Chapter 1: Features in QGIS

QGIS provides many common GIS functionalities and a mammoth collection of multiple features with plugins. Following are some features and plugins services provided with the integrated Python console.

1.1View data

We can view and overlay vector and raster data in different formats and projections. Following are supported formats in QGIS:

- View and overlay data formats using PostGIS, SpatiaLite and MS SQL Spatial, Oracle Spatial, vector formats supported by the installed OGR (OpenGIS Simple Features Reference Implementation) library, including ESRI shapefiles, MapInfo, SDTS (Spatial Data Transfer Standard), GML (Game Maker Language)etc.
- Raster and imagery formats supported by the installed GDAL (Geospatial Data Abstraction Library), such as GeoTIFF, ERDAS IMG, ArcInfo ASCII GRID, JPEG, PNG etc.
- GRASS raster and vector data from GRASS.
- OGC (Open Geospatial Consortium) web services (online spatial data services): WMS(Web Map Service), WMTS(Web Map Tile Service), WCS (Web Coverage Service) , WFS(Web Feature Service).

1.2 Create, Edit, Manage data

You can create, edit, manage and export vector and raster layers in several formats. QGIS offers the following:

- Digitizing tools to create vector layers.
- Create and edit shapefiles .
- Georeferencer plugin to geocode images: either with known GCPs (Ground Control points) or with map canvas.
- GPS tools to import and export GPX format, and convert other GPS formats to GPX or down/upload directly to a GPS unit.
- Support for visualizing and editing Open Street Map (OSM) data.
- Ability to create spatial database tables from shapefiles with DB Manager plugin.
- Tools for managing vector attribute tables.

- DXF-Export tool with enhanced capabilities to export styles and plugins to perform CAD like functions.

1.3 Export Data

Map Exported in QGIS

- BMP file: BitMap file is a mature loss-less uncompressed raster format and produces a good quality output with the limitation of large size but can be used to achieve both high-quality output and compatibility.
- GIF file: It is a Graphics Interchange Format, i.e. an uncompressed raster file format with 256-color limitation. Therefore, if file contains only a few colors (vector-based data), GIF is a better option.
- PNG file: Portable Network Graphics is an open-source standard designed and can be a better option than BMP and GIF. It is a true-color loss-less raster file format, with limitation of slightly larger size as compare JPEG and not supported by old operating systems and browsers.
- TIFF file: Tagged Image File Format. It is a major raster graphic file format provided by Adobe that is suitable to be used for raster file editing on Adobe Products, such as Photoshop.
- SVG file: Scalable Vector Graphics is an open-source vector graphic standard and now a days becoming more and more popular.

1.4 Analyze data

QGIS offers vector analysis, sampling, geoprocessing, geometry and database management tools. Processing Plugin provides a powerful geospatial analysis framework to call native and third-party algorithms from QGIS, such as GDAL, SAGA, GRASS etc.

1.5 Compose Map and Publish Maps on the Internet

QGIS produces most presentable formats of the maps and interactively explore spatial data with a friendly GUI.

Publishes maps as a WMS, WMTS, WCS or WFS and WFS-T client and as a WMS, WCS or WFS server. Furthermore, can publish the data on the Internet using a webserver with UMN (Unified Messaging Service) MapServer or GeoServer.

1.6 QGIS functionality through plugins

Plugin architecture and libraries in QGIS can be used to create plugins and to create new applications with C++ or Python.

Plugins include:

1. Coordinate Capture (Capture mouse coordinates in different CRSs)
2. Edit and view layers, tables (DB Manager, execute SQL queries)
3. Convert DXF files to shapefiles
4. GDALTools (Integrate GDAL Tools into QGIS)
5. Georeferencer GDAL (Add projection information to rasters)
6. GPS Tools (Load and import GPS data)
7. GRASS (Integrate GRASS GIS)
8. Heatmap (Generate raster heatmaps from point data)
9. Raster Terrain Analysis
10. Spatial Query Plugin
11. Semi-automatic Classification Plugin (SCP)

1.7 Python Console

PyQGIS interface allows access to the map canvas, menus, toolbars and other parts of the QGIS application that allows users to create a script to open raster, vector, drag and drop layer into the QGIS window, executed automatically.

To Open Vector Layer by Script Editor of PyQGIS

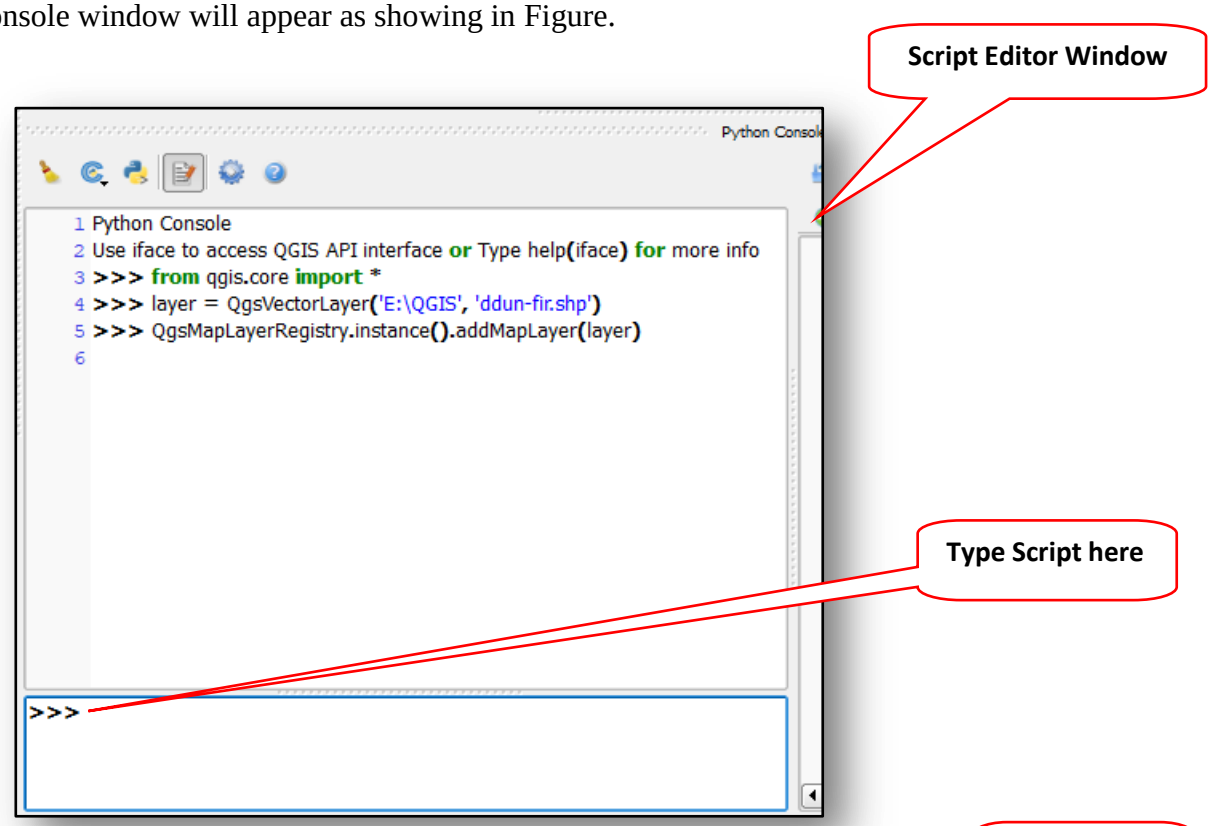
Enter the following codes in the Script editor to load vector layer.

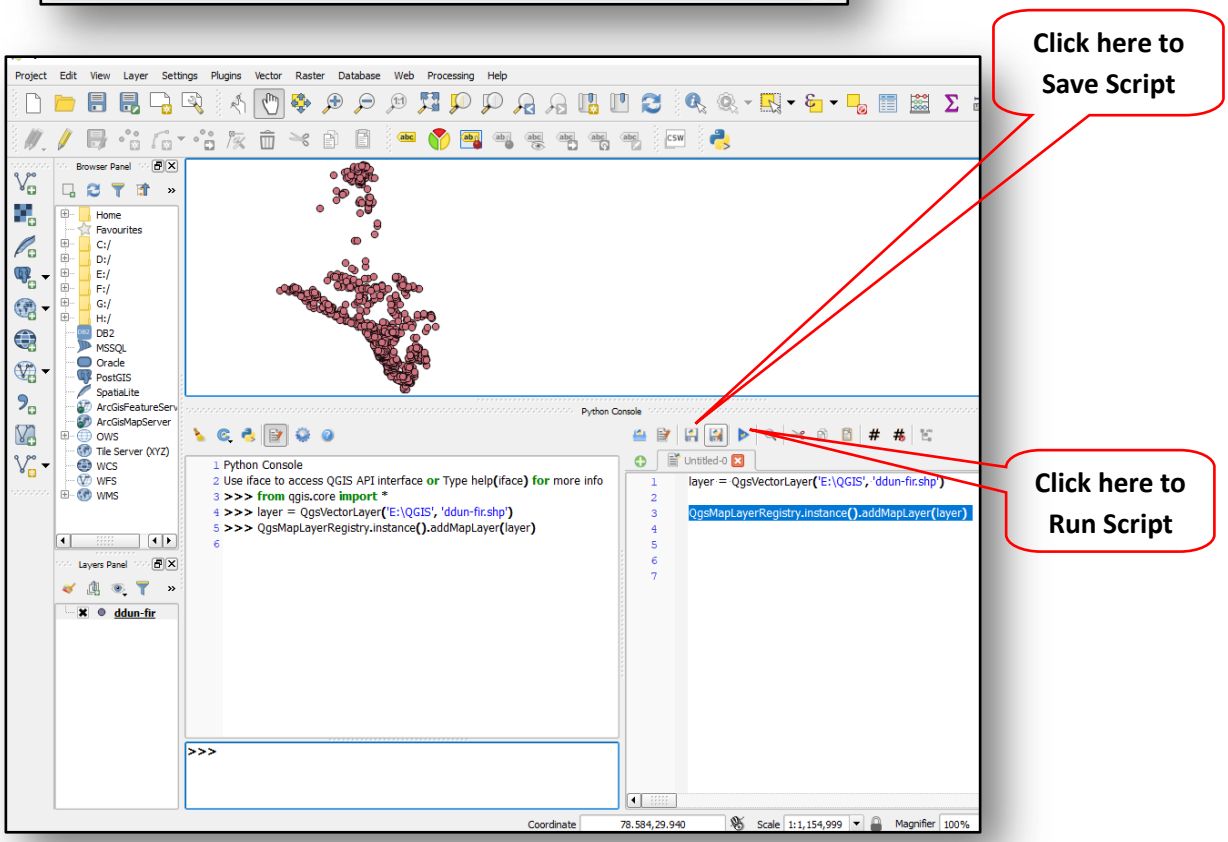
```
fromqgis.core import*

layer =QgsVectorLayer('path to the vector layer', 'display
name')

QgsMapLayerRegistry.instance().addMapLayer(layer)
```

- To open Script Editor of Python Console go to **Plugin** > **Python Console** and the Python Console window will appear as showing in Figure.

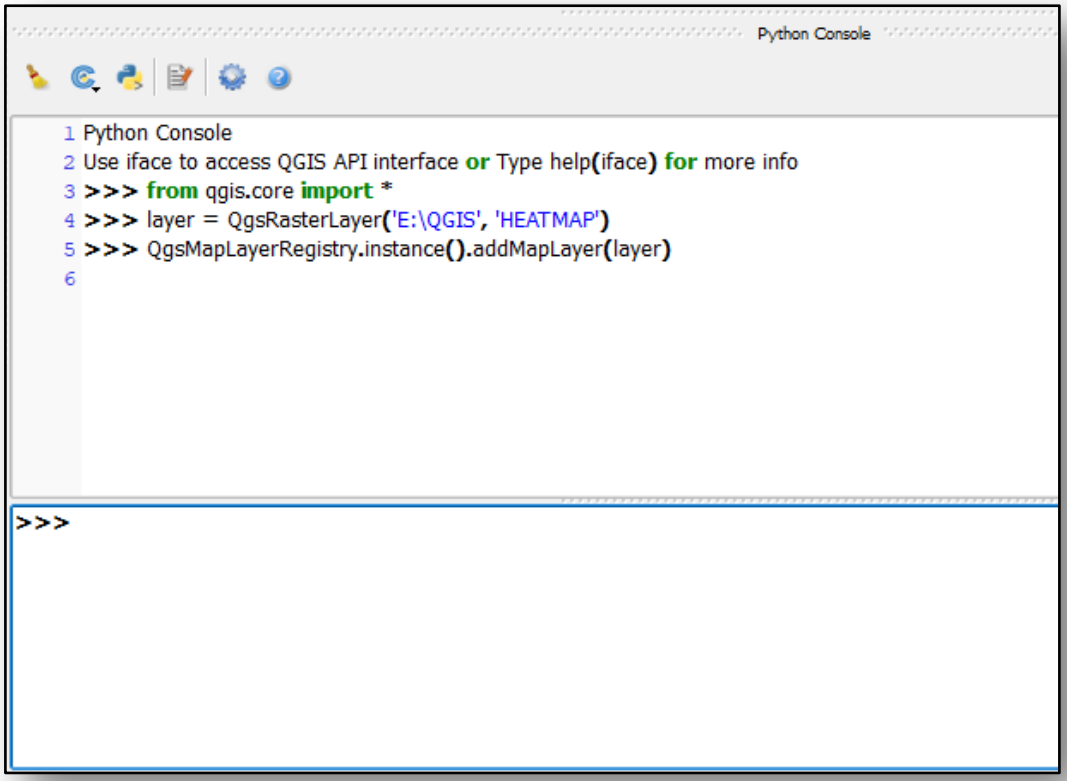




- Now, name the script > Click **Save** Button and save it at the default location under C:\Program Files\QGIS 2.18\apps\Python27\Scripts.
- In Script Editor > Click **Run** algorithm button..
- It will load vector layer on the Map Canvas.

To Open Raster Layer

- Enter the following codes in the Script Editor to load raster layer.

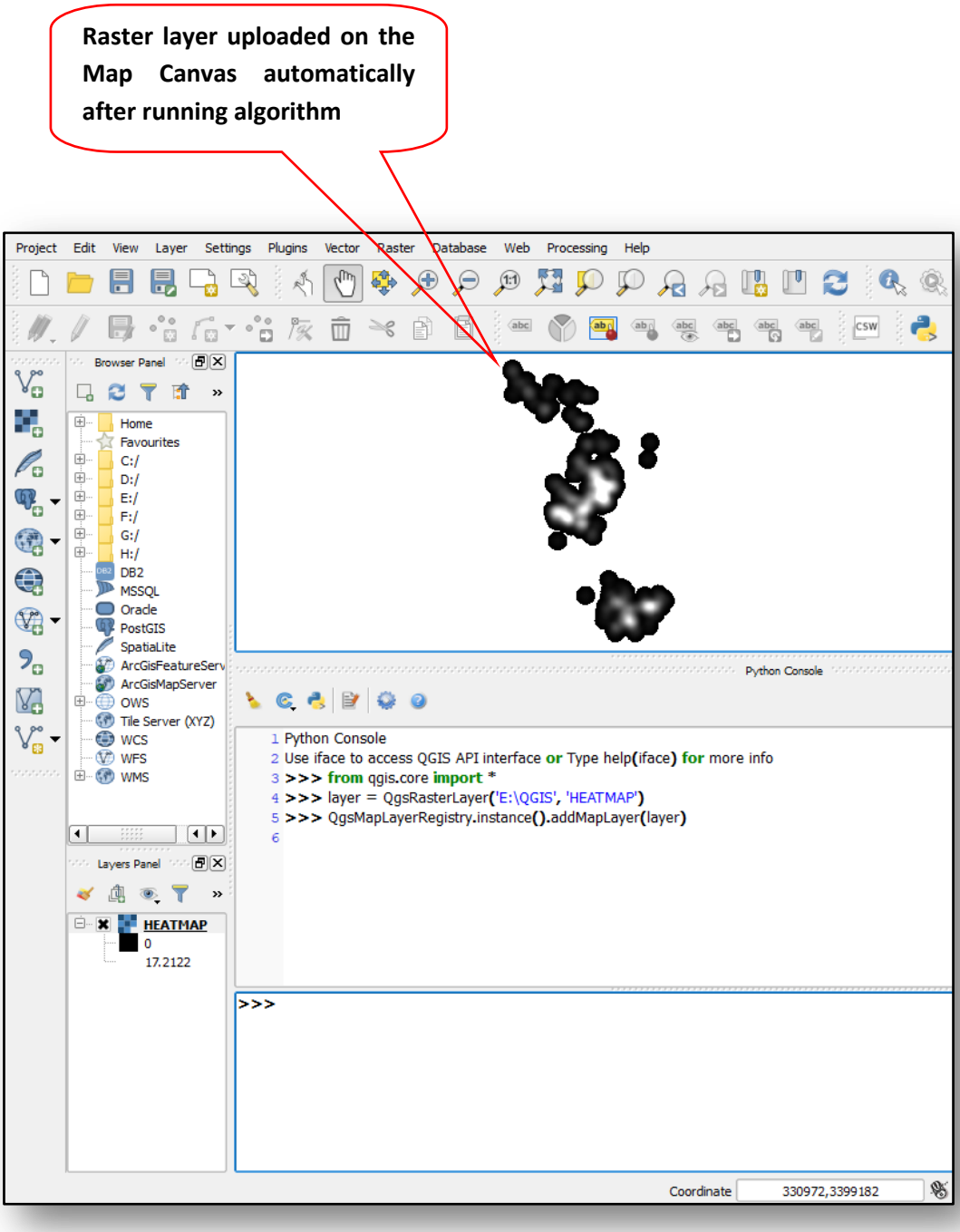



```
fromqgis.core import*

layer =QgsRasterLayer('path to the raster layer', 'display
name')

QgsMapLayerRegistry.instance().addMapLayer(layer)
```

- Click **Save** Button and save it at the default location under C:\Program Files\QGIS 2.18\apps\Python27\Scripts.
- In Script Editor > Click **Run** algorithm button to execute the query and after that raster layer will be loaded on the Map Canvas.



Some supported Vector, Raster Data Format in QGIS

- **Feature Data**: Feature data are usually organized as points, linesand polygons in vector format.
- Shapefile: The most commonly used geospatial data format. Although it appears to be one file (.shp) in ArcMap, shapefile includes multiple files with the same file name with different extensions. *.shp, *,dbf, and *.shx.
- Personal Geodatabase: These files are based on Microsoft Access (*.mdb). From user perspective, all kinds of geodatabase are the same, which include multiple layers (different geospatial data) in one geodatabase.
- MapInfo files: The following three are legendary geospatial file formats. MapInfo is the first desktop GIS software for Windows. Its files (*.tab) are widely used.
- MicroStation files: MicroStation files have the extension of *.dgn, whose vendor is GE.
- ArcInfo: ArcInfo is the previous generation of ArcGIS. Its file (*.e00) are supported in QGIS as well.
- Google Earth: *.kml and *.kmz (zipped KML) are Google Earth file formats, which are popular in Location-Based Service now. Many websites support kml and kmz files.
- GML and GeoJSON: Open source geospatial data standard, which is also popular in online applications.
- GPS: The track of GPS records can be imported into QGIS as *.gpx files. This function is very useful in surveying.
- CSV: *.csv files stands for comma separated value, which can be regarded as a legendary spreadsheet file format.
- US Census TIGER: US census publishes its data in tiger format, which belongs to “directory” source type rather than “file”.

Raster Data: Raster data uses grid to represent a region with values as a “field”. Images explicitly have the parameter of resolution. Typical raster data is:

- GeoTIFF: They have the file extension of *.tif. The key difference between normal TIFF file and GeoTIFF is that GeoTIFF has projection information. Hence, normal TIFF files cannot be correctly added to the desired location.
- GeoJPEG: Similar to GeoTIFF, but they have *.jpg extension.
- Usage: Raster data can be air photos, satellite images, elevation data (DEM). But raster data tends to be huge and slow to load.

Stronger Database Support: One major advantage of QGIS over ArcGIS lies in its superior support of different database vendors. Almost all types of relational database management system (RDBMS) are supported.

Source: University of WATERLOO Canadian GIS and Geomatics

Chapter 2: Working with Raster Data

2.1 Raster Data

Raster data is made up of pixels or grid of square shape pixels in which each grid is with different unique value (DN value),representing the attribute or feature, therefore raster data is larger in size (in bytes) as compare to vector. Raster data in GIS are matrices of discrete cells that represent features of the earth's surface. Usually satellite or areal imagery is represented in raster data format like GeoTIFF, img, pix, hdf(Hierarchical Data Format) etc.

QGIS is very powerful and useful open source software for handling Raster based analysis such as Image Classification, NDVI calculation, Terrain analysis etc.

2.2 What is Image classification?

Image classification is the process of assigning land cover classes to pixels and classify images into forest, urban, agriculture and other LULC (Land-Use Land-Cover) classes. The image classification defines the training sites to identify the land cover classes in the entire image i.e, based on the spectral signature. Digital image classification techniques are used to group pixels with similar values in several image bands.

In general, there are three main commonly used image classification techniques.

- **Supervised image classification (pixel-based classification)**

  The analyst first selects training samples (i.e. homogeneous and representative training areas) for each land cover class and then uses reference training areas to instruct the computer to identify spectrally similar areas for each and every class. The selection of training samples areas or Regions of Interest (ROI) can be based on field data collection or expert knowledge.

- **Unsupervised image classification (pixel-based classification)**

  The analyst specifies the desired number of classes when field data or prior knowledge about the study area is not available and then the computer automatically groups pixels that are statistically similar into categories using clustering algorithms include K-Means, Iterative Self-Organizing Data Analysis Technique (ISODATA) and agglomerative hierarchical (Duda and Canty, 2002). Some studies used a hybrid approach that combines unsupervised and supervised classification methods with field survey (Lane et al., 2014).

- **Object-based image analysis (OBIA)**

  The OBIA approach can incorporate spectral, spatial, textural, and contextual information into the classification process. To overcome the issues (salt and pepper effect) associated with pixel-based classification methods, OBIA methods for image classification have been developed (Blaschke, 2010; Liu et al., 2010).

Note: Object-based image analysis approach is useful for dealing with high-resolution data.

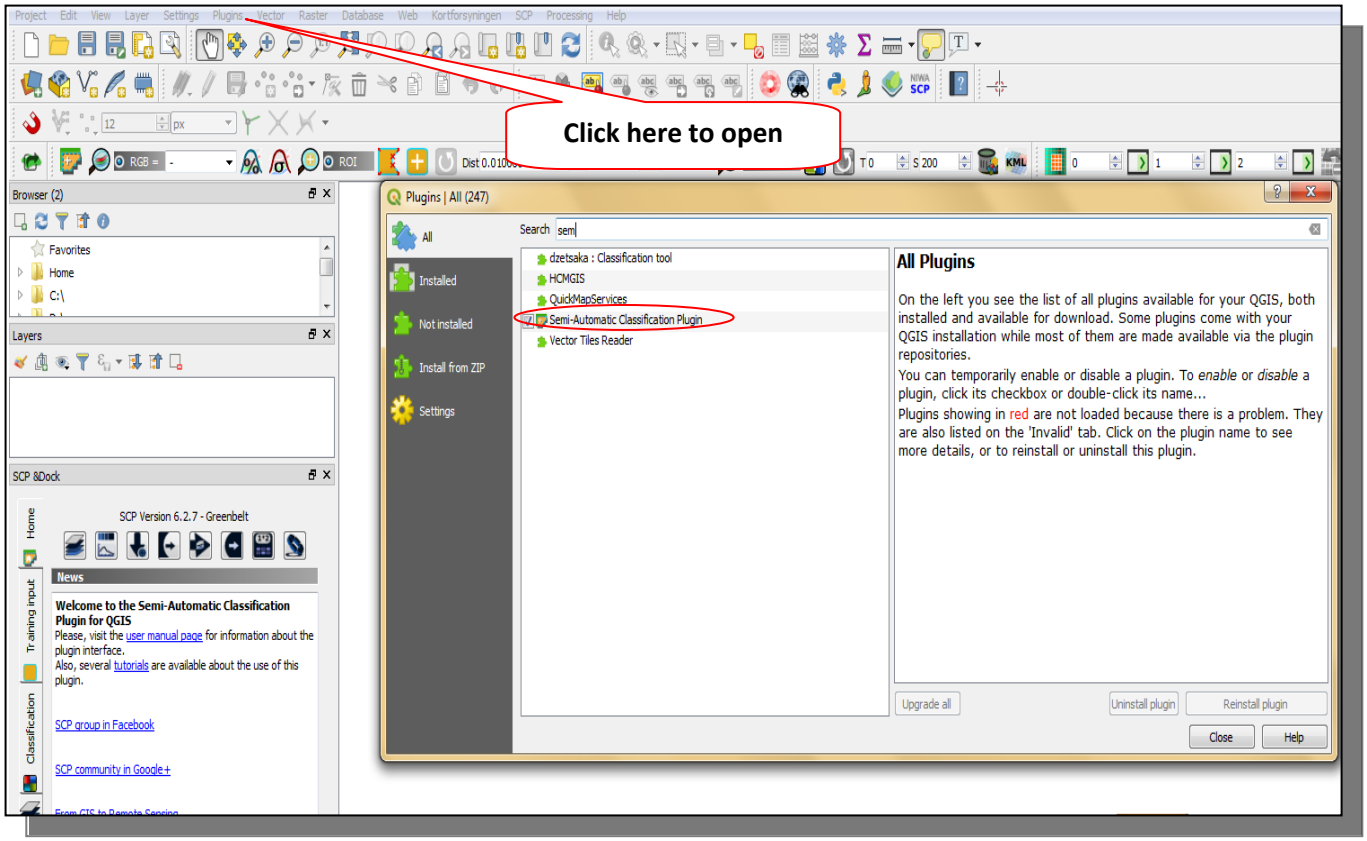
2.3 Supervised Classification:

Any supervised classification method requires prior identification of "training" samples. This can be done in the form of training polygons, which are digitized on an image as ROIs. There are some general rules to follow when creating training sites:

- Select as many training sites as per class.
- Select training sites throughout the entire image, represented whole area.
- Training site selection must be of spectrally homogenous areas.
- Training sites must be as large as possible.

