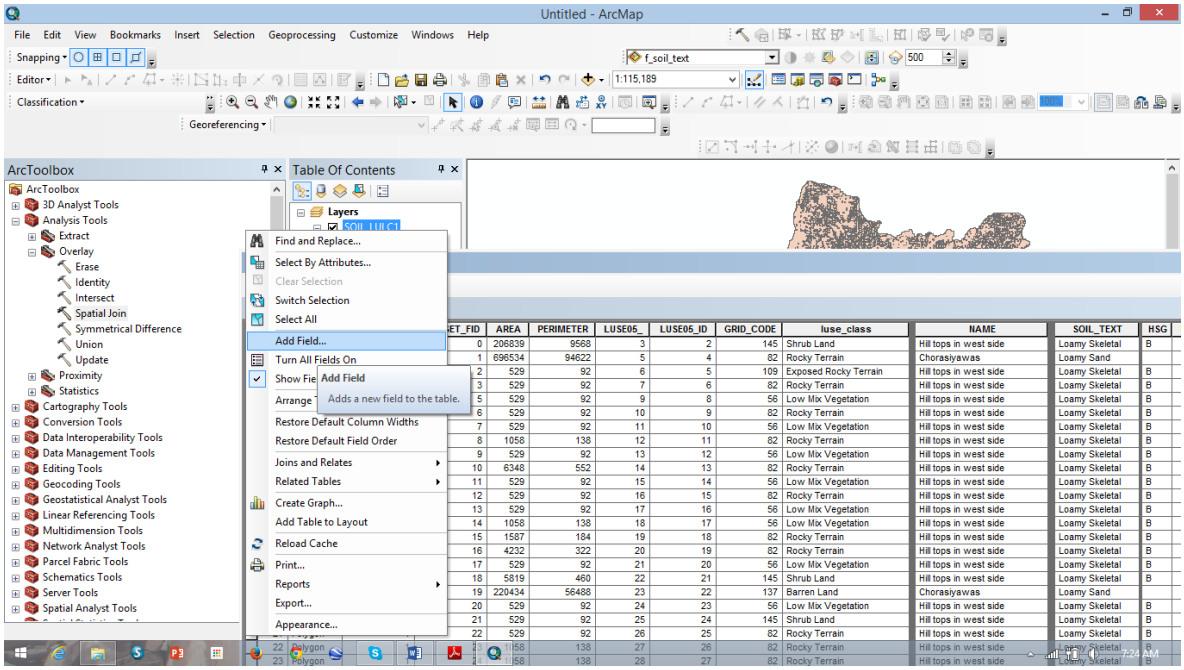


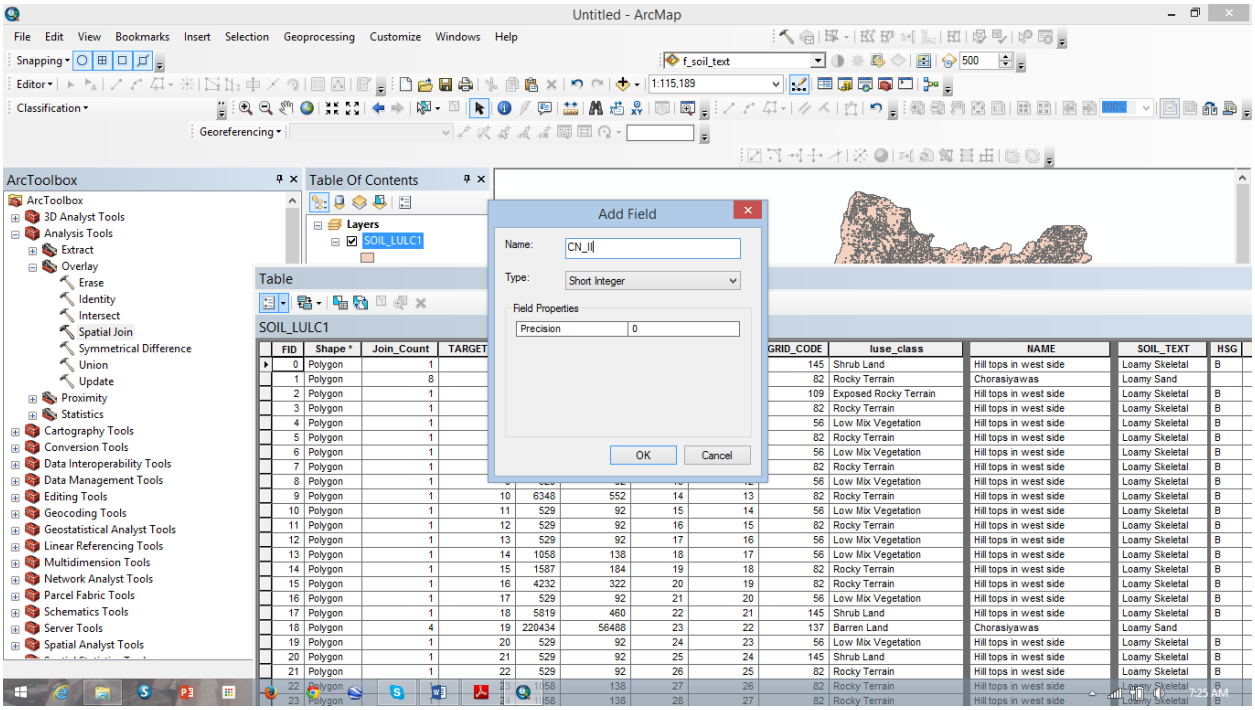
After joining the two feature layers, a map will be generated with following attributes, now you see soil class and corresponding LULC, so one can derive CN_II map for the basin.



