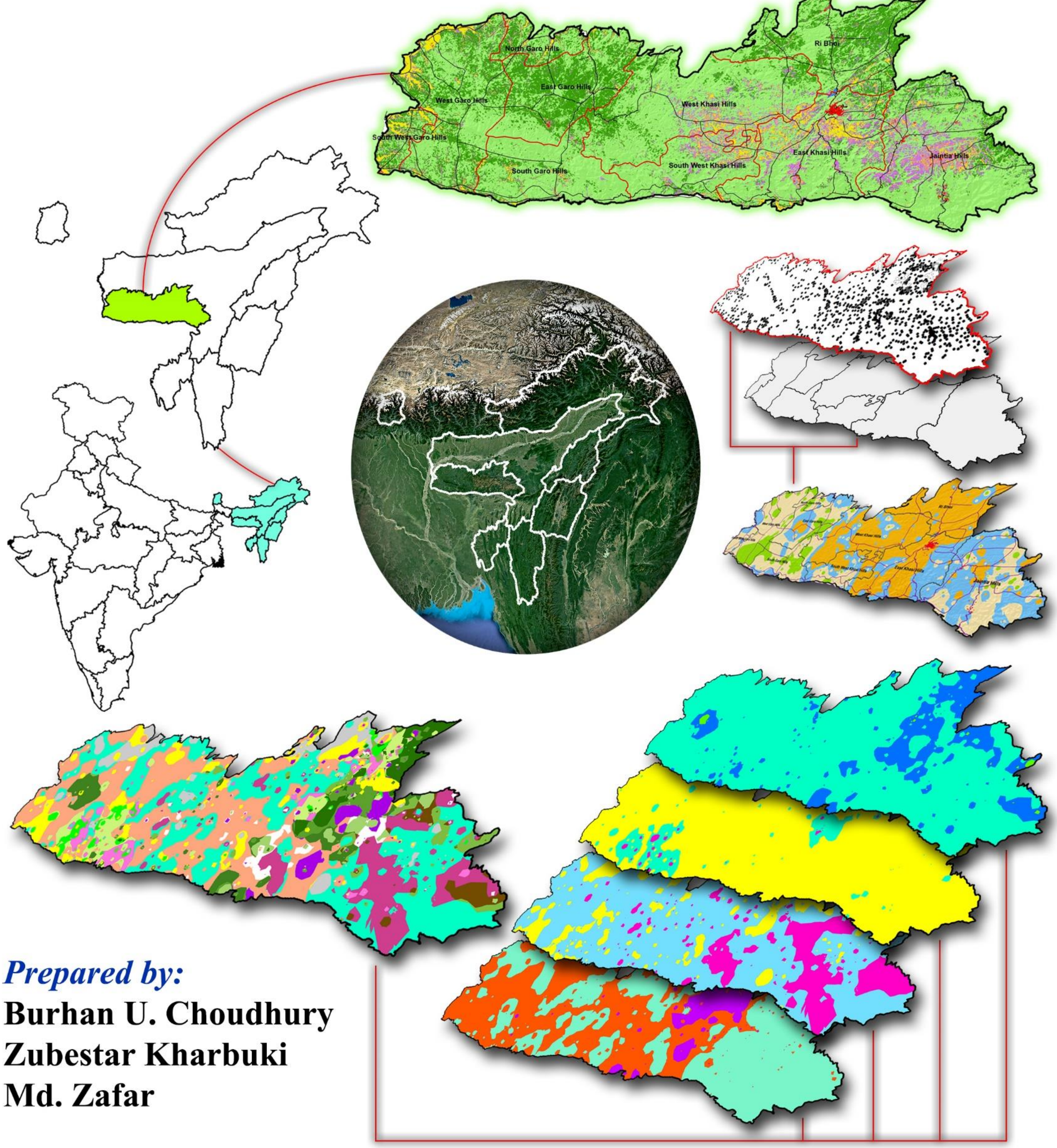
ICARNEH/KIRAN E-Pub/2021/Jan-01

Map soil using Arc GIS (v.2010.2)

E-Learning lesson for beginners in agricultural sciences



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भाकृअनुप
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Citation: Choudhury, B.U., Kharbuki, Z., and Zafar, Md. 2021. Map soil using Arc GIS (v.2010.2): ***E-Learning lesson for beginners in agricultural sciences*****. ICAR Research Complex for NEH Region. Ref. No. ICARNEH/KIRAN E-Pub/2021/Jan-01 Pages: 1-38. http:// http://www.kiran.nic.in/publication.html**

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TABLE OF CONTENTS

1 GEOGRAPHIC INFORMATION SYSTEM (GIS)

GIS: A set of computerized data management tools for collecting, storing, manipulating, retrieving, transforming, analysing, mapping and display of spatial data from the real world. The GIS integrates hardware, software, and data for capturing, managing, analysing and displaying all forms of geographically referenced information that exist and events that happen on earth. GIS is a technological field that incorporates geographical features with tabular data in order to visualize in the form of spatial maps, analyse and assess real world problems. It makes possible to map, model, query and analyse large set of spatial dataset including high volume of distribution.

In agriculture, GIS helps soil survey data seekers identify the best way to protect soil and water quality, as well as identify how land parcels are suited for specified land uses. GIS is an integral part of automated field operations, also referred to as precision agriculture or satellite farming.

1.1 Integral parts in GIS

1. **GEOGRAPHIC** - Implies that locations of the data items are known, or can be calculated in terms of Geographic coordinates (Latitude, Longitude).
2. **INFORMATION** - Implies that the data in a GIS are organized to yield useful knowledge and visualization as colour maps and images, statistical graphics, tables, and various on screen responses to interactive queries.
3. **SYSTEM**- Implies that a GIS is made up from several inter-related and linked components with different functions which gives functional capabilities for data capture, input, manipulation, transformation visualization, combinations, query, analysis, modelling and output.

1.2 Components of GIS

1. **Hardware** – It is the computer system on which a GIS software operates. The function of these components is typically divided into three main categories: Input, Storage and Output. The general hardware components of a GIS system are the Central Processing Unit (CPU). It is linked to a disk drive storage unit, which provide space for storing data and programs. A digitizer, scanner and other device are used to import input data from maps and documents into digital form. A plotter or other display device is used to present the output in computer-aided design or vector graphics.
2. **Software** - Software are computer programs and other operating information that gives instructions to the hardware to do the assigned work. GIS software is application software that provides the functions

and tools needed to store, analyse, and display geographic information. Some popular GIS software is: Arc Info, Arc View, ArcGIS, QGIS, GRASS, GIS, and ER Mapper.

3. **Data** - The most important component of a GIS is the data on which it works. Geographic and attribute data can be collected in house, compiled to custom specifications and requirements, or occasionally purchased from a commercial data provider. A GIS can integrate spatial data with other existing data resources, often stored in Database Management System (DBMS). The integration of spatial data and tabular data stored in a DBMS is a key functionality afforded by GIS.
4. **User -** They are the expert and engaged to run GIS software. GIS technology is of limited value without the user who manages the system and develops plans for applying it to real world problems. GIS users range from technical specialists who design and maintain the system to those who use it to create maps and apps, edit features, add items, share content, and create groups. The User role is compatible with the Creator, GIS Professional, Storyteller, and Insights Analyst user types.

1.3 Types of GIS Data

1. **Spatial data** - most commonly used are the following 5 types
   a. **Vector data**- They are of three types namely
      i. **Point Data** - layers containing by points (or “events”) described by x, y (lat, long; easting, northing). They represent nonadjacent features and to discrete data points (examples like city locations or place names, bore well locations)
      ii. **Line/Poly-line Data** - layers that are described by x, y points (nodes, events) and lines (arcs) joining points (line segments and polylines) like river, streams, roads, streets, railway tracks etc.
      iii. **Polygon Data -** layers of fully enclosed areas bound by straight line segments, circular arcs, elliptical arcs that are described by attributes like lakes, vegetation boundaries, and building footprints etc.
   b. **Raster or grid data- -** a raster consists of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information, such as temperature. Examples are digital aerial photographs, imagery from satellites, digital pictures, or even scanned maps.
   c. **Images or pictures** such as remote sensing data of aerial photos, satellite images, thermal images, digital elevation models (DEMs), scanned maps, land classification maps or other photos. This is special “grid” where the number in each cell (pixel) describes what

colour to paint or the spectral character of the image in that cell. (To be used, the "picture" must be placed on a coordinate system, or "geo-rectified or geo-referenced").

d. **TINs** (Triangular Irregular Networks)- are digital means to represent surface morphology. TINs are a form of vector-based digital geographic data and are constructed by triangulating a set of vertices (points). A TIN surface can be created from features, such as points, line, and polygons, which contain elevation or height information.

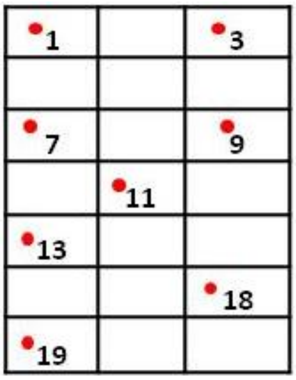
e. **Terrain data-** These are usually expressed as a series or collection of points with x-, y-, and associated z-values. They include a series of points representing the high and low extremes in the terrain that define topographic features such as streams, levees, ridges, and other phenomena.

2. **Attribute data-** they are non-spatial characteristics that are connected by tables to spatial features (points, lines, "events" on lines, polygons and in some cases GRID cells). They provide characteristics (what, where, and why) about spatial data. Examples of attribute data are soil properties like soil depth, texture, pH, nutrients, salinity and alkalinity conditions, drainage, run off, erosion etc. They are linked with spatial aspect of the soils to form the soil model. Spatial data are used to provide the visual representation of a geographic space and is stored as raster and vector types. Attribute data are descriptions, measurements, and/or classifications of geographic features in a map.

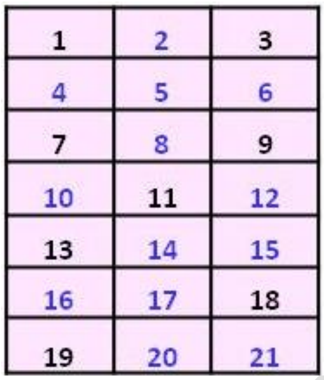
2 INTERPOLATION

It is the process of estimating unknown values that fall between known values. Spatial interpolation calculates an unknown value from a set of sample points with known values (measured) that are distributed across an area. The distance from the cell with unknown value to the sample cells contributes to its final value estimation. . It can be used to predict unknown values for any geographic point data, such as elevation, rainfall, height, soil properties etc. Measured sampling points can be either randomly or regularly spaced or based on a sampling scheme but should be well-distributed throughout the study area.

Surface interpolation functions create a continuous (or prediction) surface from sampled point values. The continuous surface representation of a raster dataset represents height, concentration, or magnitude—for example elevation, rainfall, height, soil properties etc. Surface interpolation functions make predictions from sample measurements for all locations in a raster dataset whether or not a measurement has been taken at the location. Below is the simplified example – how interpolation works. It shows the distribution and values of measured sample points (left side) and a raster interpolated from these measured points (right side). Unknown values are predicted with a mathematical formula that uses the values of nearby known points.



Before interpolation



After interpolation

2.1 Why interpolation is needed?

Surveying every location (high density sampling) to acquire information (measuring spatial and attribute in nature) in a study area, particularly landscape like Northeastern Himalayan Region of India predominant with inaccessible hilly terrains and undulating topography with poor transportation connectivity is extremely difficult, laborious, time consuming and too expensive. Under such circumstances, if we acquire measured information of a particular attribute from strategically representative sampling locations across the study area, then we can predict the values (with variable accuracy) and assigned to the non-covered sampling locations across the study area by interpolation.

2.2 Different methods of interpolation

There are different types of interpolation methods used to predict unknown values, based on sampling density, nature of attribute data, and the objectives of the study. Each method is referred to as a model and each of them produces predictions using different assumptions made of the data, calculations and applicable for specific local variation. Some of the mostly commonly used are as follows-

There are two broad types of interpolations - Deterministic interpolation, and Geo-statistical interpolation.

2.2.1 Deterministic interpolation methods

They create surfaces from the measured points, based on either the extent of similarity (inverse distance weighted) or the degree of smoothing (radial basis functions). They are directly based on the surrounding measured values or on specified mathematical formulas that determine the smoothness of the resulting surface. Most commonly used some of them are as follows: Inverse distance weighted (IDW), Radial basis functions (RBF), Spline, Local polynomial interpolation (LPI) etc.

i. **Inverse distance weighted (IDW)**: The IDW is one of the mostly applied and deterministic interpolation techniques in the field of soil science. IDW interpolation explicitly implements the assumption that things that are close to one another are more alike than those that are farther apart. To predict a value for any unmeasured location, IDW will use the measured values surrounding the prediction location. Those measured values closest to the prediction location will have more influence on the predicted value than those farther away. Thus, IDW assumes that each measured point has a local influence that diminishes with increase in distance. It weights the points closer to the prediction location greater than those farther away, hence the name inverse distance weighted. The weights assigned to the interpolating points are the inverse of its distance from the interpolation point.

ii. **Radial basis function (RBF):** RBF is one of the primary tools for interpolating multidimensional scattered data. The method's ability to handle arbitrarily scattered data, to easily generalize to several space dimensions has made it popular in the applications of natural resource management. They are exact interpolators that create smooth surfaces and produces good results for gently varying attributes. Since the predictions are exact, RBFs can be locally sensitive to outliers (that is the surfaces will contain locally high or low values in order to pass through an extreme measured values).

iii. **Spline:** It fits a mathematical function to a specified number of nearest input points while passing through the sample points. It performs a two-dimensional minimum curvature interpolation on a point dataset using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points. Conceptually, it is analogous to bending a sheet of rubber to pass through known points while minimizing the total curvature of the surface. Spline had the tendency to generate extreme data values along edges of the study area. However, the advantage of splining function is that they can generate sufficiently accurate surfaces from only a few sampled points and they retain small features. A disadvantage is that they may have different minimum and maximum values than the data set and the functions are sensitive to outliers due to the inclusion of the original data values at the sample points.

iv. **Thiessen Polygon**: It is a 2-dimensional shape whose boundaries contain all space which is closer to a point within the area than any other point without the area. Thiessen polygons are a more specific application of Voronoi diagram to meteorology and geophysics. Use: The Thiessen polygon is a commonly used methodology for computing the mean areal precipitation for a catchment from rain-gauge observations. The area of each polygon is used to weight the rainfall amount of the station in the centre of the polygon.

2.2.2 Geo-statistical interpolation

They are based on statistical models that include autocorrelation i.e. statistical relationships among the measured points. They quantify the spatial autocorrelation among the sampling points and accounts for the spatial configuration of the sampling points around the prediction location. This gives them an edge over deterministic models to have the capability of producing a prediction surface along with some measure of the certainty or accuracy of the prediction. The most commonly used geo-statistical interpolation is kriging.

Kriging is a statistical method that makes use of a variogram to calculate the spatial autocorrelation between points at graduated distances. It uses this calculation of spatial autocorrelation to determine the weights that should be applied at various distances. Spatial autocorrelation is determined by taking squared differences between points. Kriging is a multistep process; it includes exploratory statistical analysis of the data, variogram modeling, creating the surface, and (optionally) exploring a variance surface. A semi-variogram is used to display the variability between data points (direction separating two locations to quantify the spatial dependence in the data) as a function of distance. They characterize the spatial continuity or roughness of a data set. Kriging are of various types and the most commonly used are such as Ordinary kriging (OK), Universal kriging (UK) and Empirical Bayes kriging (EBK) etc.

i. **Ordinary Kriging (OK):** Ordinary Kriging is a spatial estimation method where the error variance is minimized. This error variance is called the kriging variance. It is based on the configuration of the data and on the variogram, hence is is homoescedastic. It is not dependent on the data used to make the estimate as opposed to other types of Kriging, assumes spatial autocorrelation but does not assume any overriding trends or directional drift.

ii. **Universal Kriging (UK):** The universal kriging model splits the random function into a linear combination of deterministic functions, known at any point of the region, and a random component, the residual random function. It is probably the most adequate in cases when the input data is marked by a common trend.

iii. **Empirical Bayesian kriging (EBK):** This method automates the most difficult aspects of building a valid kriging model. It differs from other kriging methods by accounting for the error introduced by estimating the underlying semivariogram. Other kriging methods calculate the semivariogram from known data locations and use this single semivariogram to make predictions at unknown locations; this process implicitly assumes that the estimated semivariogram is the true semivariogram for the interpolation region. By not taking the uncertainty of semivariogram estimation into account, other kriging methods underestimate the standard errors of prediction than EBK. It also requires minimal interactive modeling and standard errors of prediction are more accurate than other kriging methods. Similarly, it allows accurate predictions of moderately non-stationary data and more accurate than other kriging methods for small datasets. However, pprocessing time rapidly increases as the number of input points, the subset size, or the overlap factor increase. It also does not have option to do co-kriging and anisotropic corrections. Similarly, the log empirical transformation is particularly sensitive to outliers and gives predictions that are orders of magnitude larger or smaller than the values of the input points.

2.3 Similarities between IDW and Kriging

There is no single preferred method for data interpolation. All the methods have their advantages and limitations based on data structure and specific purposes to be used. However, among all the methods, IDW, Kriging and Spline are the most commonly used and preferred interpolation methods. Both IDW and Kriging perform better than spline since spline had the tendency to generate extreme data values along edges of the study area. Similarly, spline may have different minimum and maximum values than the data set. However, all these three methods are sensitive to outliers due to the inclusion of the original data values at the sample points. Like IDW interpolation, kriging forms weights from surrounding measured values to predict unmeasured locations. As with IDW interpolation, the measured values closest to the unmeasured locations have the most influence.

2.4 Differences between IDW and kriging

IDW differs from Kriging in that no statistical models are used. There is no determination of spatial autocorrelation taken into consideration. In IDW only known z values and distance weights are used to determine unknown areas. It models spatial autocorrelation with a particular function, regardless of the particular properties of the surface being estimated. However, IDW has the advantage that it is simple, easy to define, efficient and therefore, easy to understand the results (intuitive). This interpolation works best with evenly distributed points. It is often used in soil science even with thin and evenly distributed data points. Disadvantages are that it is sensitive to outliers and there is no indication of error.

Kriging has the tendency to underestimate data values compared to actual data values. Kriging also suffers when there are outliers and direction of gradients in the data point is not known. It is very difficult to build a valid kriging model when some values are several times larger than all other values. The outliers exert so much influence on the estimated semivariogram that no combination of semivariogram parameters seems to fit the data. Kriging is the most appropriate only when you know there is a spatially correlated distance or directional bias in the data. It is often used in soil science and geology.

3 TUTORIAL

3.1 How to Import GCPs arranged in Excel Data to Arc Map.

Step I: The GCPs (collected by GPS" Global positioning system) in **Excel sheet** should be arranged in a proper format and it should have the **latitude and longitude** data i.e., the **X** and **Y** coordinates of a specific point in **decimal degree format**.

The formula to convert Degrees, Minutes, Seconds (DMS generally GPS system records) to Decimal Degrees is given below.