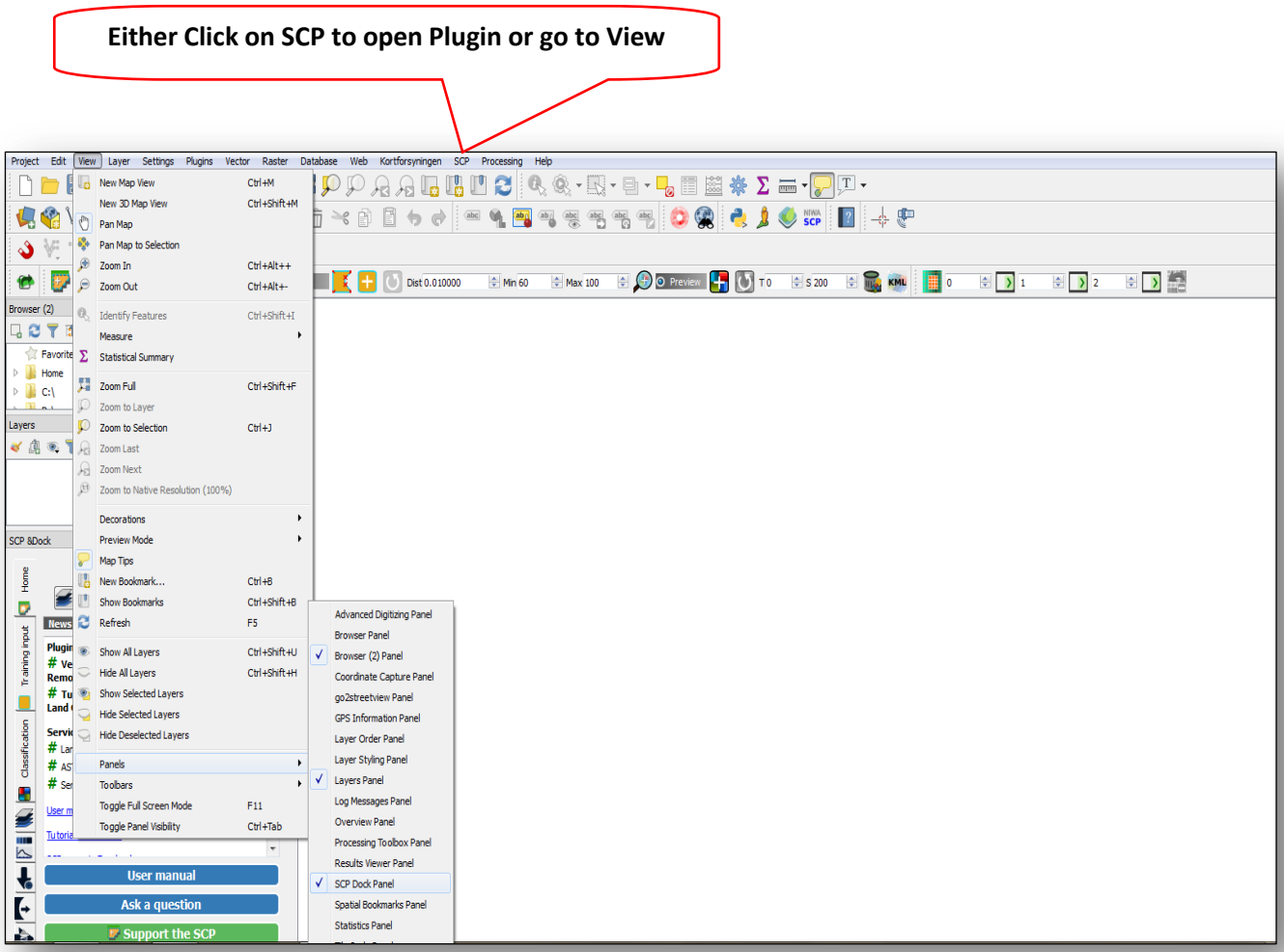
2.4 Image Classification by Semi-automatic Classification plugin (SCP) :

- Open QGIS and install Semi-automatic Classification plugin from the plugin option.
- For installation > type **Semi-automatic Classification** on search tab > Click on **Install** plugin.



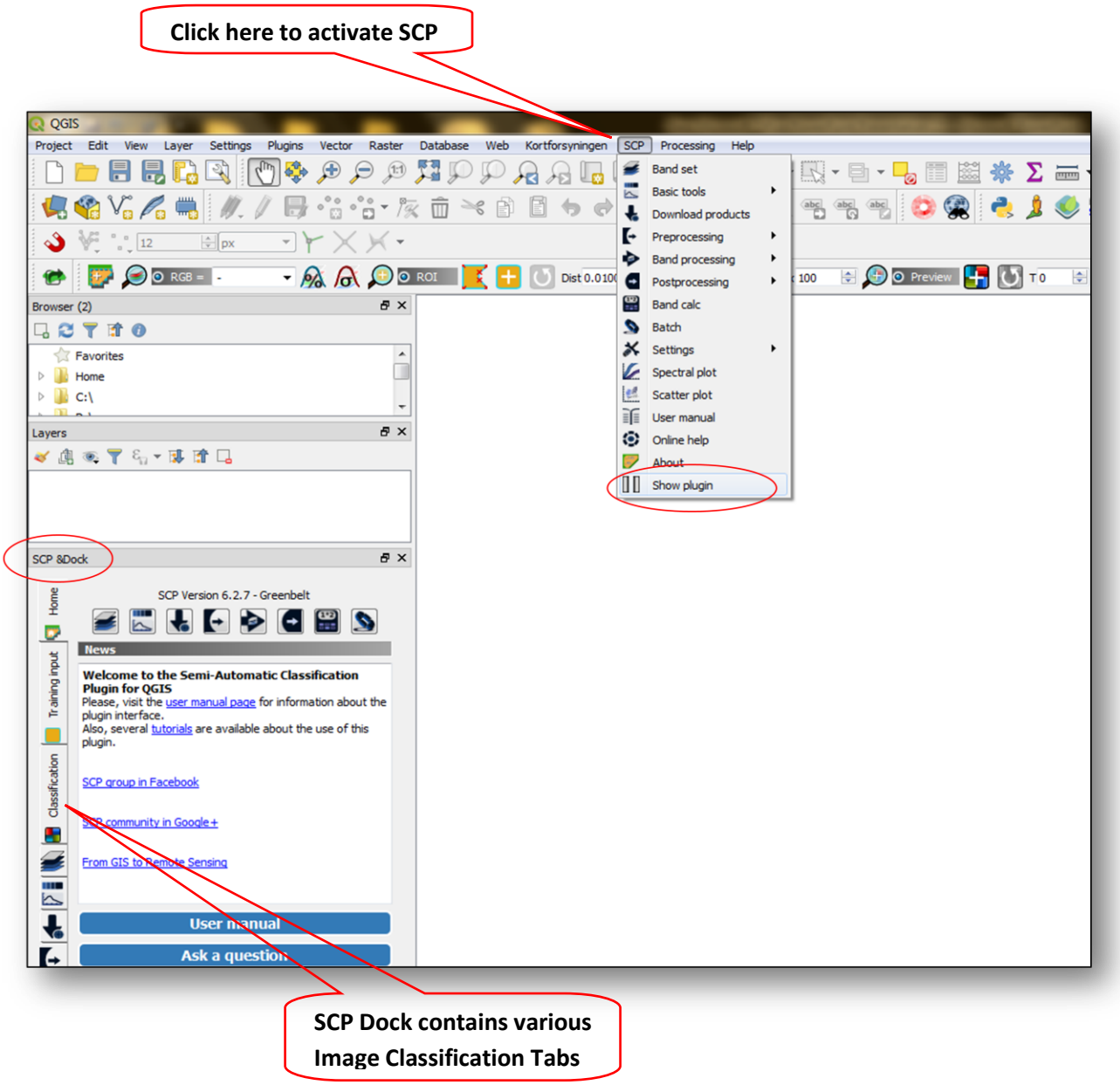
- After installation of the plugin ,if toolbox on the screen is not visible by default then, Click **View** > Click **Panels** > Check **SCP Dock** panel (ROI creation and SCP classification).**OR**

- Right Click on Right side of Toolbar > check **SCP Edit Toolbar** > **SCP Dock**.



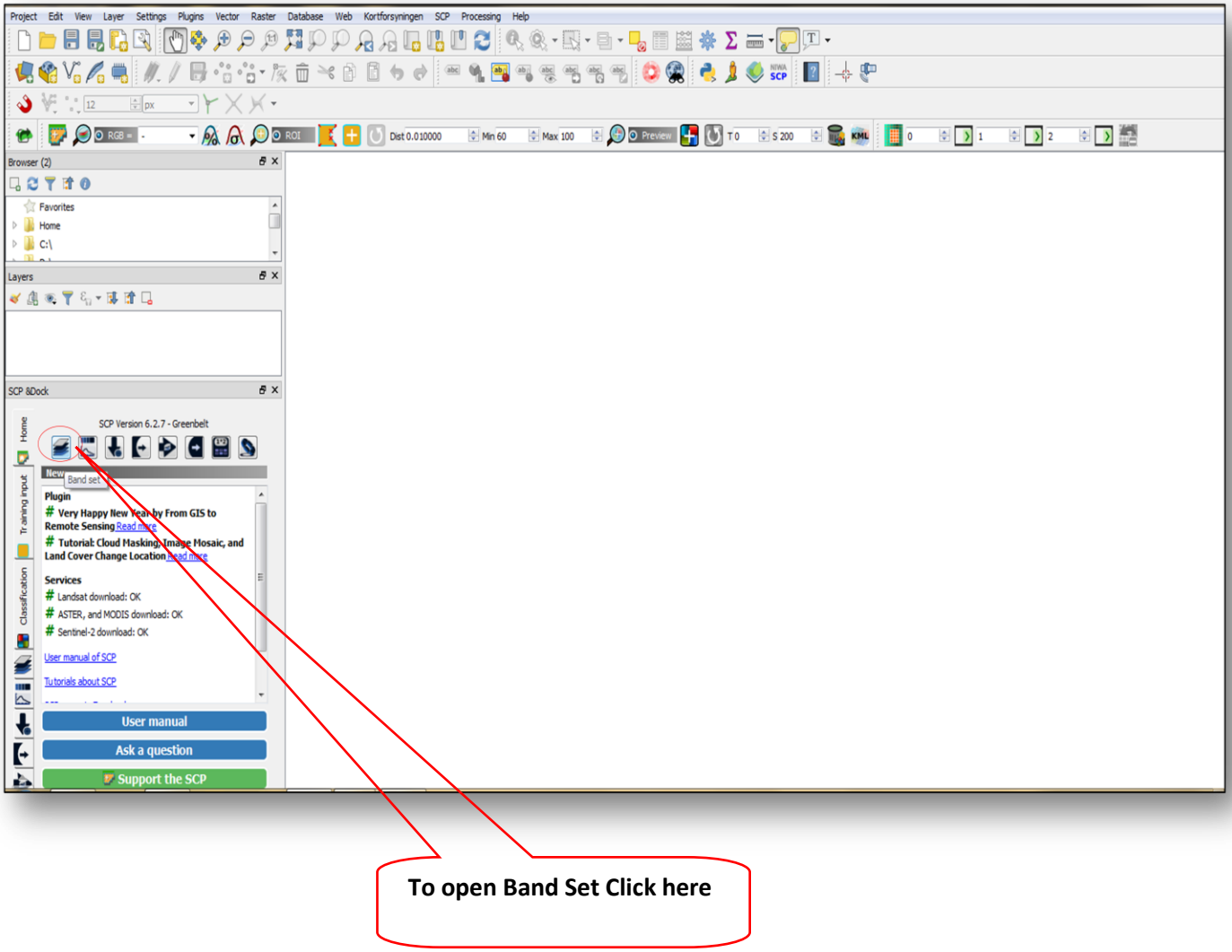
Note: SCP Dock panel is a complete package of Downloading, Data pre-processing, Post-processing, Classification and some other options to deal with Raster Analysis.

- Go to **SCP** > Check **Show Plugin**, after which SCP Dock window will appear like as shown in Figure.



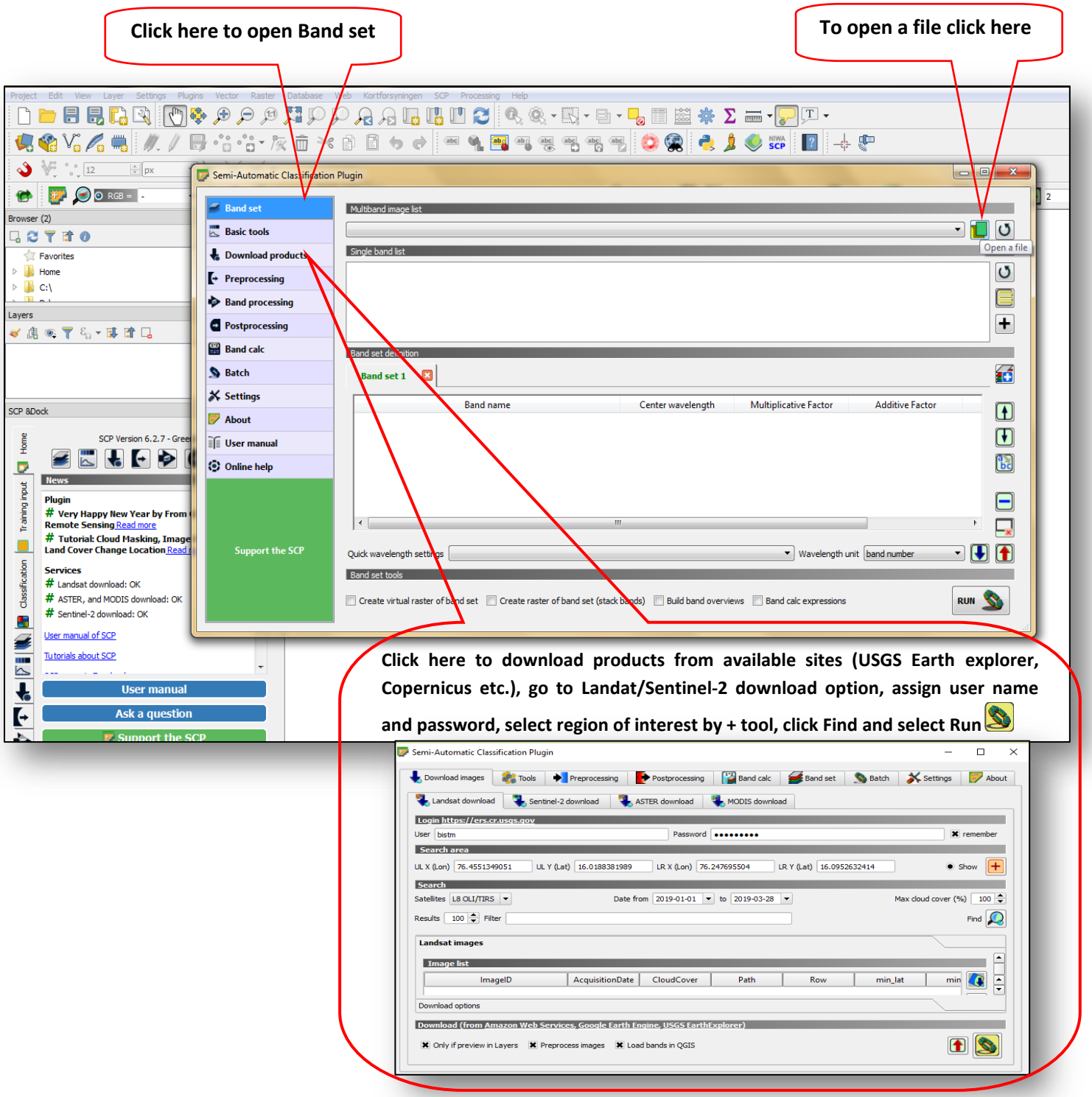
Classification by SCP Plugin

- In the SCP Dock > Click **the Band Set** button to open the file sample_image.tif.

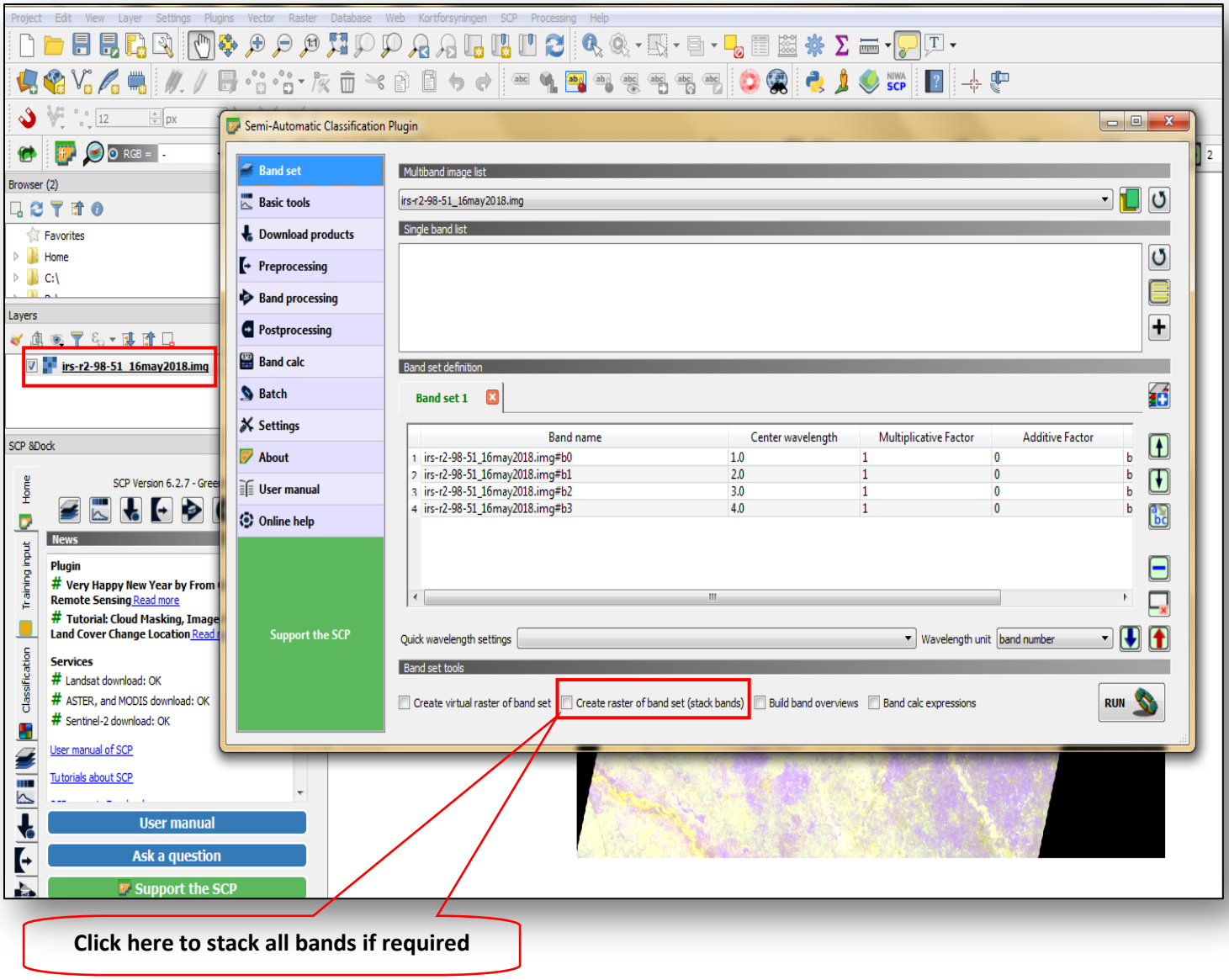


- In the Band set Tab, we can define input image to load on the canvas and specify the number of bands to stack for the display of Color Composite.

- **Band set** window will appear > now click button to open a file.
- Click on **open File** tab in extreme right corner to open the image with number of bands to Stack.

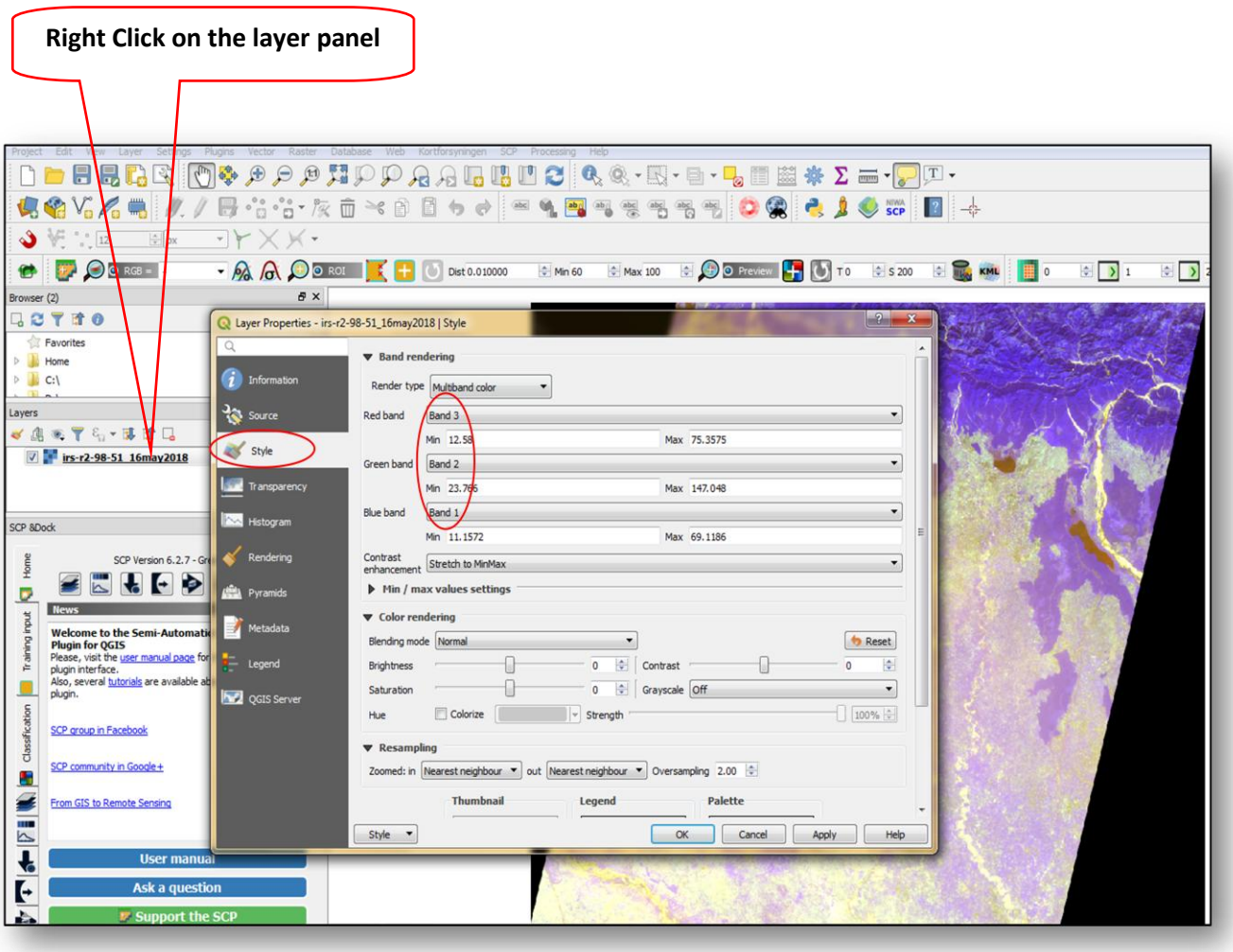


- Now, image.tif/.img is set as Input image, the image is displayed on the map canvas with loaded bands in the Band set.
- Under **Band set tools** > click on **Create raster of band set (stack bands)** at the bottom of the window > and then click on the **Run** icon.
- This process will create a new file that has a suffix Bstack_raster.tif. You will again be prompted to save the file to the folder where your original files are located and the process will begin. This may also take a couple minutes to process. Once the process is complete, you will see the stacked image is visible in the **Layers Panel.**



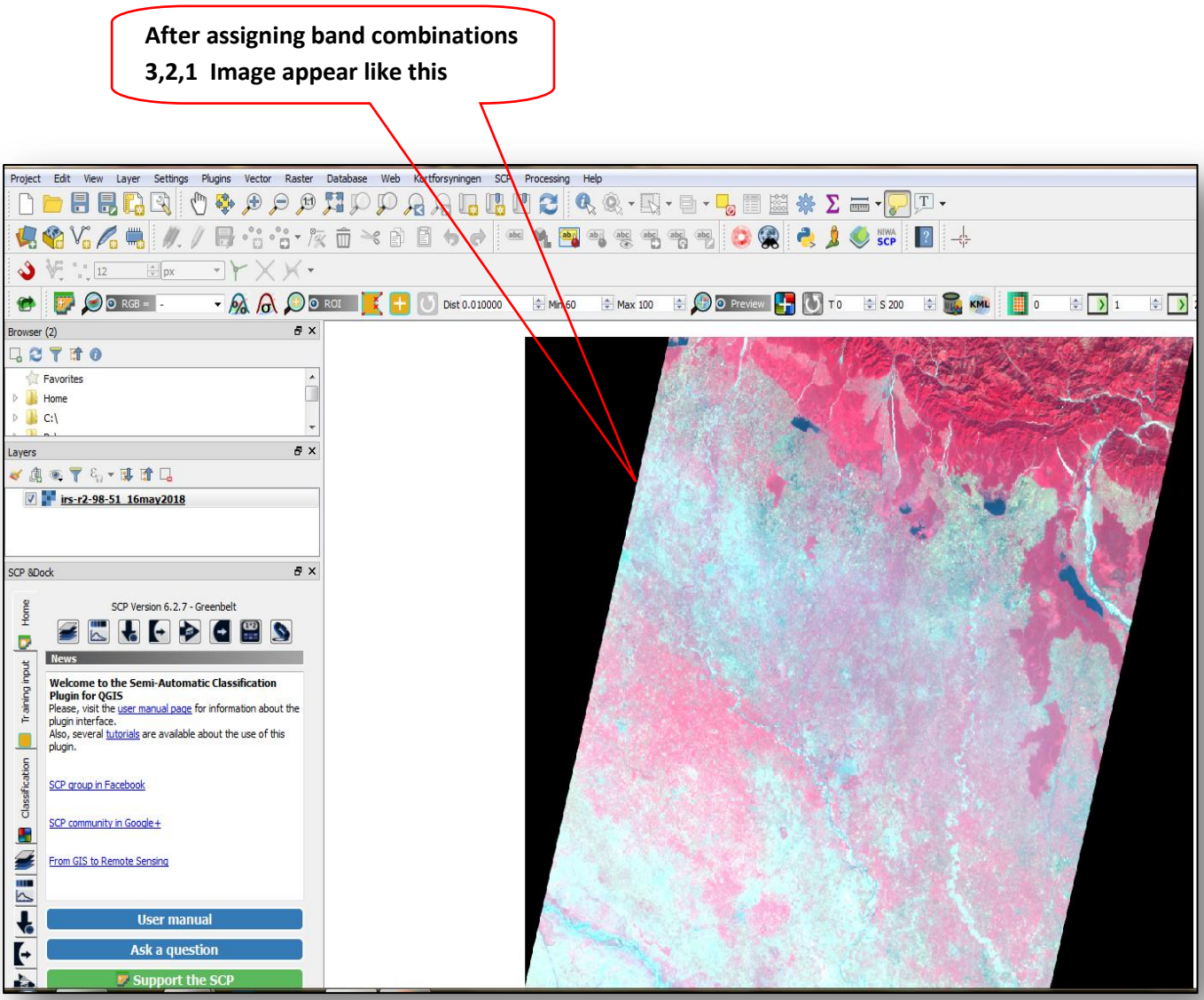
Click here to stack all bands if required

- We can display a Color Composite of bands in the working toolbar, click the list RGB > and select the item 3-2-1 (corresponding to the band numbers in Band set).
- To display the image in a usable color combination, go to the Layers Panel > and right click on the stacked raster image.
- Go to Properties > Style > and put Band 3 in the Red band, Band 2 in the Green Band and Band 1 in the Blue band.