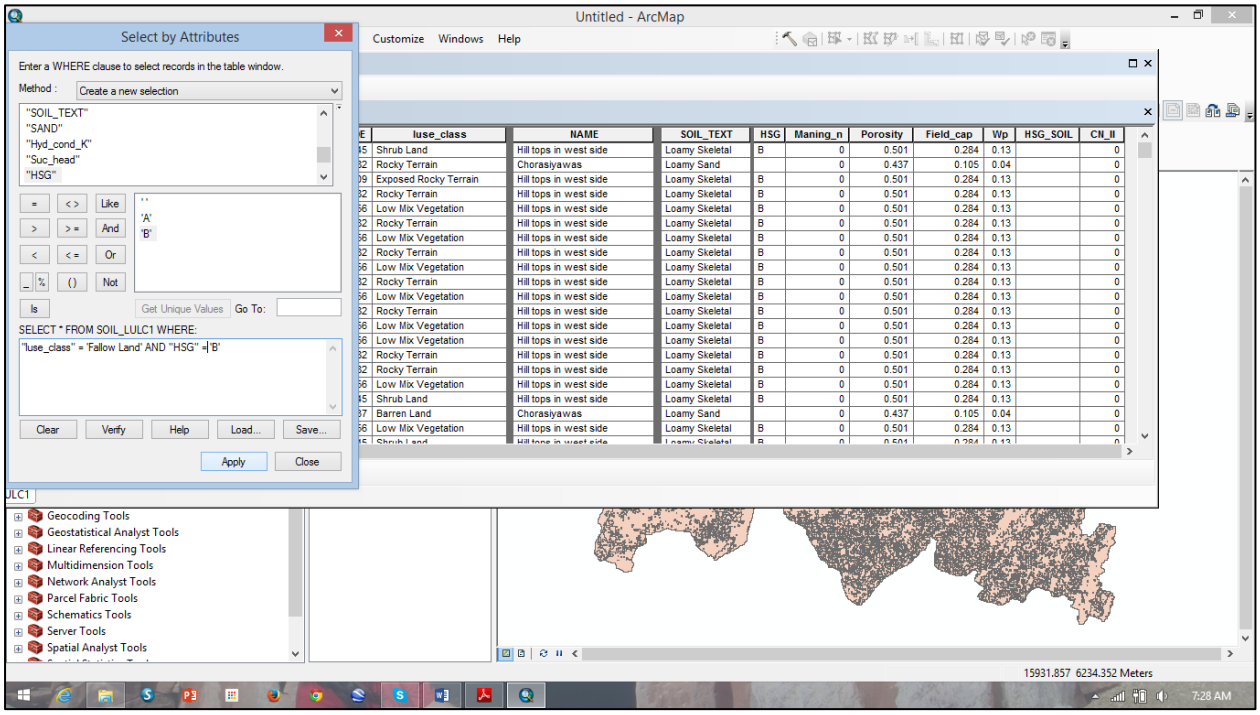


Then go to Options at the bottom of the Attribute of soil map window and click "Add Field" give Name as "CN_II" and Type as "Short Integer". Precision you can give "0" as they are integer numbers. Then click "ok".

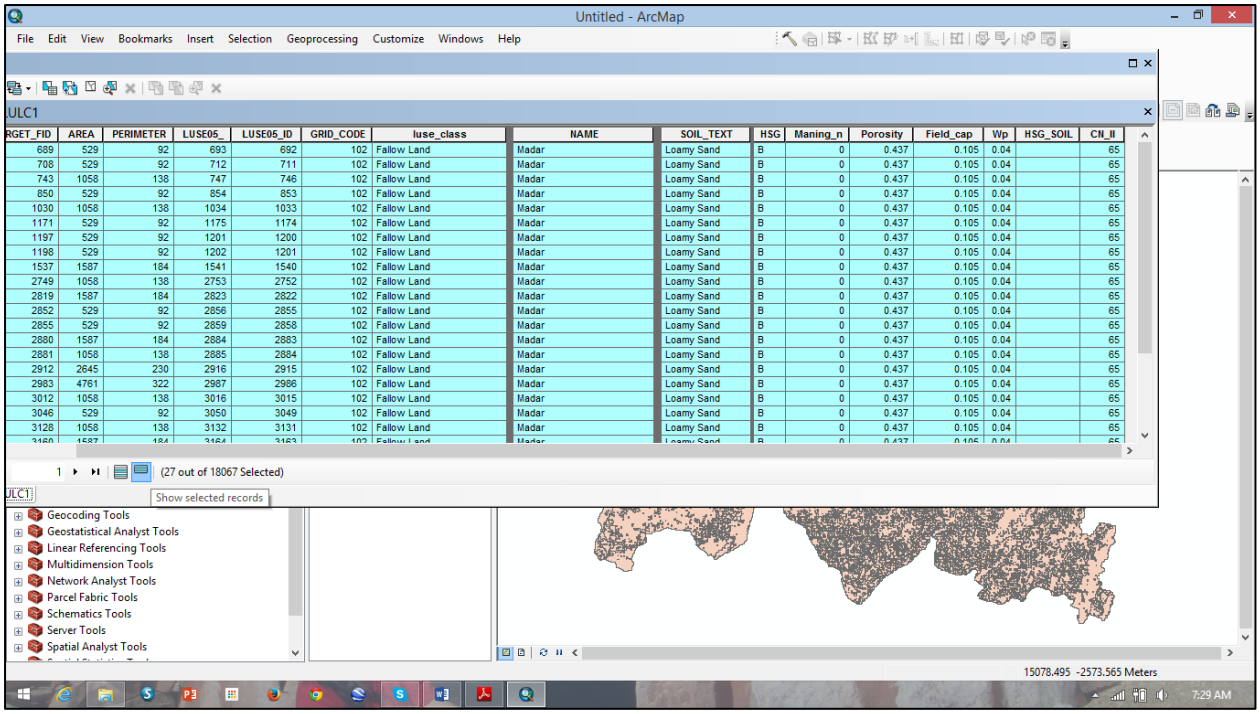




You will find CN-II column has been added to your attribute table. Now, to assign corresponding CN_II values from table in this column. Go again to Options at the top of the window, click "Select by attribute". Now, double click on "luse_class" -> = -> Get Unique Values -> 'Barren Land' -> AND -> double click "HSG" -> = 'A' -> Apply. It will select all polygons with "agriculture" LULC class and "A" HSG class.



Then go to CN-II column -> right click -> Field Calculator -> CN-II = "49" -> ok.



Follow same steps for other combinations too such as

LULC_CLASS	A	B	C	D
Barren Land'	49	69	79	84
Dense Mix Vegetation	26	40	58	61
Exposed Rocky Terrain	77	86	90	93
Fallow Land	39	61	74	80
Low Mix Vegetation	28	44	60	64
Rocky Terrain	77	86	90	93
Sandy Soil	25	44	55	60
Settlement	89	92	94	95
Shrub Land	49	68	79	84
Water	100	100	100	100
Wet Alluvium Soil	91	95	96	98

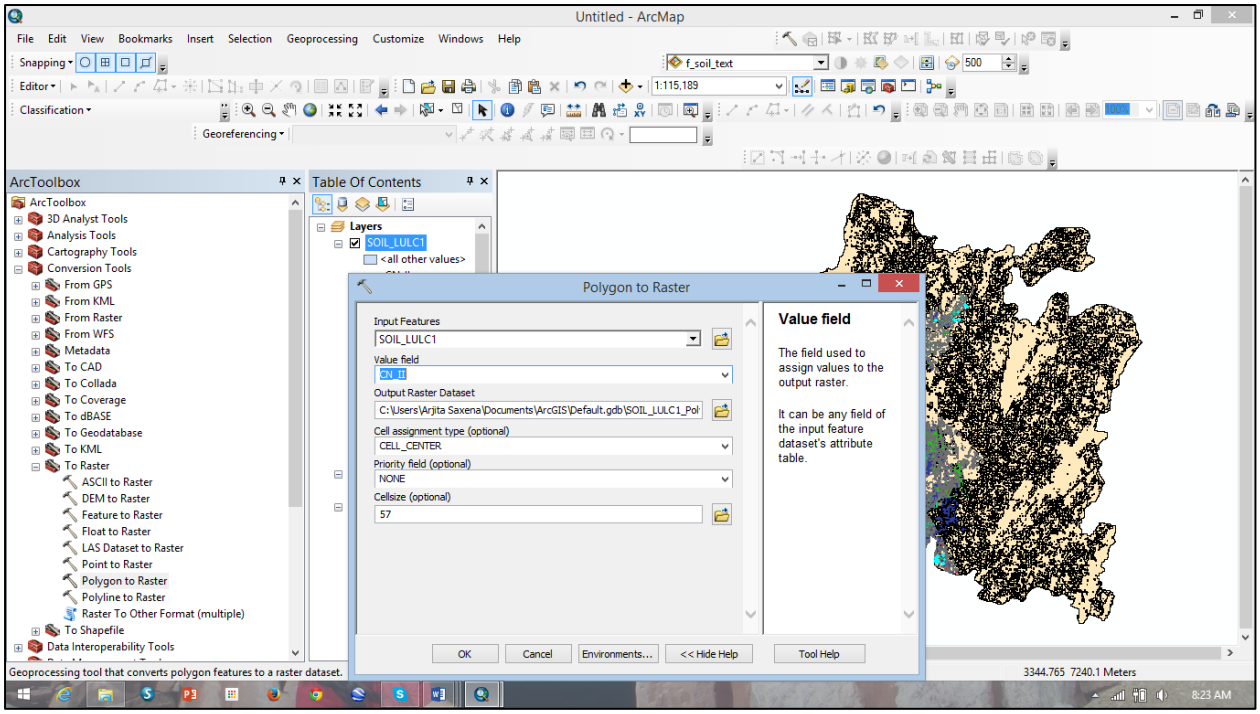
"Barren Land'" lulc class and "A" HSG, CN_II "49";