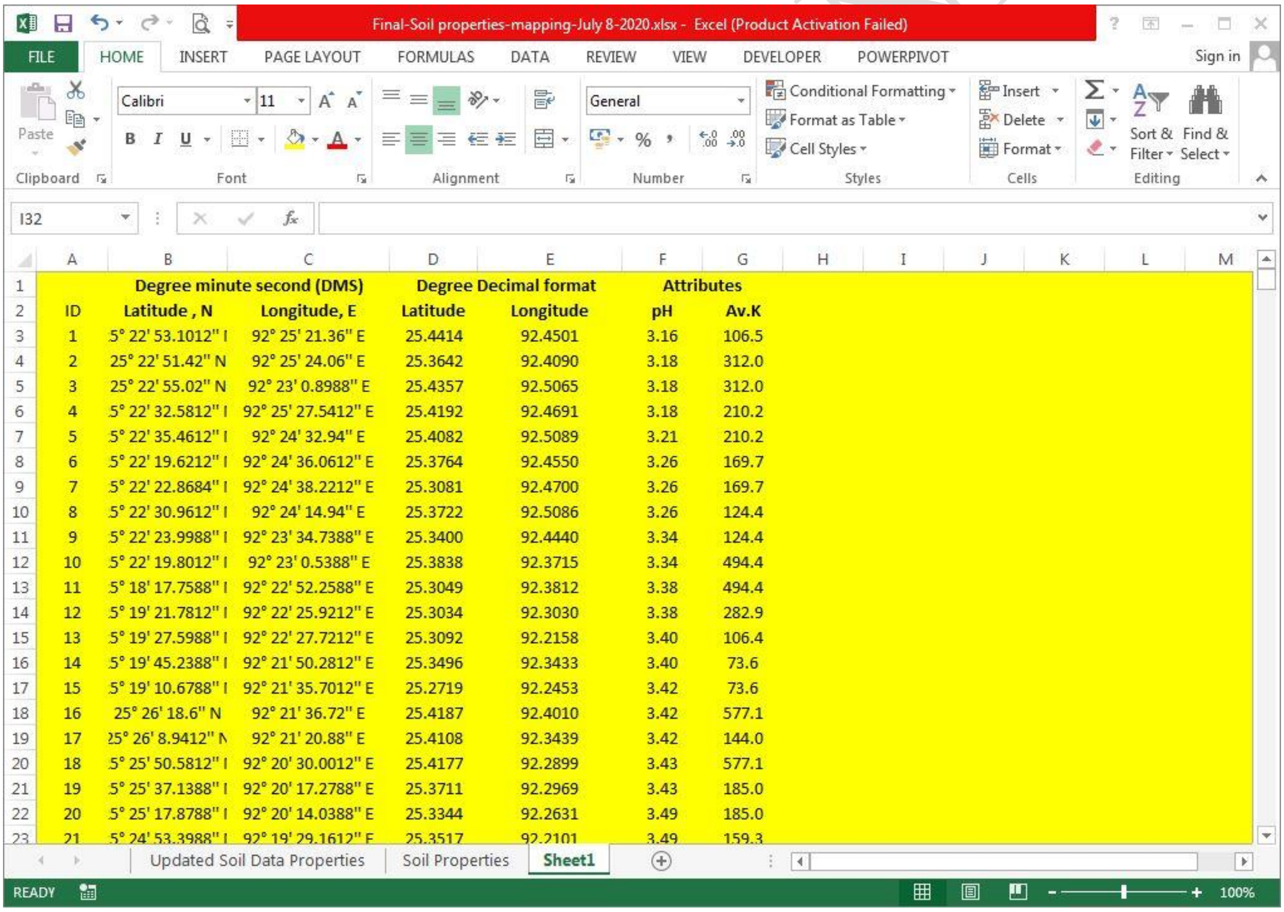
Decimal degrees = Degrees + (Minutes / 60) + (Seconds / 3600)

For example, to convert 92° 25' 21.36" to decimal degrees

Decimal degrees = 92° + (25' / 60) + (21.36" / 3600)

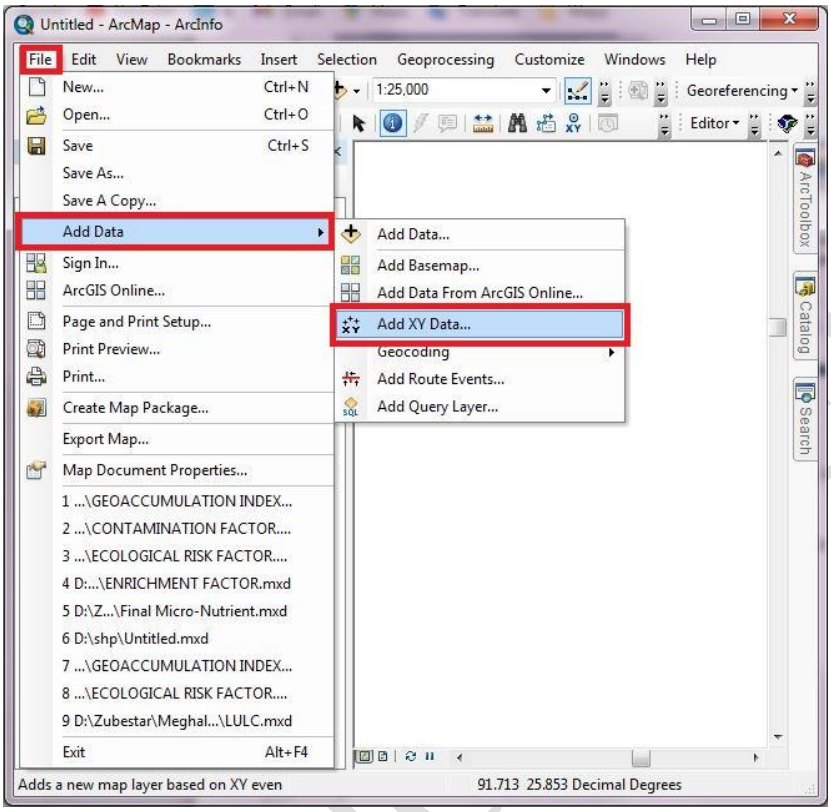
= 92° + 0.416667° + 0.005933°

= 92.422600°

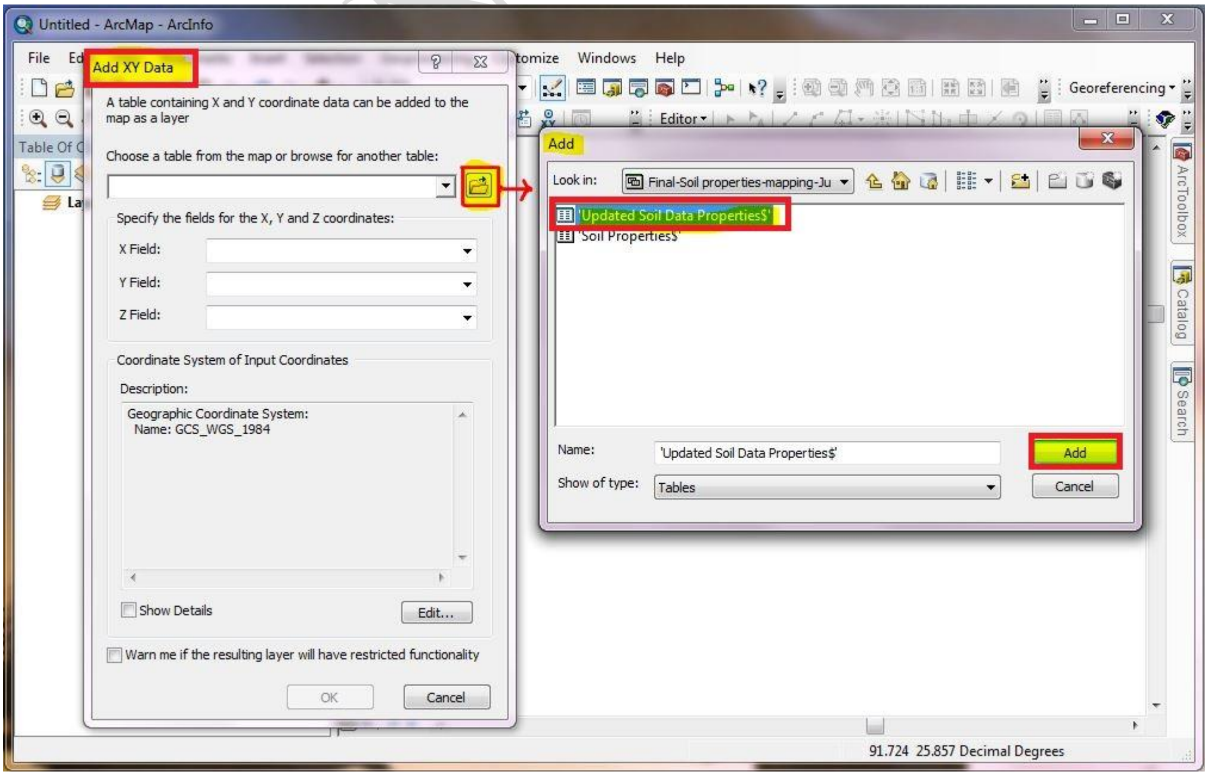


	A	B	C	D	E	F	G
1		Degree minute second (DMS)		Degree Decimal format		Attributes	
2	ID	Latitude , N	Longitude, E	Latitude	Longitude	pH	Av.K
3	1	5° 22' 53.1012" I	92° 25' 21.36" E	25.4414	92.4501	3.16	106.5
4	2	25° 22' 51.42" N	92° 25' 24.06" E	25.3642	92.4090	3.18	312.0
5	3	25° 22' 55.02" N	92° 23' 0.8988" E	25.4357	92.5065	3.18	312.0
6	4	5° 22' 32.5812" I	92° 25' 27.5412" E	25.4192	92.4691	3.18	210.2
7	5	5° 22' 35.4612" I	92° 24' 32.94" E	25.4082	92.5089	3.21	210.2
8	6	5° 22' 19.6212" I	92° 24' 36.0612" E	25.3764	92.4550	3.26	169.7
9	7	5° 22' 22.8684" I	92° 24' 38.2212" E	25.3081	92.4700	3.26	169.7
10	8	5° 22' 30.9612" I	92° 24' 14.94" E	25.3722	92.5086	3.26	124.4
11	9	5° 22' 23.9988" I	92° 23' 34.7388" E	25.3400	92.4440	3.34	124.4
12	10	5° 22' 19.8012" I	92° 23' 0.5388" E	25.3838	92.3715	3.34	494.4
13	11	5° 18' 17.7588" I	92° 22' 52.2588" E	25.3049	92.3812	3.38	494.4
14	12	5° 19' 21.7812" I	92° 22' 25.9212" E	25.3034	92.3030	3.38	282.9
15	13	5° 19' 27.5988" I	92° 22' 27.7212" E	25.3092	92.2158	3.40	106.4
16	14	5° 19' 45.2388" I	92° 21' 50.2812" E	25.3496	92.3433	3.40	73.6
17	15	5° 19' 10.6788" I	92° 21' 35.7012" E	25.2719	92.2453	3.42	73.6
18	16	25° 26' 18.6" N	92° 21' 36.72" E	25.4187	92.4010	3.42	577.1
19	17	25° 26' 8.9412" N	92° 21' 20.88" E	25.4108	92.3439	3.42	144.0
20	18	5° 25' 50.5812" I	92° 20' 30.0012" E	25.4177	92.2899	3.43	577.1
21	19	5° 25' 37.1388" I	92° 20' 17.2788" E	25.3711	92.2969	3.43	185.0
22	20	5° 25' 17.8788" I	92° 20' 14.0388" E	25.3344	92.2631	3.49	185.0
23	21	5° 24' 53.3988" I	92° 19' 29.1612" E	25.3517	92.2101	3.49	159.3

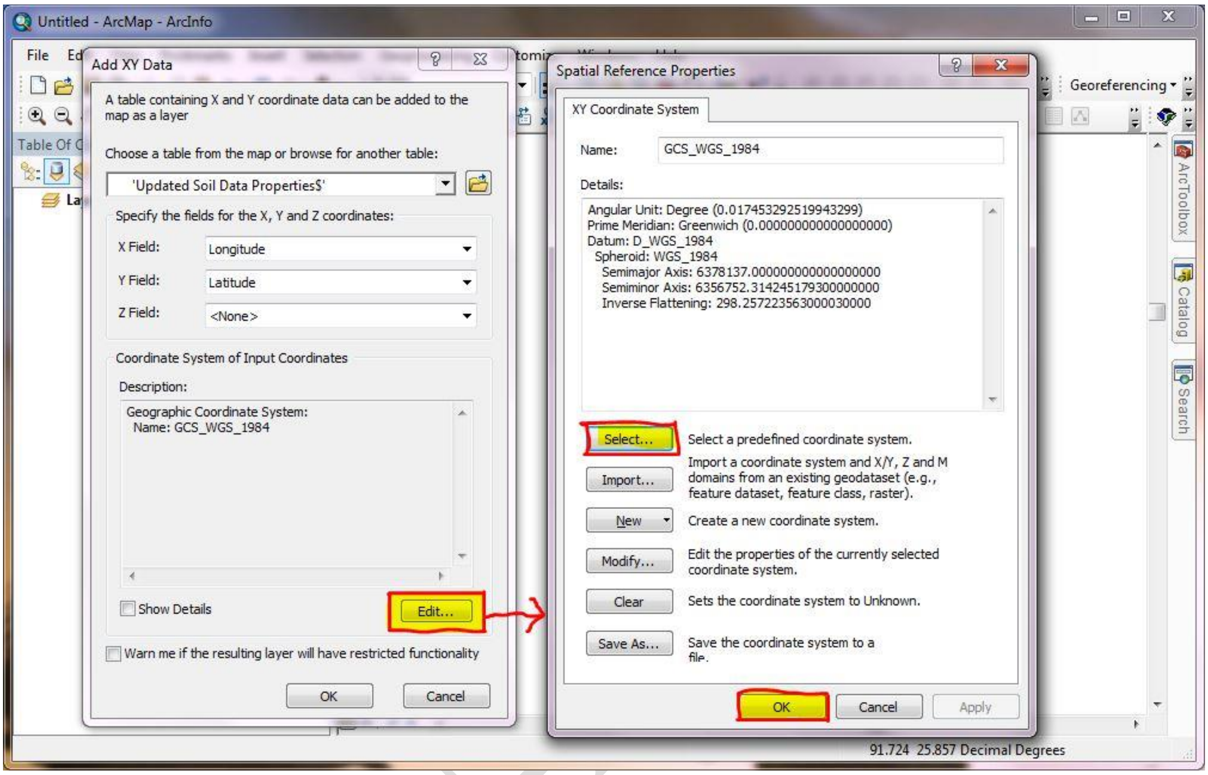
Step II: After conversion to Degree decimal, these data points (X, Y) need to be added in Arc Map. Open **Arc Map** and add the **X, Y Data** from **file** tab, according to the figure given below.

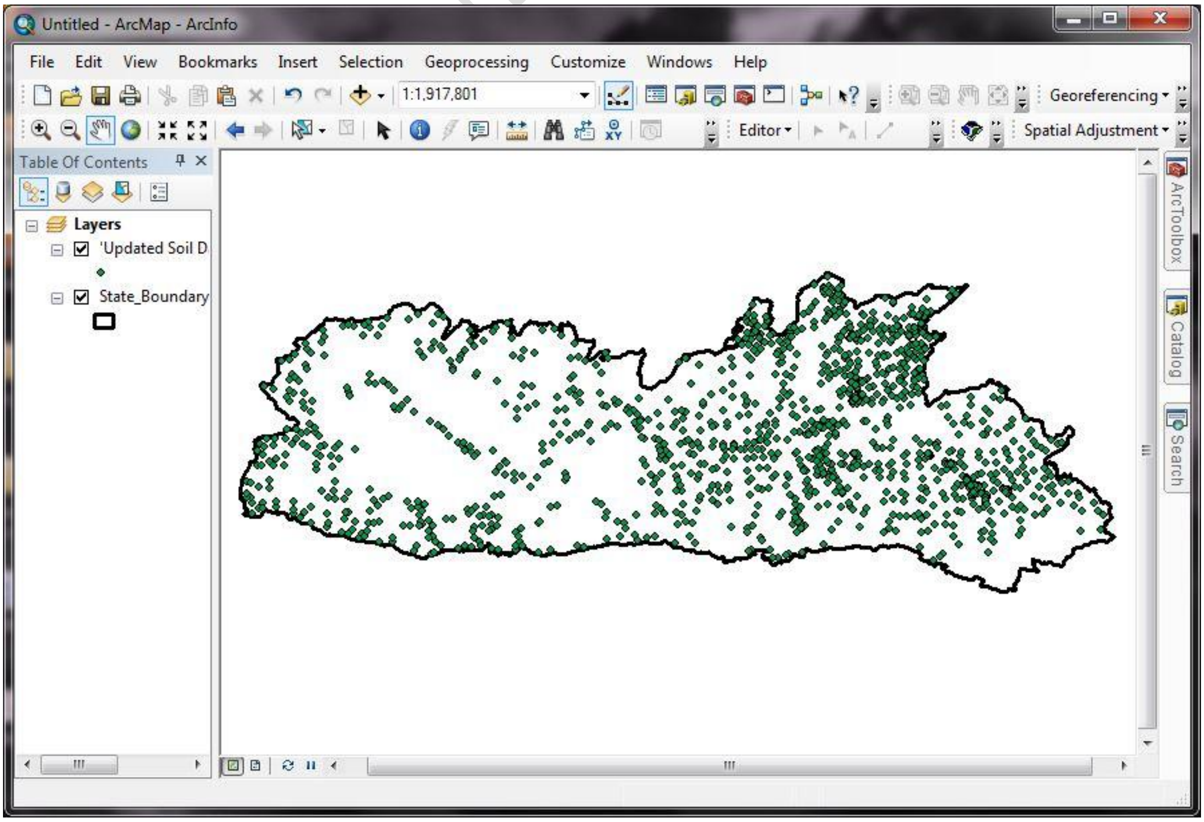


Step III:Add XY Data window will appear. To Choose an **Excel Data** file, go to Browser and select the Excel file from the folder where they are saved.

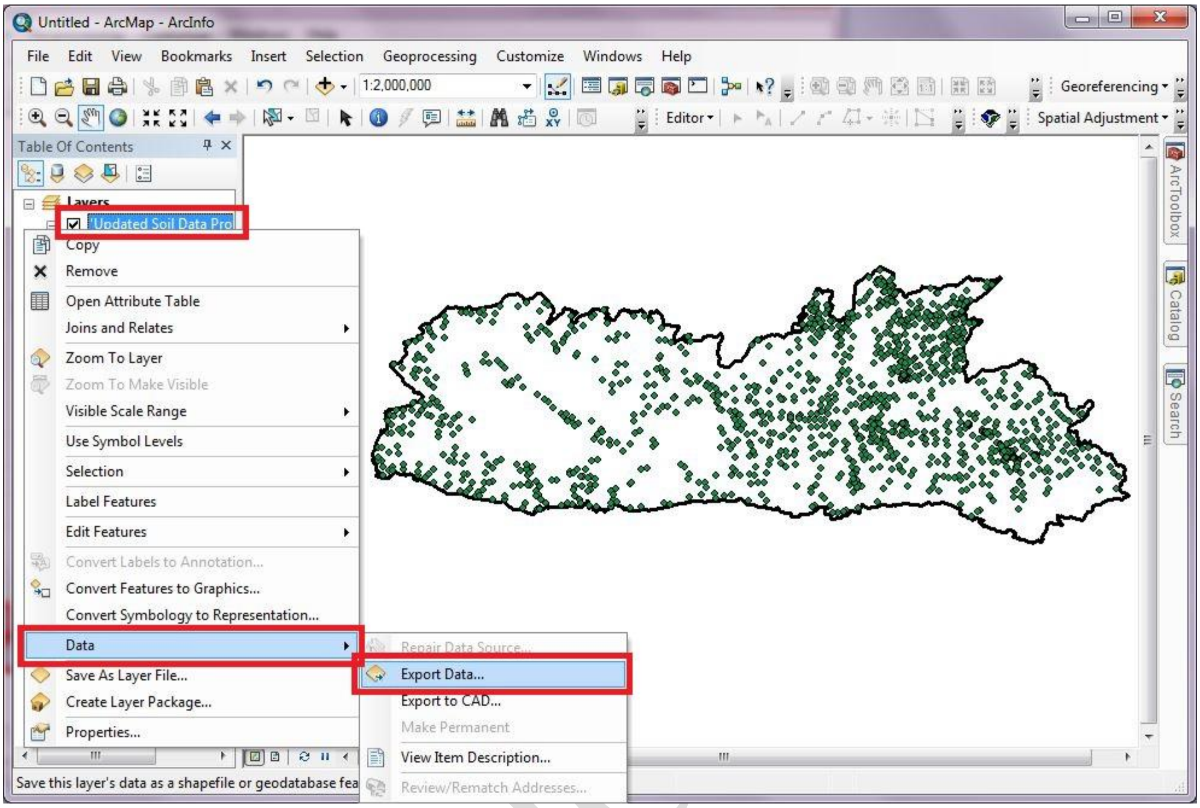


Step IV: After choosing the Excel Data File, Select **Edit** of the Coordinate System of Input Coordinates and the display window of **Spatial Reference Properties** will appear. On display Window of the Spatial Reference Properties, go to **select…** to select a **predefined coordinate system** according to the data location which is going as an input in Arc Map, select **OK** again and the data will be displayed in Arc Map data view