- Click **Apply** and then **OK.**

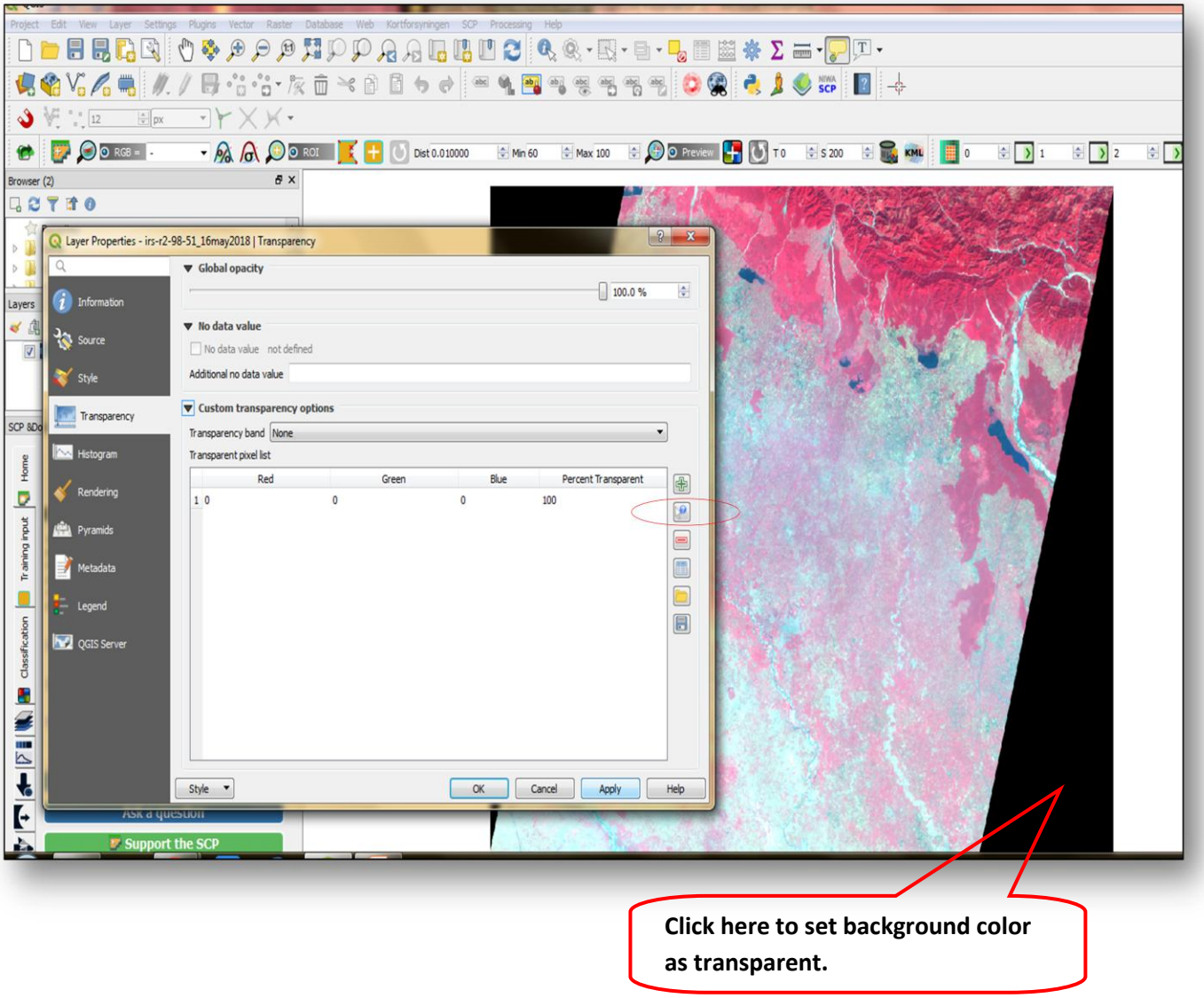
- Image colors in the map change according to the selected bands (3-2-1) and vegetation is highlighted in red, while on selecting 1-2-3,natural colors would be displayed.
- After selecting Band 3,Band 2 and Band 1, the image would appear as showing in Figure.



- Once the process is complete, you will see the image in the Layers Panel.

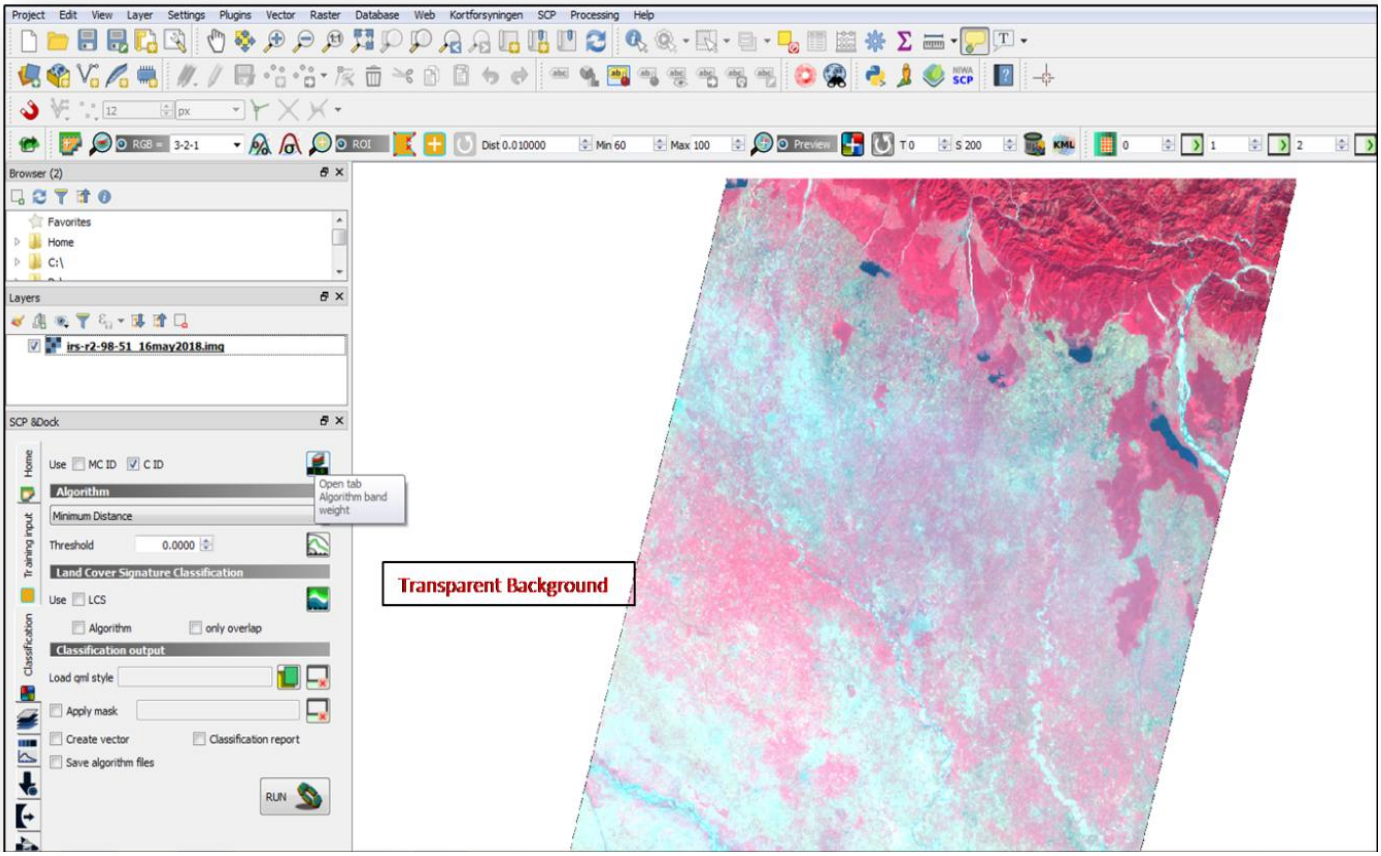
- To make background layer transparent > go to **Layer Panel** and Right click on selected file > and select **Layer properties** > or double click on File to open Layer properties directly.

- Go to Transparency > and Click Button > Click inside Black area in Task bar to set background color of the image as transparent.



- Click Apply and OK

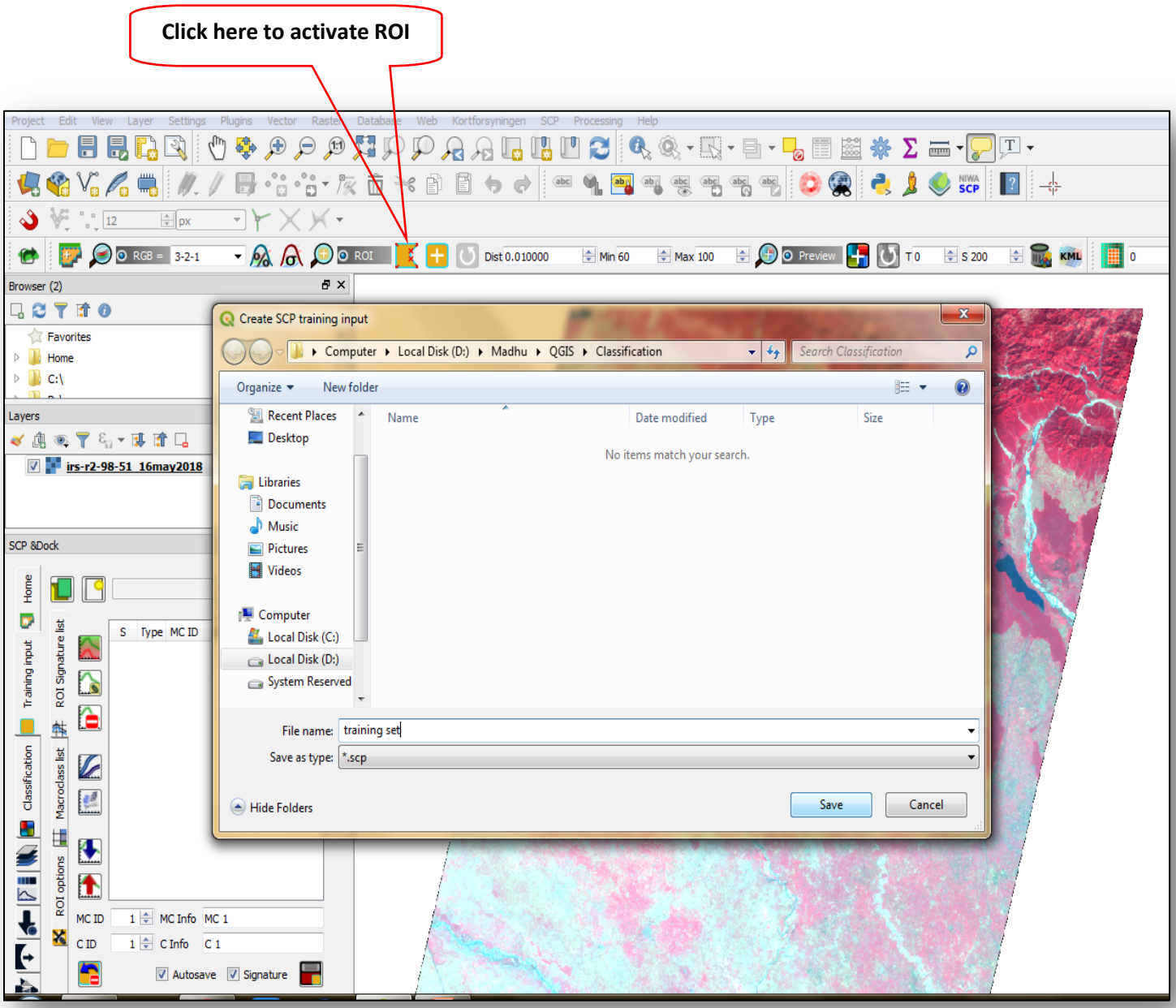
- Now image will appear with transparent background as showing in the Figure.



2.5 Create Region of Interest (ROI)

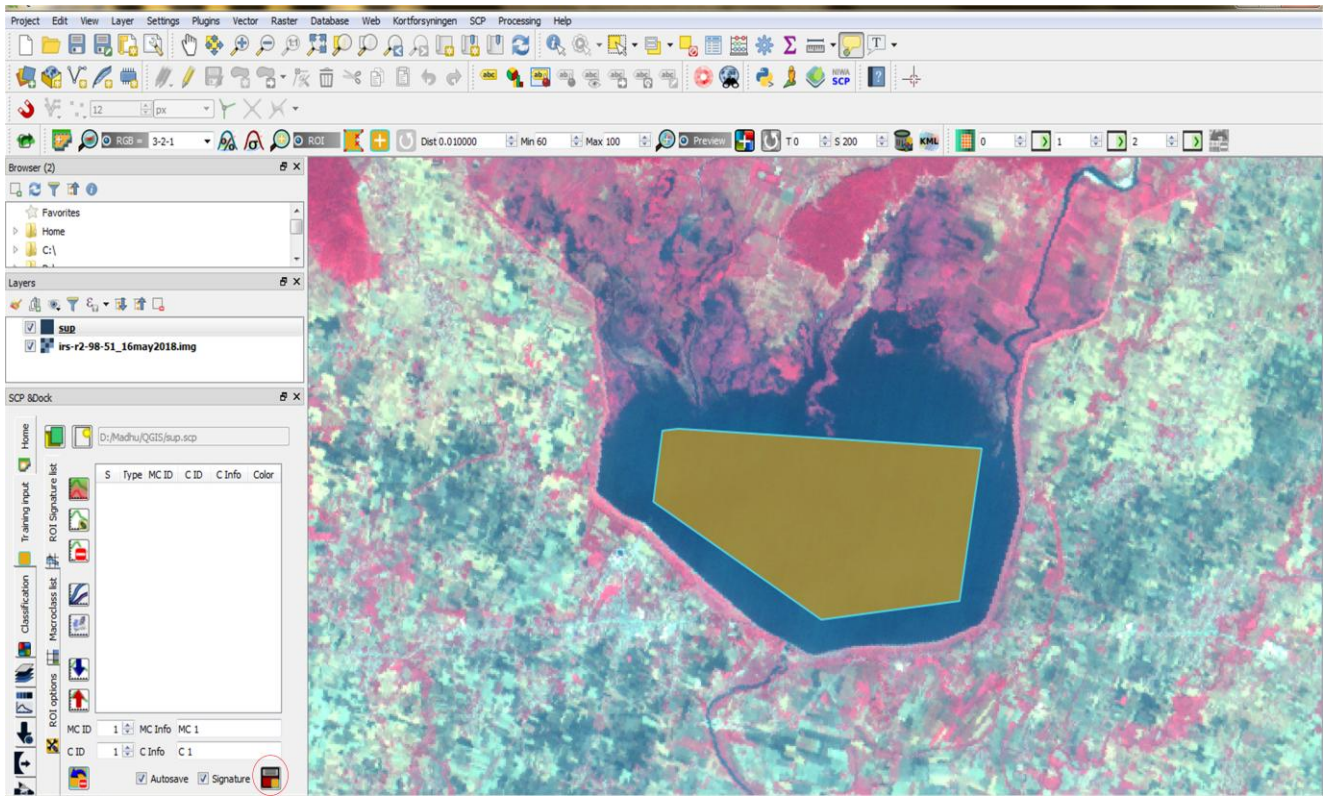
- Create the Training input in order to collect Training Areas (ROIs) to calculate the Spectral Signature.
- In the SCP dock click the button and define a name (e.g. training.scp) to create the Training input.

- Click **Create a new training input** > the path of the file is displayed in the Training input > if click on the Layers Panel, a vector layer “training” is added.
- Save training output as filename.scp format.



- A temporary ROI can be created manually by drawing polygon by clicking ROI polygon button.

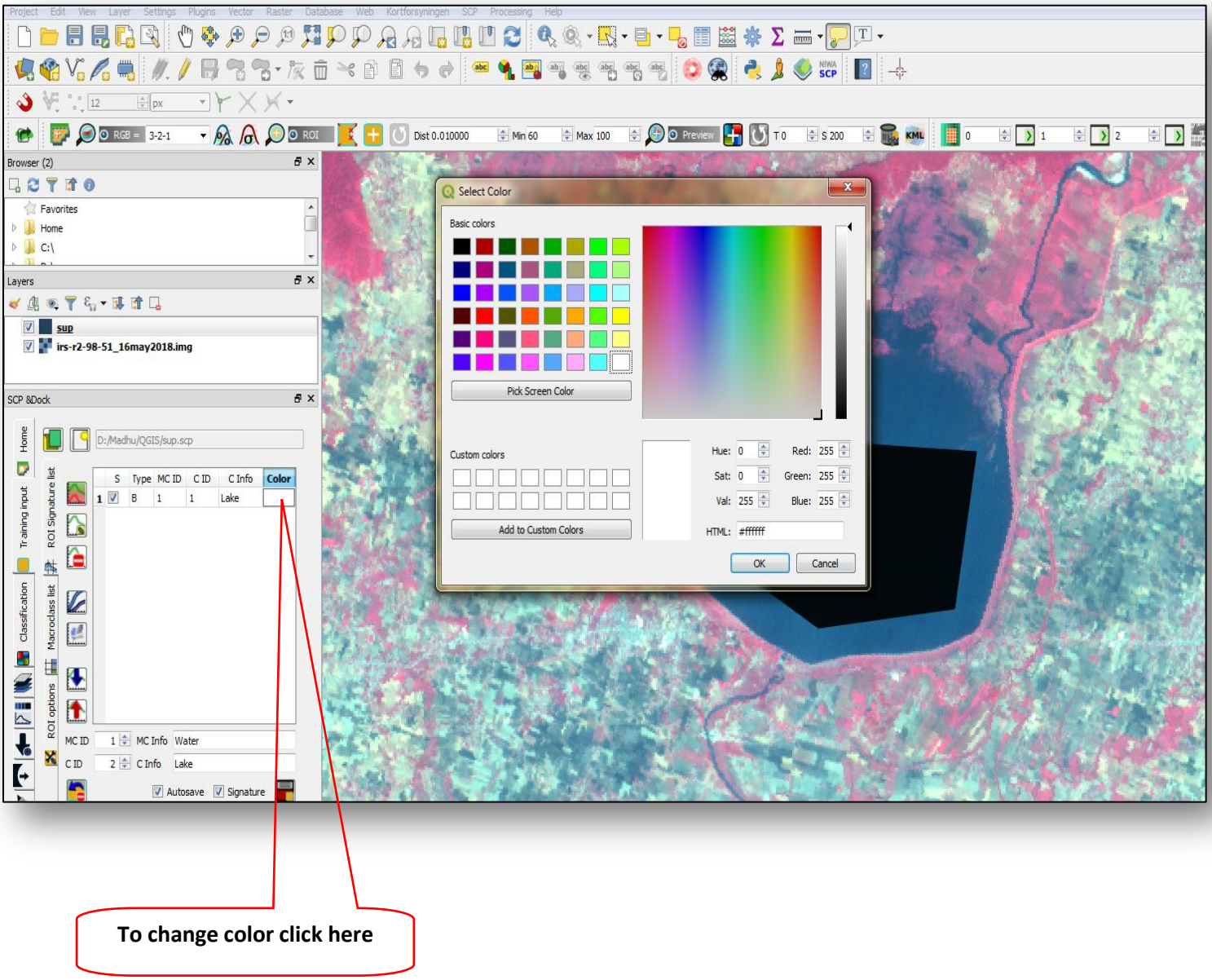
- To define the vertices of the polygon, left click on the image > and right click to close the polygon on the last vertex. While clicking on the 4th vertex, make sure to click right mouse button to close the polygon.
- After closing the digitized polygon an orange polygon is displayed over the image.



- When polygon is created, save it to the Training input.
- Open the Classification dock and set MC ID = 1 , C ID = 1, MC Info = Water; and C Info = Lake.
- Now click to save the ROI in the Training input.

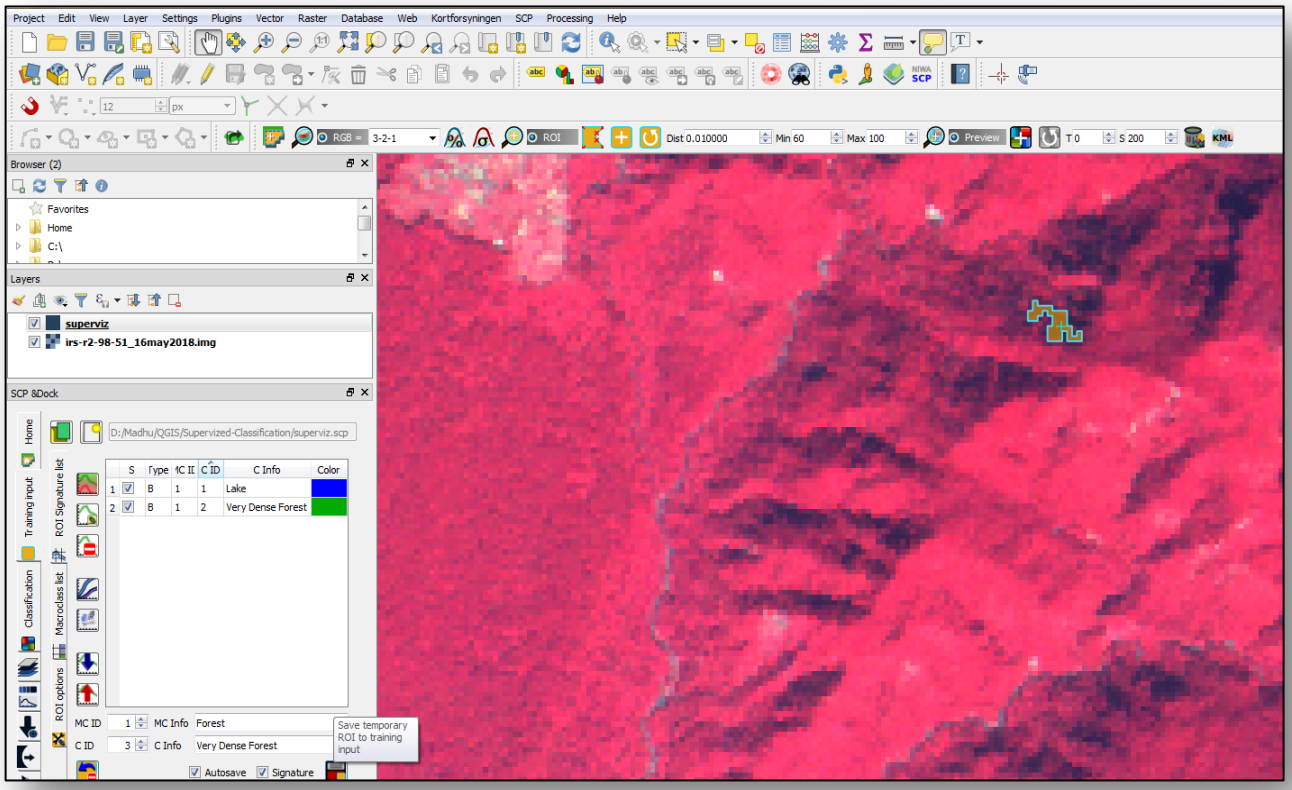
Note: Macroclass (MC ID) classes are broad land cover classes and the Class classes (C ID) are more detailed classes of Macroclass, i.e. several Class IDs within one Macroclass ID. It is useful when there is a need to classify land cover that has different spectral signatures in the same land cover class.

- Click on Color option > and set color from Basic color option.



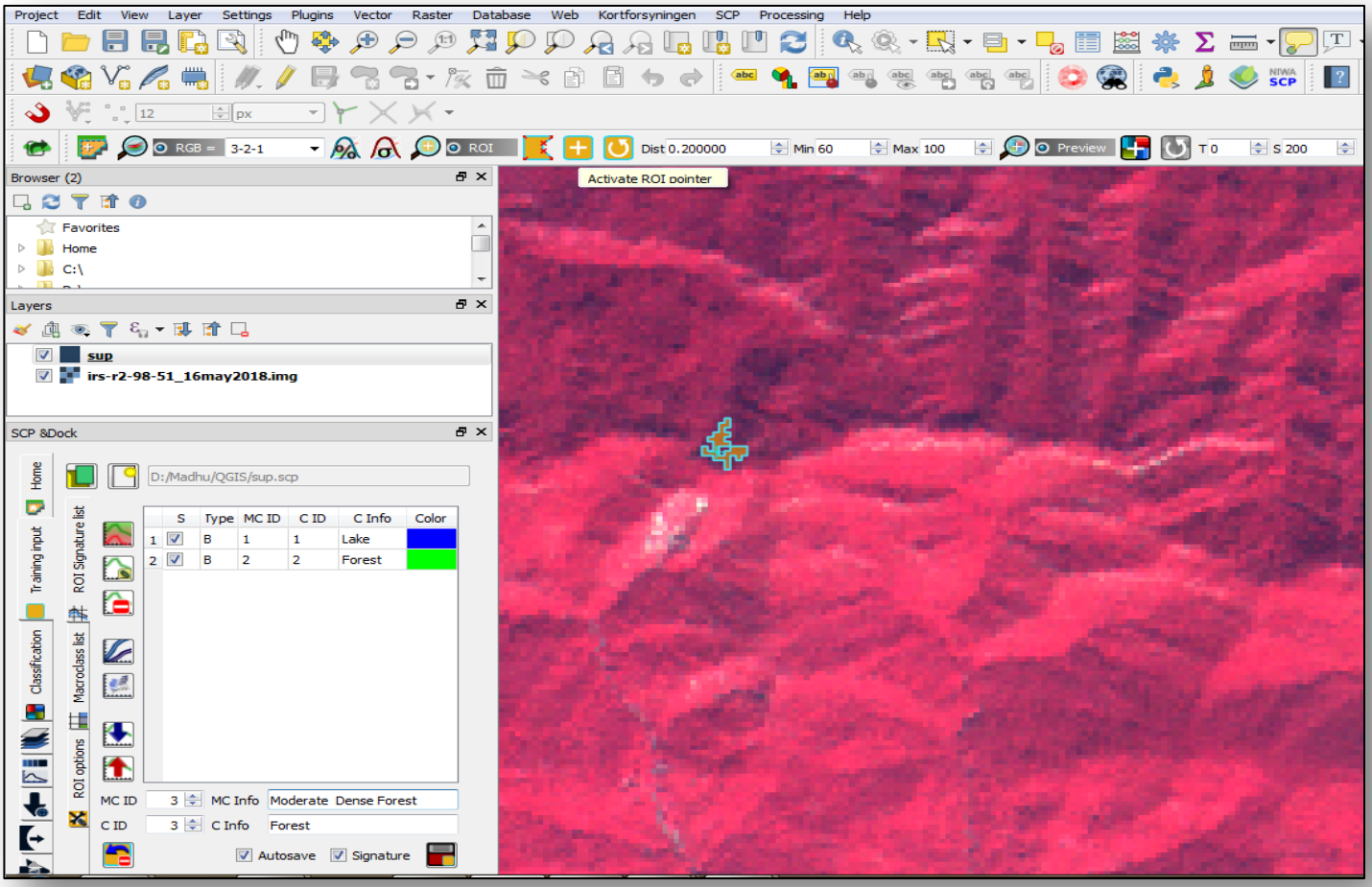
- Now, create a second ROI for the vegetation class using the automatic region growing tool .

- In the SCP toolbar across the top, to the right of ROI, enter **0.08, 0.01 or else** as the **Dist** (Distance). Click on the **Activate ROI** pointer icon and Zoom in the map over the Forested area and click somewhere in the darker green forested area. You will see an irregular shaped polygon appear. Increase your MC ID to 2, leave the C ID to 2, change the MC Info to Vegetation and the C Info to Dense Forest and save the signature.
- Set, MC ID = 2 , C ID =2, MC Info = Forest; and C Info = Dense Forest.
- Now click to save the ROI in the Training input.
- In the SCP toolbar, Type is B, meaning that the ROI spectral signature was calculated and saved in the Training input.
- The region growing algorithm requires to understand the pixel values on the basis of similarity of spectral signature in the image.