"Dense Mix Vegetation" lulc class and "A" HSG, CN_II "26";

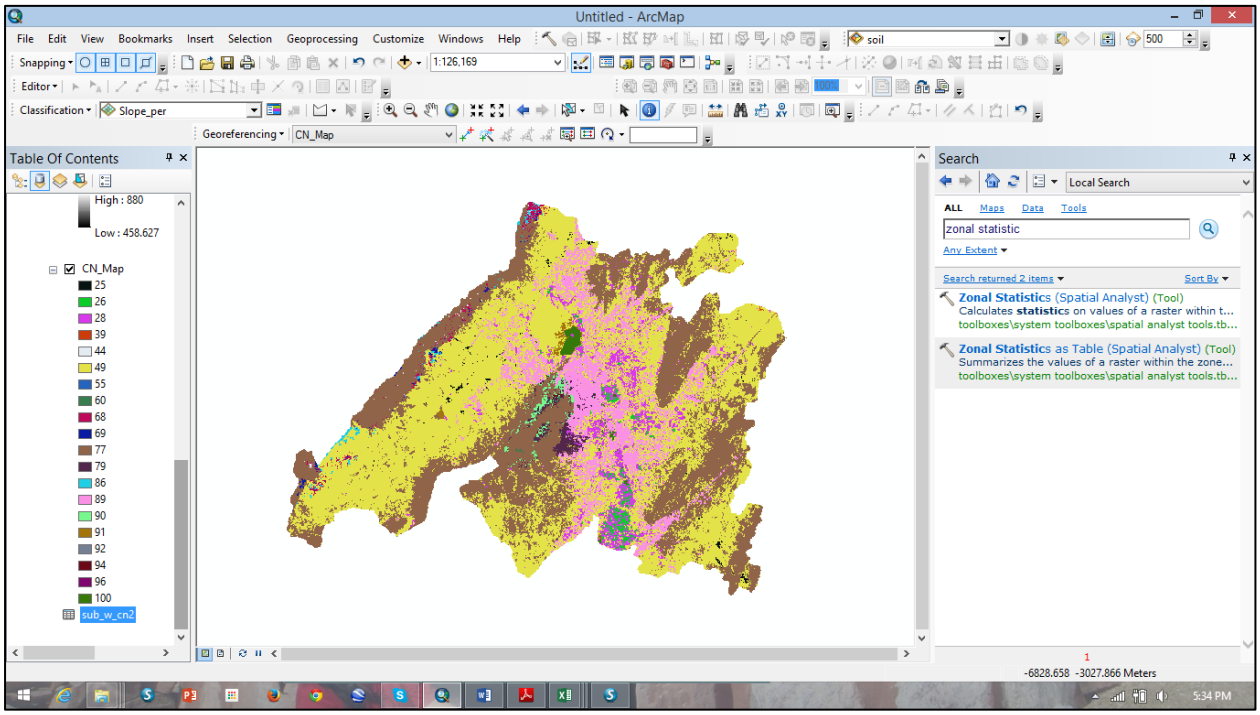
"Exposed Rocky Terrain" lulc class and "B" HSG, CN_II "86";

Now we will use the raster calculator for further calculations.

Now, to prepare CN-II map by converting polygon map into raster map, go to ArcToolbox -> Conversion Tools -> To Raster -> Polygon to Raster



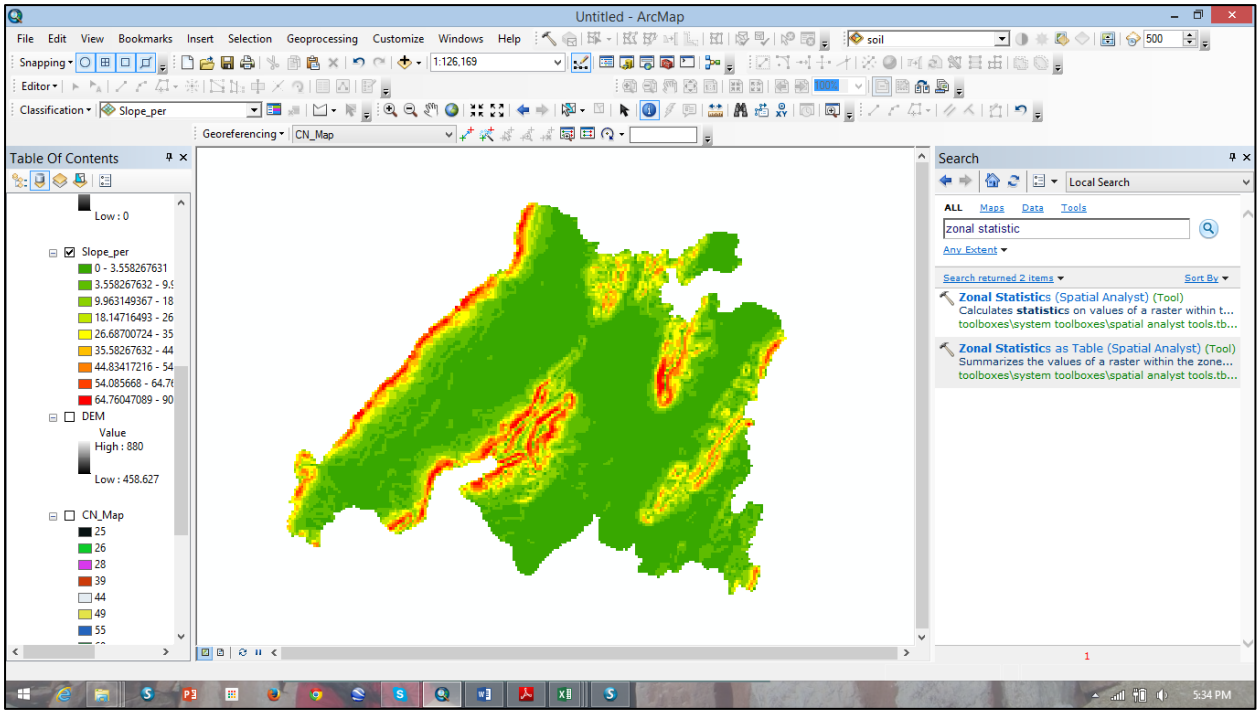
Input Feature will your spatially joined soil and LULC map, Value Field will be CN_II column, Output Raster Dataset will be your CN_II_Map. Make Sure the cell size should be same as DEM cell size, as we have to all analysis at DEM cell size.