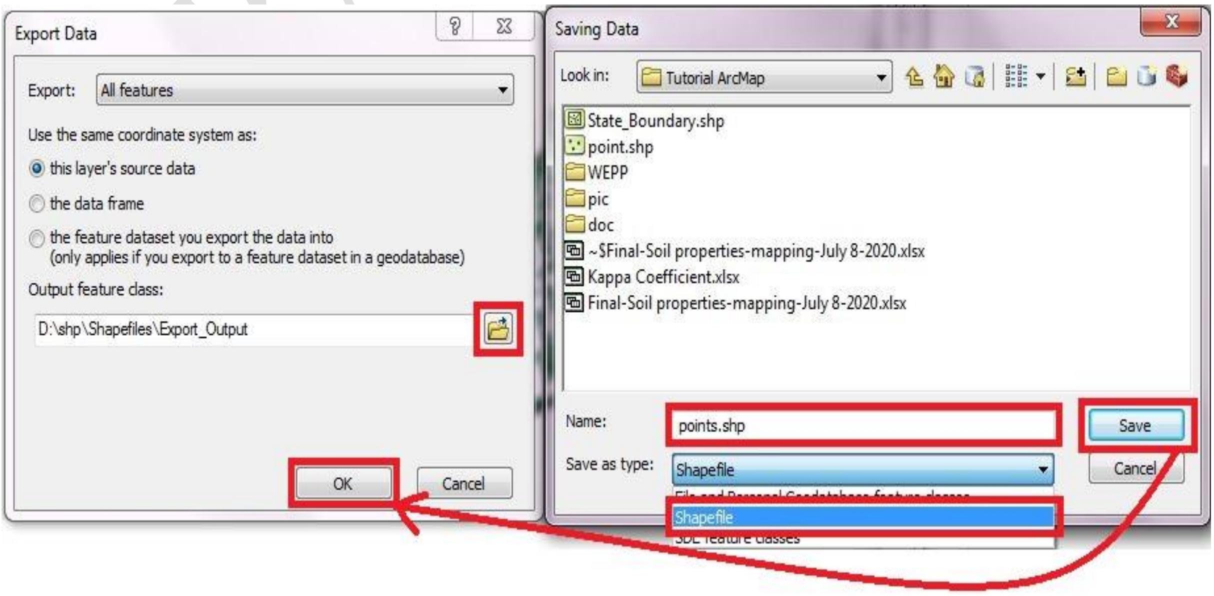




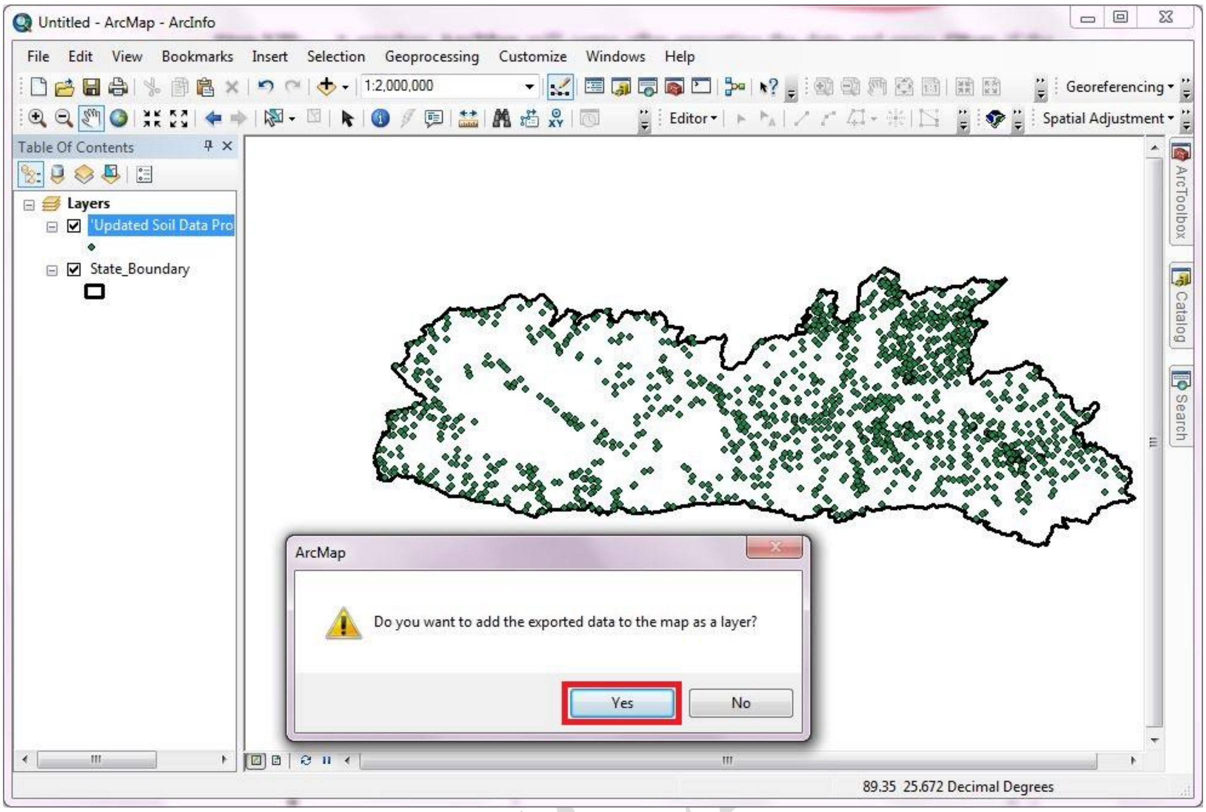
Step V: After adding the XY data in Arc Map. Go to **Table of Content - Layer** and select the data to export it to the shape file by **Right Click** on the data and go **Data - Export Data** as shown in the figure below



Step VI: Display window of the **Exported Data** will appear on the screen and go to **Output Feature Class** and select **Browse**. A window **Saving Data** will come to select the specific folder of the export data and rename it. Select **Shape file** in the **Save as type** tab to save it in shape file, then select **Save,** then **OK** in the Export Data window and it will be saved in the selected folder.

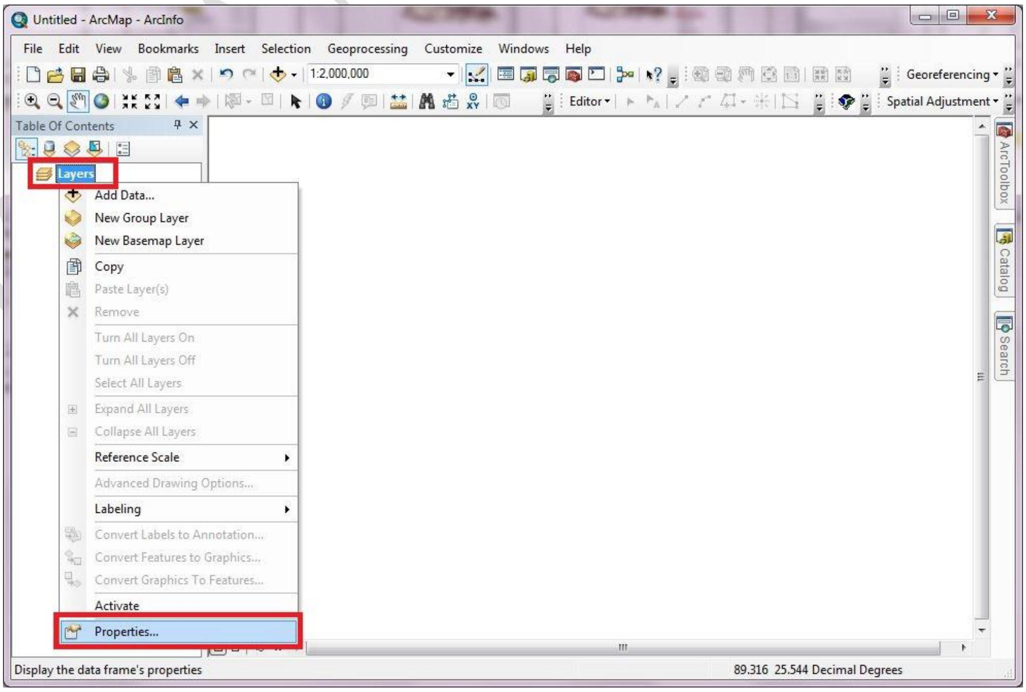


Step VII: A window **Arc Map** will appear after exporting the data. Press **OK** if you want to add the exported data in the layer of the Arc Map.

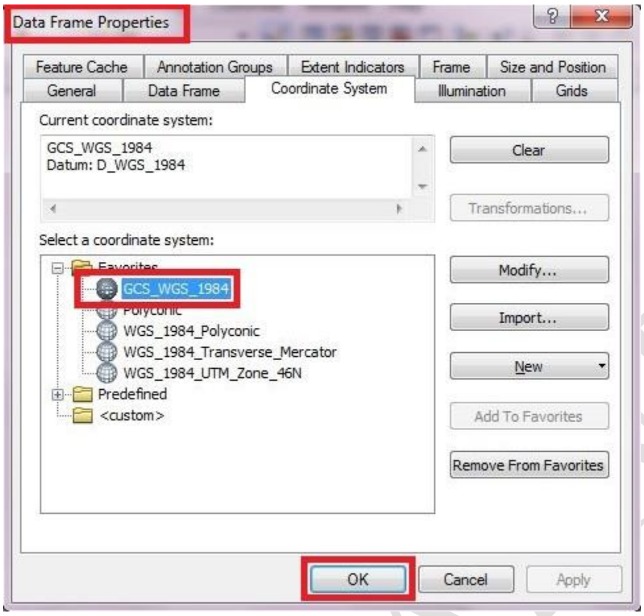


3.2 IDW interpolation In Arc Map (Point layer to raster layer).

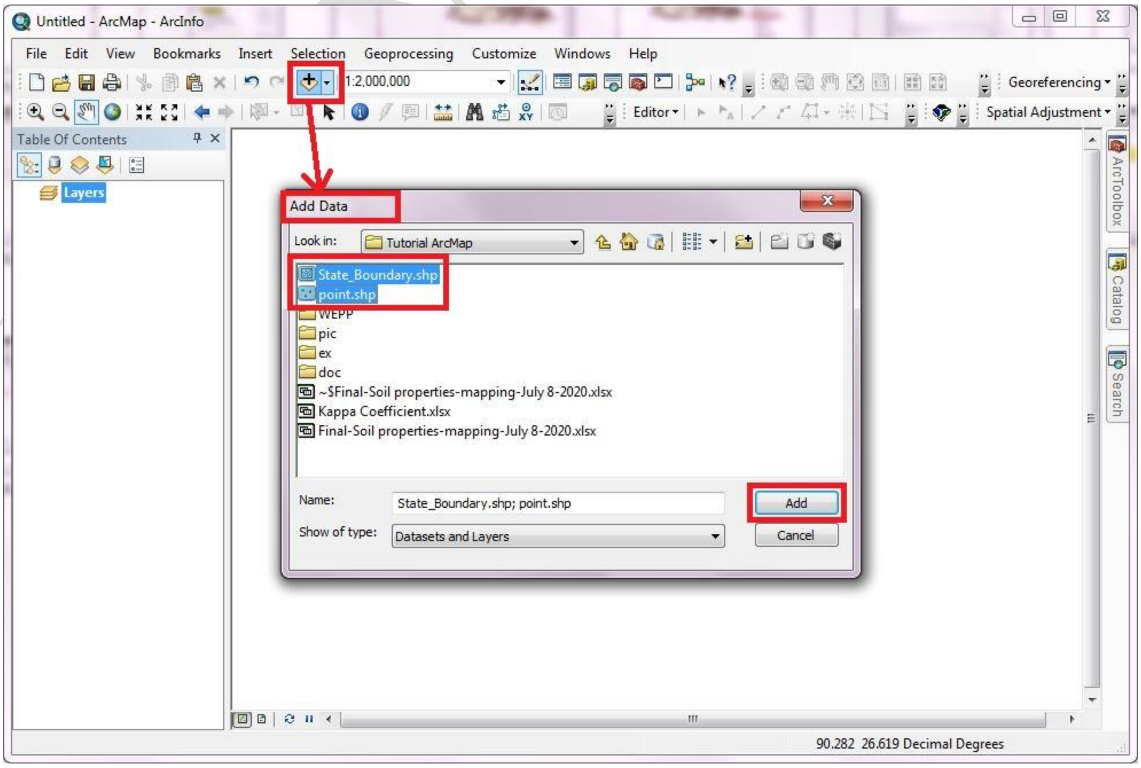
Step I: Open **Arc Map**. Check the **Coordinate System** of the layer before adding the data. By right click on the **Layer** go to **Properties…** to select the coordinate system as shown in the figure below



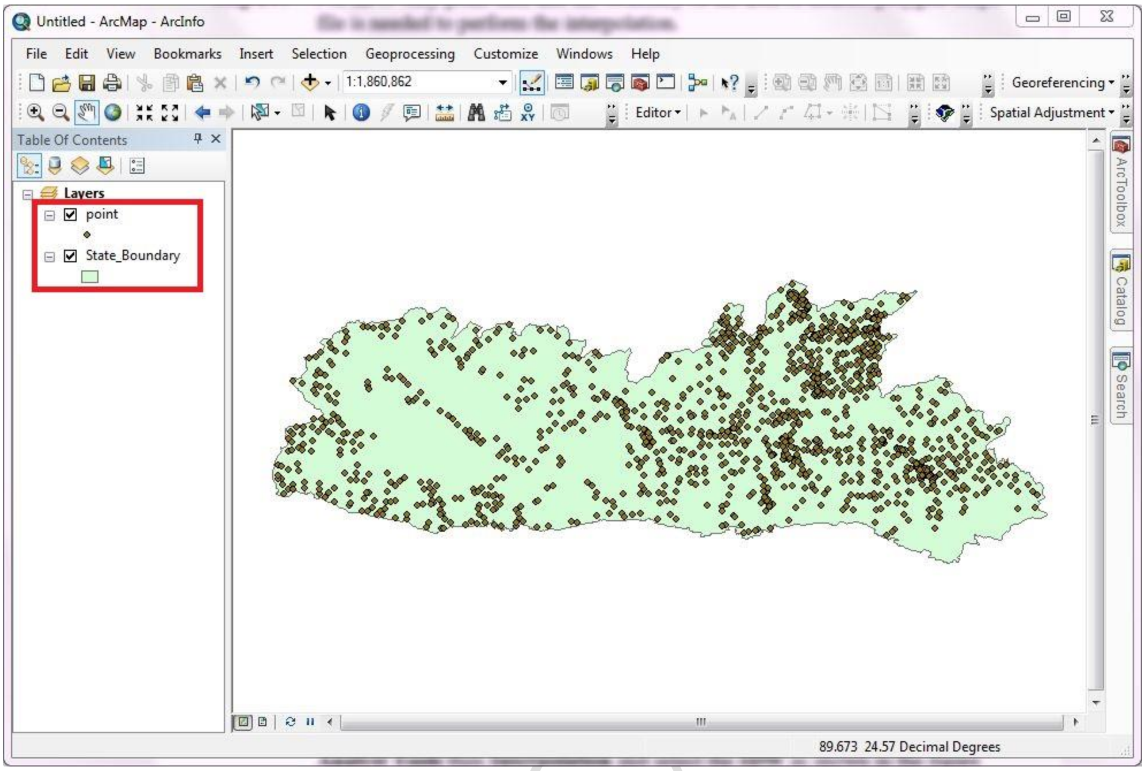
Step II: A **Data Frame Properties** window will appear. Go to **Coordinate System** tab from the selection of coordinate system of the layer by going to **Favourites** or it can be selected from the **Predefined** coordinate system. After selection of coordinate system, press **OK**.



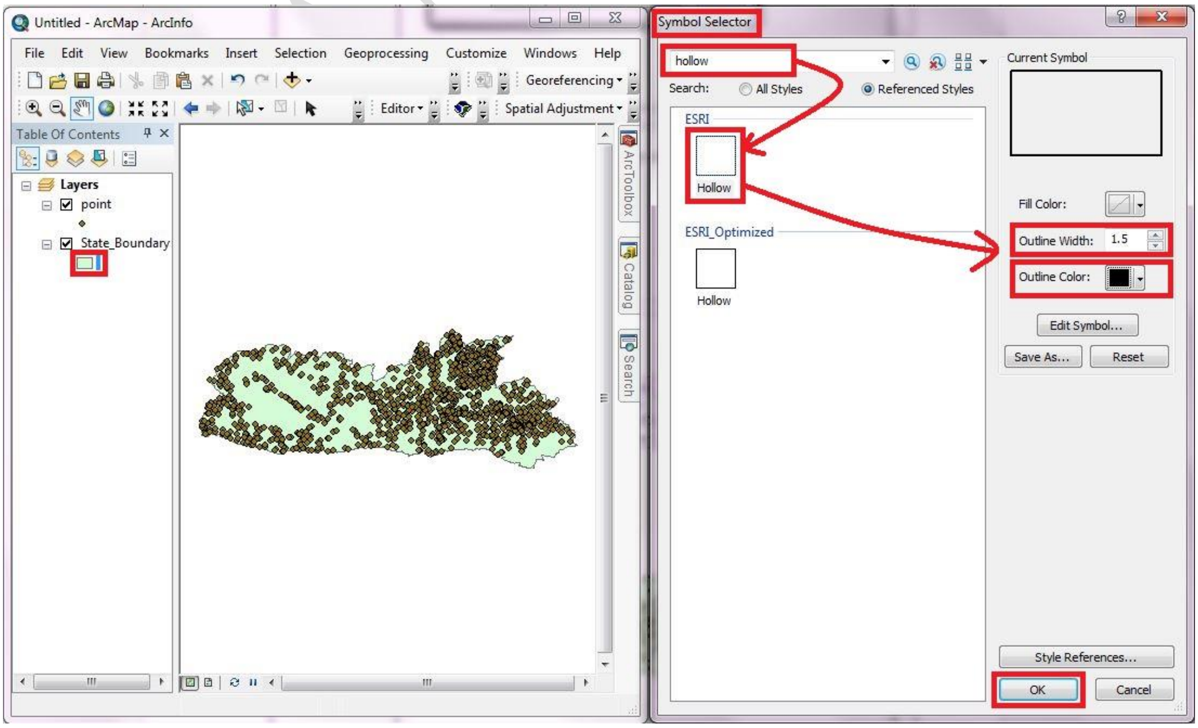
Step III: Add the data after selecting the coordinate system of the layer. All the data whether in the shape of line, polylines and polygon should have the same **Coordinate System** as the layer. To **Add** the data, go to **Add Data** and an **Add Data** window will appear on the screen, then select the data from a folder and press **OK**.

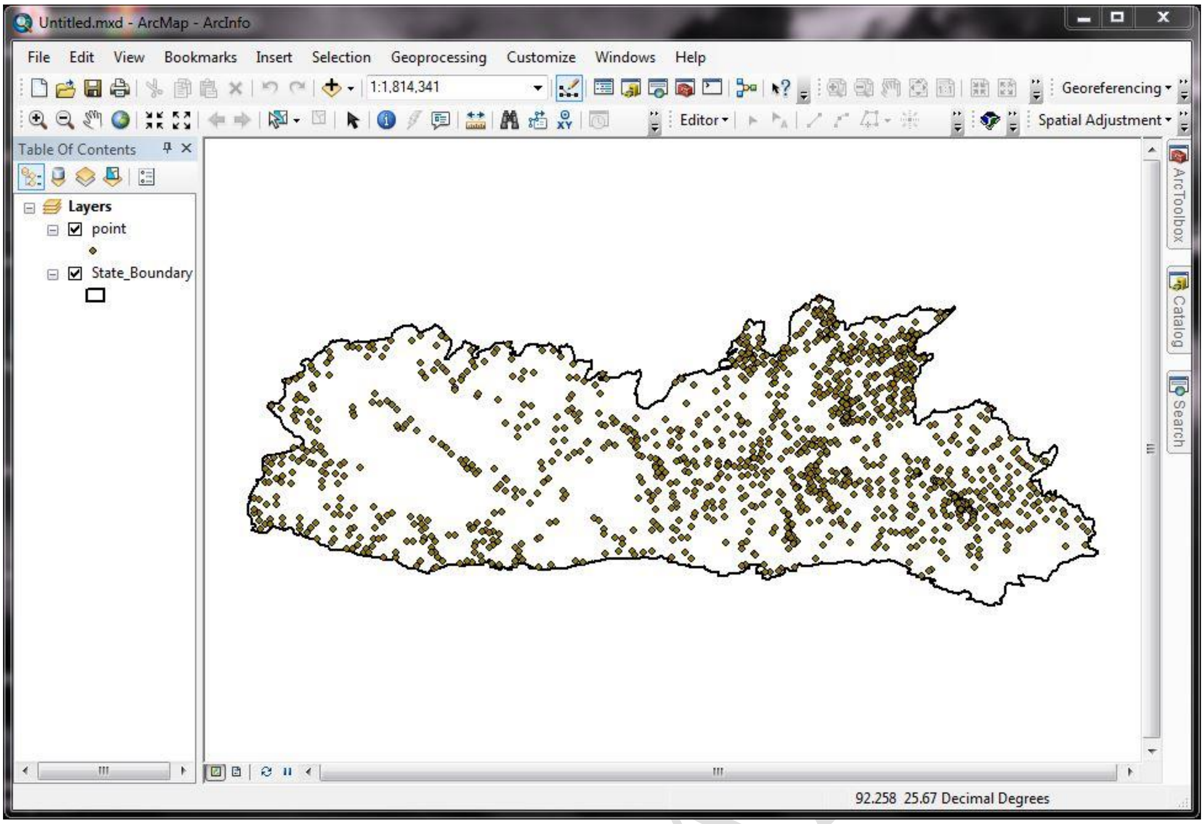


Step IV: For **IDW,** only point data and the boundary of the area of interested polygon shape file is needed to perform the interpolation.