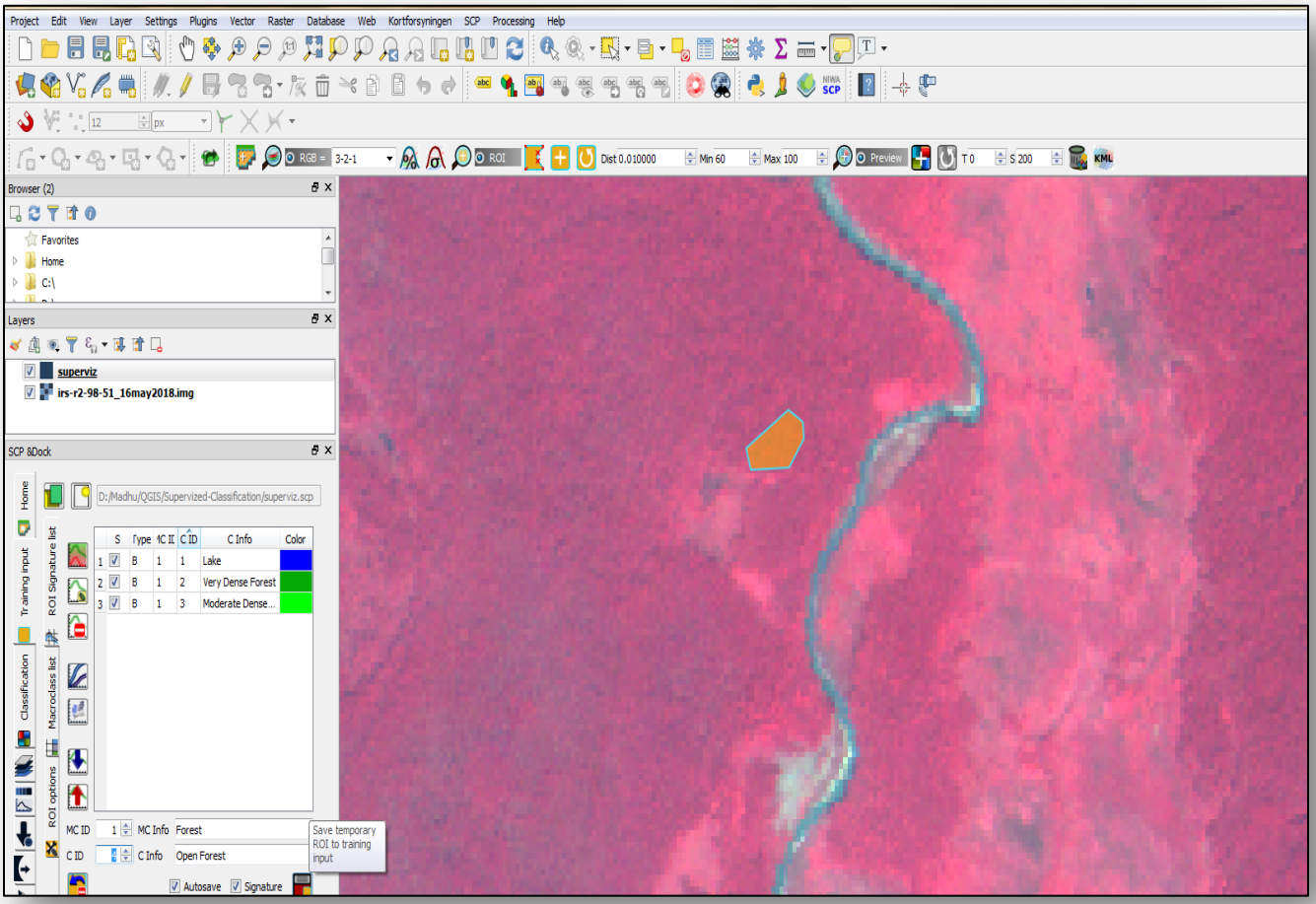
Note: Dist value should be set according to the range of pixel values, in general increasing this value creates larger ROIs.

- In order to create ROI for the next class, Zoom out to the entire image and Zoom in further to one of the less darker areas of vegetation as compare to previous ROI class.
- Using the ROI pointer tool, draw a training site in this area. According to the table,
- Set, MC ID = 3 , C ID =3, MC Info = Forest; and C Info = Moderate Dense Forest.
- Now click to save the ROI in the Training input.



Moderate Dense Forest

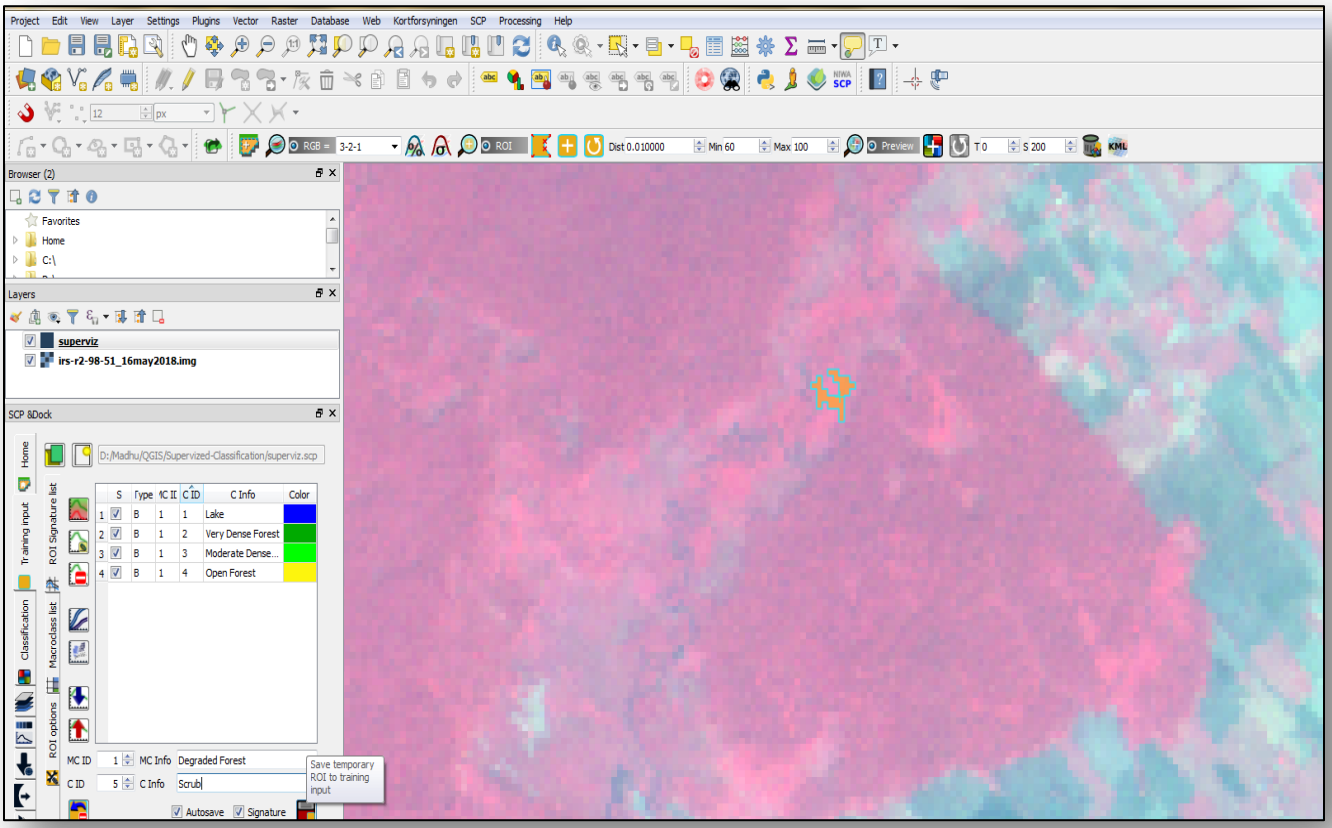
- To create fourth ROI, Click on the **Activate ROI** pointer icon and Zoom in the map over somewhere in low canopy density class ,i.e. Open Forest areas.
- Increase MC ID to 4, C ID to 4, change the MC Info to Forest and the C Info to Open Forest and save the signature.



Open Forest

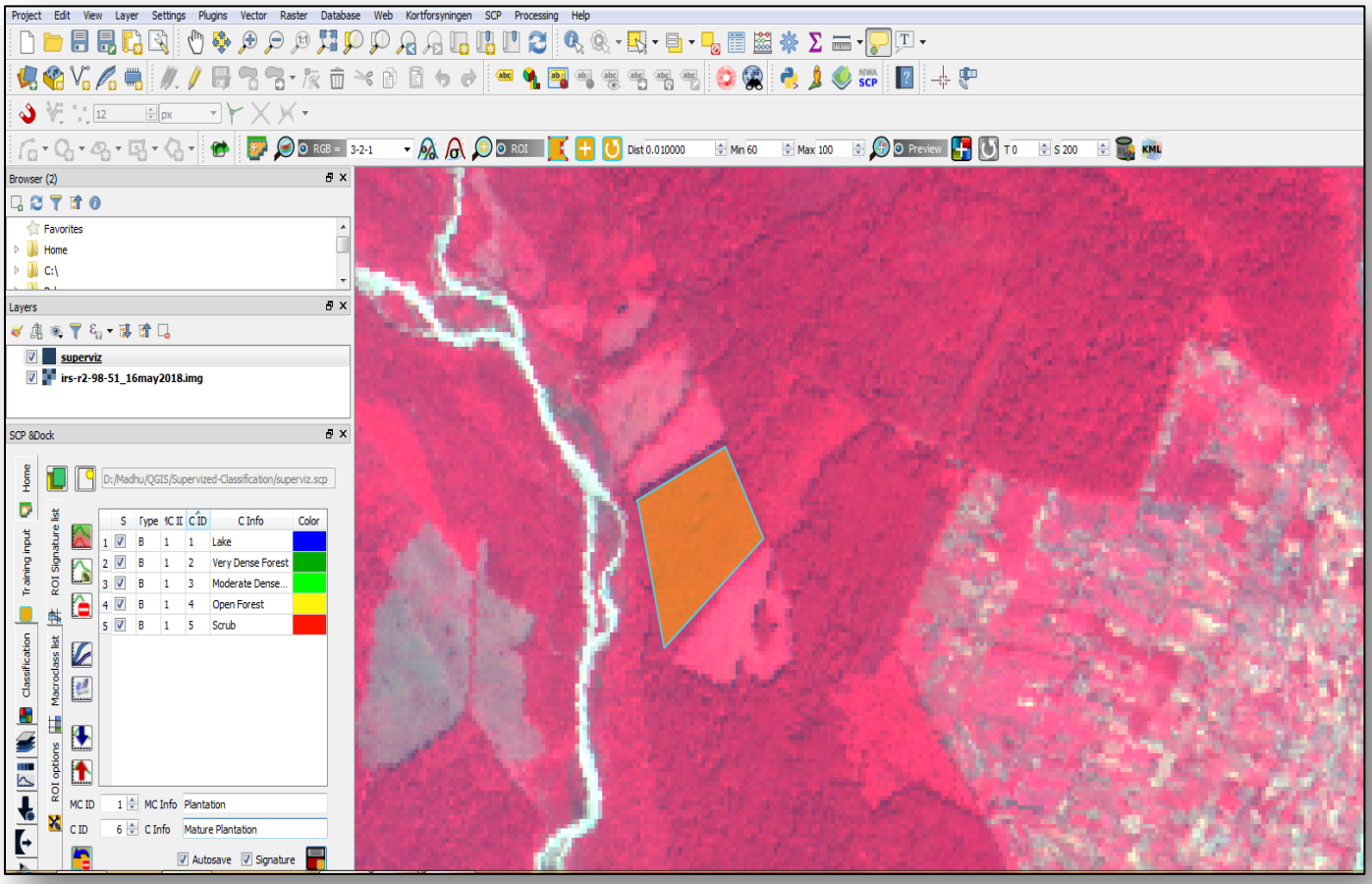
- Once again, Click on the **Activate ROI** pointer icon and Zoom in the map over the Degraded Forested area and click somewhere in the very light coloured spectral signature of degraded forested area.

- Now, an irregular shaped polygon appear. Accordingly, Increase your MC ID to 5, leave the C ID to 5, change the MC Info to Degraded Forest and the C Info as Scrub and save the signature.



Degraded Forest/Scrub

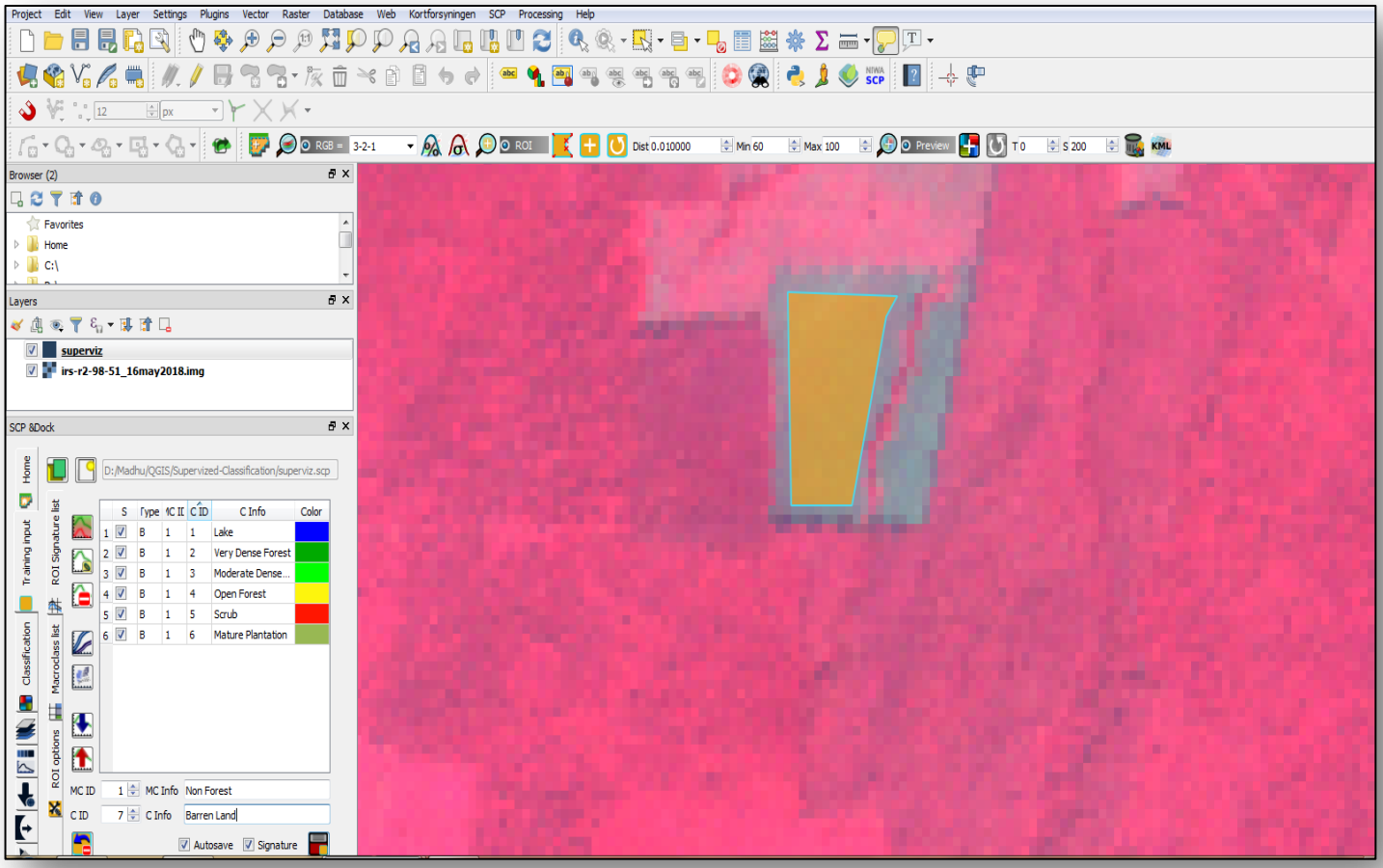
- Zoom out to the entire image. Now, Zoom into the Plantation area.
- Temporary ROI of the above can be created manually by drawing polygon by clicking ROI polygon button.



Plantation

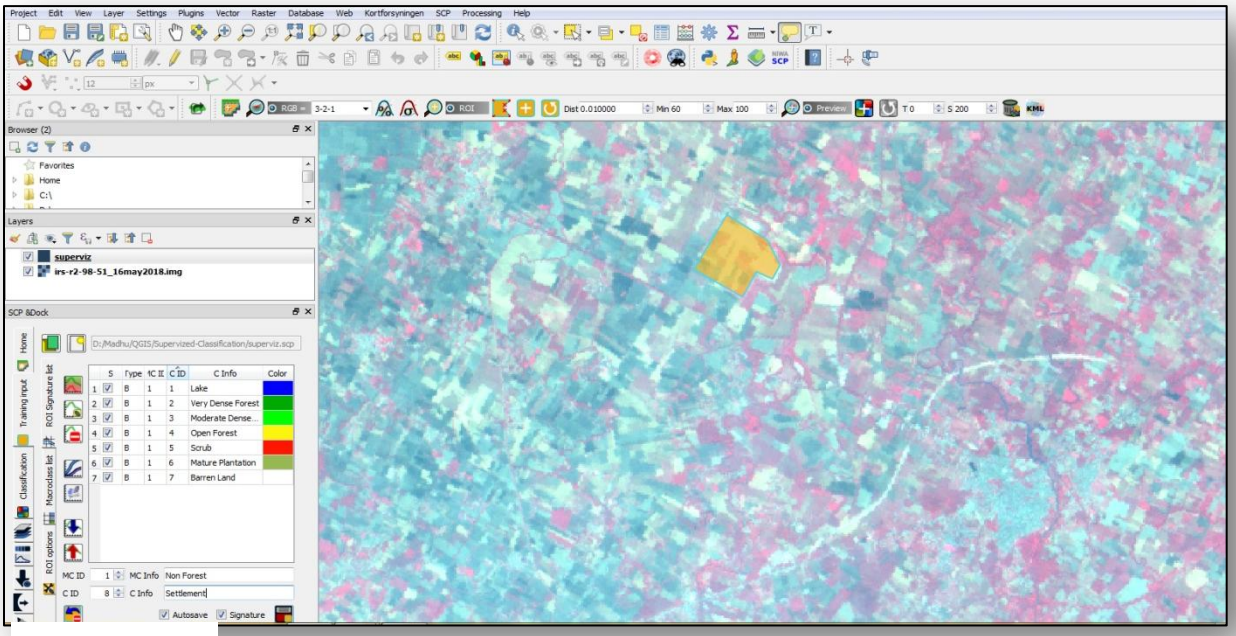
- Using the ROI pointer tool, draw a training site in this area. As per the given table, the MC ID should be 6 and the C ID should be 6 and save the signature.

- The next, for bare ground signature, Zoom back out to the entire image and Zoom into the bare ground/ Barren areas. Use the ROI pointer tool to create a signature in one of these areas.
- At this time, the MC ID should be 7 and the C ID should be 7.
- Now, Save the signature.

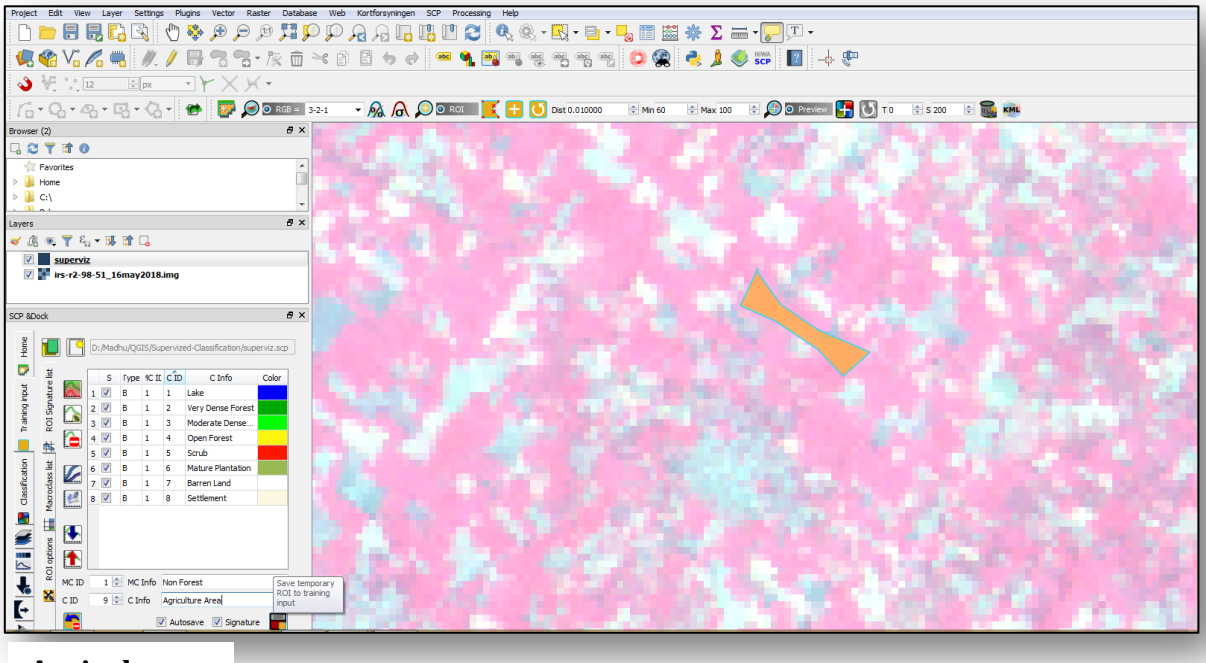


Barren Area/Bare Soil

- Similarly, to create ROI's of Settlement and Agricultural areas, click somewhere in the desirable areas as per area of interest and Use the ROI Polygon button to create a polygon or use the ROI pointer tool to create a signature in one of these areas. Accordingly, the MC ID should be 8,9 and the C ID should be 8,9 respectively.

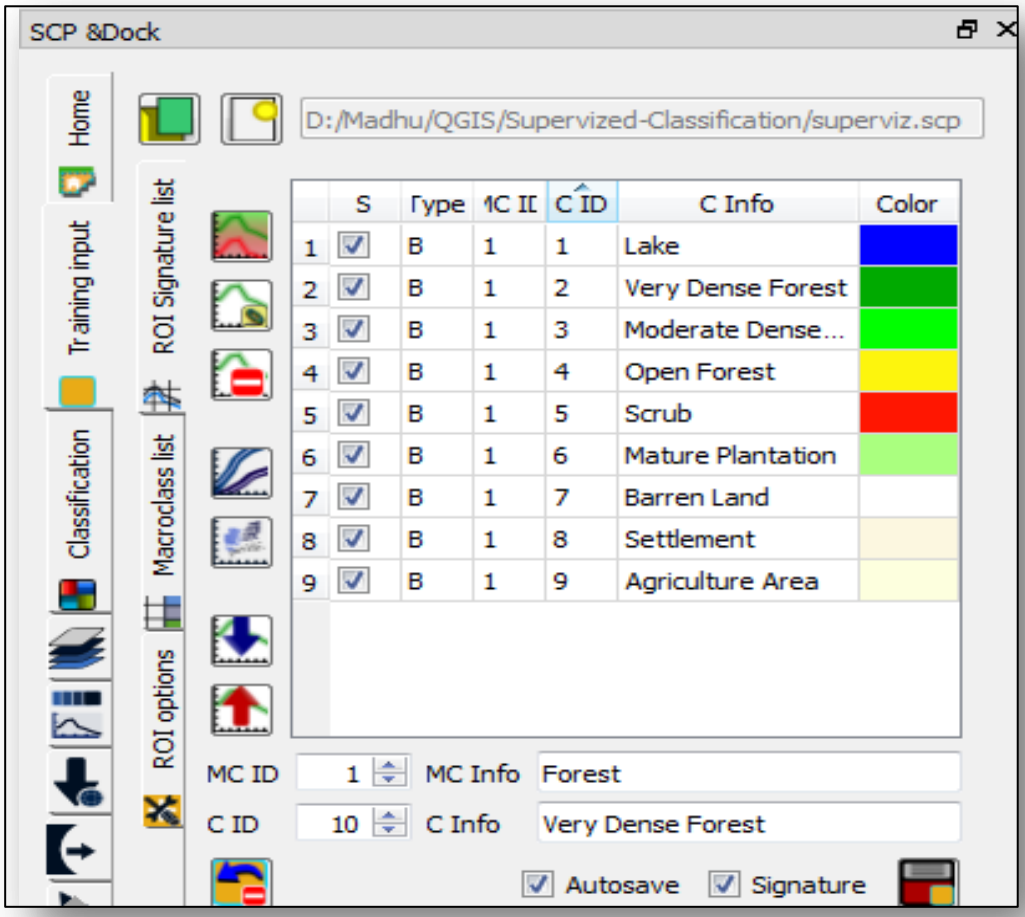


Settlement



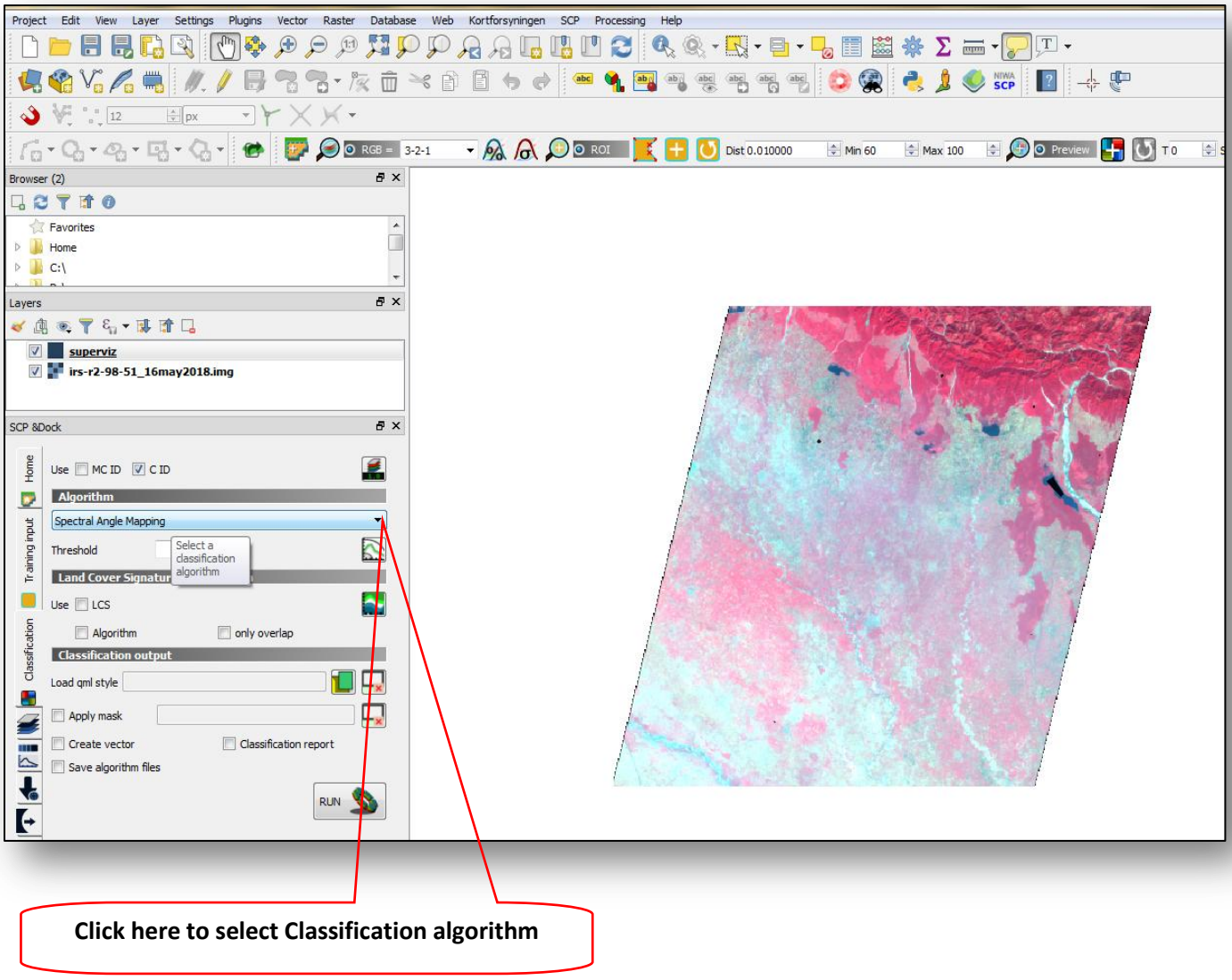
Agriculture

- Now, Save the signature for the same.
- In the table given below, showing the defined training sites/ classes identified on the map.



- Repeat the above mentioned steps for defining further Land Cover Classes. Furthermore, can add some additional ROIs to the classes as per the objective.
- To improve the classification, can add more training sites and analyzing the training site spectral signatures.

- In Classification algorithm window select a Spectral Angle Mapping Algorithm.