Then carry out slope correction in CN-II using Huang (2006) approach. Derive slope map from provided ASTER DEM using Spatial Analyst Tool.

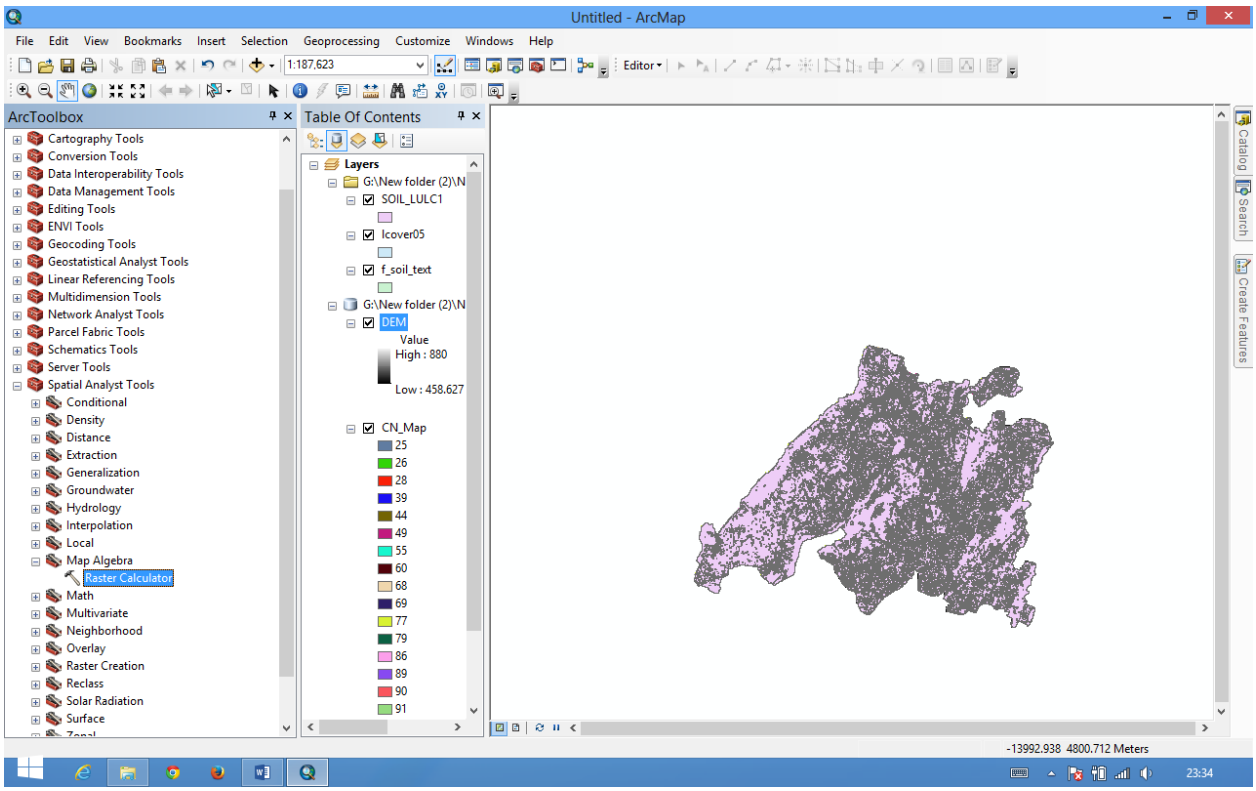
Go to ArcGIS Toolbox -> Spatial Analyst Tools -> Surface -> Slope
Input Rater will be **dem**, **Output Raster** will be **Slope** and **Output Measurements**