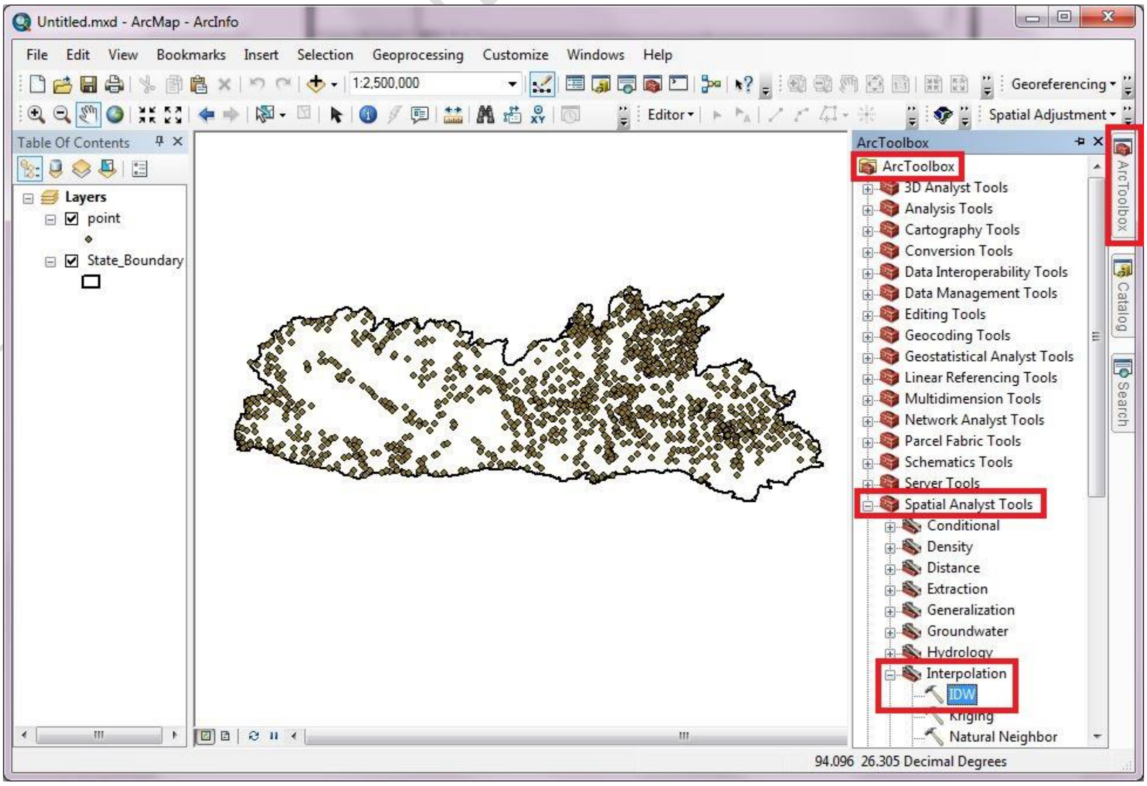


Step V: To show only the outline of the boundary layer, select the symbol selector as shown in the figure below. A **symbol selector** window will appear on the screen, on the search tab, type **hollow** and select the **hollow**. Go to **outline width** and give the **thickness** of the outline width and again go to **outline colour** here select **No Colour** then select OK.

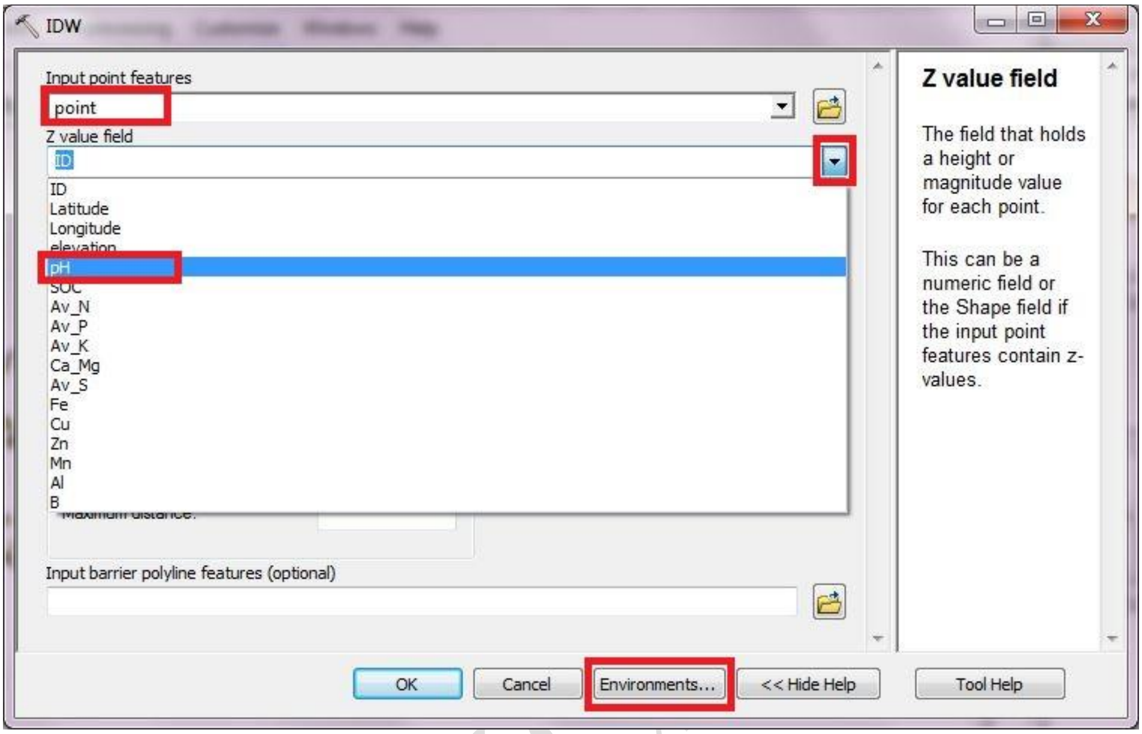




Step VI: To perform the interpolation **IDW,** go to **Arc Toolbox,** select the **Spatial Analyst Tools** then **Interpolation** and select the **IDW** as shown in the figure below



Step VII: The **IDW** window will appear on the screen after selecting the **IDW** from the Arc Toolbox. Go to **Input Point Features** to select the point for interpolation and then select the **Z Value Field** i.e., depend on the data which is needed to interpolate as given in the figure below.



The Attributes table of the Input Point Features appears as

Table

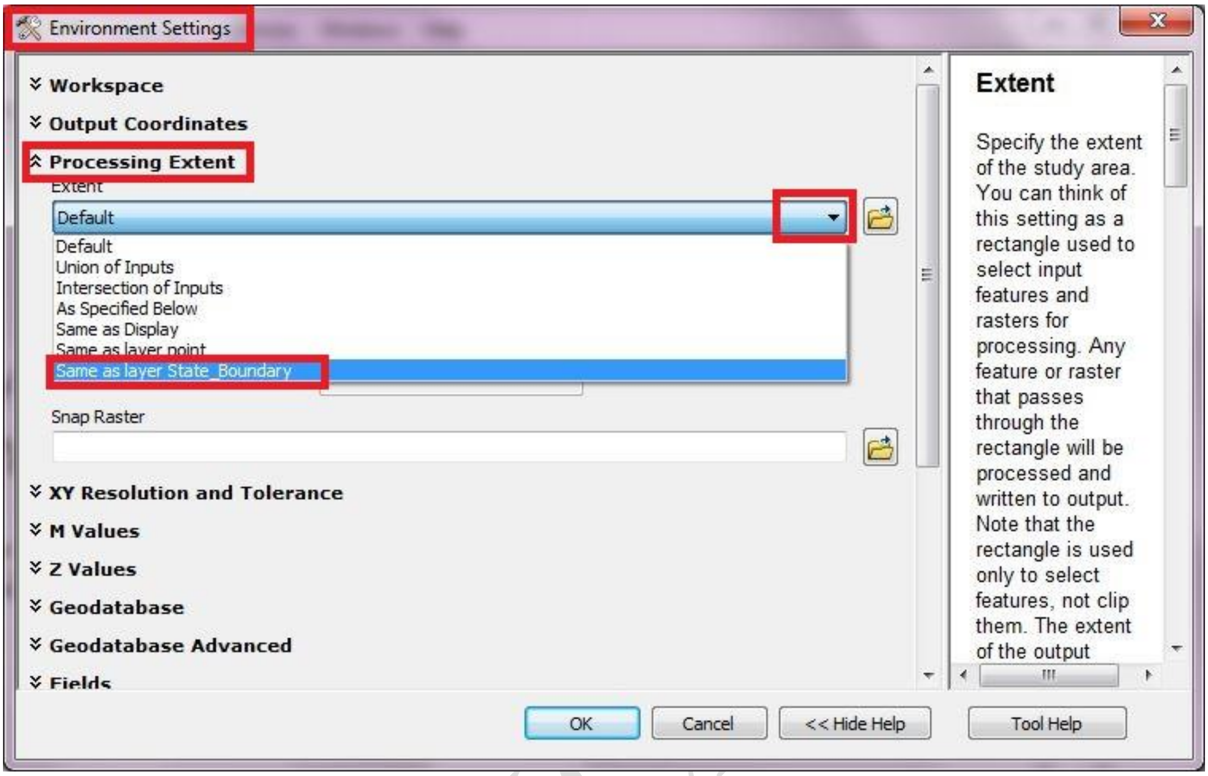
point

FID	Shape *	ID	Latitude	Longitude	elevation	pH	SOC	Av_N	Av_P	Av_K	Ca_Mg	Av_S	Fe	Cu	Zn	Mn
0	Point	1	25.391883	92.2822	1315	2.5	0.12	12.544	0.173091	10.64	0.1	1860.24948	297.14	0.227	0.15	59.26
1	Point	2	25.409381	92.20228	1346	2.6	0.06	12.544	0.173091	12.544	0.1	1028.108108	8.14	0.072	0.15	59.26
2	Point	3	25.423067	92.286667	1648	2.6	0.06	25.088	0.323422	12.544	0.15	1778.378378	249.91	0.072	0.155	56.96
3	Point	4	25.4301	92.3809	1229	2.7	0.06	25.088	0.374332	47.712	0.15	1763.825364	169.67	0.005	0.155	56.96
4	Point	5	25.567118	92.274952	1349	2.7	0.06	37.632	1.302674	42.224	0.15	1671.850312	169.67	0.112	0.225	55.32
5	Point	6	25.383671	92.485399	1650	2.7	0.06	62.72	1.37754	42.224	0.2	1465.779626	165.38	0.112	0.225	51.96
6	Point	7	25.423067	92.286667	1317	2.8	0.06	62.72	1.37754	11.312	0.2	1387.775468	112.73	0.14	0.24	51.96
7	Point	8	25.423067	92.286667	1648	2.8	0.06	62.72	1.6128	11.312	0.2	1341.787942	111.4	0.14	0.25	37.46
8	Point	9	25.381662	92.158202	1337	2.9	0.06	62.72	1.6128	90.496	0.2	1324.906445	7.4	0.077	0.26	37.46
9	Point	10	25.39887	92.267749	1647	2.9	0.12	62.72	1.7136	90.496	0.225	1257.380457	95.96	0.077	0.26	37.26
10	Point	11	25.448493	92.42728	1186	3.0	0.12	62.72	2.096257	44.8	0.25	1250.39501	95.96	0.023	0.31	37.26
11	Point	12	25.4101	92.3909	1139	3.0	0.12	62.72	2.096257	8.736	0.25	1220.706861	94.72	0.5	0.31	29.94
12	Point	13	25.42255	92.286617	1336	3.0	0.12	62.72	2.296	31.024	0.25	1211.975052	79.5	0.069	0.31	29.94
13	Point	14	25.366667	92.328583	1221	3.0	0.12	62.72	2.296	137.536	0.25	1181.704782	73.785	0.084	0.315	23.5
14	Point	15	25.257554	92.25688	1351	3.0	0.12	62.72	2.3632	30.016	0.25	1181.122661	65.43	0.05	0.33	23.34
15	Point	16	25.423417	92.285933	1365	3.0	0.18	62.72	1.048128	30.016	0.25	1089.72973	65.43	0	0.33	23.34
16	Point	17	25.366667	92.328583	1650	3.0	0.18	62.72	1.3216	137.536	0.275	1075.758836	59.81	0.084	0.34	23.12
17	Point	18	25.381883	92.2622	1272	3.1	0.18	62.72	1.3216	38.416	0.3	1007.650728	51.39	0.05	0.34	22.7
18	Point	19	25.566174	92.509976	924	3.1	0.18	75.264	1.792	67.088	0.3	1007.650728	51.39	0.05	0.35	22.7
19	Point	20	25.33933	92.084581	1199	3.1	0.24	75.264	1.792	67.088	0.35	543.700624	48.48	0	0.36	66.18
20	Point	21	25.363538	92.598887	969	3.1	0.24	75.264	2.3968	76.944	0.35	523.326403	47.23	0.056	0.36	66.18
21	Point	22	25.193849	92.272105	1199	3.1	0.24	75.264	2.3968	76.944	0.35	506.444906	47.23	0.056	0.39	59.31
22	Point	23	25.340213	92.410565	1048	3.1	0.3	75.264	2.4304	95.2	0.35	500.04158	37.15	0.01	0.39	40.05
23	Point	24	25.38239	92.577139	1239	3.1	0.3	75.264	2.4304	92.9	0.35	396.424116	37.15	0.01	0.39	49.26
24	Point	25	25.694053	92.393679	910	3.1	0.33	75.264	2.5088	72.912	0.4	211.891892	25.5	0.027	0.39	49.26
25	Point	26	25.304933	92.381183	1011	3.1	0.33	75.264	2.5648	31.024	0.4	186.2	21.77	0.05	0.43	38.182
26	Point	27	25.312636	92.497333	1199	3.1	0.42	75.264	2.5648	72.912	0.4	186.2	21.77	0.027	0.445	38.862
27	Point	28	25.456311	92.290944	1212	3.2	0.45	75.264	3.08	47.488	0.4	177.546778	7.2	0.01	0.48	41.419
28	Point	29	25.389609	92.54731	879	3.2	0.45	75.264	3.2816	9.968	0.4	170.8	9.2	0.014	0.48	42.221
29	Point	30	25.353722	92.454079	966	3.2	0.46	75.264	3.4048	95.2	0.425	170.8	192.29	0.105	0.48	43.524
30	Point	31	25.365902	92.648863	1237	3.2	0.48	75.264	3.4048	109.7	0.425	166.611111	182.82	0	0.48	45.212

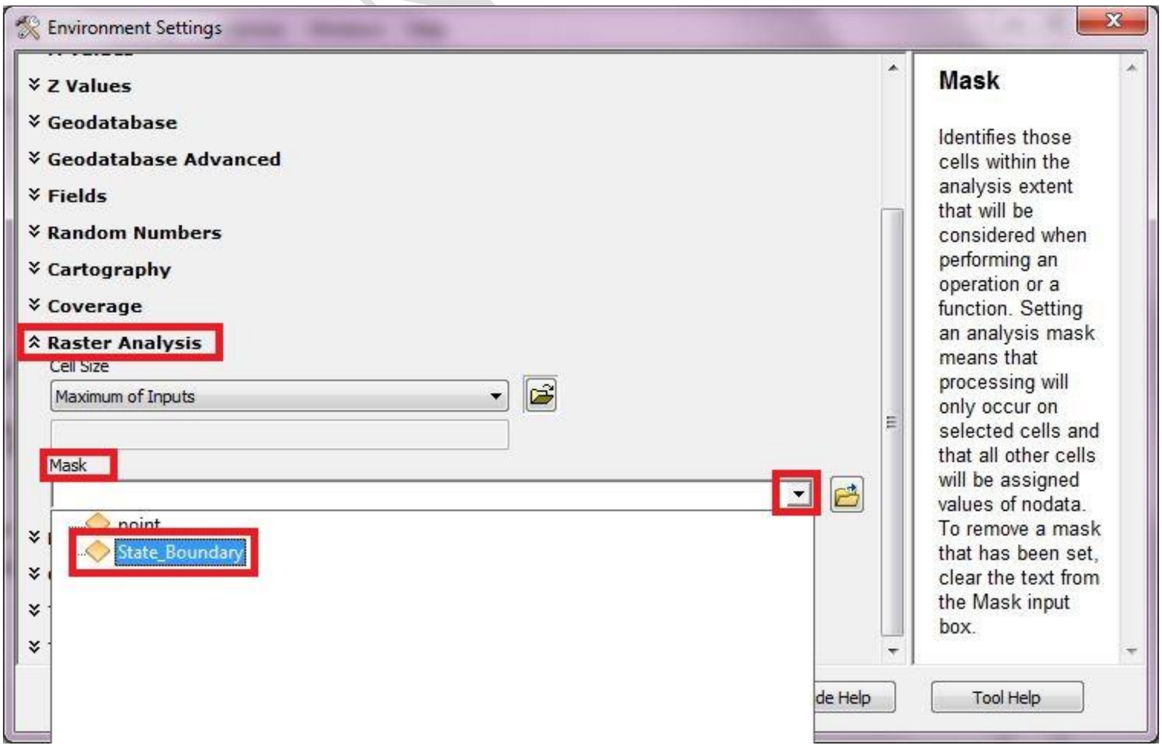
(0 out of 1473 Selected)

point

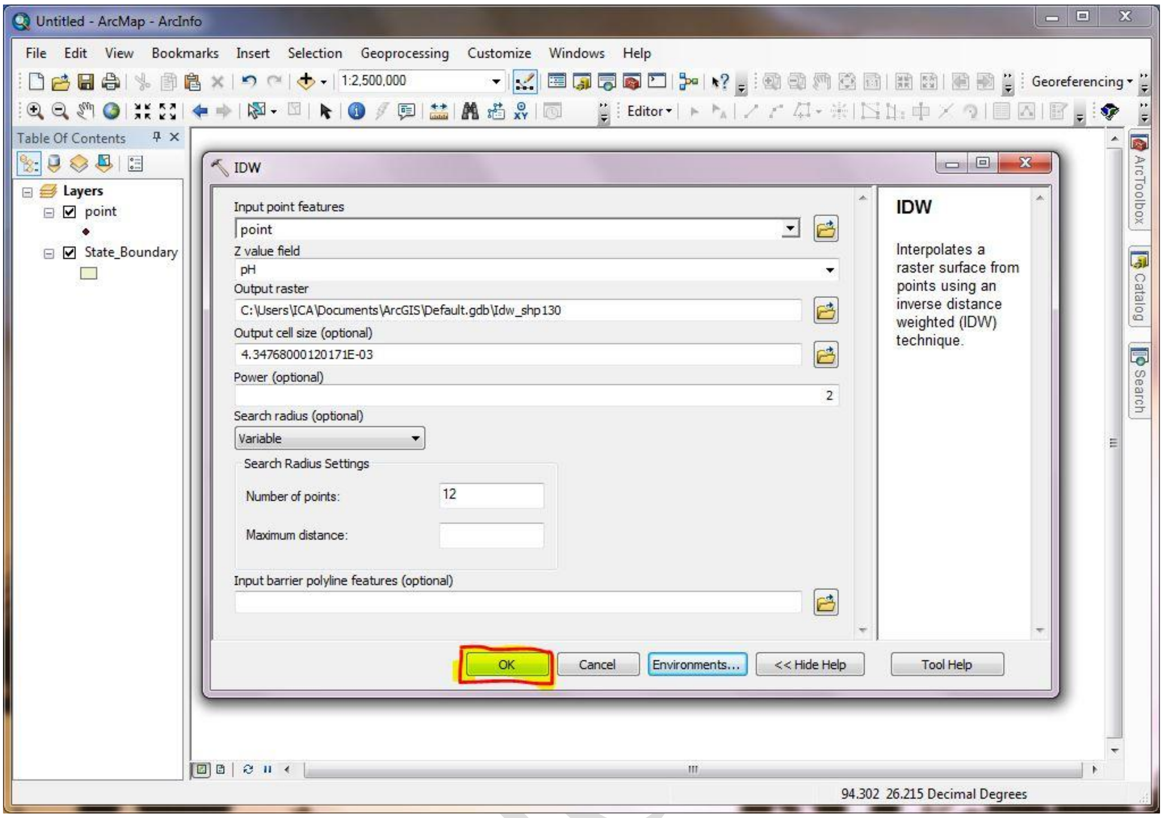
Step VIII: Select the **Environments…** tab after input the **Z Value Field**. The window **Environment Setting** will appear, select **Processing Extend** and within the extend tab, select the layer of the **AOI boundary**.