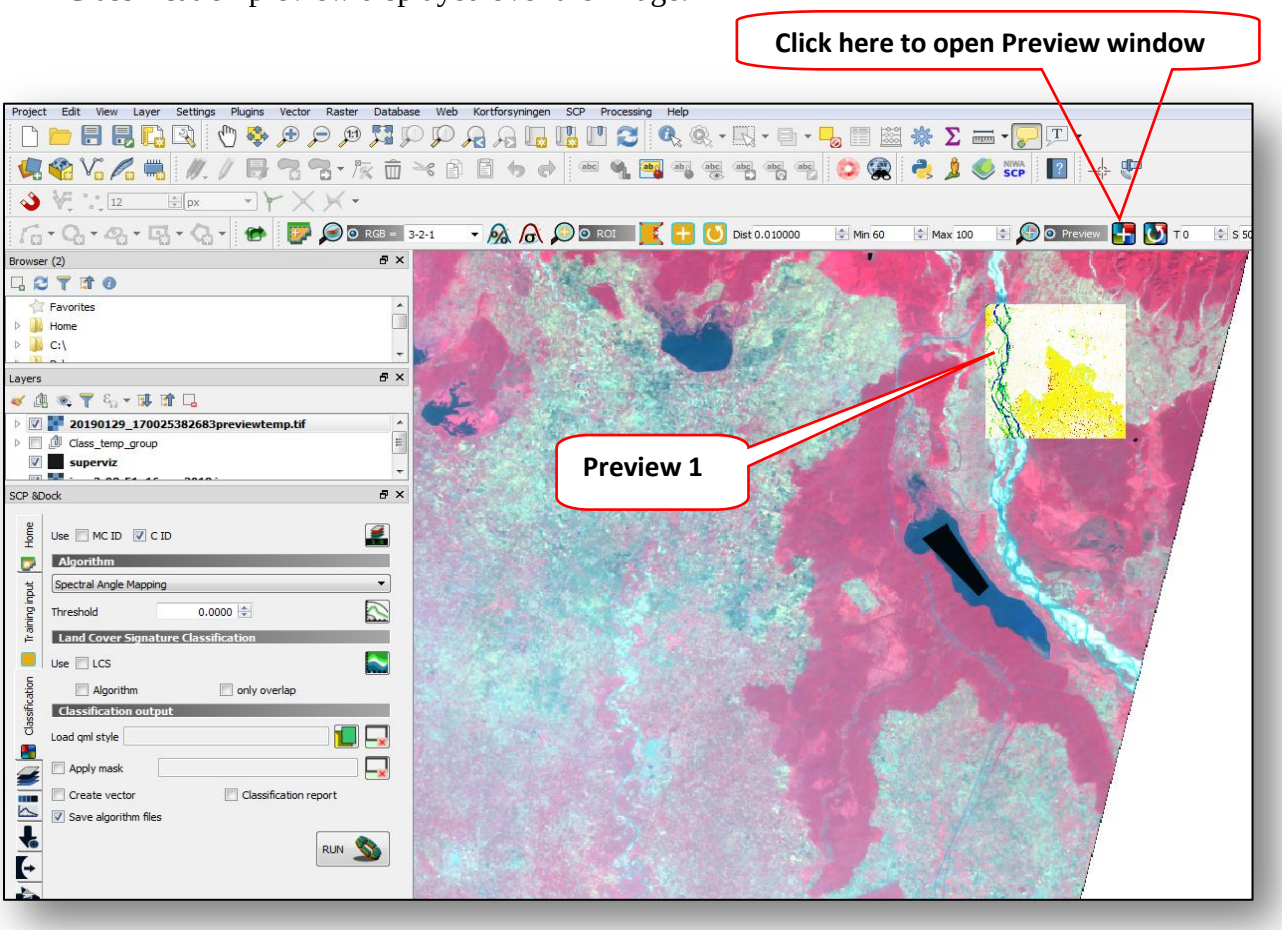


Click here to select Classification algorithm

- The Spectral Angle Mapping calculates the spectral angle between spectral signatures of image pixels and training spectral signatures.

2.6 Create Classification Preview

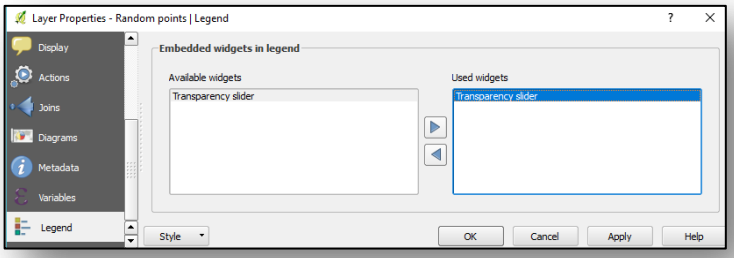
- The classification process is based on collected ROIs (spectral signatures). It is useful to create a classification preview in order to assess the results (influenced by spectral signatures) before the final classification. In case the results are not good, we can collect more ROIs to better classify land cover.
- In Classification preview set Size =200 or 500 as per the study area.
- Click the preview button and then left click in a particular point of the image. The classification process should be rapid and the result is a classified square centered in clicked point.
- Classification preview displayed over the image.



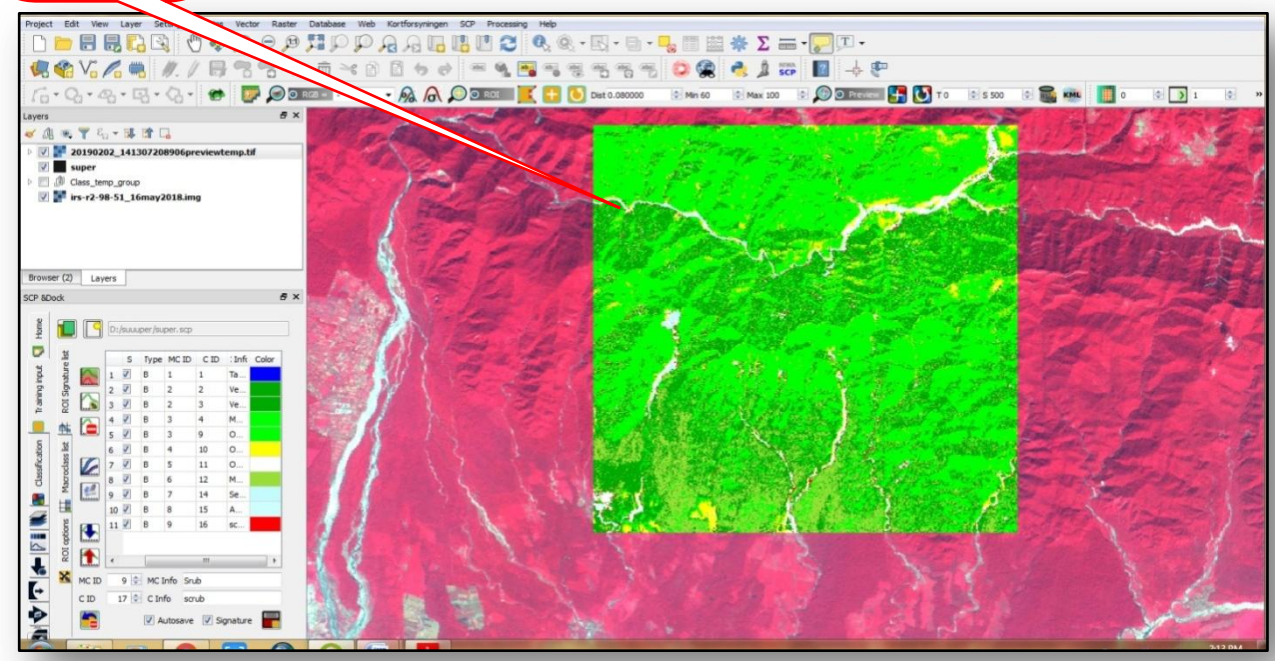
Note: At this point in order to check the result of preview, we can turn on swiping option by right clicking on peviewtemp.tif (temporary) file available in layer panel while creating preview.

Previews are temporary rasters (deleted after QGIS is closed) placed in a group named Class_temp_group in the QGIS panel Layers.

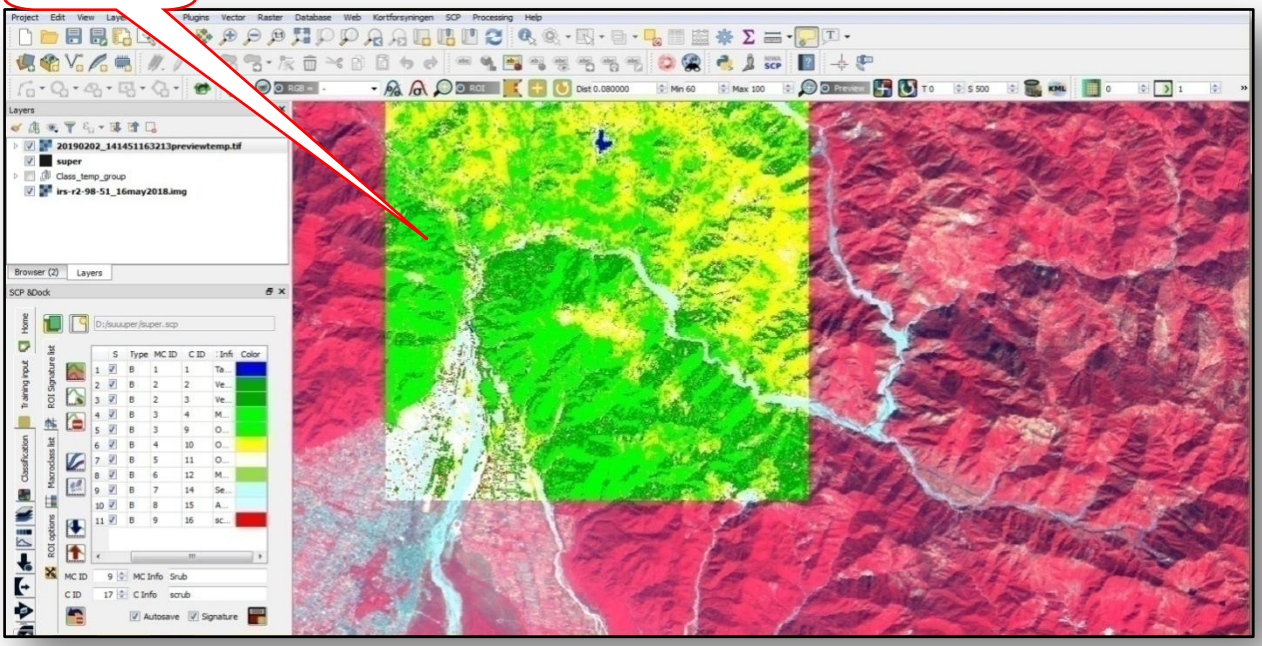
- To open transpirancy window, go to legend option and check transpirancy slider click ok. It will open transpirancy window to check the result by swiping on layer panel.

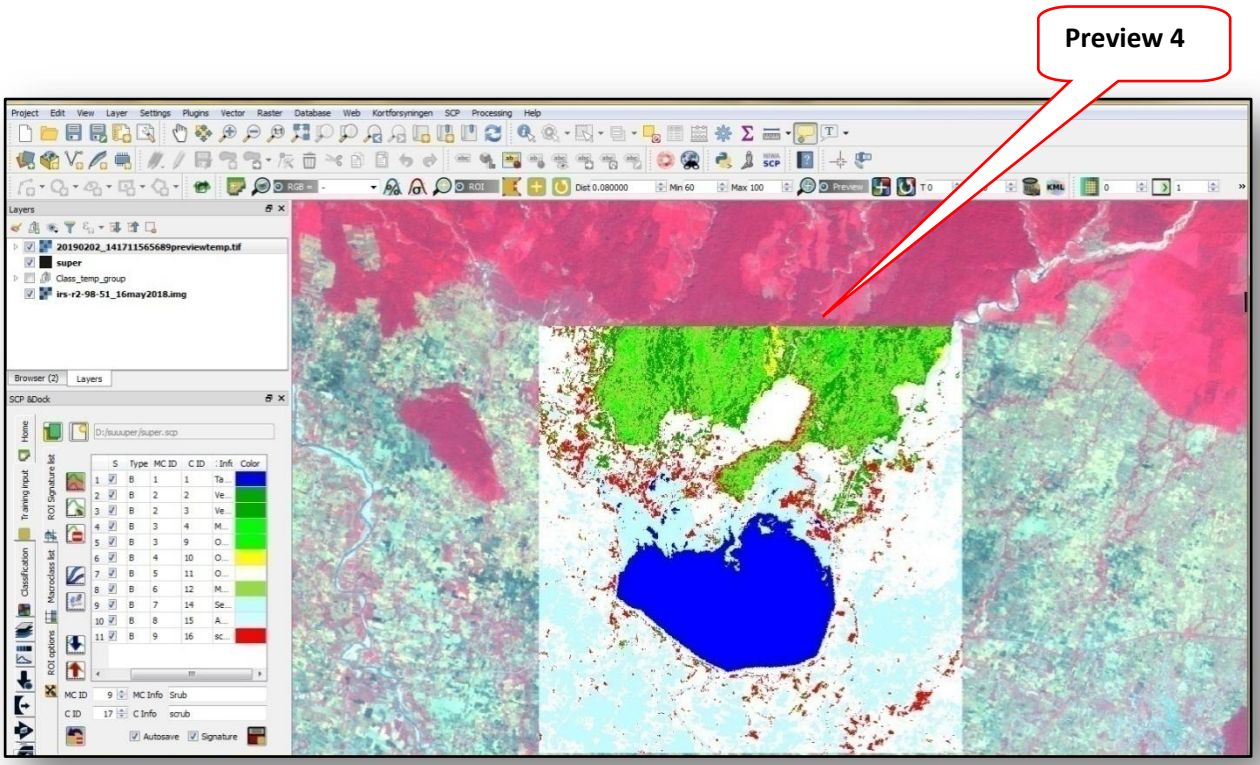


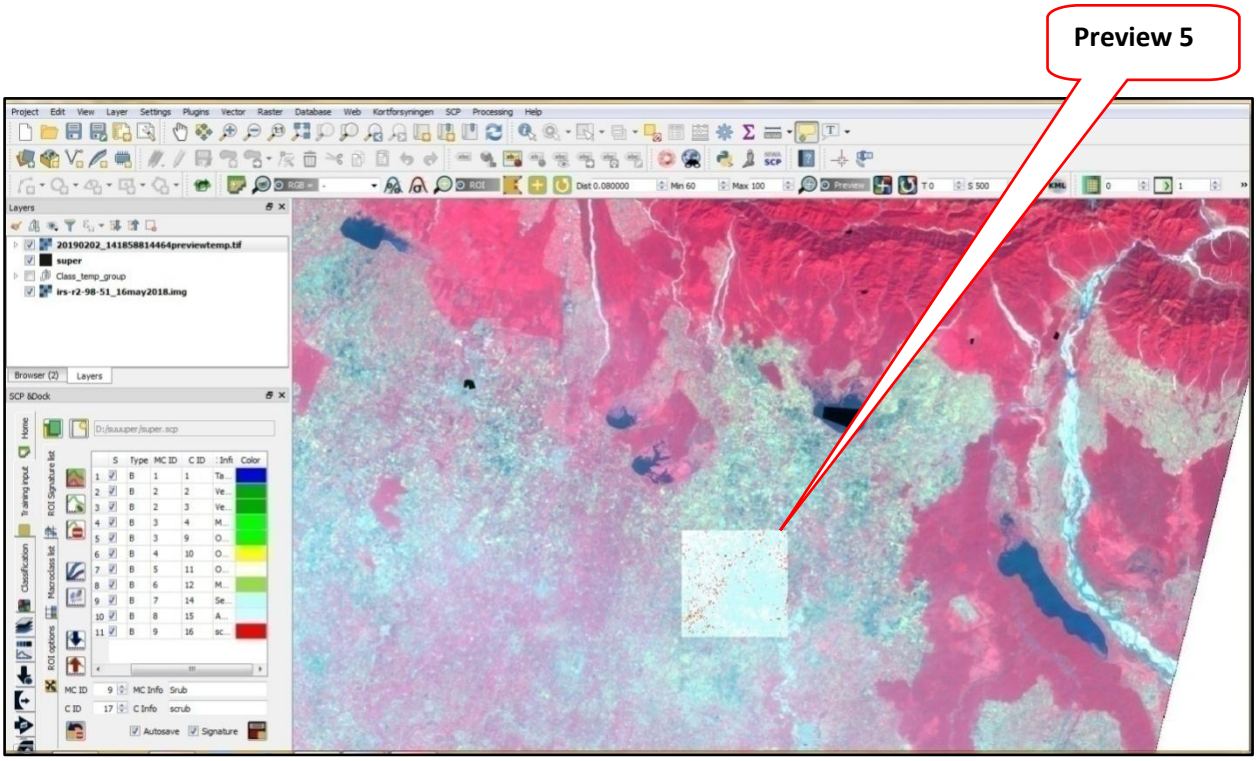
Preview 2



Preview 3

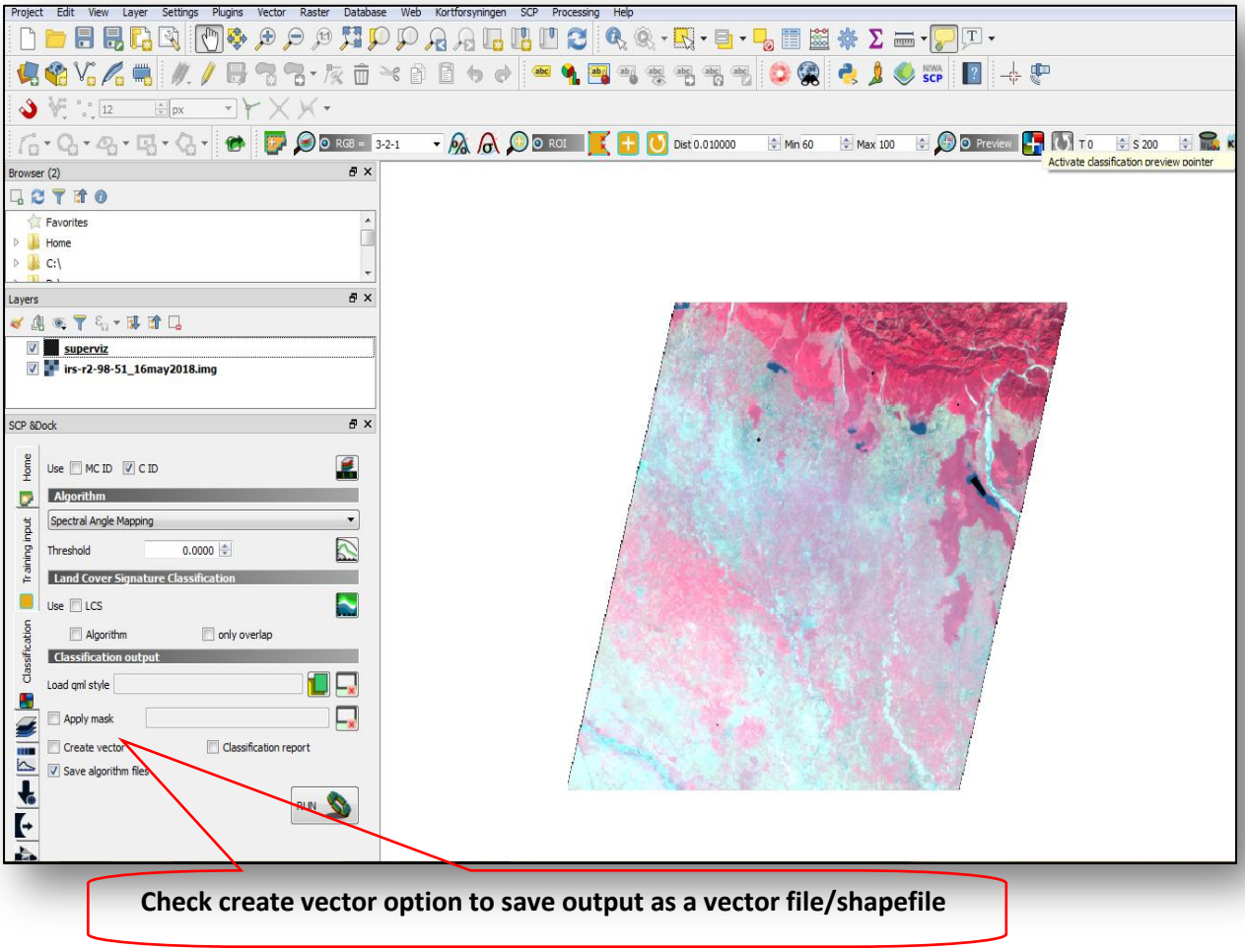



Preview 4


Preview 5

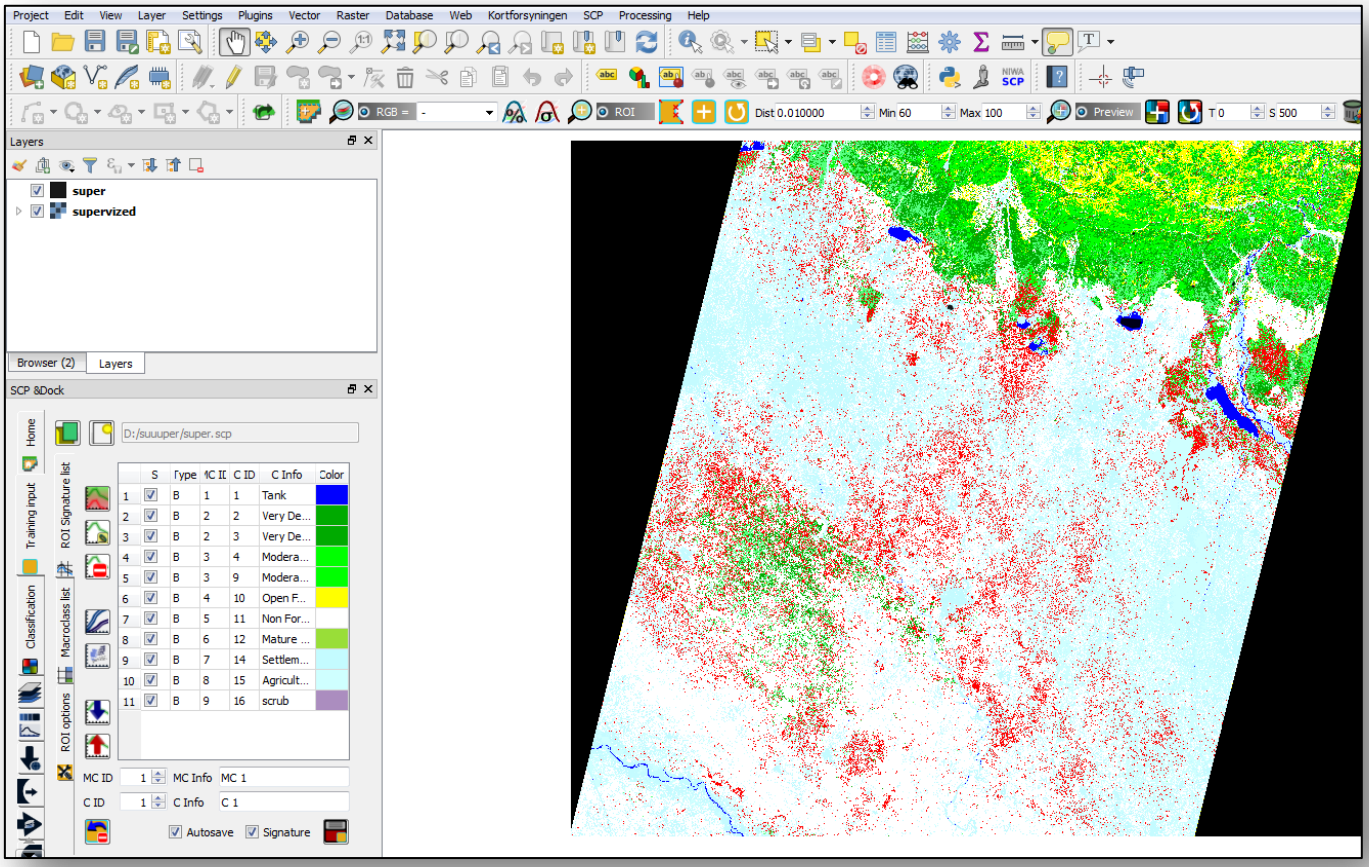
Create the Classification Output

- To create classification output go to Classification Tab > Check Save algorithm files > Check Create vector option before running the algorithm to save the output as a shapefile.



- In the Classification output > Click the Run button and define the path of the classification output, which is a raster file (.tif).

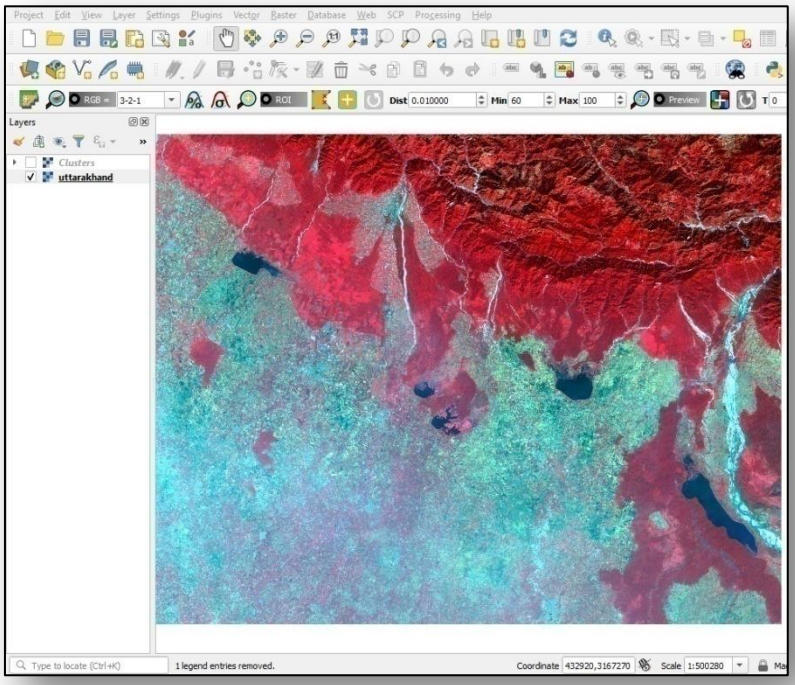
- Once classification process is finished, the final classified image appears in the classifier window as appear in Figure.



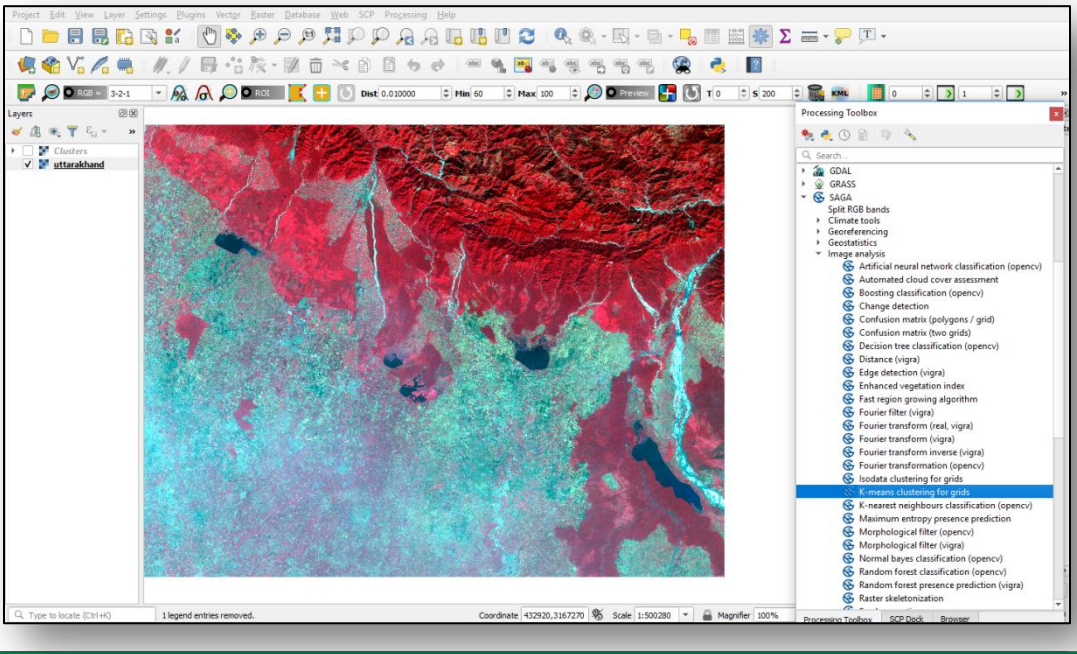
- The output file generated after running the algorithm will be in a .tif format and signature file or ROI file saved as .scp format.
- If suppose, we want output of a file in a vector/ shapefile format to edit the classes, so in this case check create vector option under Classification Tab.
- Otherwise, for editing Raster layer, we have Edit Raster Tab in Classification or SCP Dock window.