(optional) will be **PERCENT_RISE,** then click **"ok".**

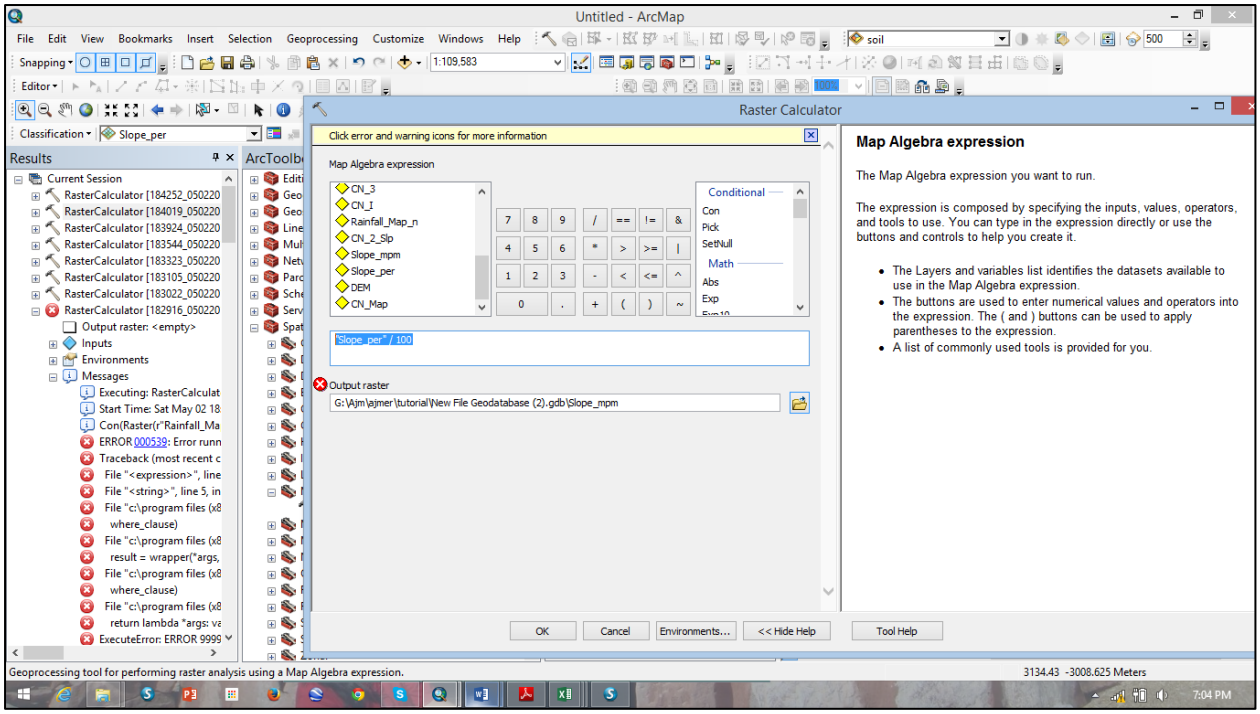


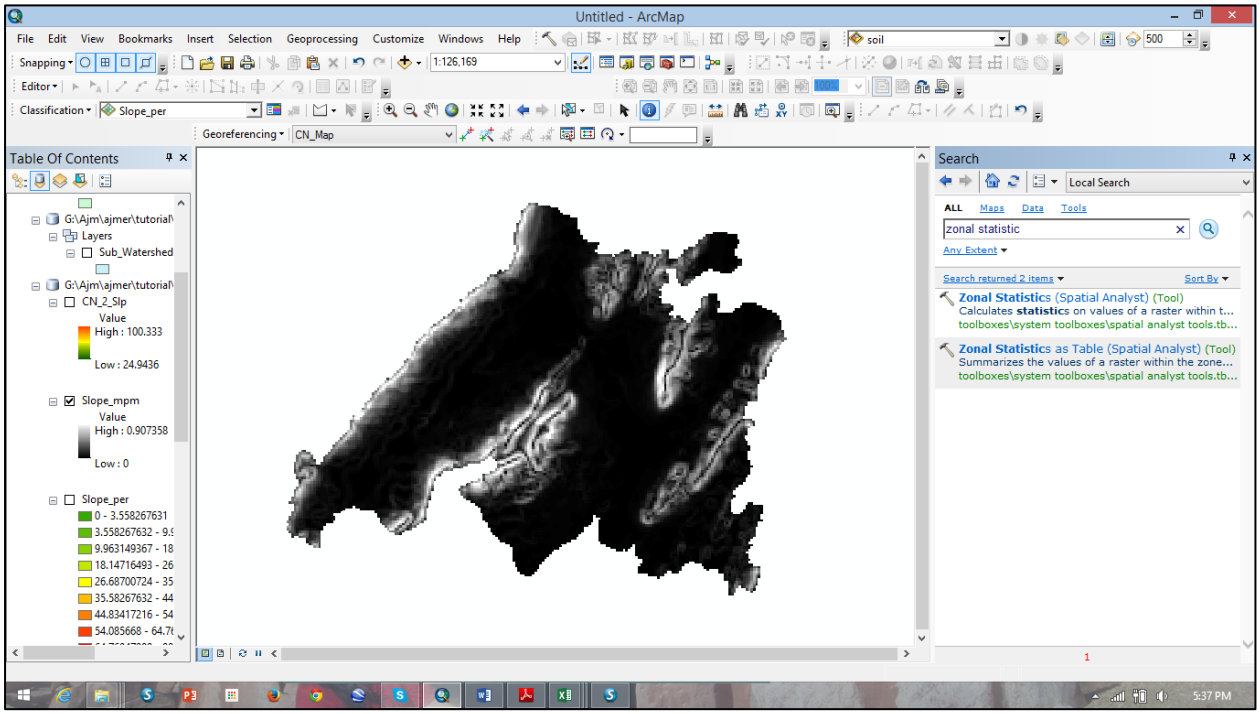
To convert slope percentage map in *slope meter per meter*, the slope percentage map should be divided by 100. For this operation use raster calculator. Using following equation.

Go to Spatial Analyst Tools **->** Map Algebra **->** Raster Calculator



Slope_mpm = "Slope_per" / 100





The original NRCS method has been developed for slope less than 5% but in your case slope may vary more than 5%. So to incorporate slope in calculation Huang (2006) proposed following equation for NRCS method:

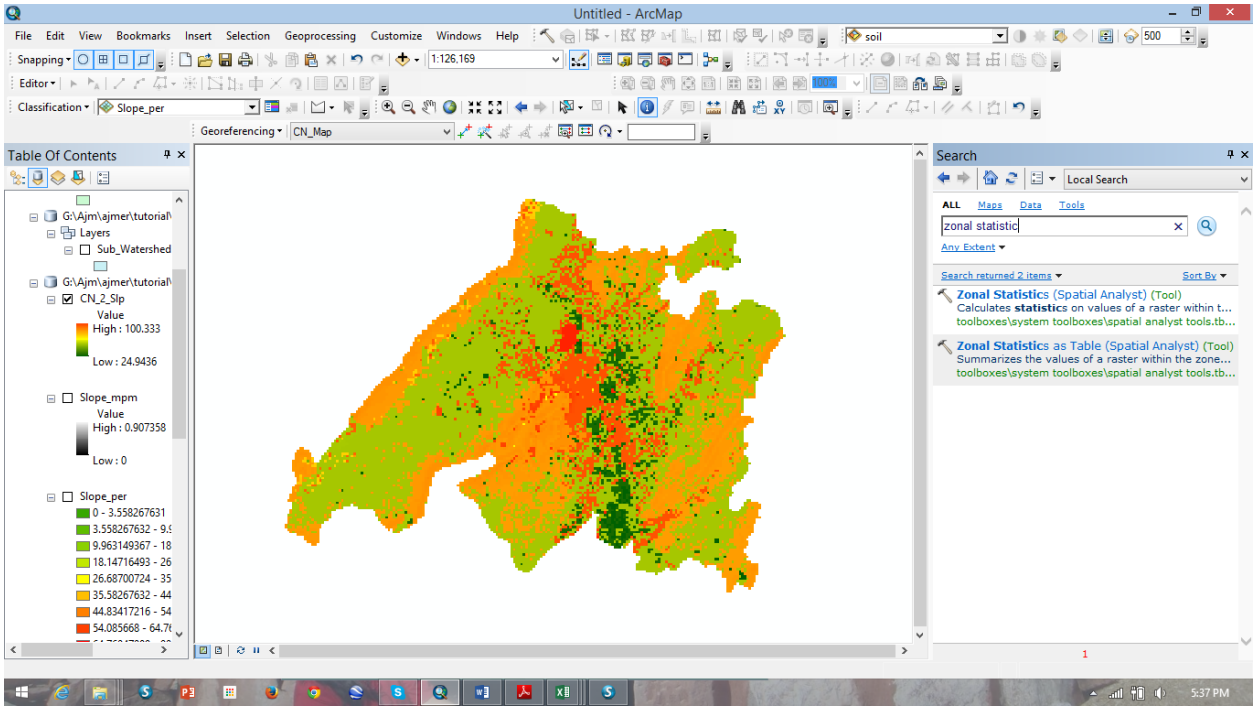
Huang (2006)

$$CN_{2\alpha} = CN_2 \frac{322.79 + 15.63(\alpha)}{\alpha + 323.52}$$

Same equation has been used in raster calculator for slope correction.

"CN_II_Map" *((322.79 + (15.63 * "Slope_mpm")) / ("Slope_mpm" + 323.52))

Give output names as "CN_II_slp"



Keep a check, the value of CN-II slope corrected should not exceed 100. If it is exceeding 100, then open Raster Calculator again and put following

Con("CN_II_slp" > 100,100,"CN_II_slp")