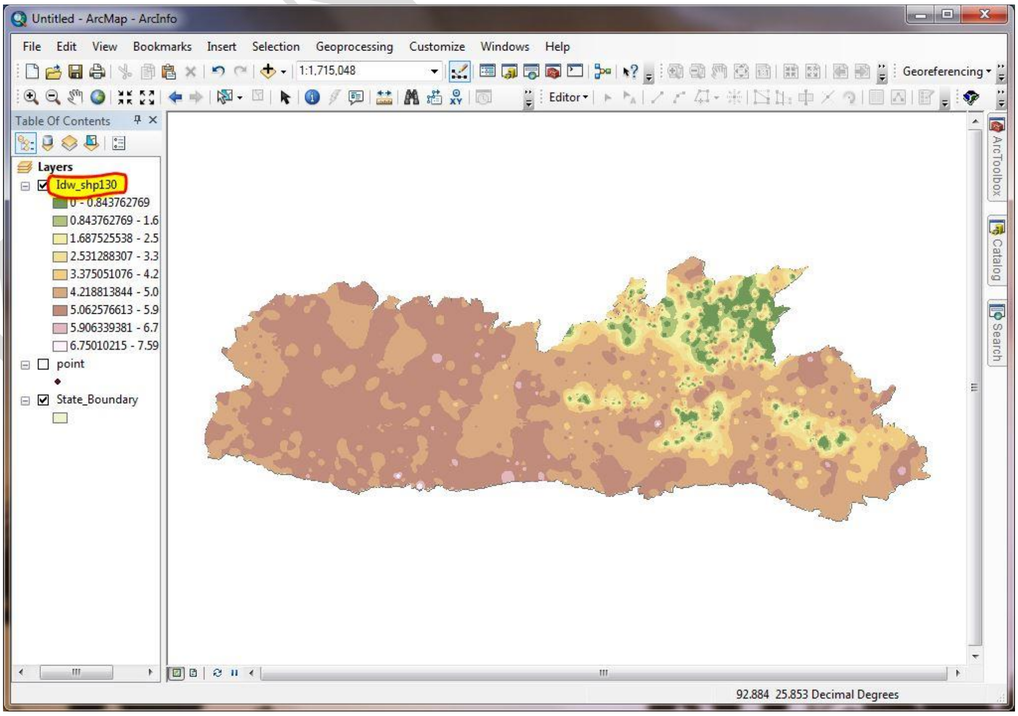
Step IX: After selecting the processing extent, scroll down and select the **Raster Analysis,** then in the **Mask,** select the **AOI boundary** and select **OK**, as shown in the figure below



Step X: After selecting OK in the Environmental Setting, a window IDW will come again and select **OK** and the IDW of the AOI will appear in the **Data View**

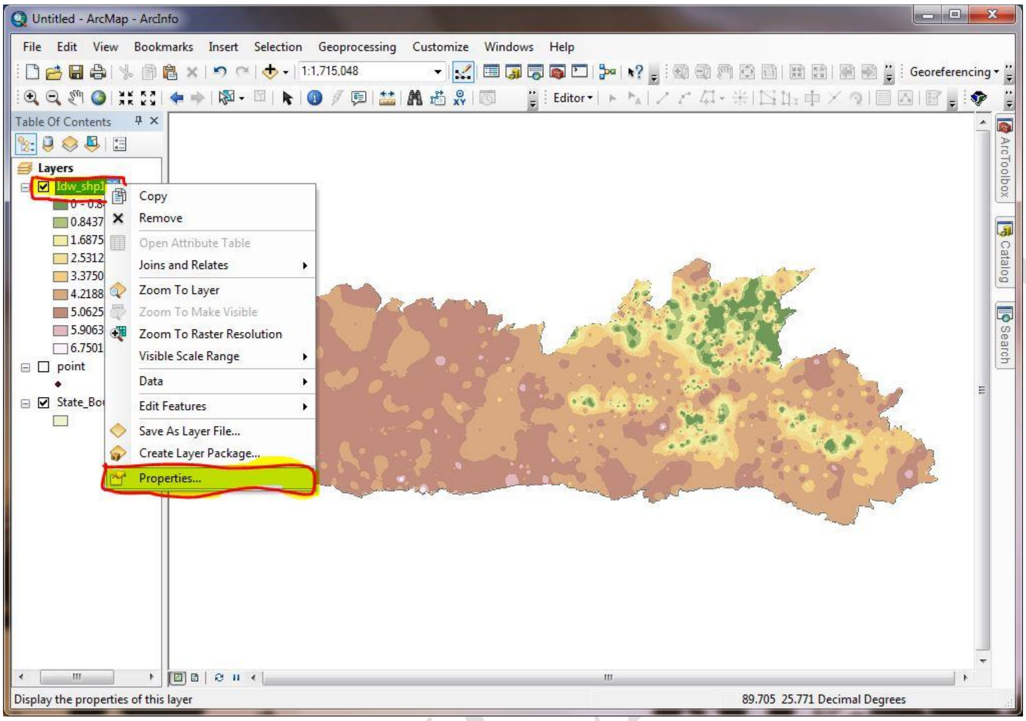


Step XI: The figure below is the IDW of the Data on soil pH selected from the attributes of the point shape file.

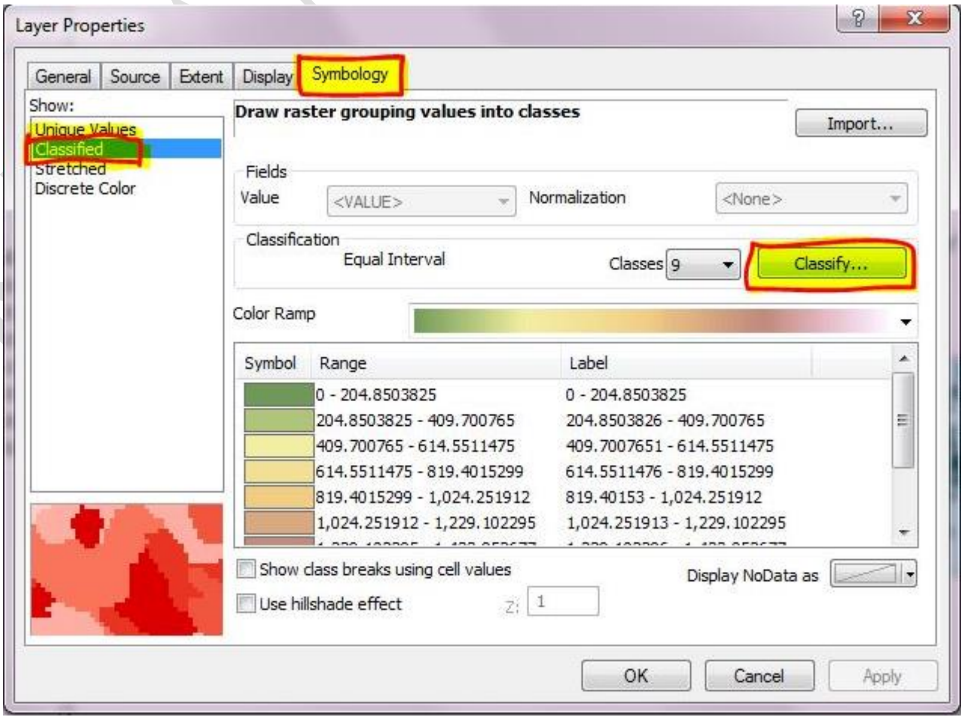


3.3 How to Reclassify Raster Layer in Arc Map.

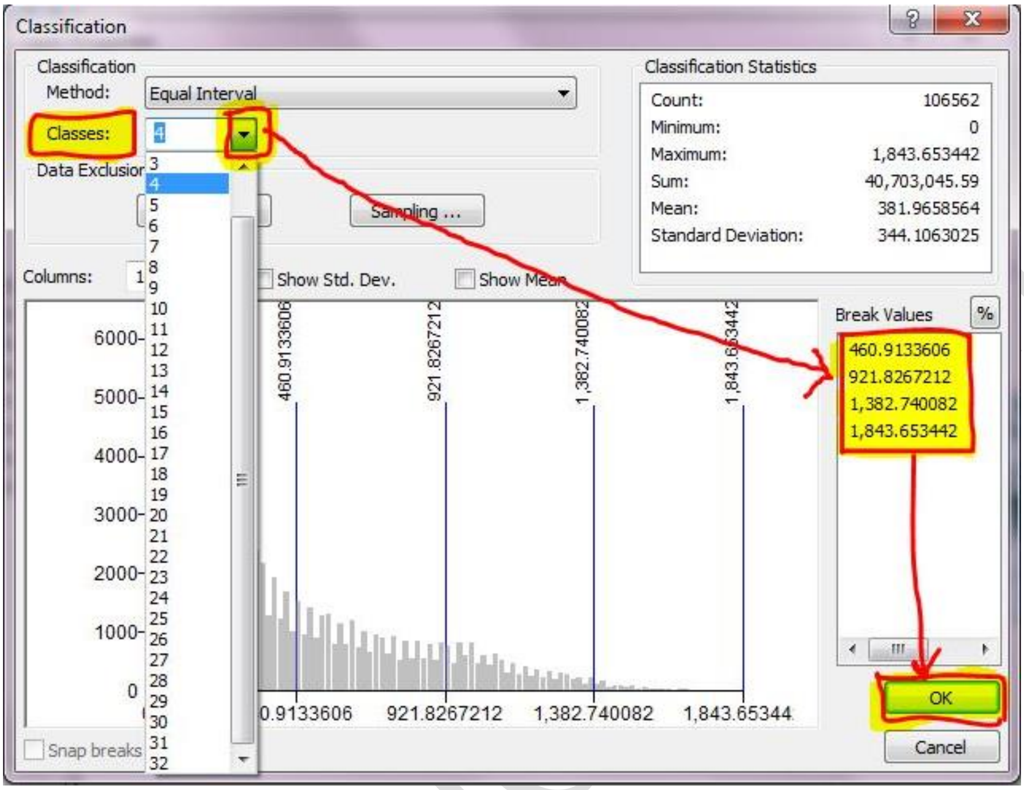
To **Reclassify Raster Layer,** first it is needed to classify the raster layer. Then reclassify the classified raster layer. Add the **Raster Layer** in the Arc Map. Right Click on the raster layer and select **Properties** to classify the Raster Data.



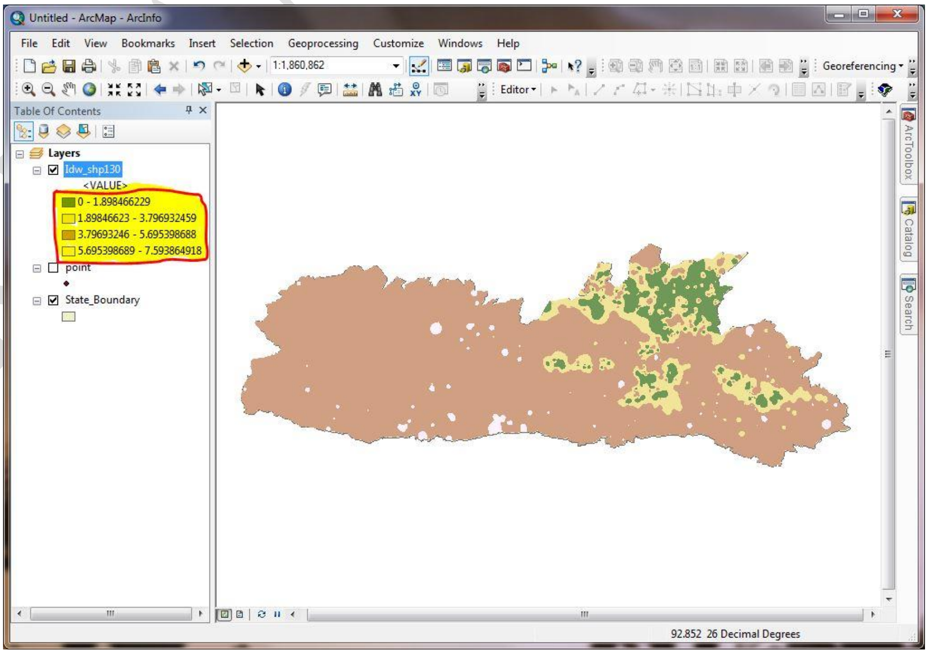
Step I: A window of **Layer Properties** will appear after selecting the properties. In the Layer Properties window, go to **Symbology** and select the **classified** tab. Within the classified tab, select the **Classify…** as shown in the figure below.



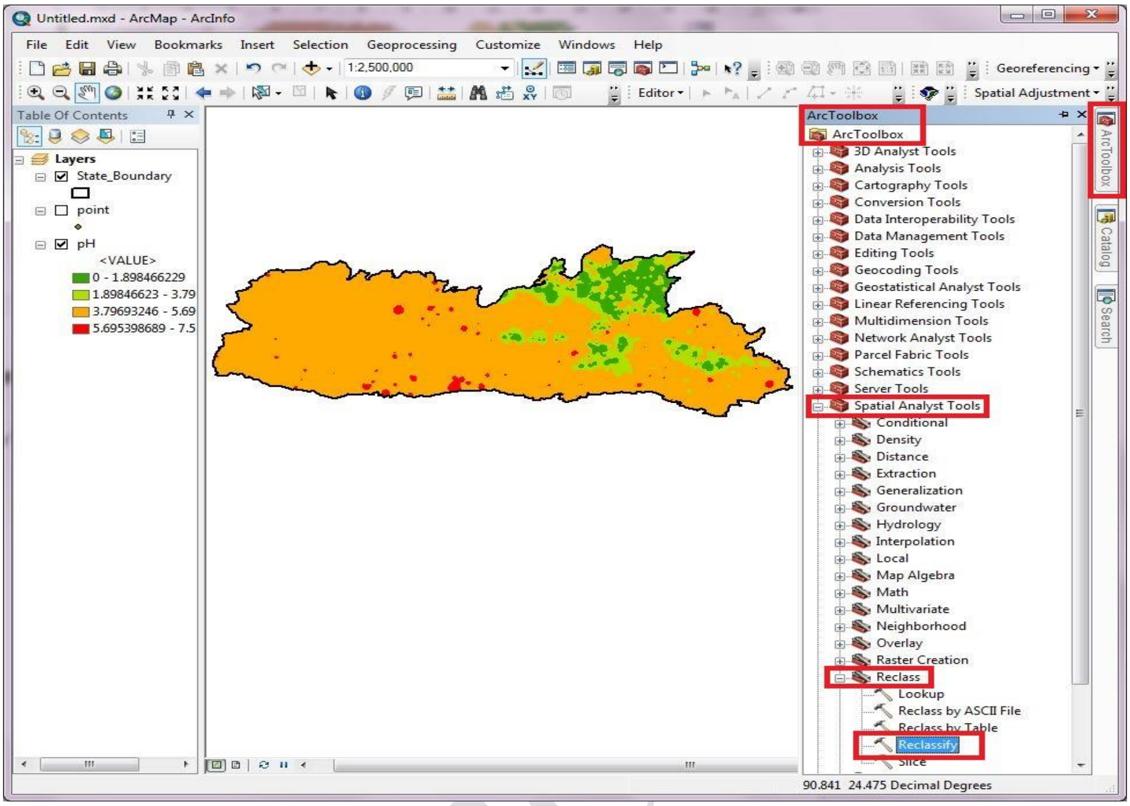
Step II: A window screen of **Classification** will appear. On the **Classes,** select the number of class to be classified the layer and then go to **Break Value** and rewrite the Class range from one class to another if needed, then press OK as shown in the figure below



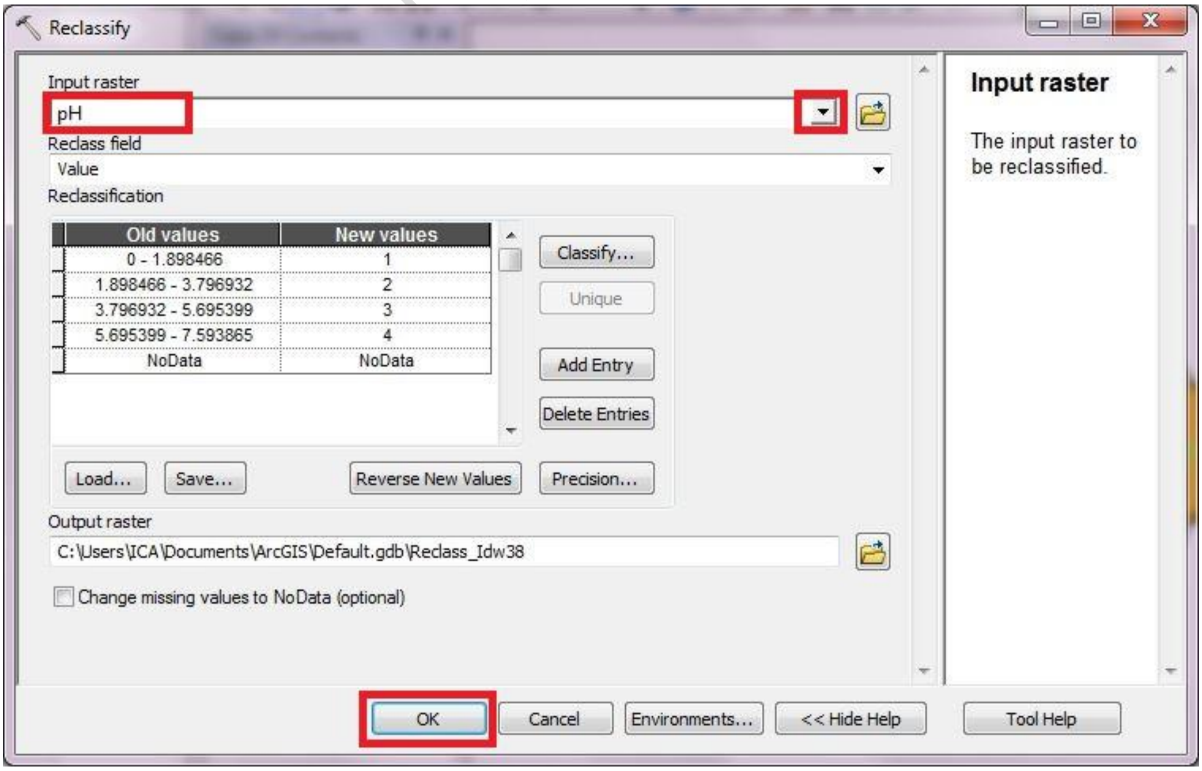
Step III: After selecting OK, the Raster Layer will be classified into the desired number of classes (users' choice) which has already input in the previous Classification window screen.



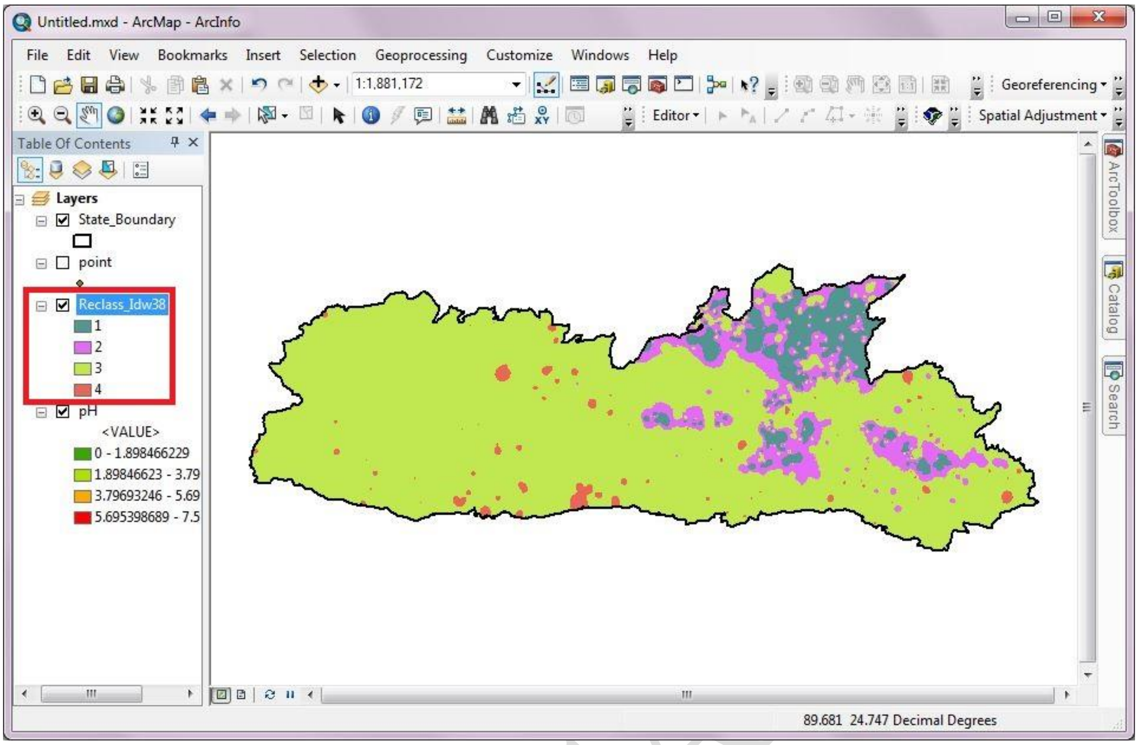
Step IV: To Re-class the Classified Raster Layer, go to **Arc Toolbox,** select on the **Spatial Analyst Tools,** then go to **Re-class** and double click on the **Reclassify** as shown in the figure below.



Step V: A **Reclassify** window will appear on the screen. Input the raster by selecting the **classified raster layer** (e.g. soil **pH**) and the select **OK** as shown below.