2.7 Unsupervized Classification

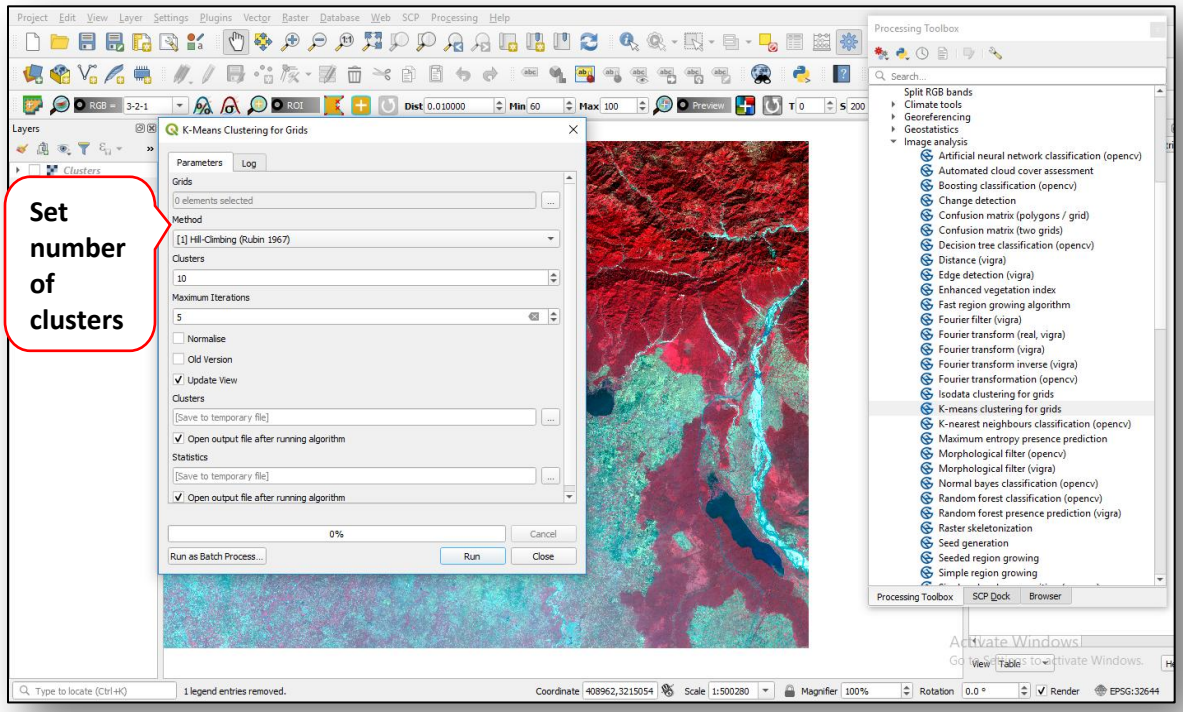
- Load the image and set bands to display the image as an RGB composite.



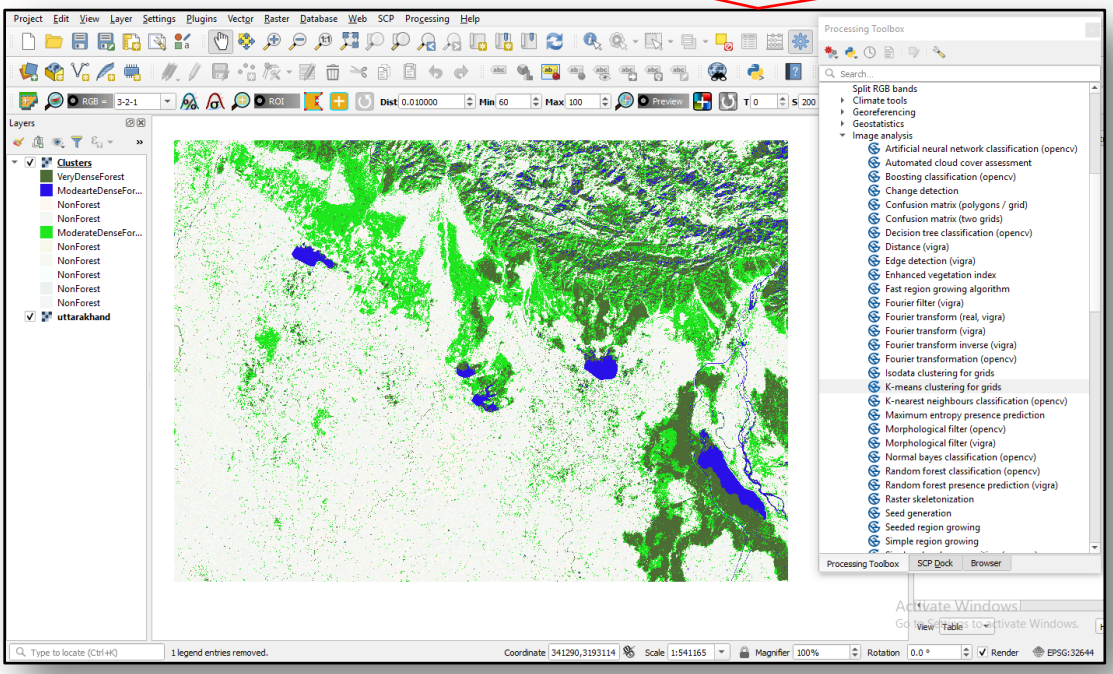
- Open processing Tab at top of Toolbar > go to processing toolbox.



- Go to the Learning section of the Orfeo Toolbox and double click on Unsupervised K-Means image classification.
- If Orfeo tool is notinstalled then go to K-means clustering for grids or Isodata clustering for grids under SAGA option.

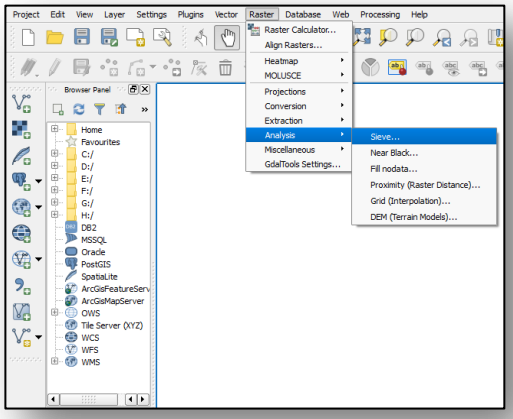


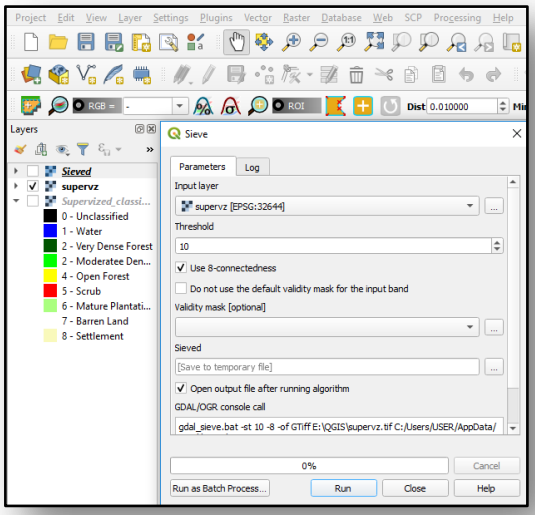
After running algorithm the unsupervized file appear as showing in Map Canvas.

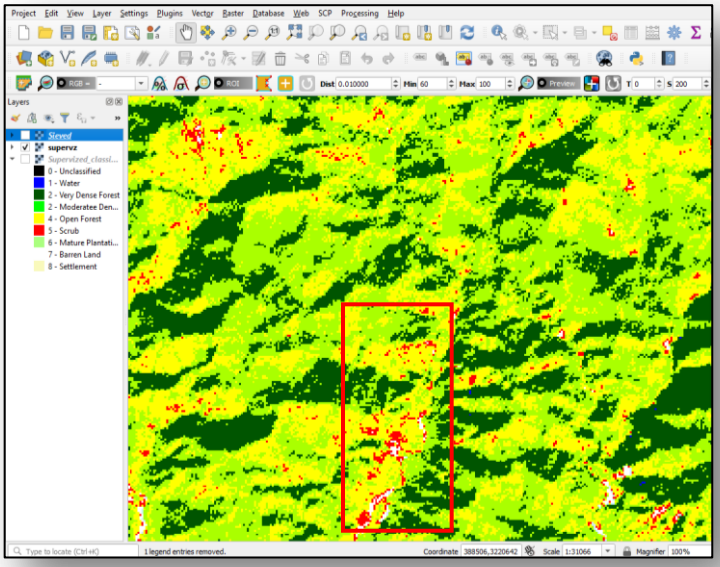


2.8 Sieve: To Eliminate the undesirable threshold size of pixels from Raster

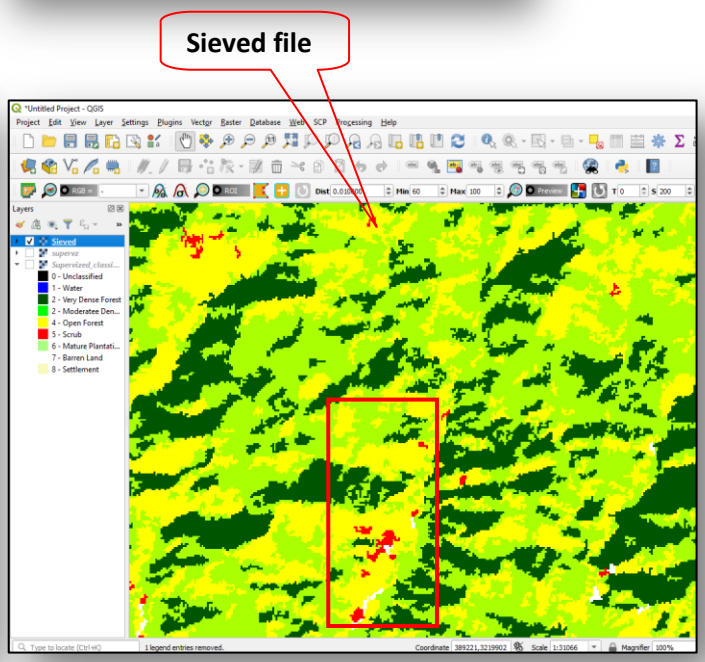
- Go to Raster > Analysis > Sieve, to remove the sinks/ pixels smaller than 10 (square metres), because it gives somewhat salt and pepper effect and messy appearance to the image, therefore removes raster polygons smaller than a provided threshold size (in pixels) and replaces them with the pixel value of the largest threshold neighbor polygon.
- Only raster polygons smaller than the threshold size will be removed, either 4 connectedness or 8 connectedness should be used.







Input File

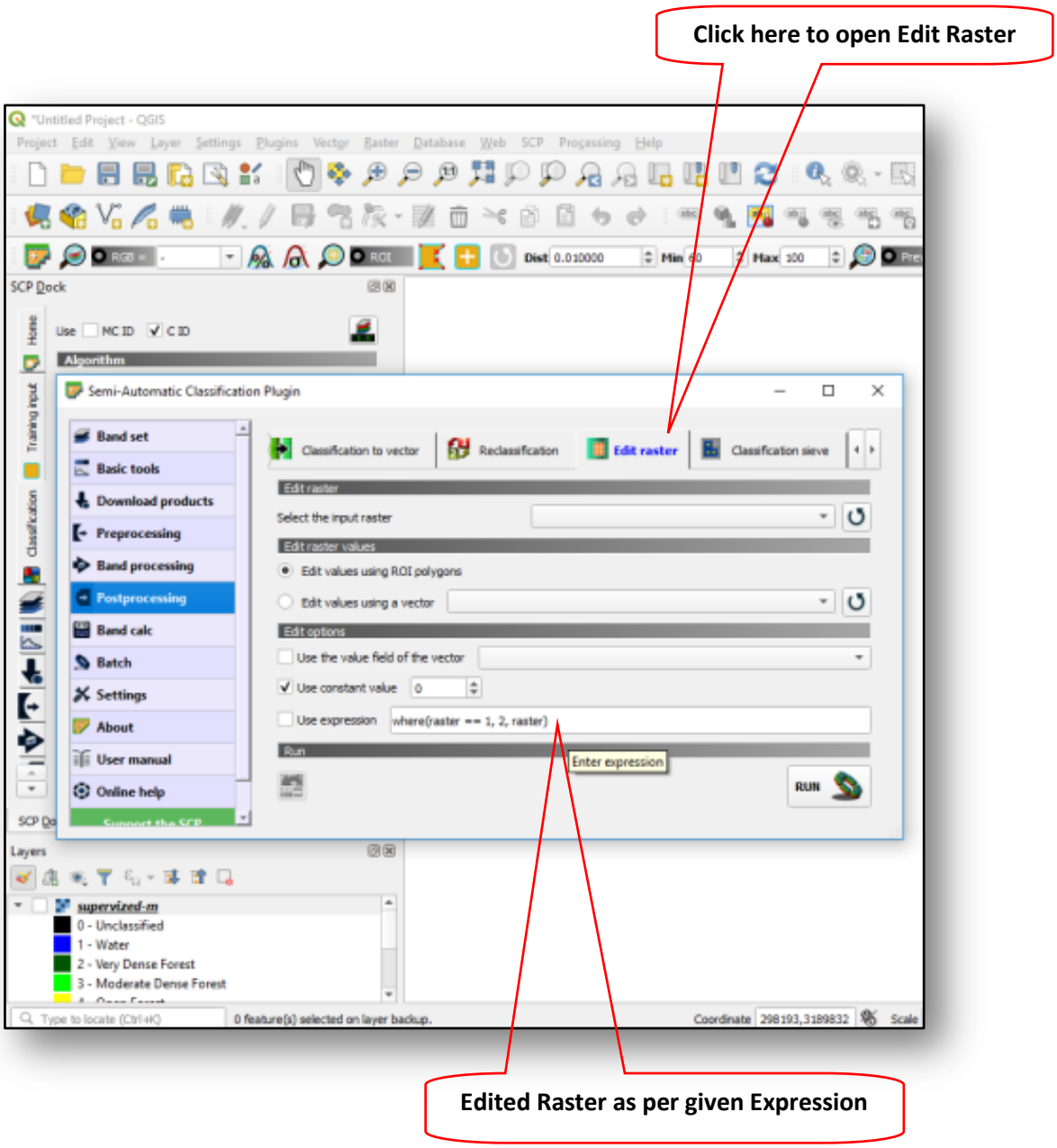


Output File

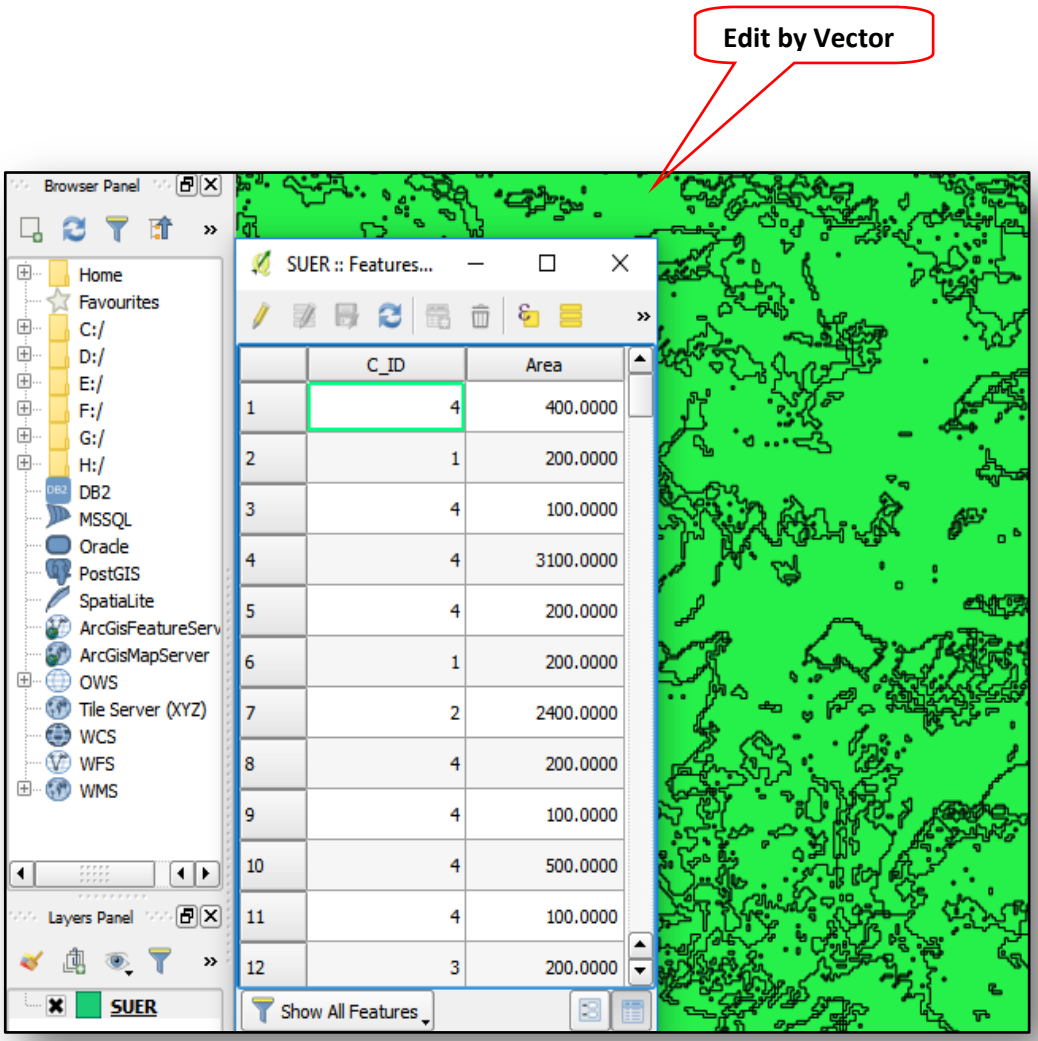
2.9 Edit Raster

The edit raster utility is available to edit raster values either using temporary ROI polygons in the map or by defining reference vector layer, so that raster is edited using all the polygons of selected vector.

- Go to SCP Dock > select Edit Raster Tab.
- To edit raster values by using ROI, select > Edit values using ROI Polygons.
- To edit raster values by using vector, select > Edit values using a vector.



- In the expression box type expression:
  Where (raster == 1, 2, raster) , assigns 2 where raster equals 1 and leaves unchanged the values where raster is not equal to 1.
- We can also edit Raster by using vector/shapefile as a reference, in that case select Edit values using a vector option.



Chapter 3. Normalized Differential Vegetation Index (NDVI)

The Normalized Differential Vegetation Index is used to detect green vegetation from Remote Sensing data. A vegetation index can be defined as a parameter calculated from reflectance values at different wavelengths, particularly sensitive to vegetation cover, according to Gilabert et al (1997).The use of these indices is based on the particular radiometric behavior of the vegetation. If vegetation cover in good health has a spectral signature characterized by the contrast between the red band (between 0.6 and 0.7 µm.), which is largely absorbed by the leaves, and the Infrared (between 0.7 and 1.1 µm.), is mostly reflected. This quality of the vegetation allows the realization of its qualitative evaluation.

The Normalized Differential Vegetation Index is calculated by the following expression:

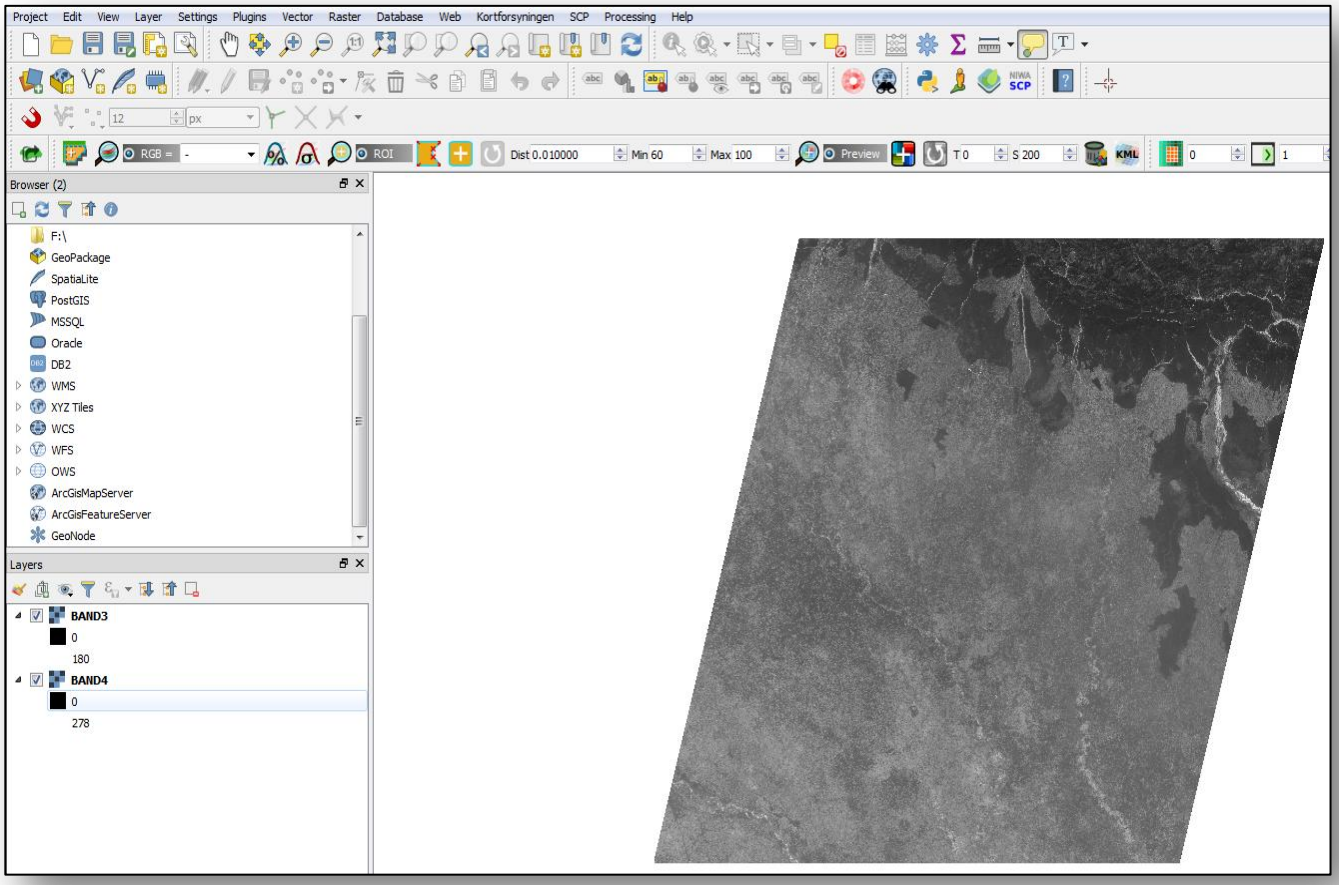
NDVI= (NIR-R)/(NIR+R)

Where: NIR is the reflectivity in the near infrared and R is the reflectivity in the red portions of the electromagnetic spectrum.Theoretically, NDVI values ranges from -1 to +1. An NDVI value is negative or close to 0 means no vegetation, whereas, if it is close to +1 indicates the highest concentration of green vegetation.

The range of values of the spectral reflections is between 0 and 1; Since both near infrared and red reflectivity are ratios of the reflected radiation on incoming radiation in each spectral band. As a consequence of these values ranges, the NDVI varies its value between -1 and 1. The NDVI has a great value in ecological terms, since it is a good estimator of the fraction of photosynthetically active radiation intercepted by vegetation (fPAR) (Monteith, 1981). Green vegetation from multispectral remote sensing data is the normalized difference vegetation index (NDVI) (Tucker, 1979).

Whereas,NIR and RED represent the spectral reflectance values acquired in the near-infrared and red portions of the electromagnetic spectrum.

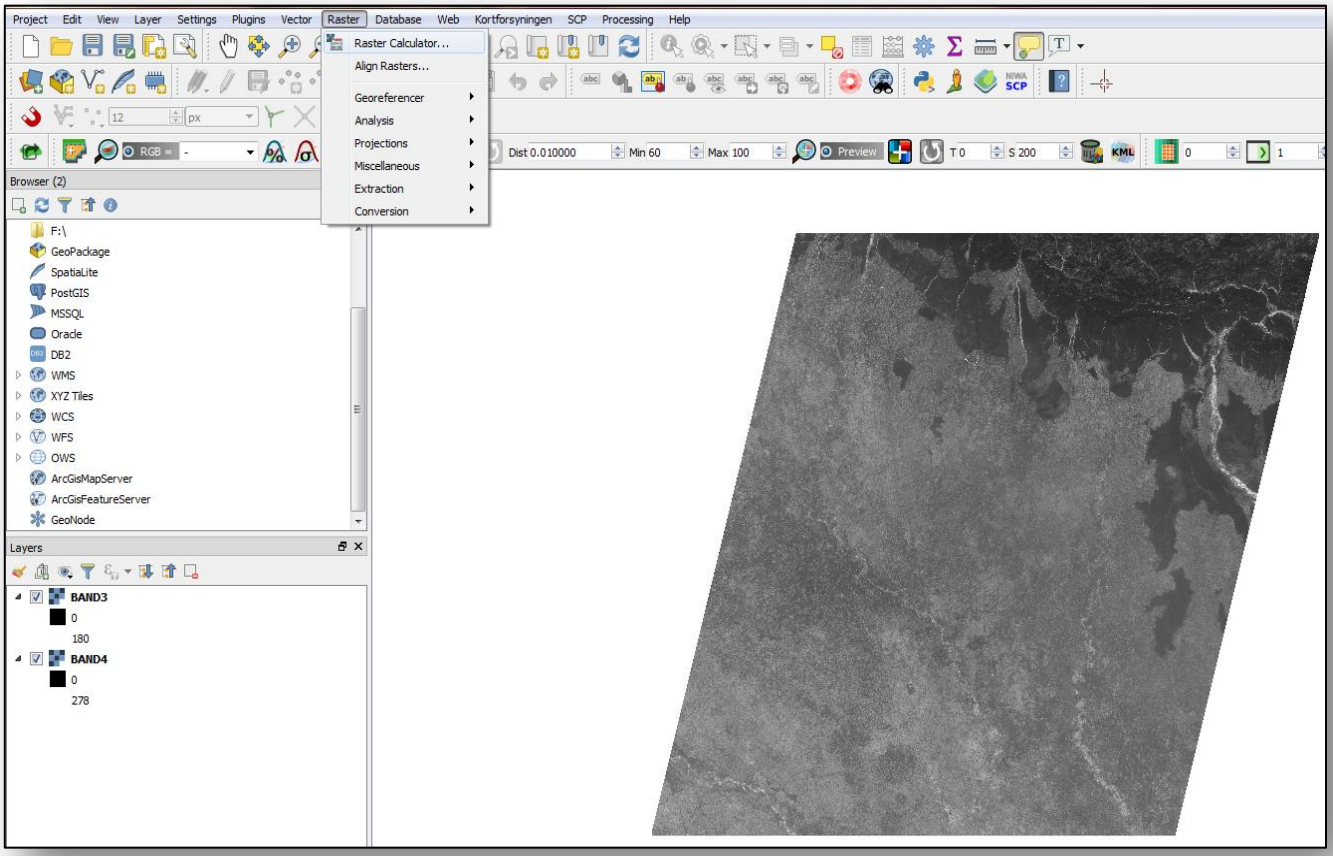
- In spectrum, theoretically, NDVI values range from -1 to +1 respectively and NDVI value that is negative or close to zero means no vegetation whereas an NDVI value close to +1 indicates the highest concentration of green vegetation.
- We are using LISS III Resourcesat-2 orthorectified data that procured from NRSC, Hyderabad with 4 spectral bands 2,3,4,5, i.e.Band 2 (Green), Band 3 (Red), Band 4 (Near Infrared), Band 5 (Short Wave Infrared).