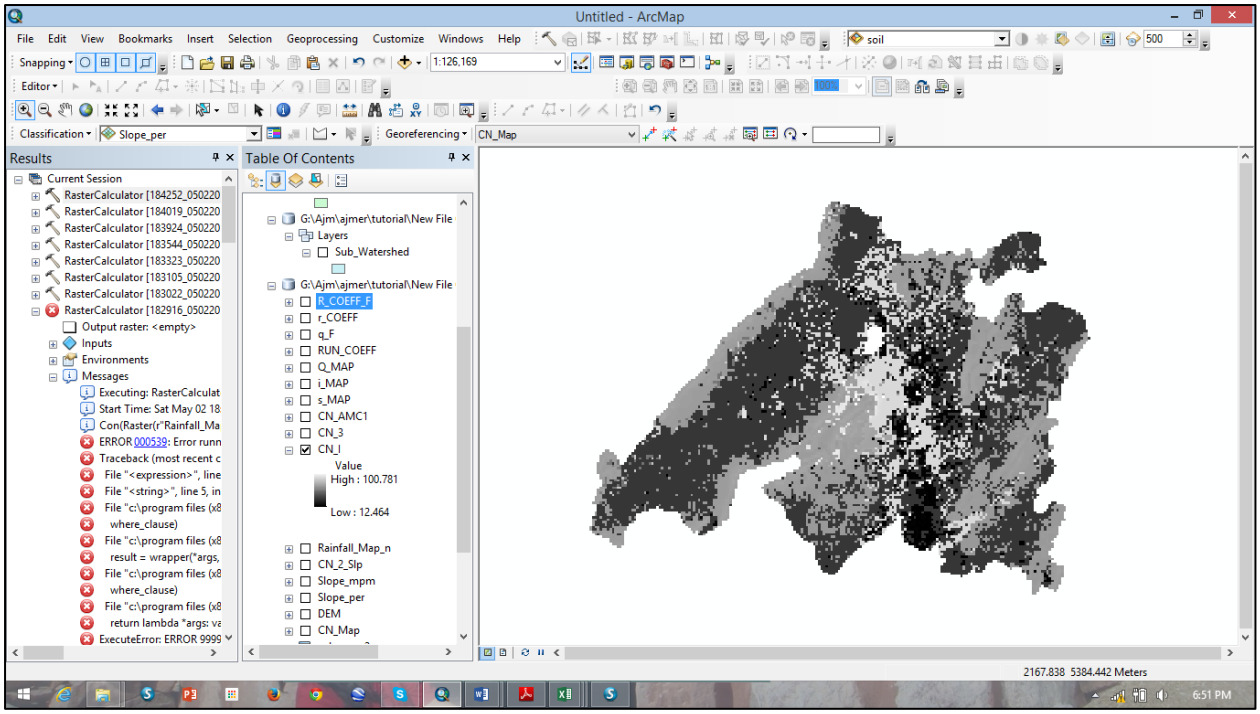
Give output names as "CN_2"

Further, as discussed above, depending upon the AMC condition (Antecedent Moisture Condition) which is to be calculated based on last five days precipitation, CN2 needs to be converted into CN_1 or CN_III

To convert CN2 TO CN1 according to AMC condition use following condition in raster calculator.

"CN_2" / (2.334 - 0.01334 * "CN_2")

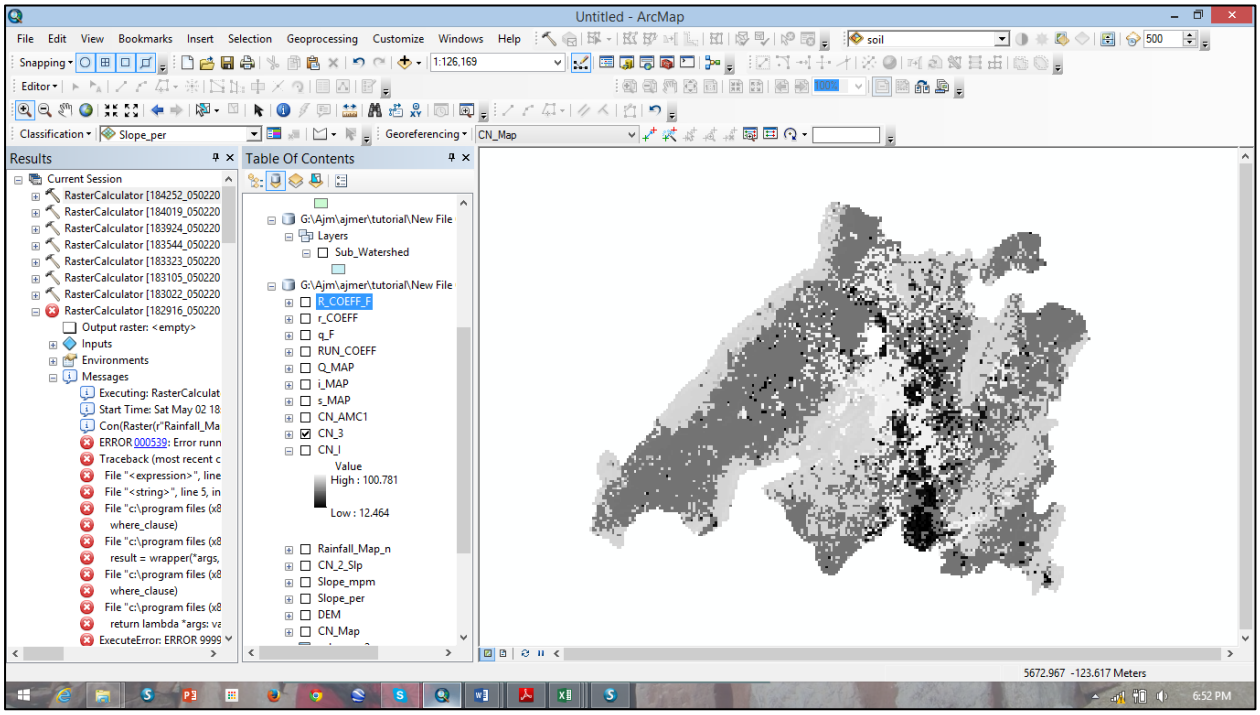
Give output names as "CN_I"



To convert CN2 TO CN3 Acc. To AMC condition

"CN_2" / (0.427 + 0.00573 * "CN_2")

Give output names as "CN_III"



To find out actual CN according to AMC, first of all add 5 raster data having preceding 05 days precipitation. Click on Add data then go to data folder where your 05 days rainfall data set is available (*rainfall*). Select rainfall and click ok. Then to calculate Curve number

as per the AMC condition use raster calculator and put following condition in Raster calculator

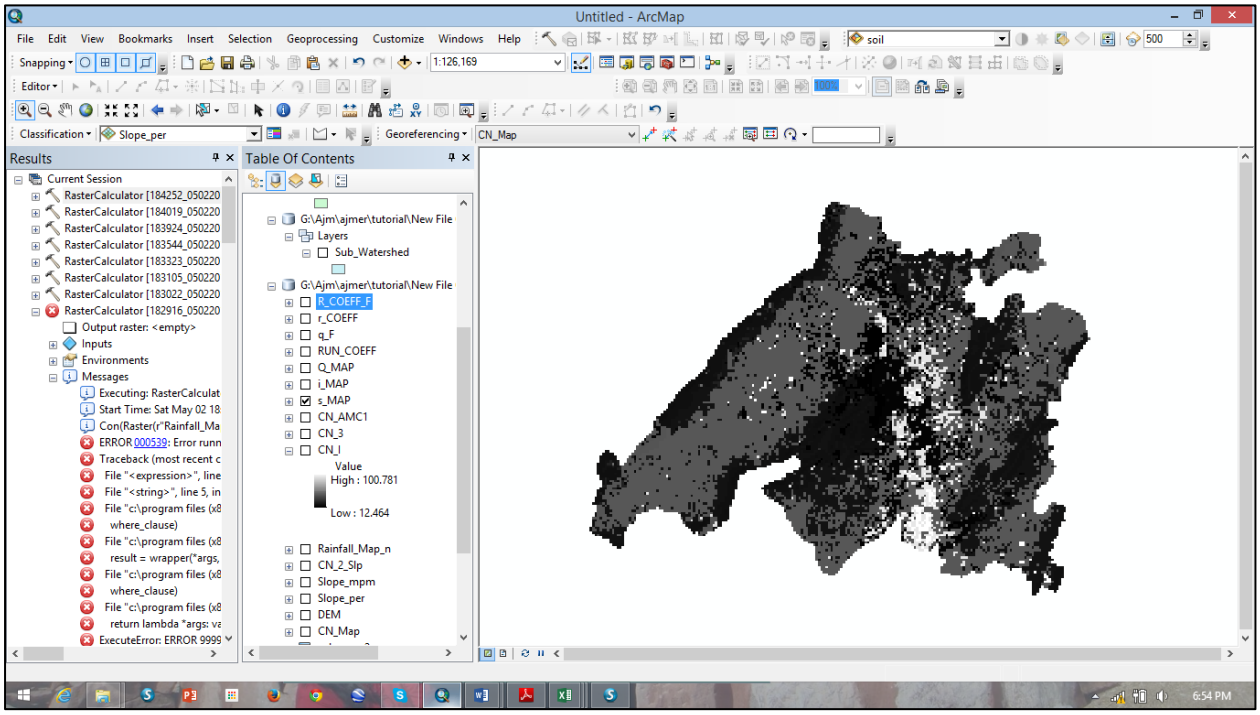
Con("rainfall" <= 35,"CN_I",(Con("rainfall" >= 52.5,"CN_III","CN_2")))