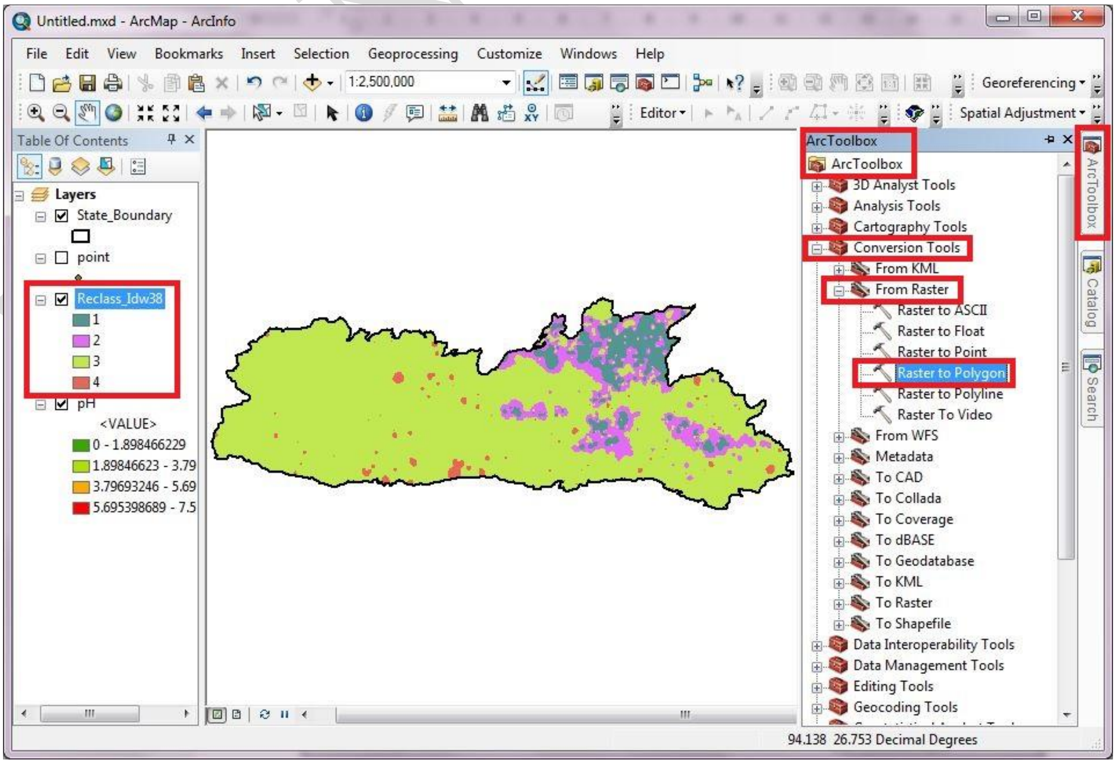


Step VI: After selecting OK, the reclassify raster layer will appear on the Data View of the Arc Map.

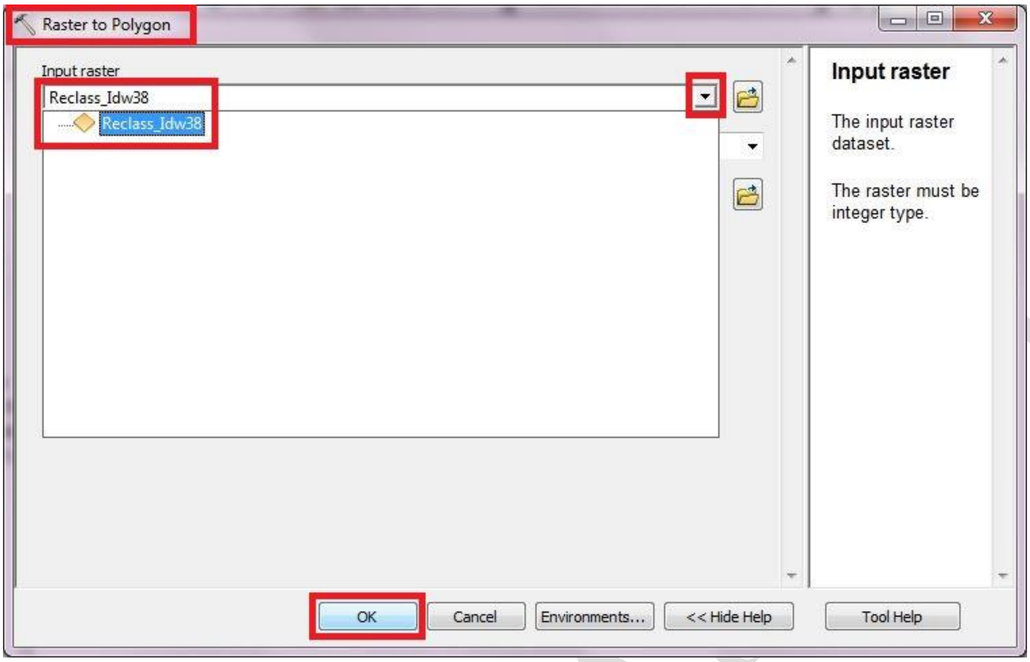


3.4 How to convert the reclassified raster layer to vector layer (polygon shape file).

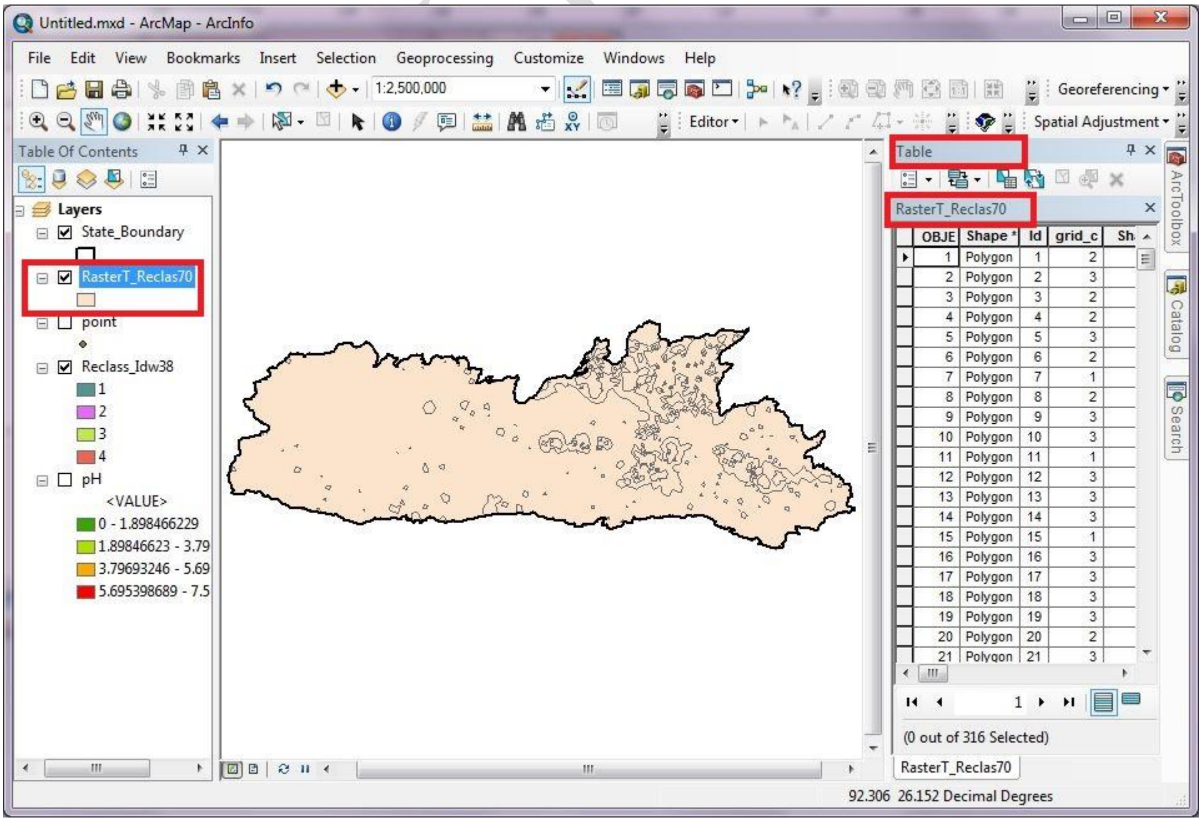
Step I: Following the steps on how to reclassify the Raster layer. Go to the **Arc Toolbox** and select the **Conversion Tools,** again select **From Raster,** then double click on the **Raster to Polygon** as shown in the figure below



Step II: After clicking on the raster to polygon, a window screen of **raster to polygon** will appear on the screen and on the **input raster,** select the **Reclassify Raster Layer** (**Reclass_Idw38**), then press **OK**.



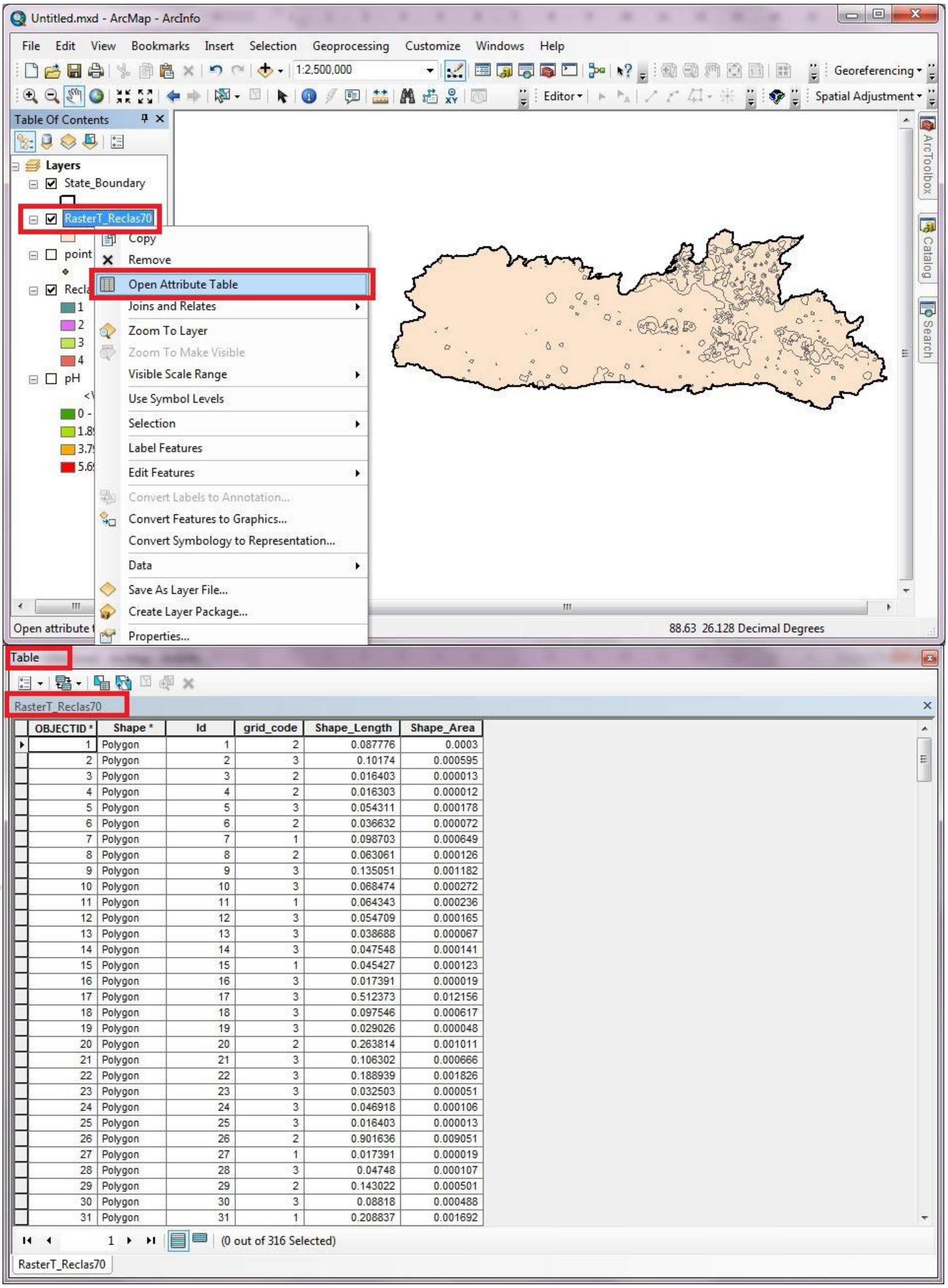
Step III: After pressing OK, the **Vector layer** (**RasterT_Reclass70**) will appear on the **Data View.** To view the attribute table, **right click** on the **Vector layer** (**RasterT_Reclass70**) and select **Open Attribute Table** as shown in the figure below.



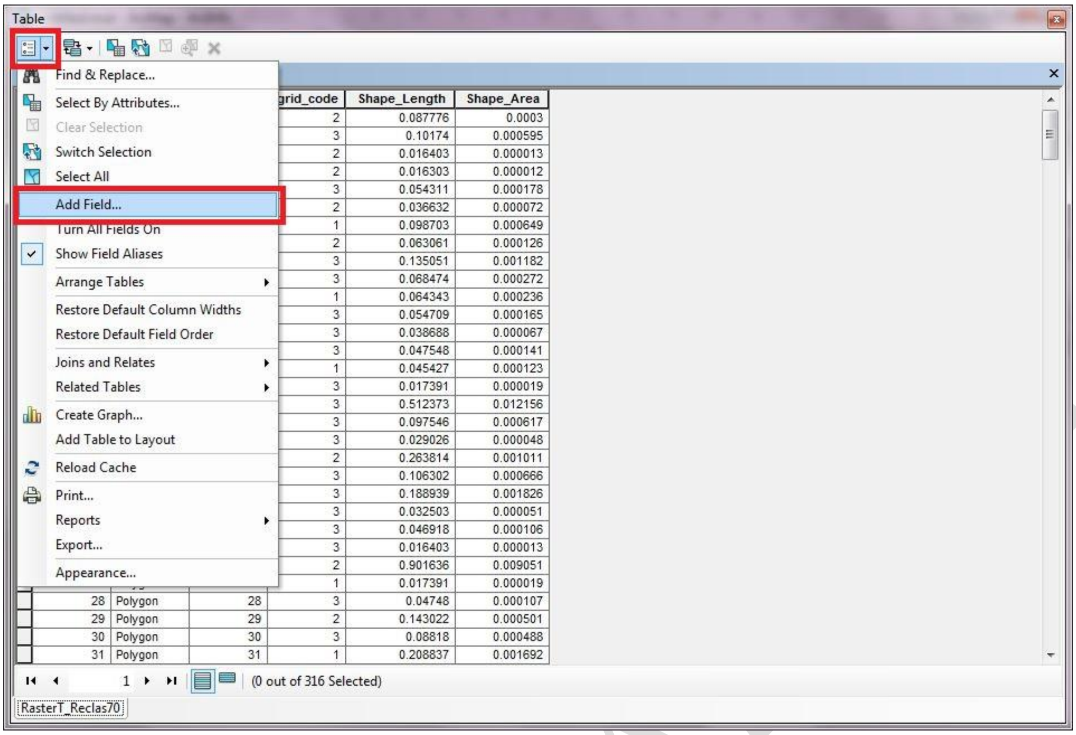
3.5 How to Calculate the Area of a Raster Layer of attribute soil pH

To calculate the area of a raster layer (e.g. attribute soil pH), first of all, the raster layer should be converted into vector layer (as shown below). The next step is to calculate the area of the converted vector layer (as shown below)

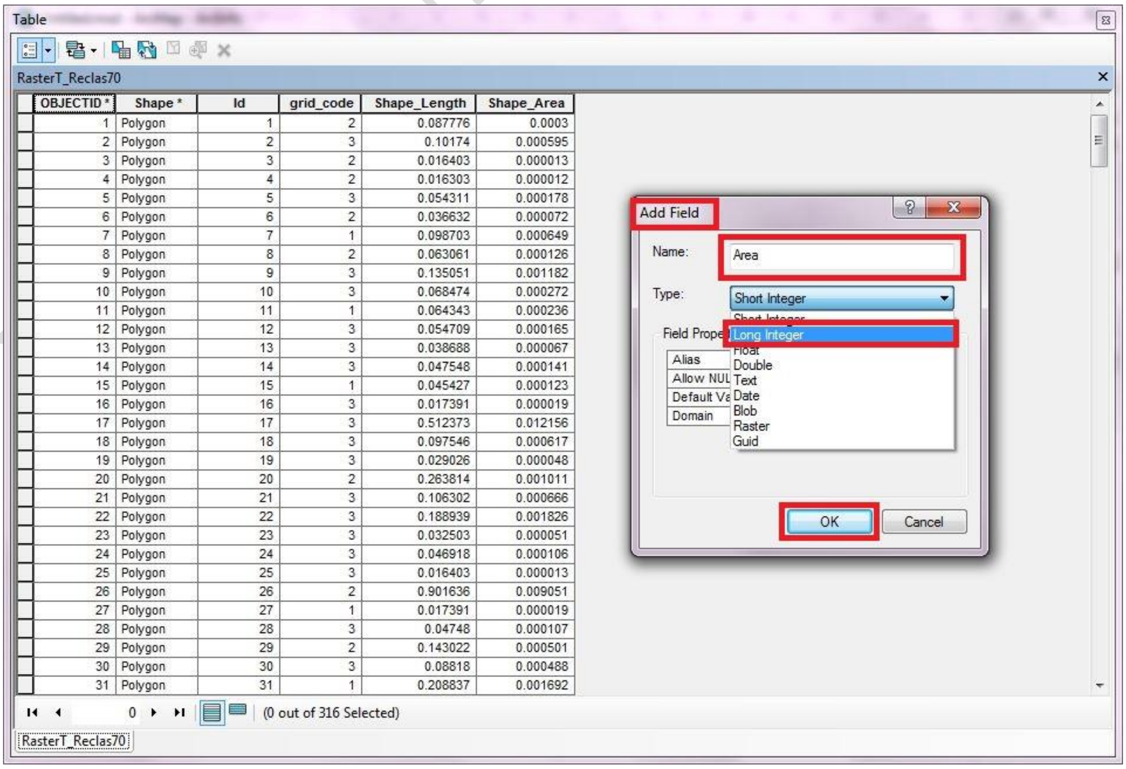
Step I: Go to **Vector layer** (**RasterT_Reclass70**) and right click on it, then select on **Open Attribute Table** and the **Table** of the vector layer will appear on the screen as shown in the figure below.

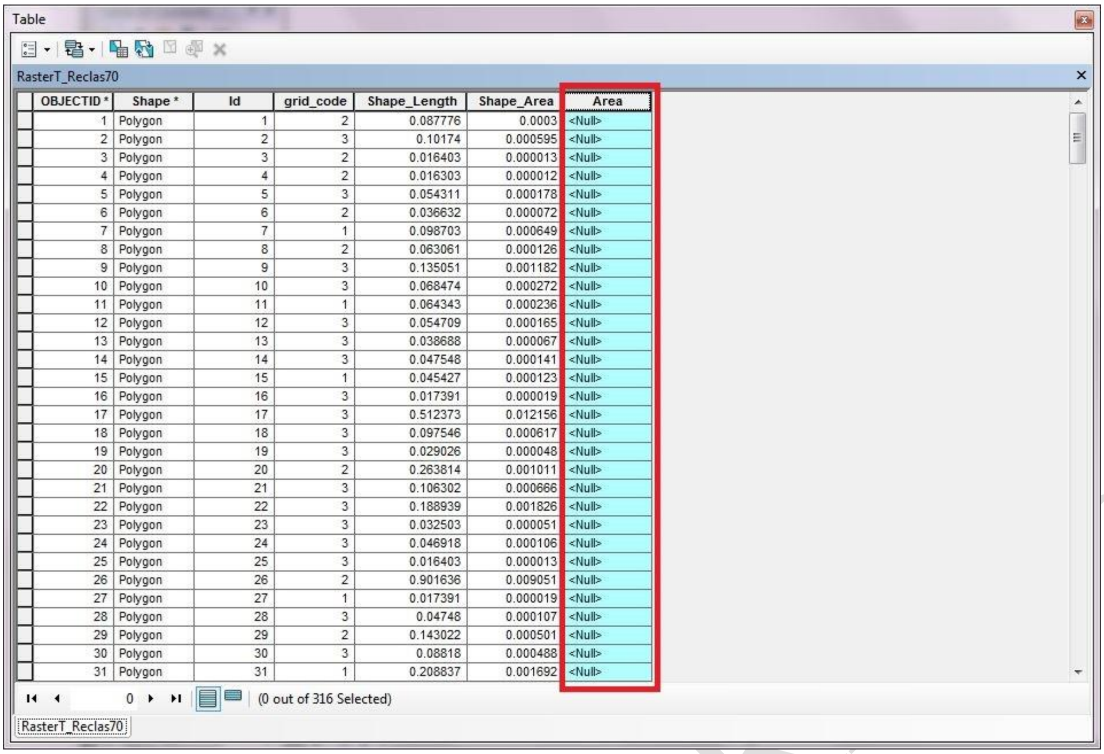


Step II: Go to the Table Option and click on Add Field… as shown in the figure below.