- To calculate NDVI open Band 3 (R), Band 4 (NIR) by Clicking on Open Raster Tab.

3.1 NDVI by using Raster Calculator

- Click on Raster > Go to Raster Calculator.

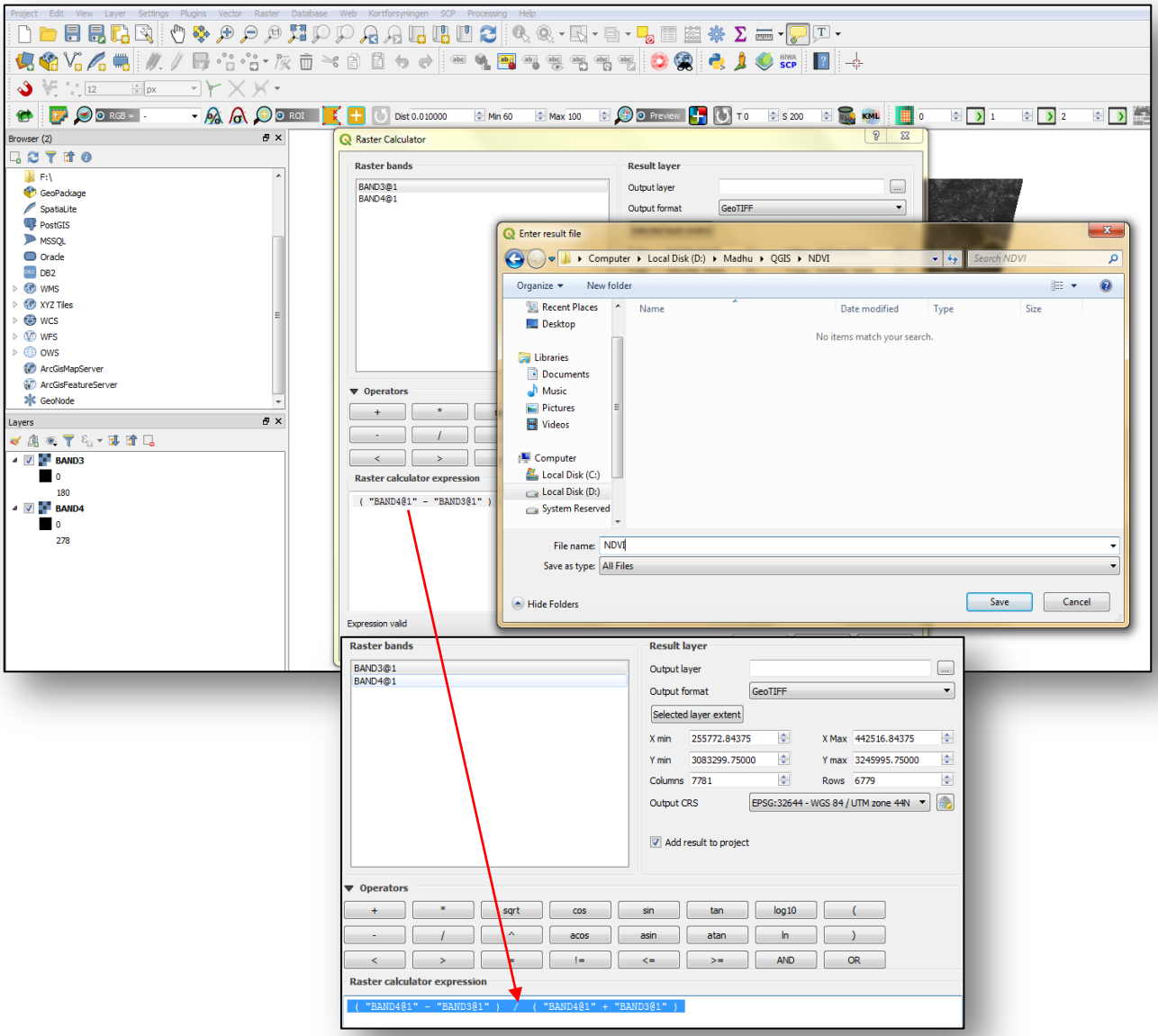


- In Raster Calculator window select the expression for calculating NDVI.

- The NDVI calculation is entered in the Raster Calculator Expression as:

  (NIR - RED) / (NIR + RED)

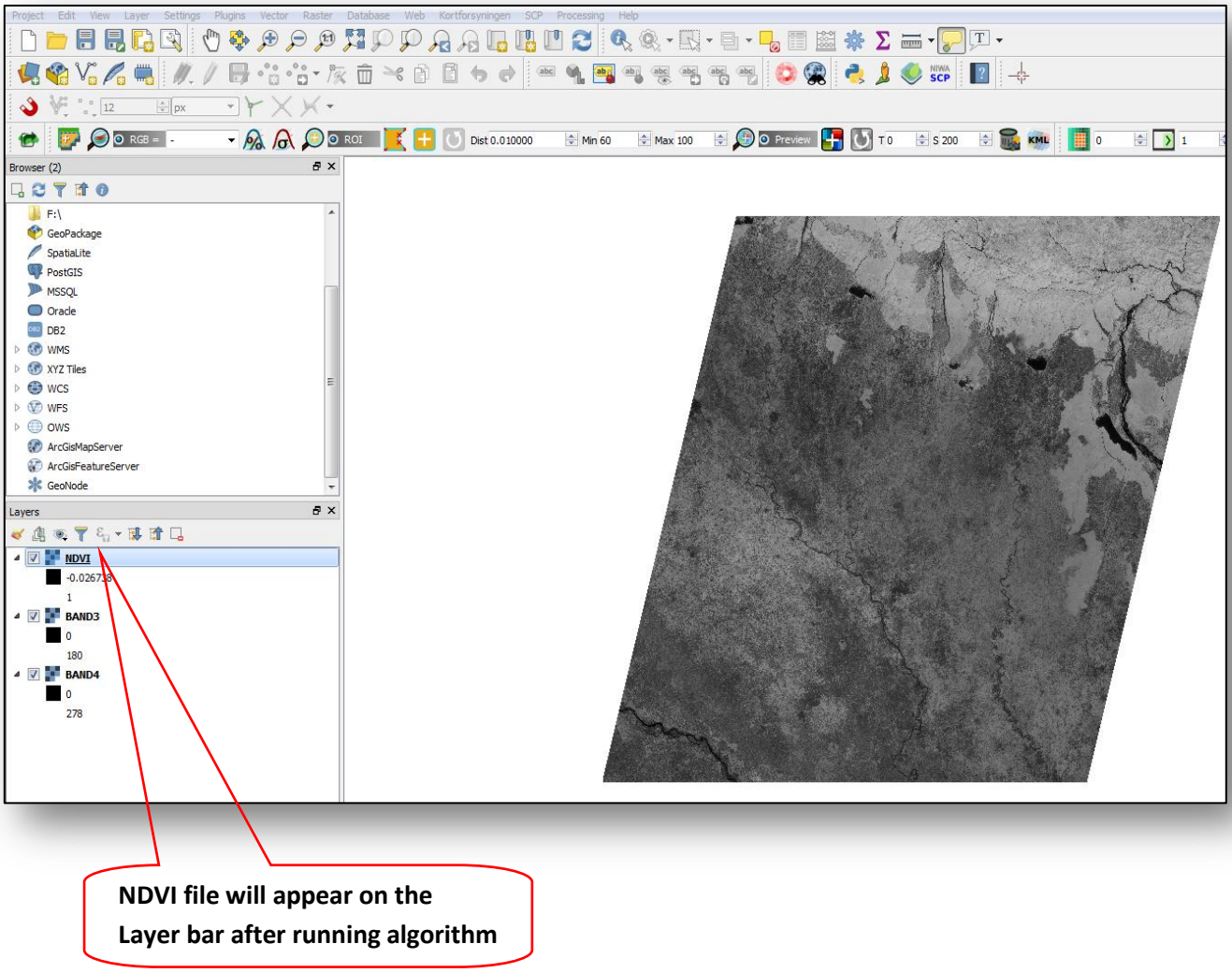
- To select the expression, first select '(', Band4, now choose '-' operator and select Band3, close the opened bracket by selecting')' , now choose '/' operator and select '(', select Band4, now this time choose '+' operator and select Band3 and finally select ')' to close the expression.Now, Click OK and Save file.



Type expression as:

("Band4@1"- "Band3@1") / ("Band4@1"+ "Band3@1")

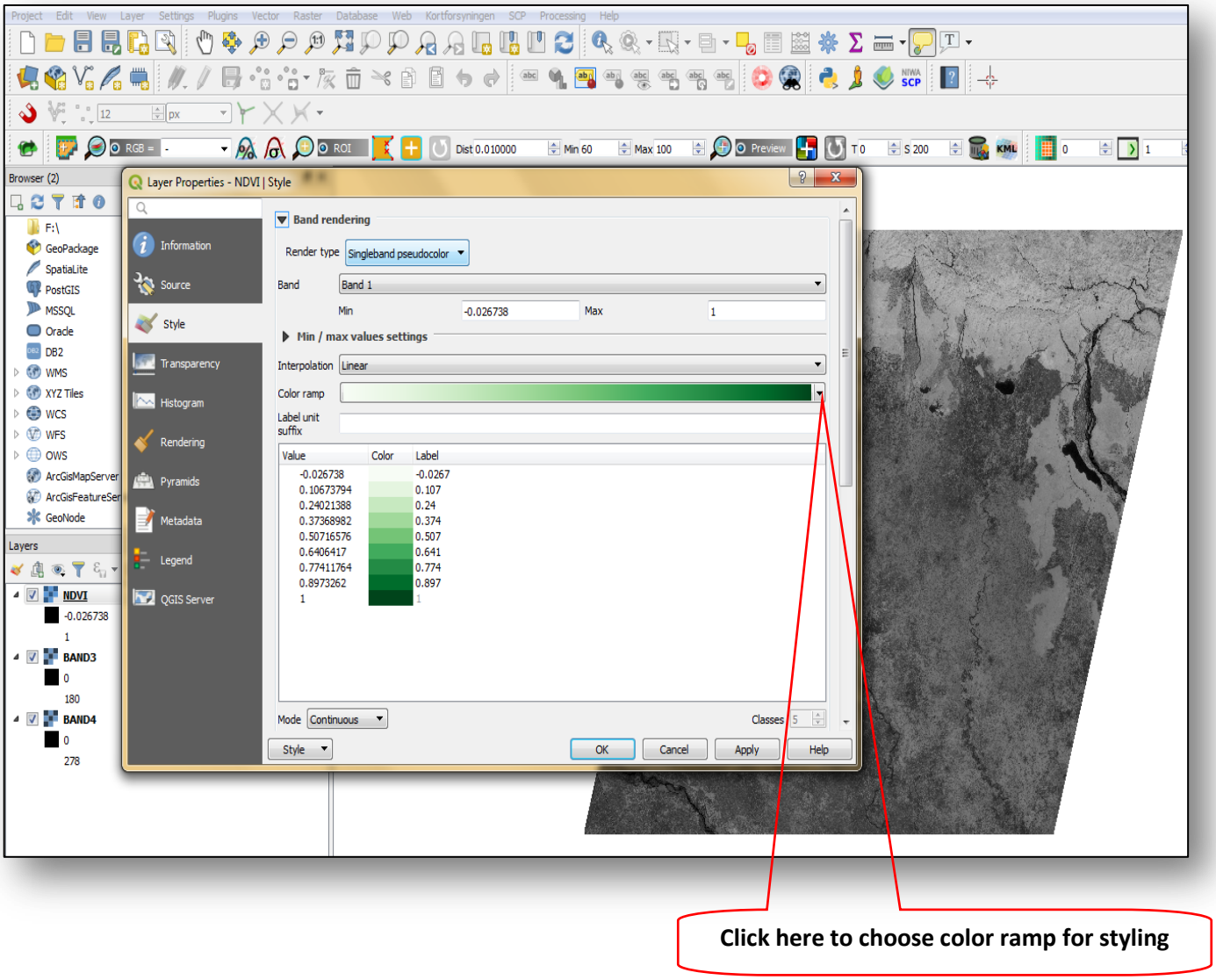
- Then the File (NDVI) opened in the task bar as showing in Figure.



- The output after running the algorithm would appear in greyscale.

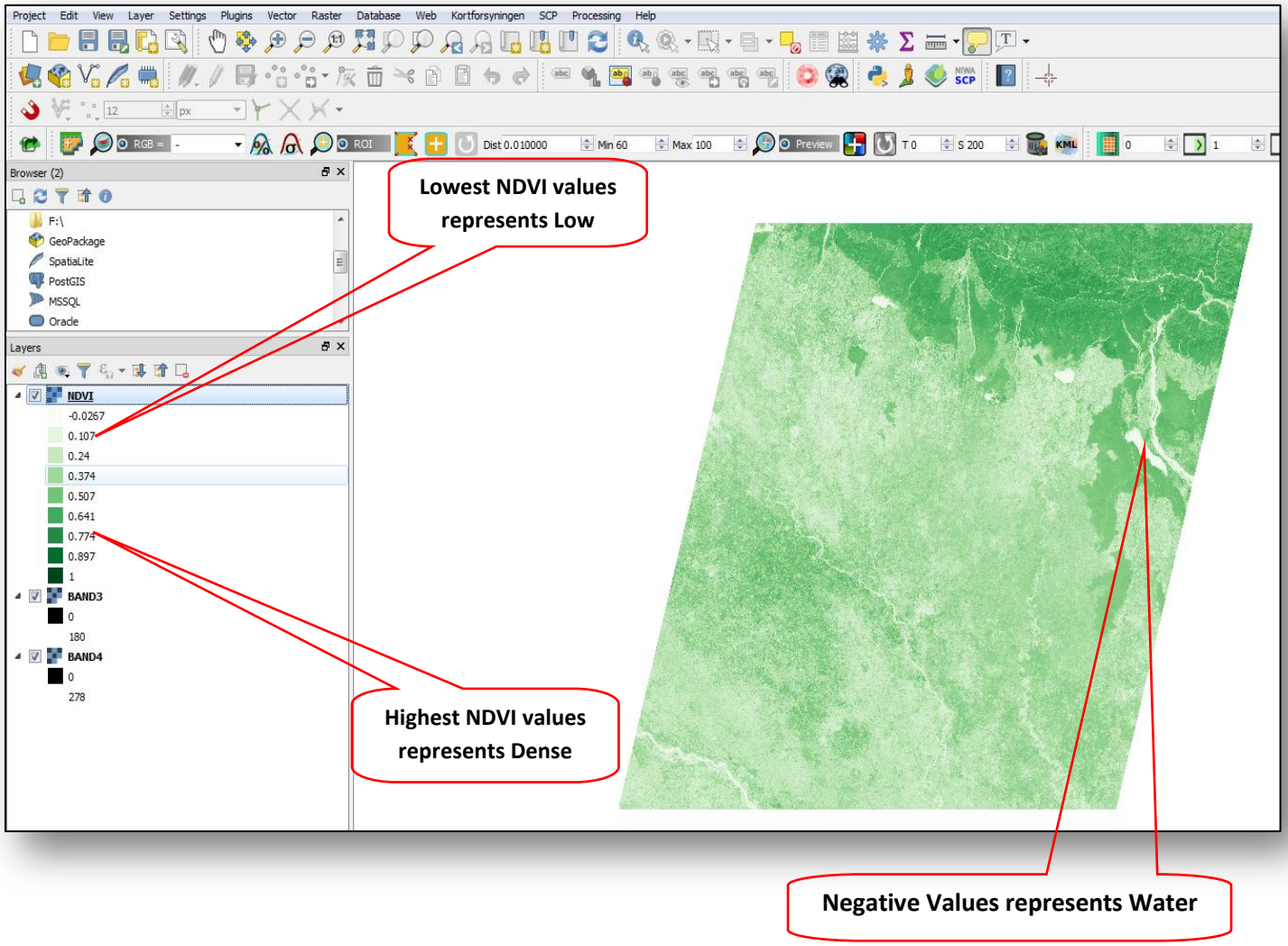
- Lighter color areas has higher values and signify a larger difference between the red and near infrared radiation recorded by the sensor, i.e. a condition associated with highly photosynthetically active vegetation, wherein the method is applied according to its characteristic like vegetation at different NDVI threshold values such as 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4 and 0.5.

- In the Layers Panel, right click on NDVI file > and select Properties or double click on file > directly go to Layer properties > then click on Style on the left hand side. Select Single band pseudocolor in Render type tab > and in Interpolation option select Linear > now select color ramp.



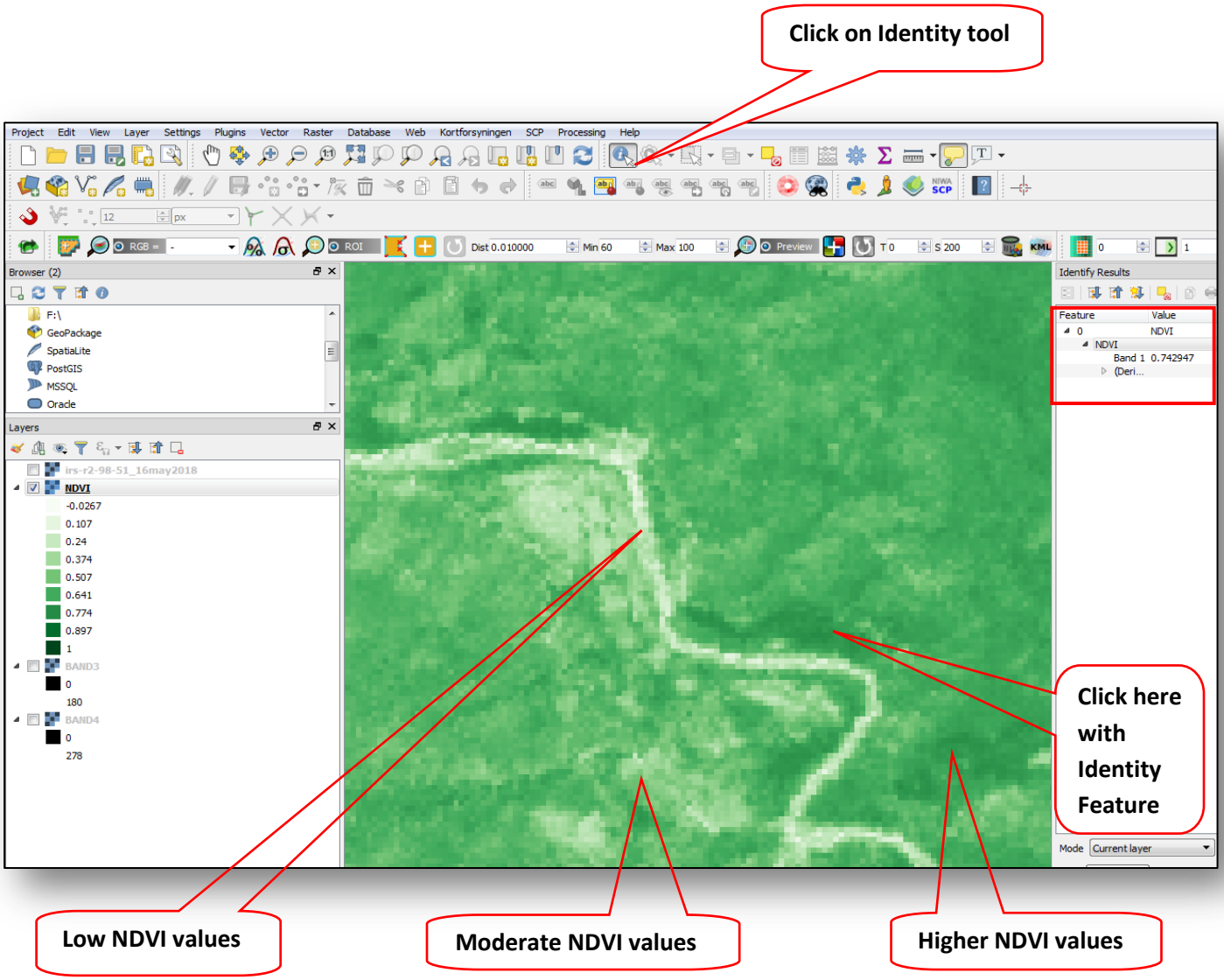
- Click **Apply** > **OK** at the bottom.

- The vegetation has positive NDVI values, generally between 0.1 and 0.7. The highest values corresponding to the most dense vegetation cover, whereas lowest value representing low or no vegetation cover.



- Now the pixels with a high NDVI value will be displayed as a dark green. We can more clearly see areas where there is an abundance of vegetation (green areas) and areas with sparse vegetation (white or lighter areas).

- Now, select Identity icon to check the information about each and every pixel by clicking inside the file and that will provide the NDVI value of particular selected location.



Low NDVI Values:	**(0.1 and below) barren areas of rock, sand, or snow**
Moderate NDVI Values:	**(0.2 to 0.3) shrub and grassland**
High NDVI Values:	**(0.6 to 0.8) temperate and tropical rainforests**
0	**Bare soil**
Negative	**Water**

Chapter 4. Terrain Analysis

Terrain Analysis is a process that describes terrain, i.e. roughness, altitude, etc. quantitatively. Such analysis can be very useful in forestry, agriculture and environmental studies such as, assessing site suitability for plantation, land suitability for agriculture and other land use features. The following terrain parameters will be computed from DEM data using stand alone QGIS software, as well as GRASS and SAGA plugins in QGIS. QGIS can create the following DEM derived terrain rasters most efficiently.

1. Hillshade

2. Slope

3. Aspect

4. Color relief

5. Terrain Ruggedness Index (TRI)

6. Topographic Position Index (TPI)

7. Roughness 8. Curvature

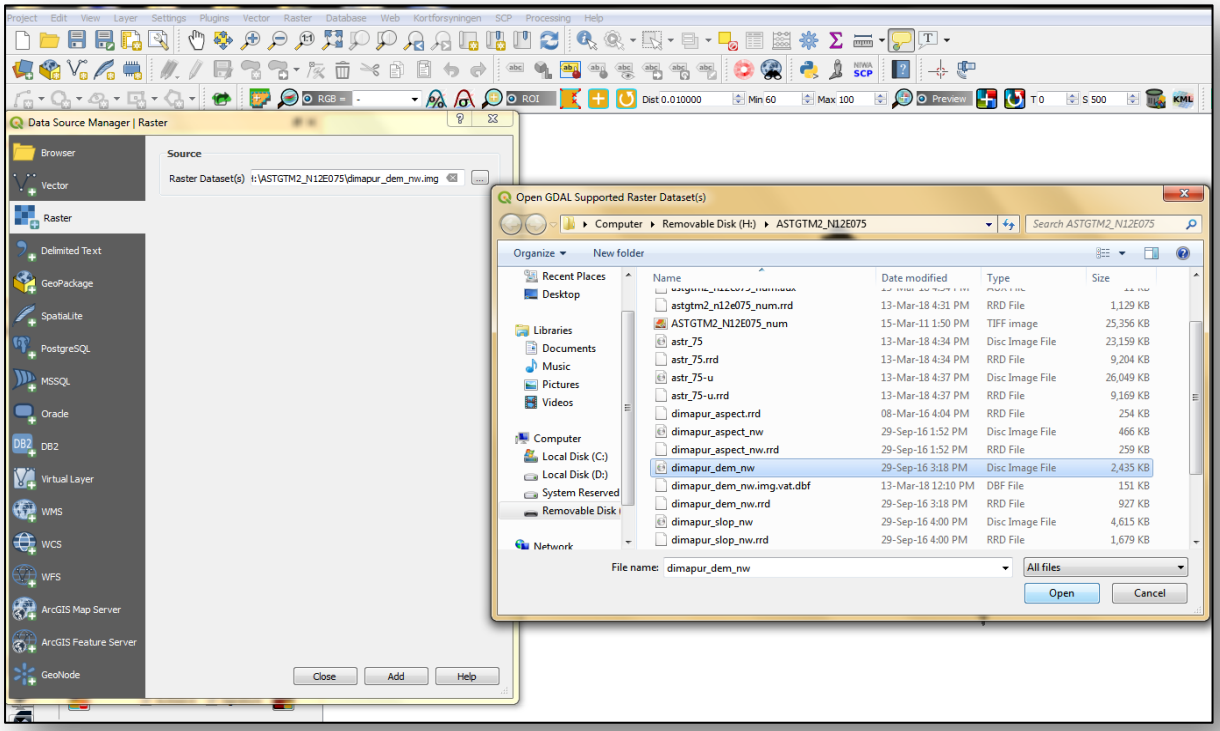
4.1 Calculate Slope from a DEM

Slope is the steepness or the degree of incliness of a surface. The resulting grayscale image shows flat areas as dark pixels, and pixel brightness increases as the terrain becomes steeper. Slope can be measured in degrees or in percentage.

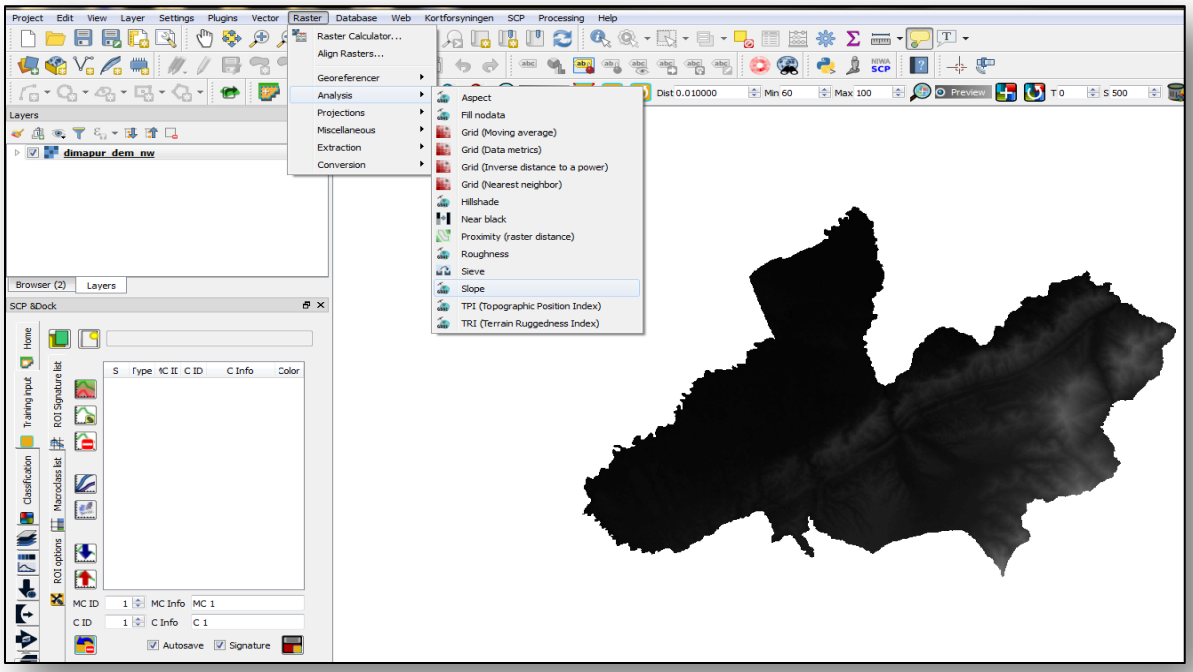
- 0 indicates a flat area, with no slope
- 90 indicates a vertical slope.