Give output names as "CN_actual

Please refer NRSC method of runoff estimation, now we need to calculate Maximum Potential Retention "S". Again go to spatial analyst in ArcTool Box and click on map algebra and then Raster calculator. Then use the mathematic expression to compute S.

S = (25400 / "CN_actual") – 254

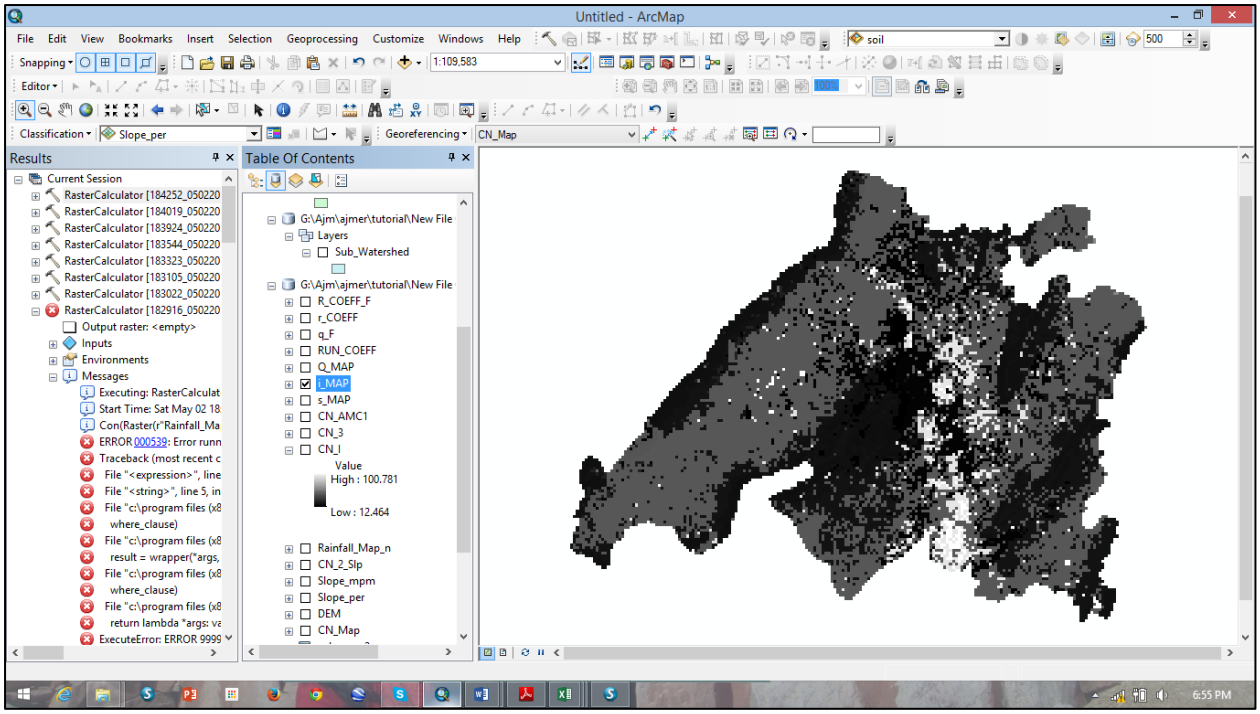
Give output names as "S_MAP"



To calculate initial abstraction "I", again go to Raster calculator and use following expression (condition) to calculate initial abstraction.

I=0.2 * "S_MAP"

Give output names as "I_MAP"

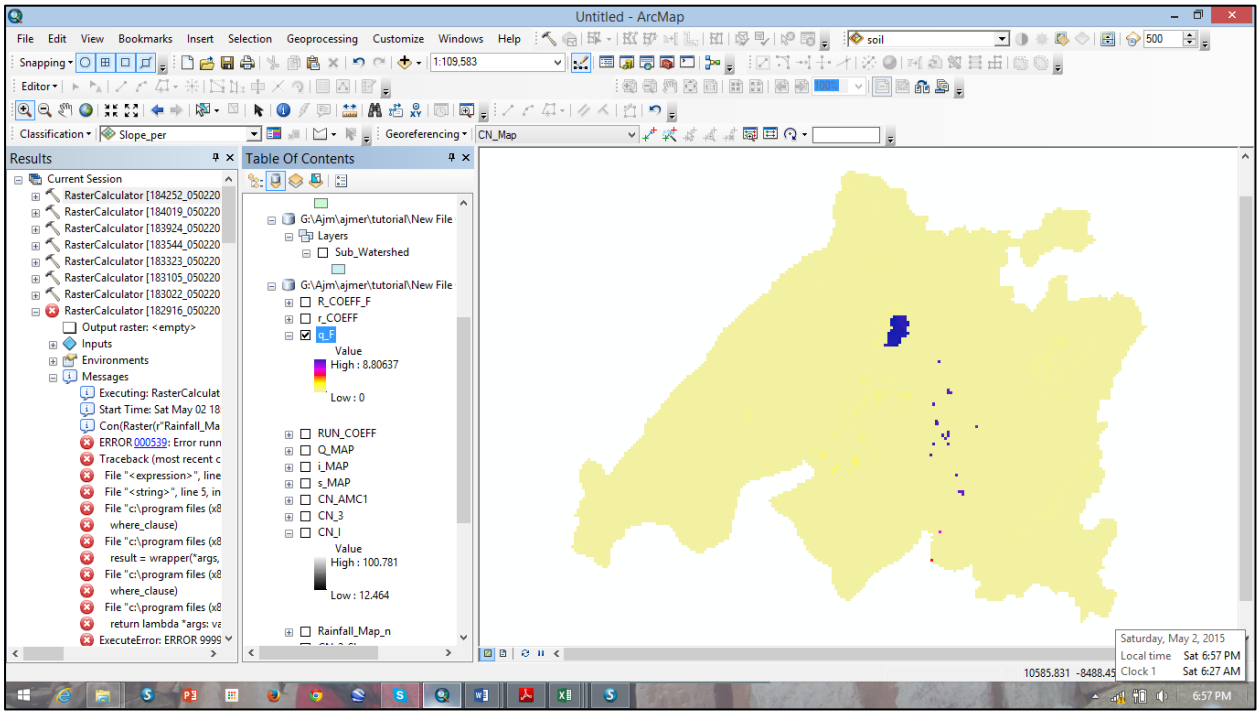


To calculate runoff depth "Q"

Q will be estimated only when rainfall P > I that means whenever Initial abstraction is less than rainfall, then only runoff will occur. We will use event rainfall which is available as rainfall_aoi (one day rainfall) to calculate runoff.