Step III: The window screen of **Add Field** will appear on the screen. Give the **name** of the field (Area), then under the **type,** select as **Long Integer** and click **OK**. The field **Area** column will appear in the Attribute Table of the **Vector Layer** (polygon shape file i.e., **RasterT_reclass70**) as shown in the figure below





Table

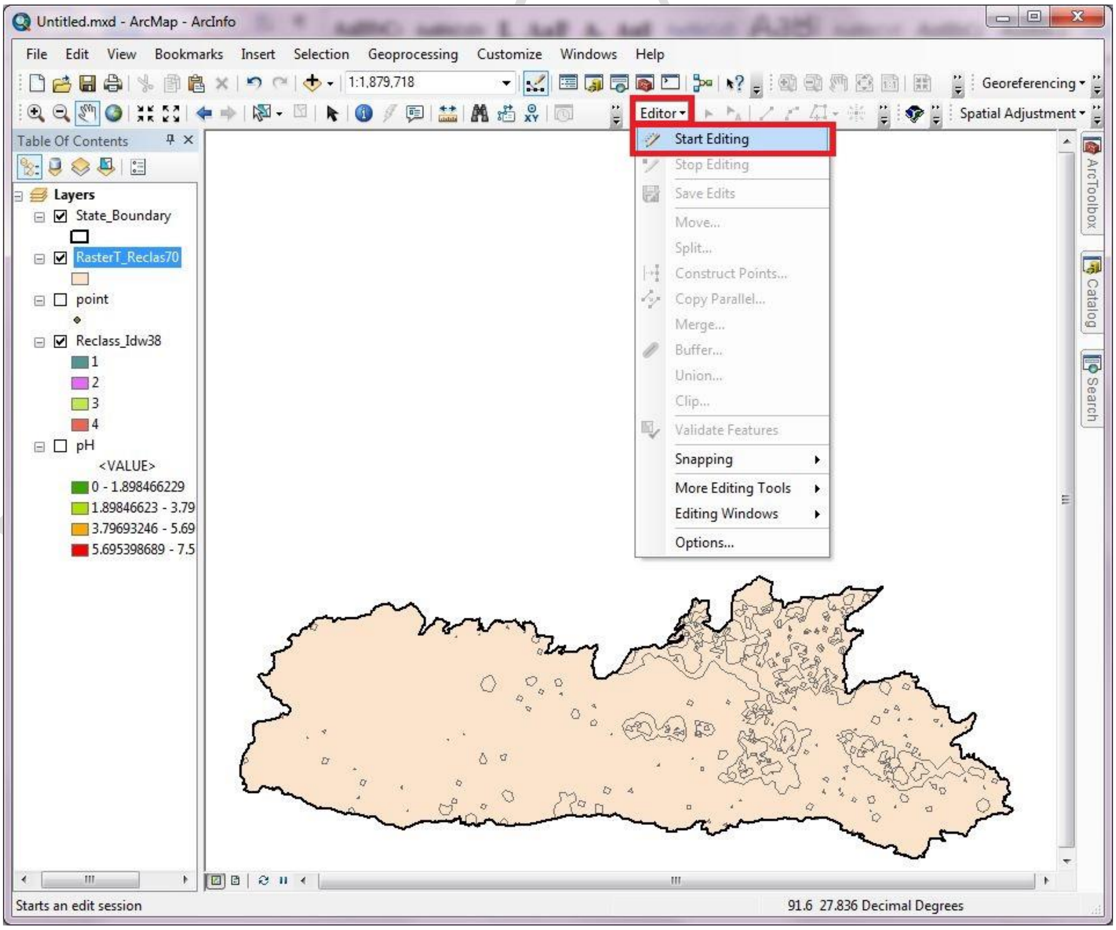
RasterT_Reclas70

OBJECTID *	Shape *	Id	grid_code	Shape_Length	Shape_Area	Area
1	Polygon	1	2	0.087776	0.0003	<Null>
2	Polygon	2	3	0.10174	0.000595	<Null>
3	Polygon	3	2	0.016403	0.000013	<Null>
4	Polygon	4	2	0.016303	0.000012	<Null>
5	Polygon	5	3	0.054311	0.000178	<Null>
6	Polygon	6	2	0.036632	0.000072	<Null>
7	Polygon	7	1	0.098703	0.000649	<Null>
8	Polygon	8	2	0.063061	0.000126	<Null>
9	Polygon	9	3	0.135051	0.001182	<Null>
10	Polygon	10	3	0.068474	0.000272	<Null>
11	Polygon	11	1	0.064343	0.000236	<Null>
12	Polygon	12	3	0.054709	0.000165	<Null>
13	Polygon	13	3	0.038688	0.000067	<Null>
14	Polygon	14	3	0.047548	0.000141	<Null>
15	Polygon	15	1	0.045427	0.000123	<Null>
16	Polygon	16	3	0.017391	0.000019	<Null>
17	Polygon	17	3	0.512373	0.012156	<Null>
18	Polygon	18	3	0.097546	0.000617	<Null>
19	Polygon	19	3	0.029026	0.000048	<Null>
20	Polygon	20	2	0.263814	0.001011	<Null>
21	Polygon	21	3	0.106302	0.000666	<Null>
22	Polygon	22	3	0.188939	0.001826	<Null>
23	Polygon	23	3	0.032503	0.000051	<Null>
24	Polygon	24	3	0.046918	0.000106	<Null>
25	Polygon	25	3	0.016403	0.000013	<Null>
26	Polygon	26	2	0.901636	0.009051	<Null>
27	Polygon	27	1	0.017391	0.000019	<Null>
28	Polygon	28	3	0.04748	0.000107	<Null>
29	Polygon	29	2	0.143022	0.000501	<Null>
30	Polygon	30	3	0.08818	0.000488	<Null>
31	Polygon	31	1	0.208837	0.001692	<Null>

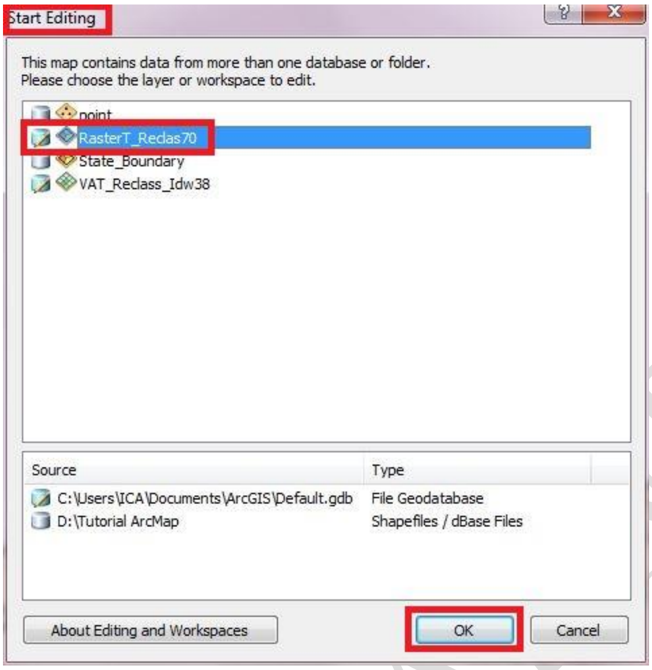
(0 out of 316 Selected)

RasterT_Reclas70

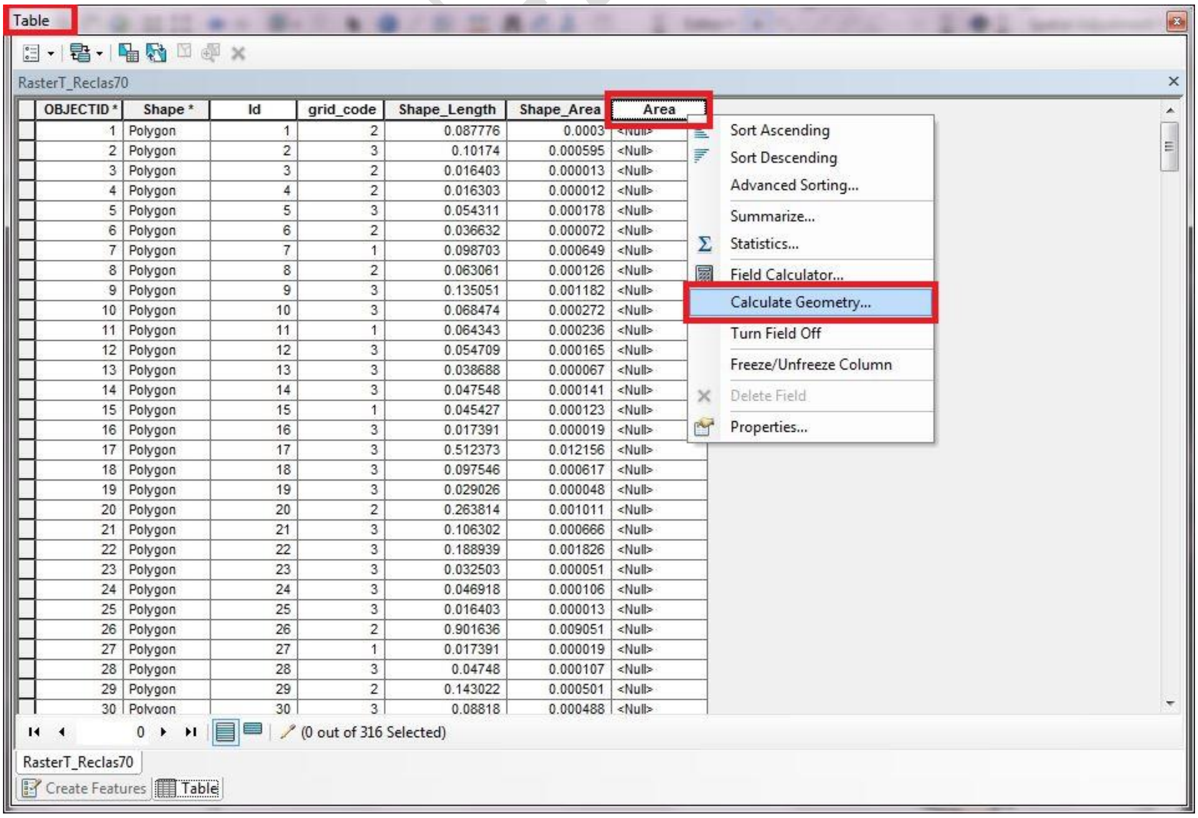
Step IV: After adding the field, go to the main window of **Arc Map** and select the **Editor Option,** then click on **Start Editing** as shown in the figure below.



Step V: A window screen of **Start Editing** will appear on the screen and select the **Vector Layer** (polygon shape file i.e., **RasterT_reclass70**) and click **OK**.

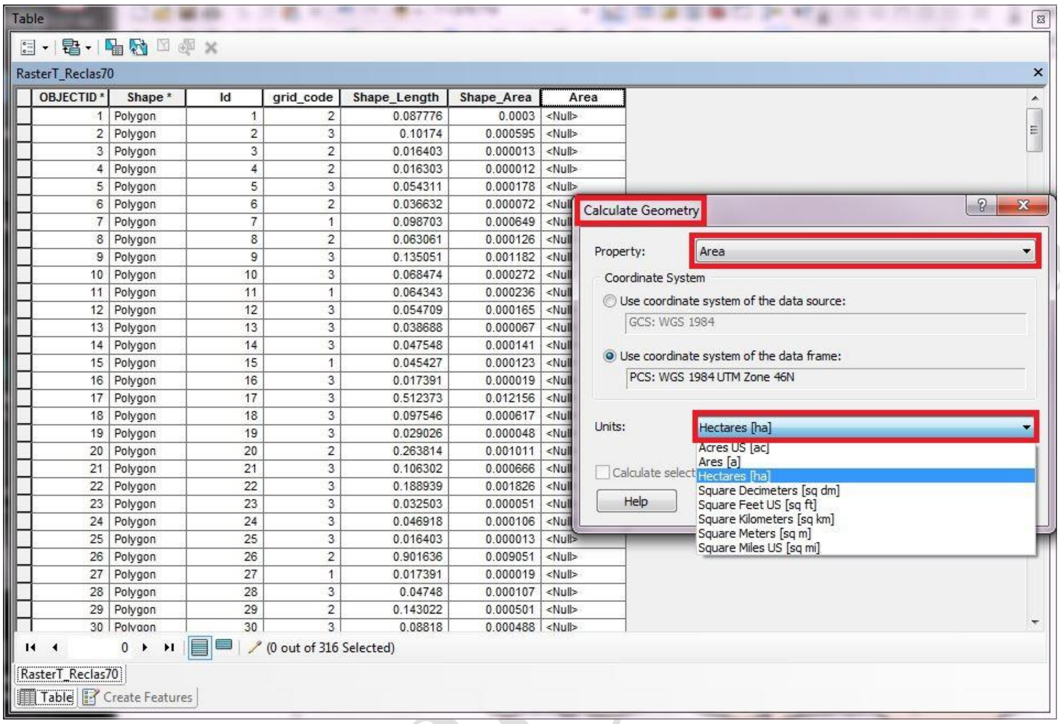


Step VI: After start editing, go to the attribute table of the **Vector Layer** (polygon shape file i.e., **RasterT_reclass70**), then on the area column, **Right Click** on the **Area** and click on **Calculate Geometry**… as shown in the figure below



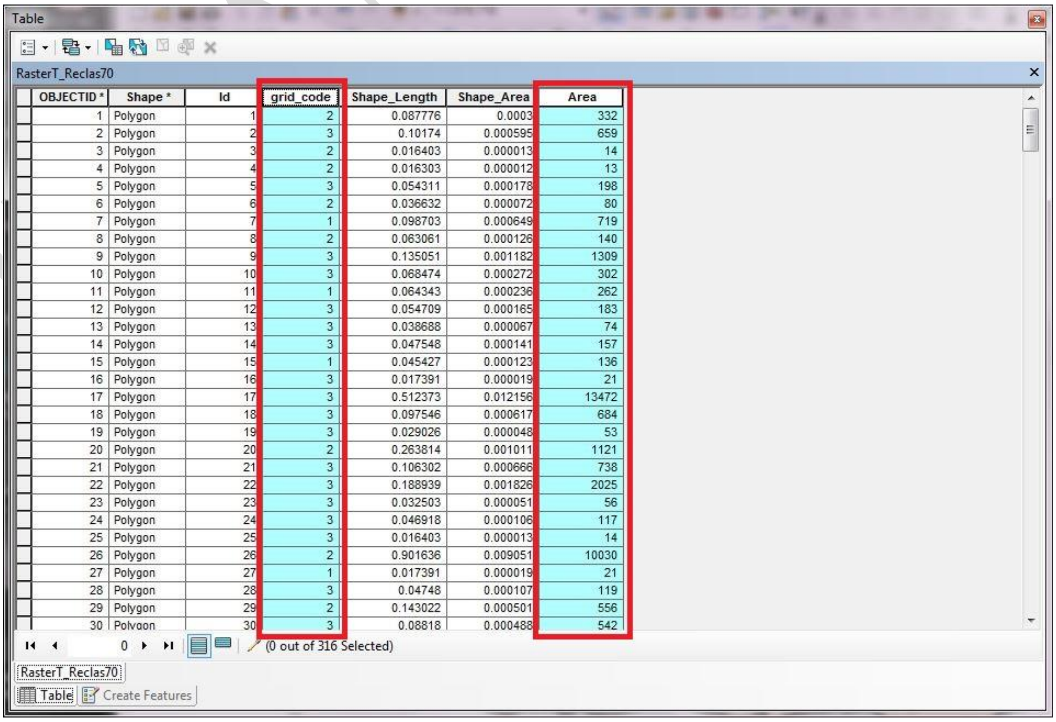
OBJECTID *	Shape *	Id	grid_code	Shape_Length	Shape_Area	Area
1	Polygon	1	2	0.087776	0.0003	<Null>
2	Polygon	2	3	0.10174	0.000595	<Null>
3	Polygon	3	2	0.016403	0.000013	<Null>
4	Polygon	4	2	0.016303	0.000012	<Null>
5	Polygon	5	3	0.054311	0.000178	<Null>
6	Polygon	6	2	0.036632	0.000072	<Null>
7	Polygon	7	1	0.098703	0.000649	<Null>
8	Polygon	8	2	0.063061	0.000126	<Null>
9	Polygon	9	3	0.135051	0.001182	<Null>
10	Polygon	10	3	0.068474	0.000272	<Null>
11	Polygon	11	1	0.064343	0.000236	<Null>
12	Polygon	12	3	0.054709	0.000165	<Null>
13	Polygon	13	3	0.038688	0.000067	<Null>
14	Polygon	14	3	0.047548	0.000141	<Null>
15	Polygon	15	1	0.045427	0.000123	<Null>
16	Polygon	16	3	0.017391	0.000019	<Null>
17	Polygon	17	3	0.512373	0.012156	<Null>
18	Polygon	18	3	0.097546	0.000617	<Null>
19	Polygon	19	3	0.029026	0.000048	<Null>
20	Polygon	20	2	0.263814	0.001011	<Null>
21	Polygon	21	3	0.106302	0.000666	<Null>
22	Polygon	22	3	0.188939	0.001826	<Null>
23	Polygon	23	3	0.032503	0.000051	<Null>
24	Polygon	24	3	0.046918	0.000106	<Null>
25	Polygon	25	3	0.016403	0.000013	<Null>
26	Polygon	26	2	0.901636	0.009051	<Null>
27	Polygon	27	1	0.017391	0.000019	<Null>
28	Polygon	28	3	0.04748	0.000107	<Null>
29	Polygon	29	2	0.143022	0.000501	<Null>
30	Polygon	30	3	0.08818	0.000488	<Null>

Step VII: The window screen of **Calculate Geometry** will appear on the screen and on the **Properties,** select the **Area,** then on the **Units,** select the units of the area (as desired) to calculate/estimate the area under each class/range of soil pH values (here the unit we selected is in **Hectares**) and select **OK**.



OBJECTID *	Shape *	Id	grid_code	Shape_Length	Shape_Area	Area
1	Polygon	1	2	0.087776	0.0003	<Null>
2	Polygon	2	3	0.10174	0.000595	<Null>
3	Polygon	3	2	0.016403	0.000013	<Null>
4	Polygon	4	2	0.016303	0.000012	<Null>
5	Polygon	5	3	0.054311	0.000178	<Null>
6	Polygon	6	2	0.036632	0.000072	<Nul
7	Polygon	7	1	0.098703	0.000649	<Nul
8	Polygon	8	2	0.063061	0.000126	<Nul
9	Polygon	9	3	0.135051	0.001182	<Nul
10	Polygon	10	3	0.068474	0.000272	<Nul
11	Polygon	11	1	0.064343	0.000236	<Nul
12	Polygon	12	3	0.054709	0.000165	<Nul
13	Polygon	13	3	0.038688	0.000067	<Nul
14	Polygon	14	3	0.047548	0.000141	<Nul
15	Polygon	15	1	0.045427	0.000123	<Nul
16	Polygon	16	3	0.017391	0.000019	<Nul
17	Polygon	17	3	0.512373	0.012156	<Nul
18	Polygon	18	3	0.097546	0.000617	<Nul
19	Polygon	19	3	0.029026	0.000048	<Nul
20	Polygon	20	2	0.263814	0.001011	<Nul
21	Polygon	21	3	0.106302	0.000666	<Nul
22	Polygon	22	3	0.188939	0.001826	<Nul
23	Polygon	23	3	0.032503	0.000051	<Nul
24	Polygon	24	3	0.046918	0.000106	<Nul
25	Polygon	25	3	0.016403	0.000013	<Null>
26	Polygon	26	2	0.901636	0.009051	<Null>
27	Polygon	27	1	0.017391	0.000019	<Null>
28	Polygon	28	3	0.04748	0.000107	<Null>
29	Polygon	29	2	0.143022	0.000501	<Null>
30	Polygon	30	3	0.08818	0.000488	<Null>

Step VIII: After selecting **OK,** the area of each and every polygon will appear on the attribute table in the **Area Column** of the **Vector Layer** (polygon shape file i.e., **RasterT_reclass70**) and the **Grid Code** in the attribute table is the class of the **Classified Raster Layer**.

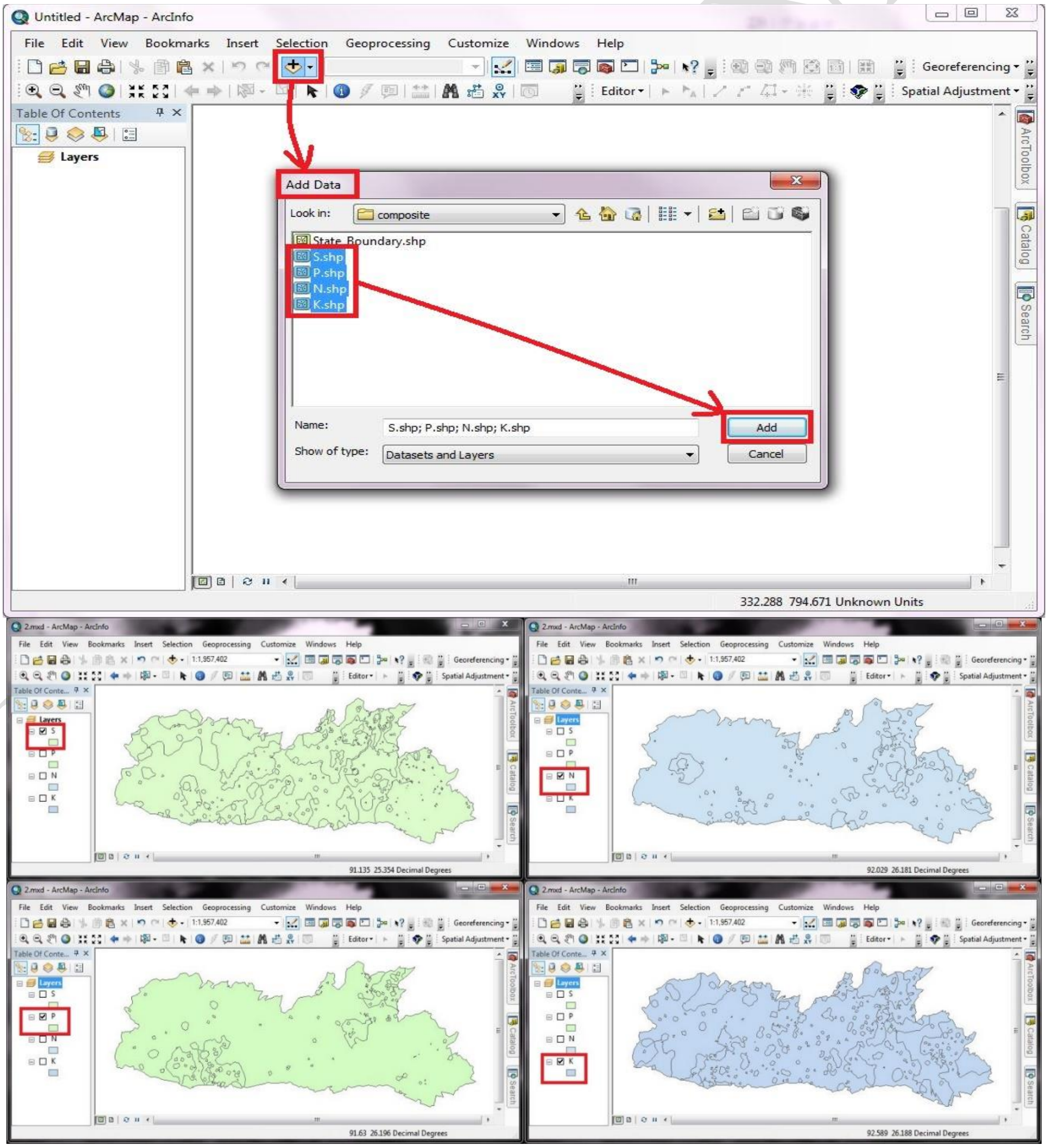


OBJECTID *	Shape *	Id	grid_code	Shape_Length	Shape_Area	Area
1	Polygon	1	2	0.087776	0.0003	332
2	Polygon	2	3	0.10174	0.000595	659
3	Polygon	3	2	0.016403	0.000013	14
4	Polygon	4	2	0.016303	0.000012	13
5	Polygon	5	3	0.054311	0.000178	198
6	Polygon	6	2	0.036632	0.000072	80
7	Polygon	7	1	0.098703	0.000649	719
8	Polygon	8	2	0.063061	0.000126	140
9	Polygon	9	3	0.135051	0.001182	1309
10	Polygon	10	3	0.068474	0.000272	302
11	Polygon	11	1	0.064343	0.000236	262
12	Polygon	12	3	0.054709	0.000165	183
13	Polygon	13	3	0.038688	0.000067	74
14	Polygon	14	3	0.047548	0.000141	157
15	Polygon	15	1	0.045427	0.000123	136
16	Polygon	16	3	0.017391	0.000019	21
17	Polygon	17	3	0.512373	0.012156	13472
18	Polygon	18	3	0.097546	0.000617	684
19	Polygon	19	3	0.029026	0.000048	53
20	Polygon	20	2	0.263814	0.001011	1121
21	Polygon	21	3	0.106302	0.000666	738
22	Polygon	22	3	0.188939	0.001826	2025
23	Polygon	23	3	0.032503	0.000051	56
24	Polygon	24	3	0.046918	0.000106	117
25	Polygon	25	3	0.016403	0.000013	14
26	Polygon	26	2	0.901636	0.009051	10030
27	Polygon	27	1	0.017391	0.000019	21
28	Polygon	28	3	0.04748	0.000107	119
29	Polygon	29	2	0.143022	0.000501	556
30	Polygon	30	3	0.08818	0.000488	542

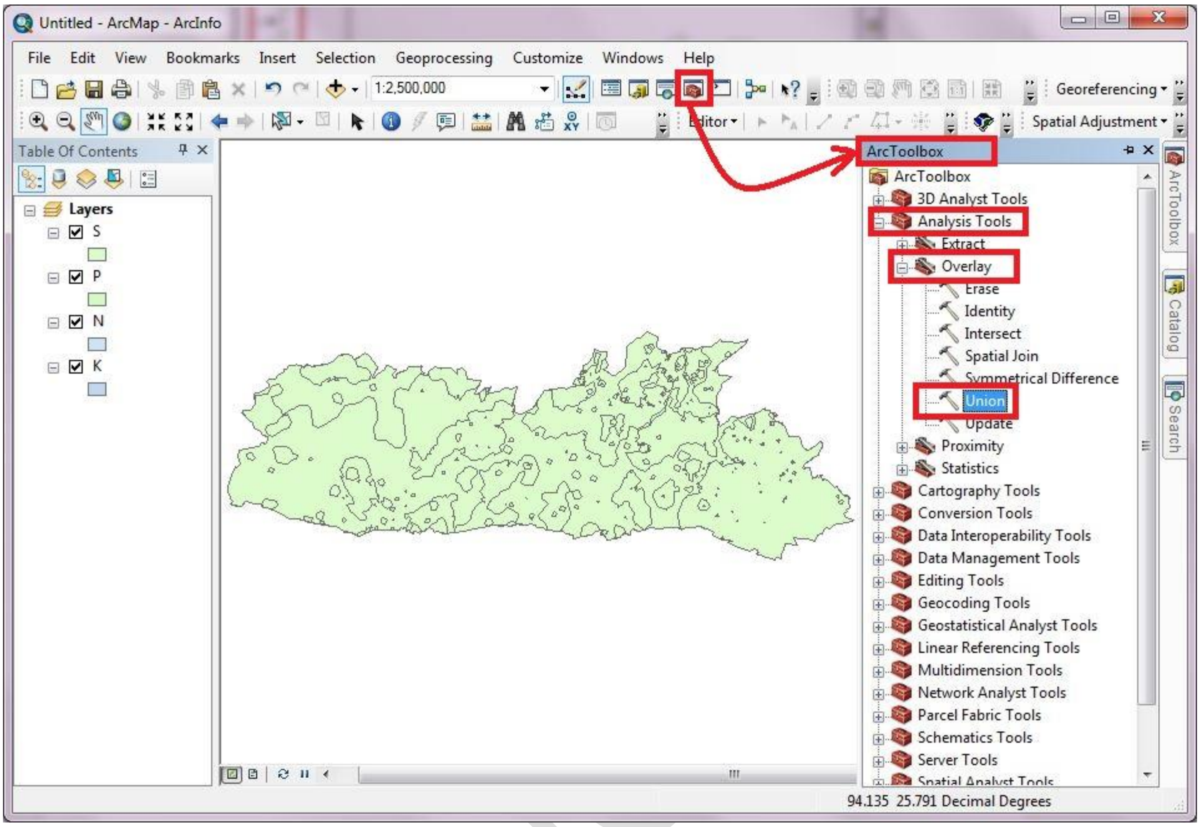
3.6 How to Prepare a Composite Layer Map of Different Soil Properties.

Composite map is a map on which several levels of layer (several thematic layers of attributes like available nutrients of N, P, K, S etc.) are shown on a single map. More than two layers of map are needed to prepare a composite map. In the tutorial, we are using the layer of soil fertility properties i.e. Nitrogen (N), Phosphorus (P), Potassium (K) and Sulphur (S) as an example to prepare the composite map of macro-nutrients - NPKS.

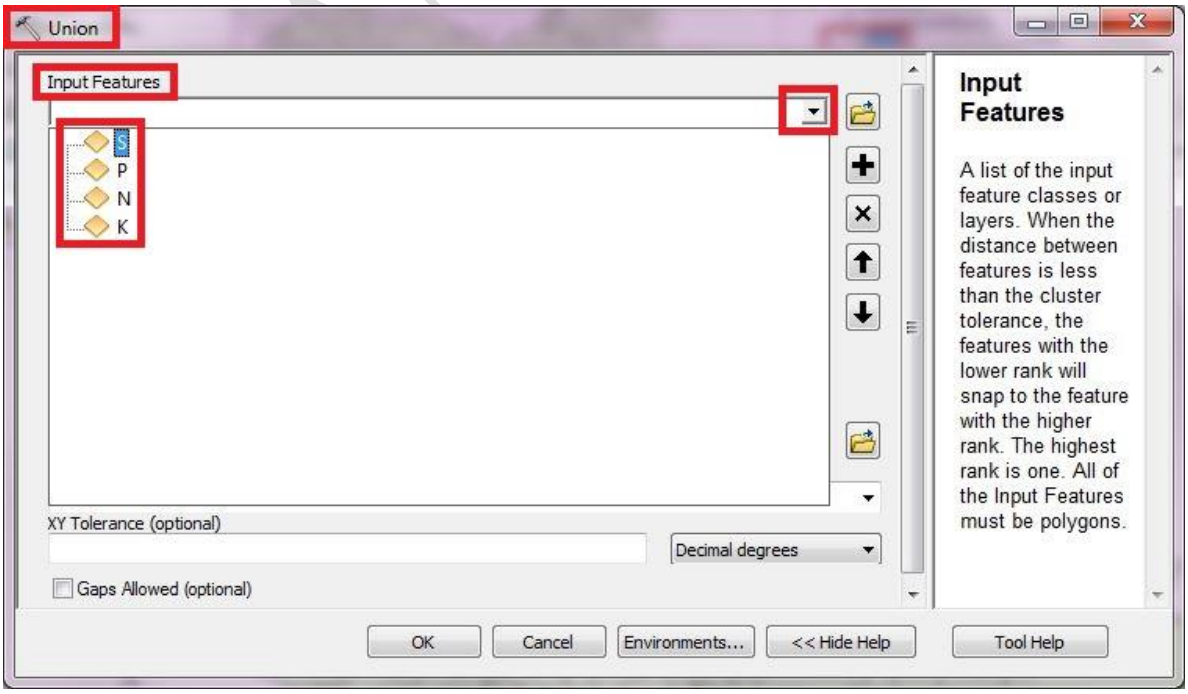
Step I: By following the above mentioned step on how to **Convert the Reclassified Raster Layer to Vector Layer** (polygon shape file) of all the reclassified raster layers of individual **N, P, K and S layers**. Open **Arc Map,** then select **Add Data** icon. A window screen of **Add Data** will appear and **look in**to folder where the **Vector Layer** (polygon shape file) is saved. Then select the Vector Layer of **N, P, K and S** and click on **Add** as shown in the figure below.

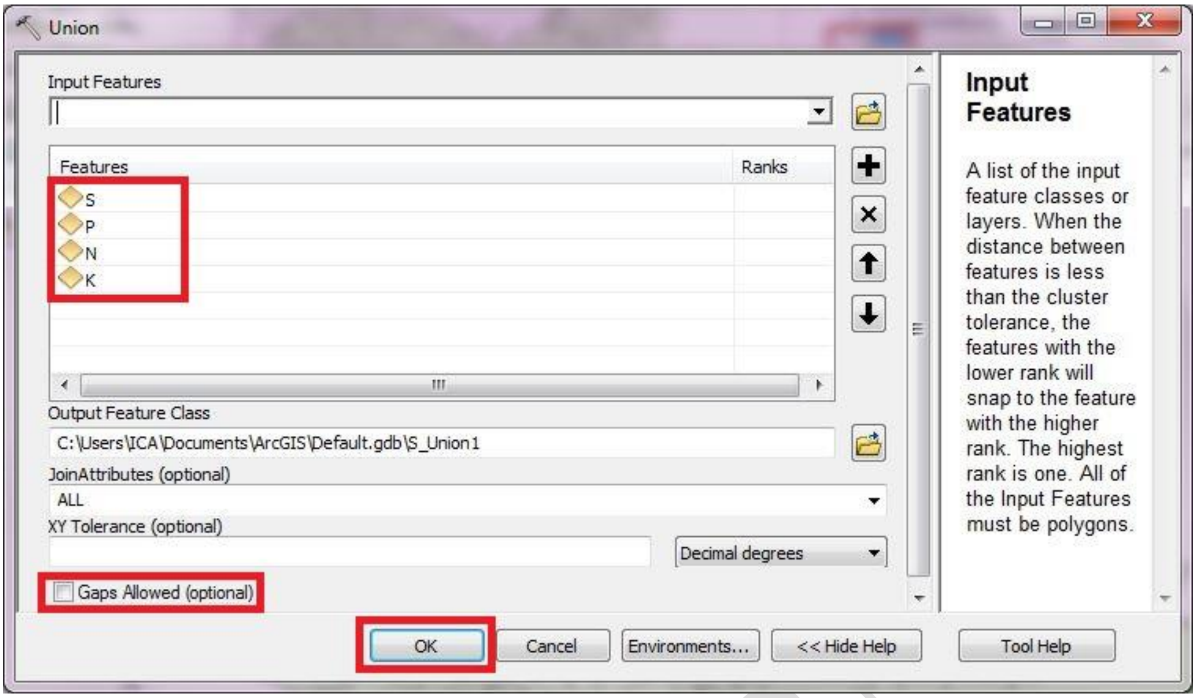


Step II: After adding the layer, go to **Arc Toolbox** icon, then select on **Analysis Tools** and again select on **Overlay** followed by **Double Click** on **Union** as shown in the figure below.

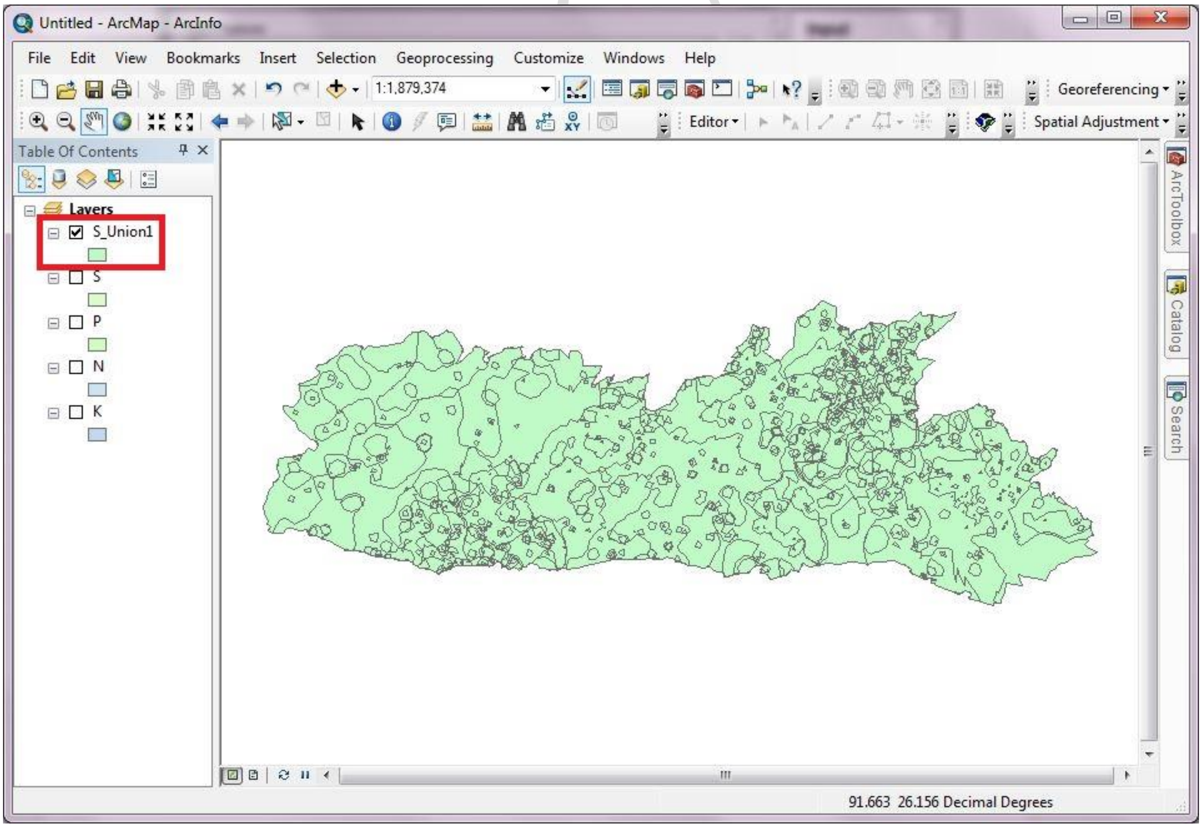


Step III: A window screen of **Union** will appear on the screen. Go to **Input features** and select **one by one** of all the four (N, P, K, S) layers. Then **Uncheck** the **Gaps Allowed (optional)** then select **OK**.

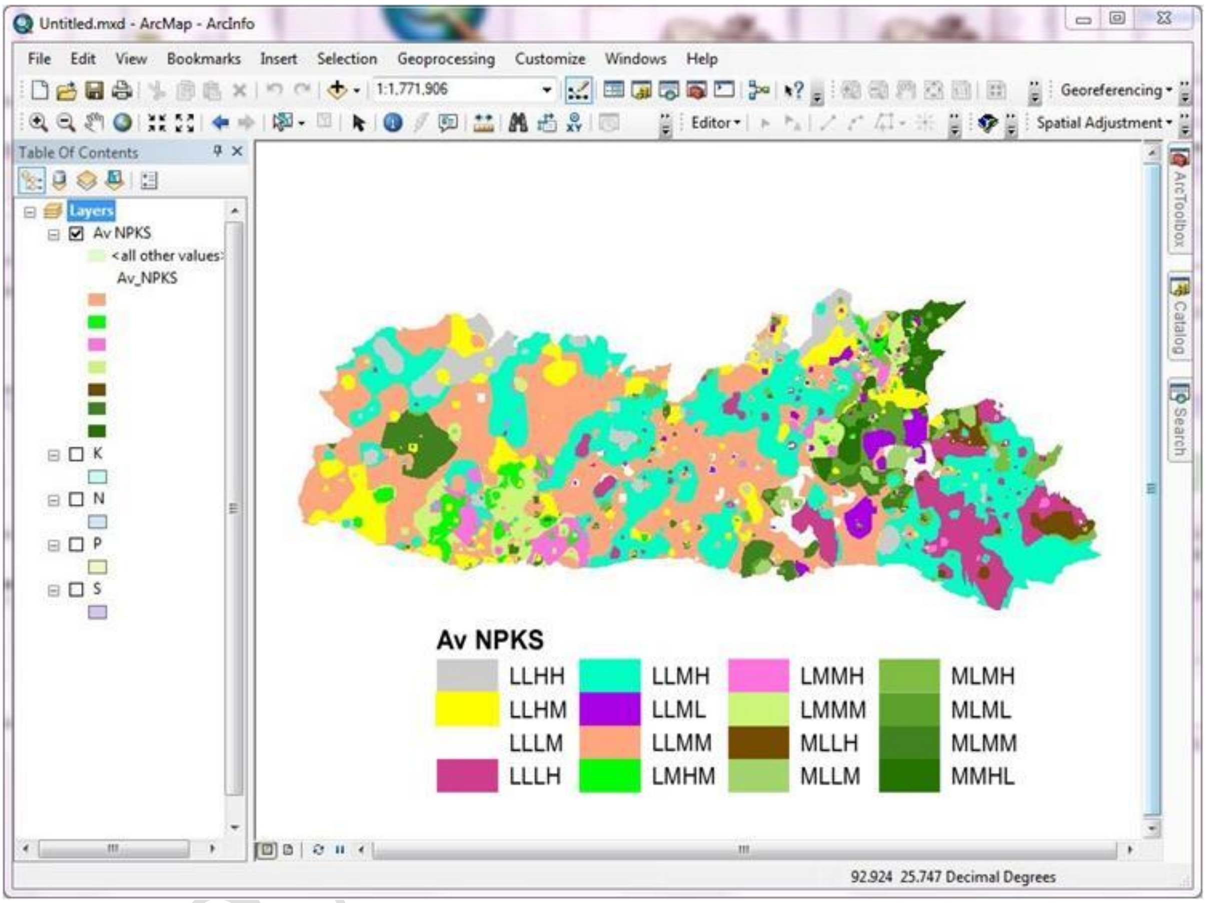




Step IV: After selecting **OK**, the layer of **S_Union1** will appear on the Data View of the Arc Map which is the Composite Layer of N, P, K and S.



Step V: The output composite will appear like this (given below). Classes in each thematic map (of N, P, K, S) as well as composite map of N-P-K-S will depend on the user to define as he/she desires. Here, one example is given as: High (H), Medium (M), and low (L) to classify composite map of all the four nutrient elements (N-P-K-S). Each level/class such as High (H) will have certain user defined ranges for each nutrient element. Same with M and L as well for each layer.



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