Con("rainfall_aoi" >= "I_MAP", Power(("rainfall_aoi" -"I_MAP"),2) / ("rainfall_aoi" + "S_MAP" - "I_MAP"),0)

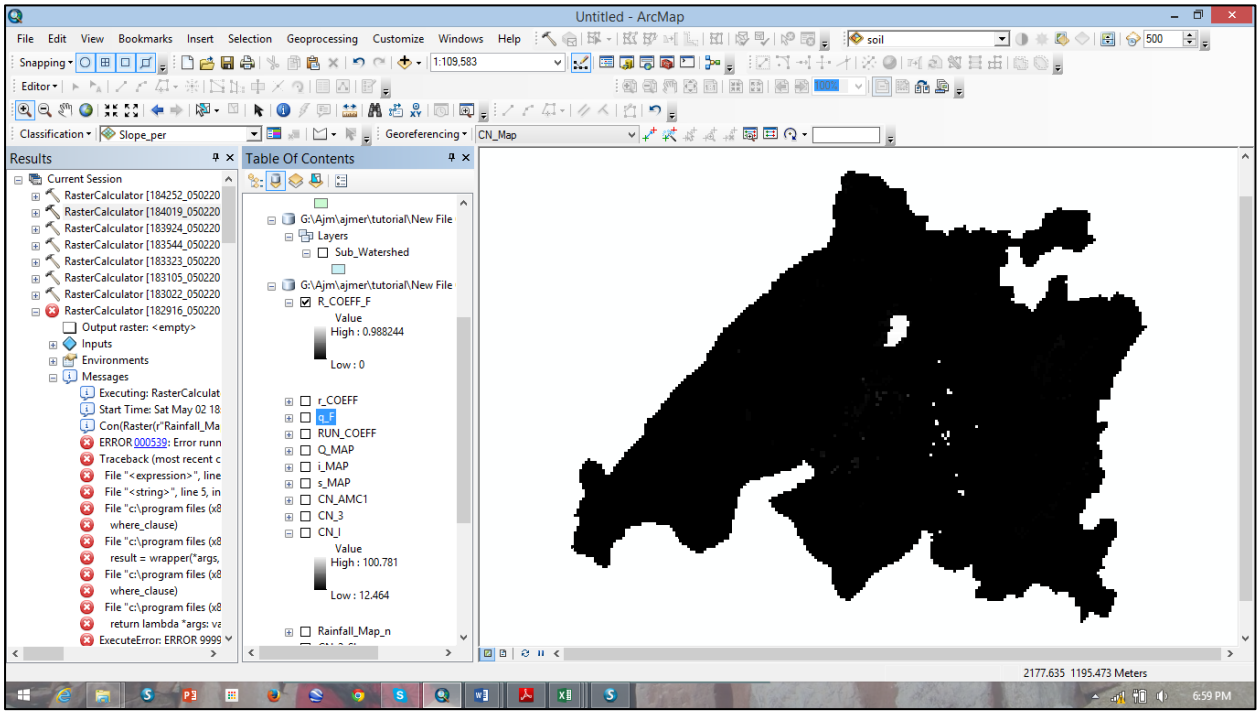
Give output names as "Q_MAP"



To Calculate runoff coefficient –Runoff coefficient is a ration of runoff and rainfall for a particular area. If we have runoff coefficient for any watershed then we can calculate runoff for any given rainfall event. Please go to again raster calculator use following expression to estimate runoff coefficient for above discussed watershed.

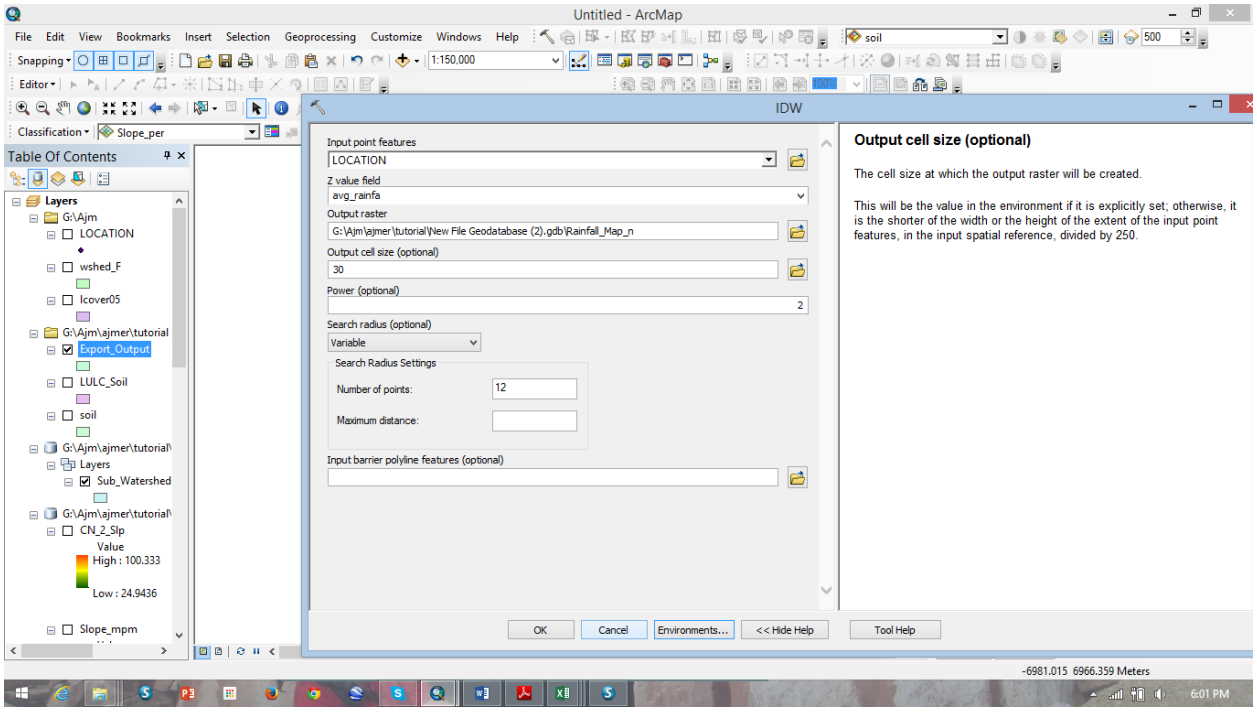
"Q_MAP" / "rainfall_aoi"

Give output name as runoff_coe and click ok.



Further exercise to calculate runoff will be done in excel

1. You have been given daily rainfall of ajmer , identify dormant and growing season (1 june to 31 October has been consider as a growing season)
2. Calculate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File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
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Classification
Slope_per
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Maximum distance:
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Tool Help
Output cell size (optional)
The cell size at which the output raster will be created.
This will be the value in the environment if it is explicitly set; otherwise, it is the shorter of the width or the height of the extent of the input point features, in the input spatial reference, divided by 250.
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