- **The slopes are classified on the basis of angle into**:
  1. 0º to 5º Level
  2. 5º to 10º Gentle
  3. 10º to 15º Moderate
  4. 15º to 25º Steep
  5. 25º to 45º Very Steep
  6. >45º Precipitous

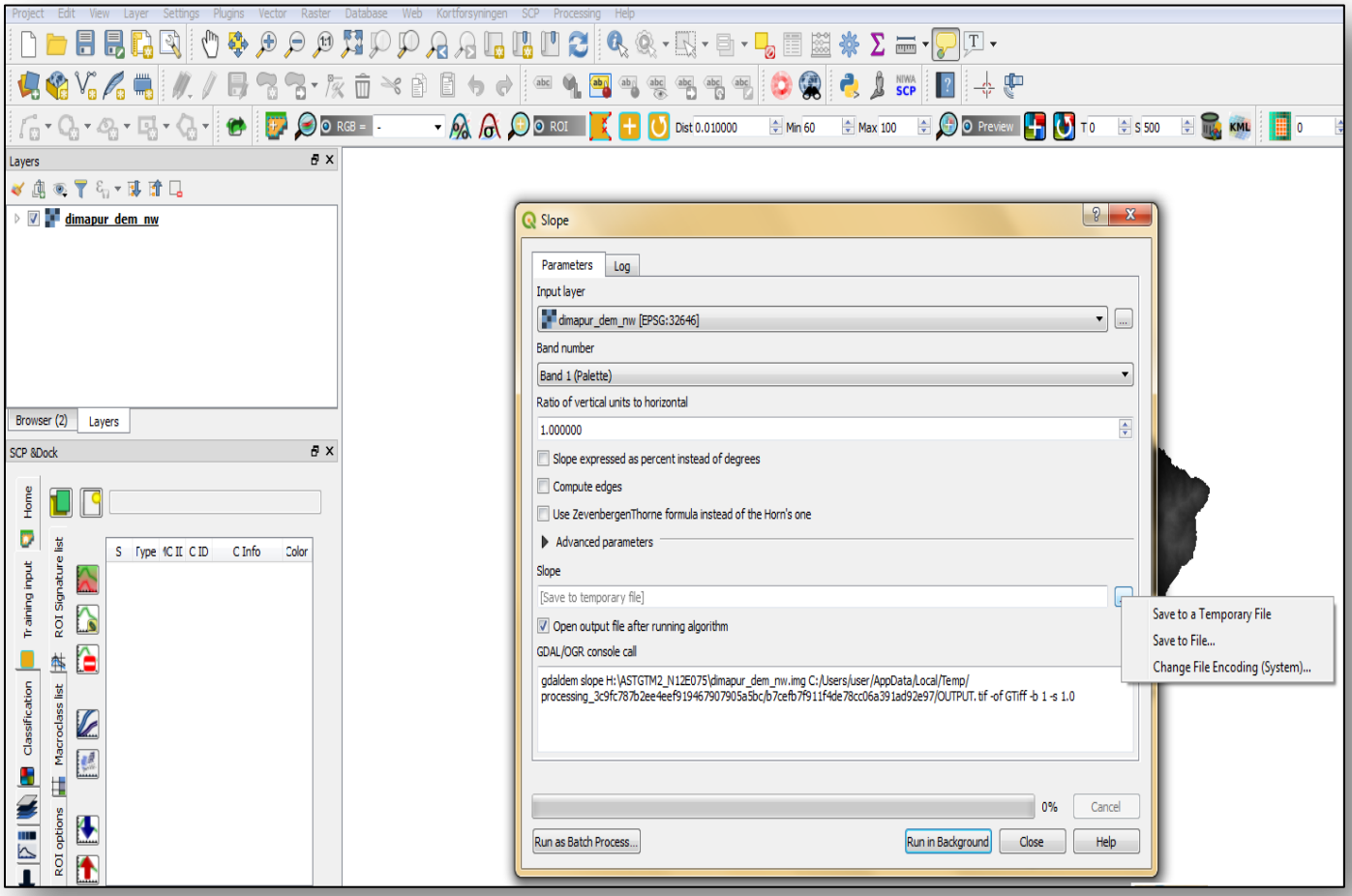
- Click on open Raster > open GDAL supported Raster dataset > now open DEM (Data Elevation Model) file to create Slope Map from DEM to start the process.



- Go to Raster > and select Analysis. In analysis tab select Slope option that allows to calculate the slope.

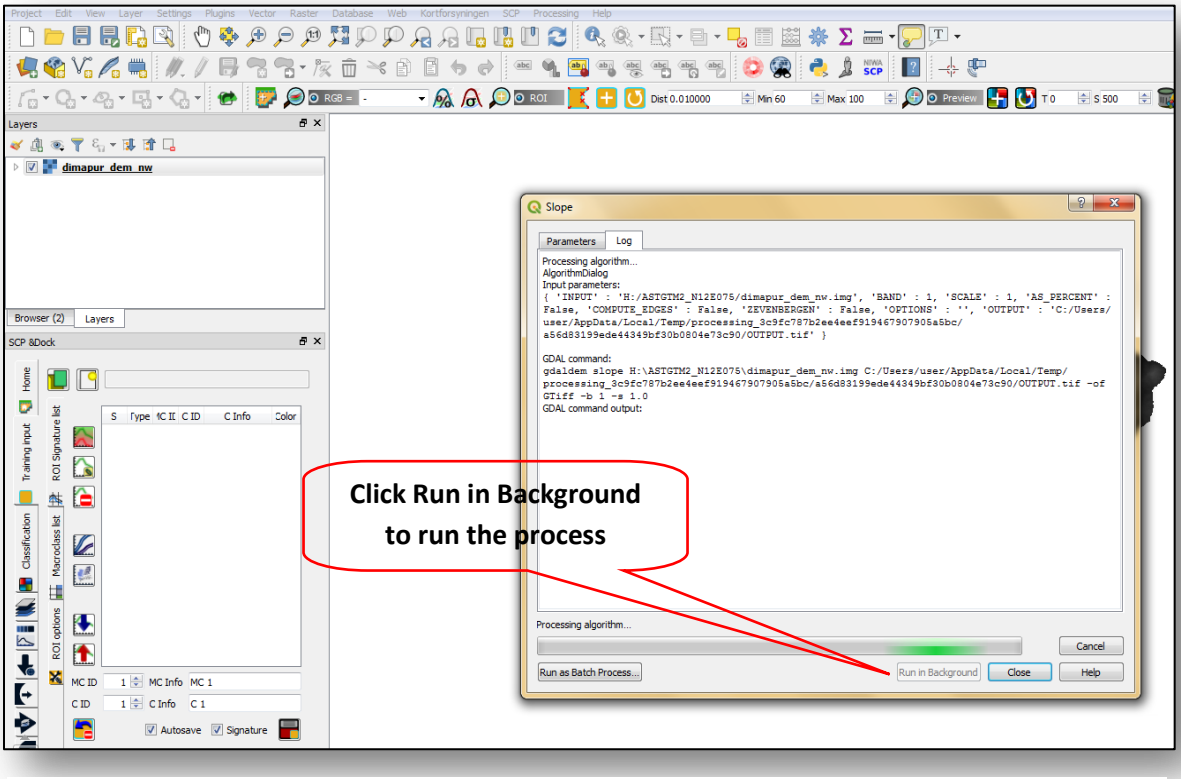


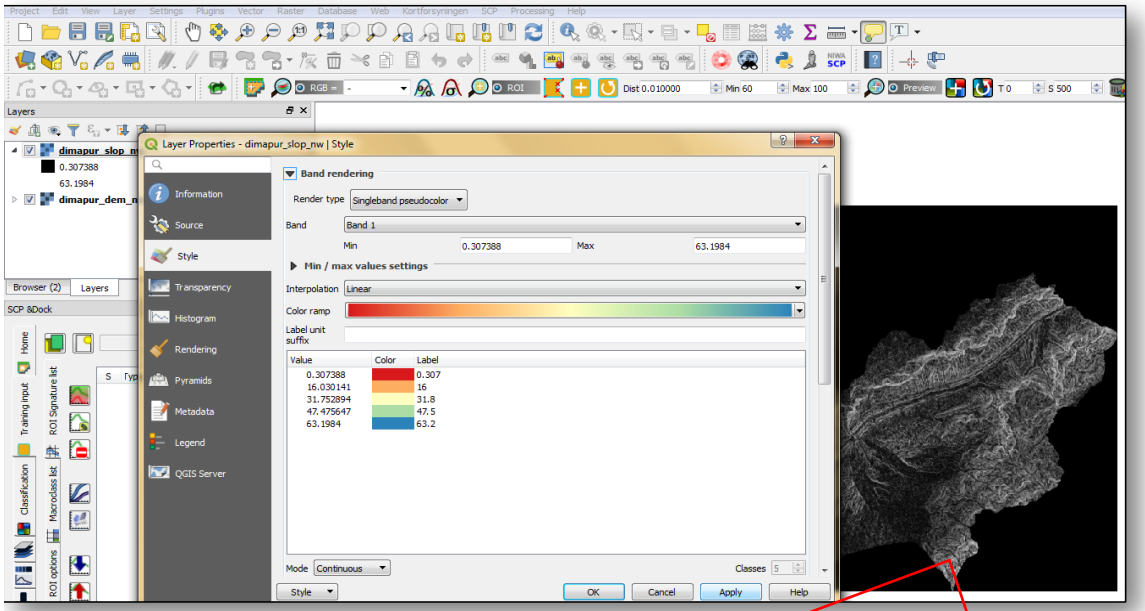
- In the Slope dialog, choose DEM file as the Input file, name the Output file as Slope.tif and leave all other options as it is. Assign the type of slope value to degrees or percent.
- Set the parameter scale (ratio of vertical units to horizontal) to 1, when the measuring units of the CRS and the elevation measuring units are the same.



- Make sure to check open output file while running algorithm before Clicking on Run in Background option to open output file by default.

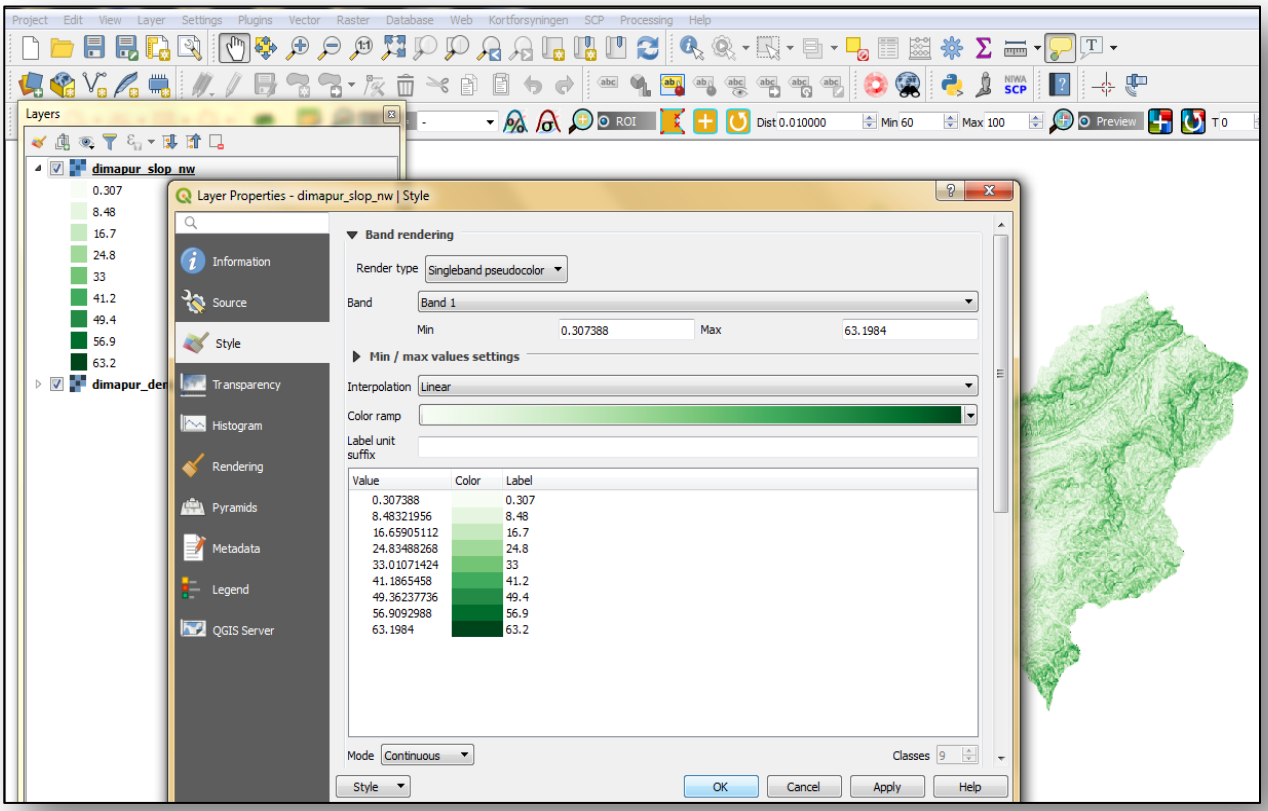
- After clicking OK, the process run and will take time for the processing of creating Slope.





The slope of the terrain, with black pixels being flat terrain and white pixels, steep terrain

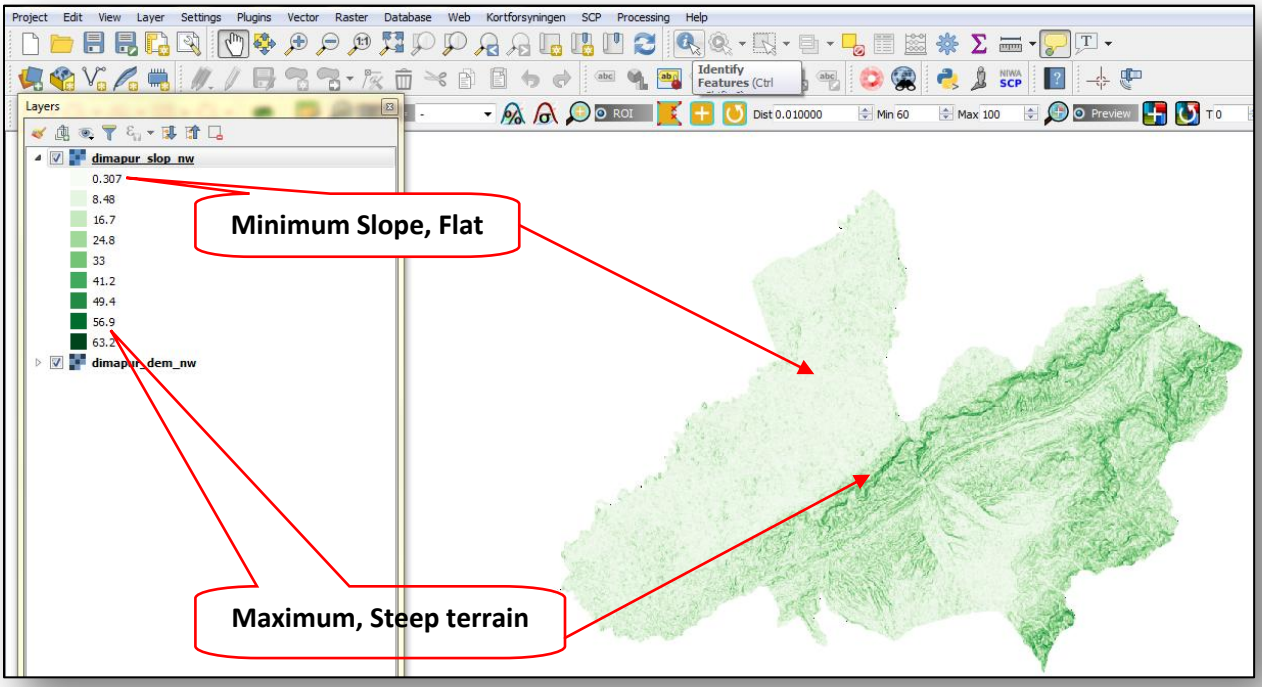
- Once classification process is finished, the final classified image appears in the classifier window as appear in Figure.



.

- In the Layers Panel > right click on Slope file > and select Properties.
- Go to Layer properties > click on Style on the left hand side > select single band pseudocolor in Render type tab > select Linear in Interpolation option.
- Select color ramp in min. max. value setting.
- Click OK at the bottom.
- The labeled unit defining the minimum value of the Slope in the first record, i.e. 0.3, while maximum value of Slope is 63.2 and that is residing in the last record.

- Once, selected color ramp in min. max. value setting of Layer properties, the generated Slope file appears in the classifier window as per the selected color ramp.



Note: While Styling the data, should know about the types of Symbology used in QGIS :

•**Single Symbol:** To mark geographic features on a map.

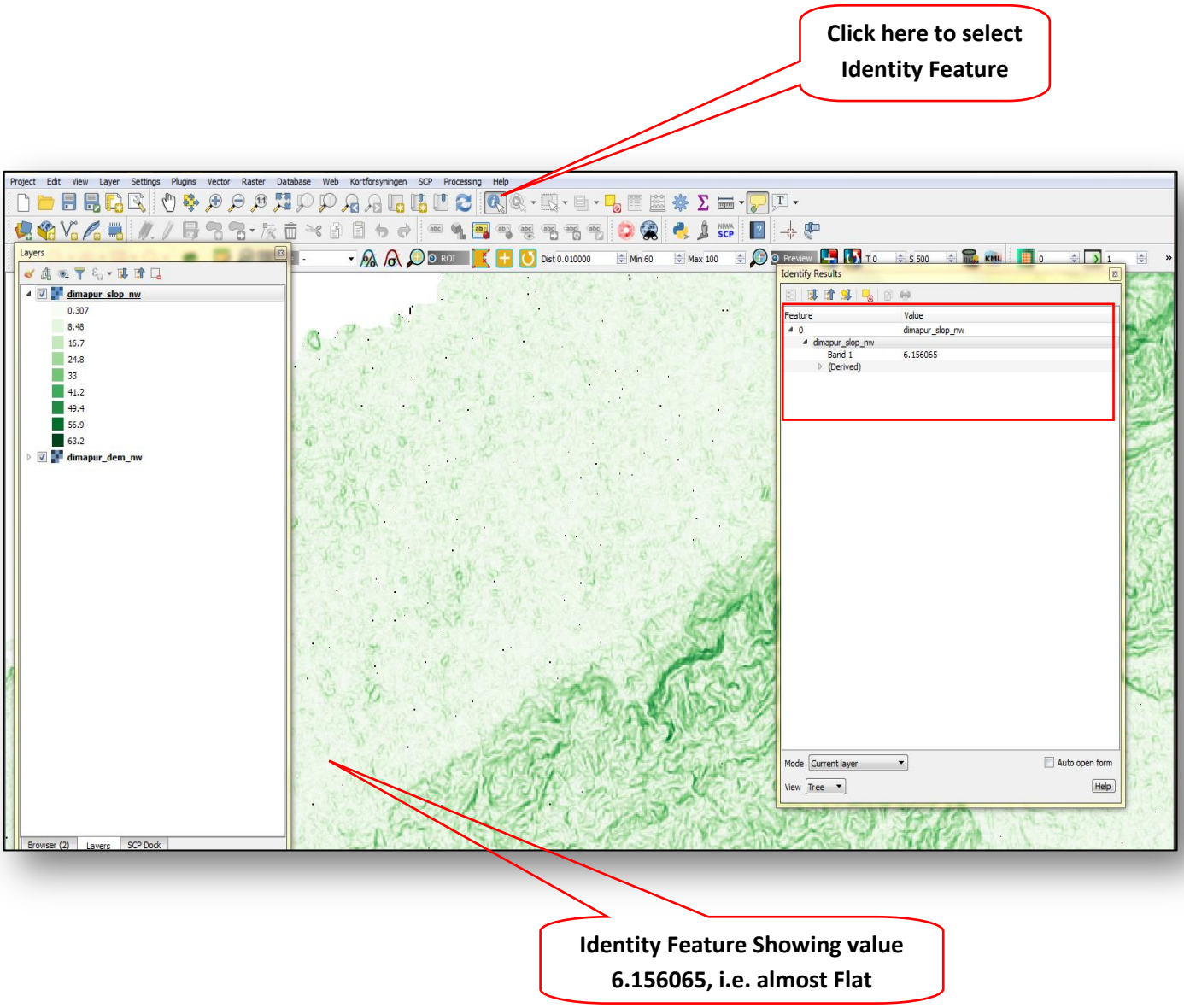
•**Graduated Symbol:** Graduated symbol marked attributes with decretive numbers in a statistical way.

•**Continuous Color:** Continuous color can represent continuous values, such as population density, elevation etc.

•**Unique Value:** Unique value mark every possible value of an attribute a distinct symbol based on colors presents Unique value to all kinds of attributes.

•**Diagram Overlay**: QGIS places multiple attribute mapping into an independent tab called diagram overlay. Information like the percentage of populations in different age intervals at different locations.

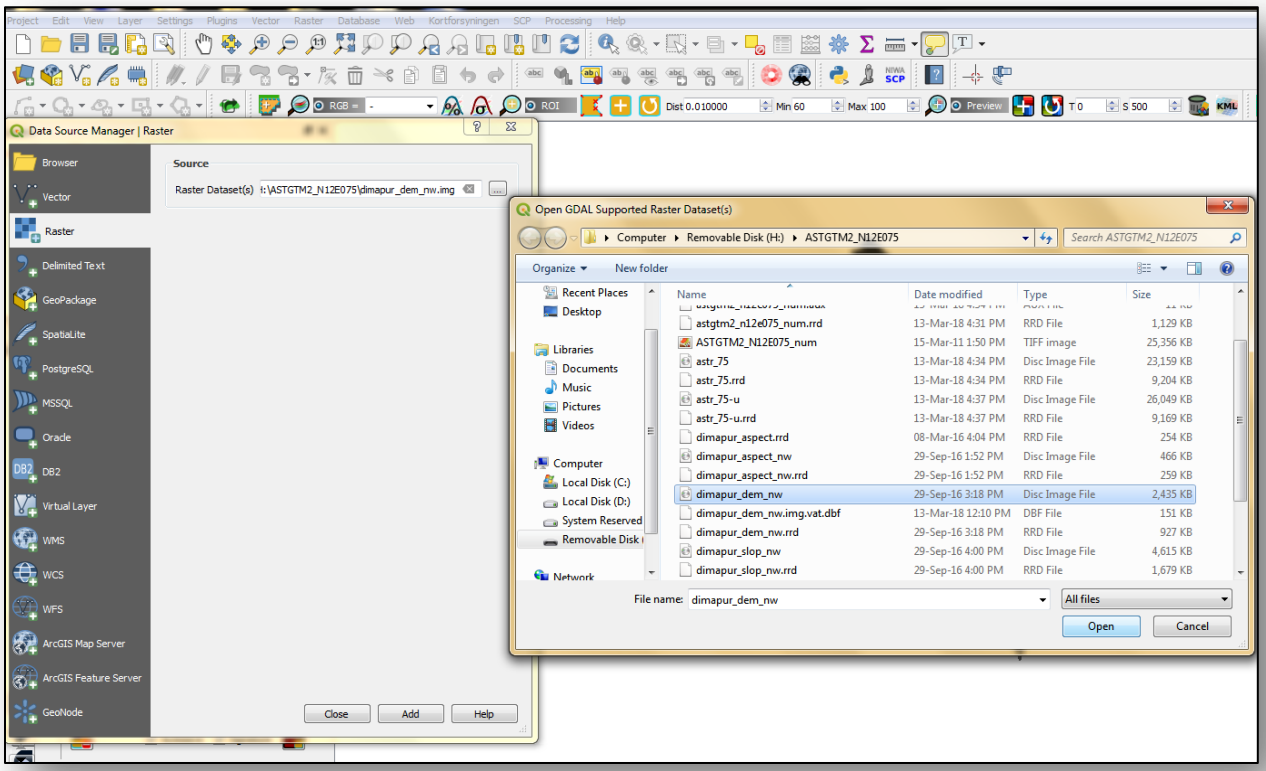
- Select Identity icon to check the information about slope of each and every pixel by clicking inside the file and that will provide the slope value of particular selected location.



4.2 Calculate Aspect from a DEM

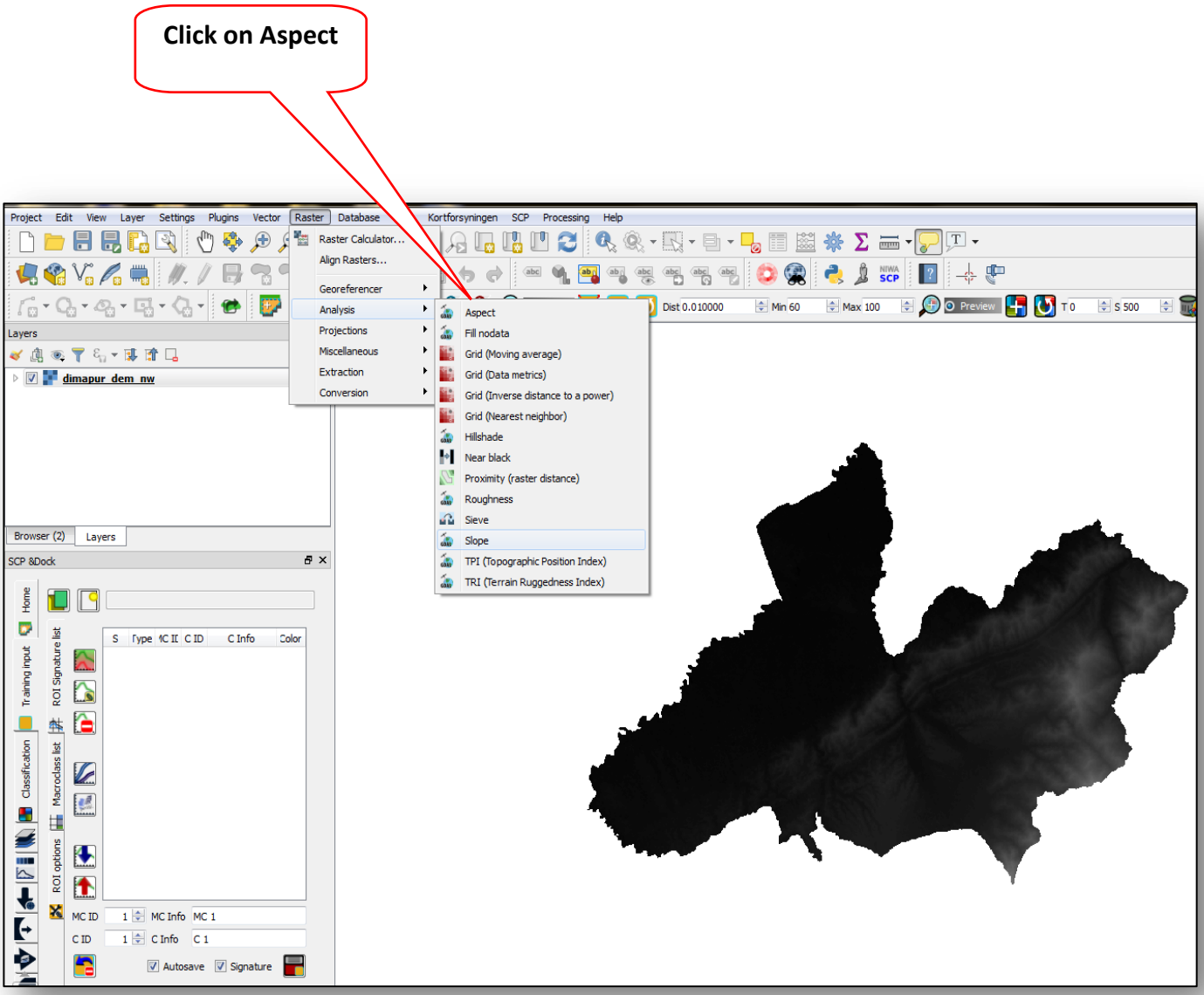
Aspect is defined as the direction of the gradient vector. It is the orientation of slope, measured clockwise in degrees from 0 to 360, where 0 is north-facing, 90is east-facing, 180 is south-facing, and 270 is west-facing.

- Click on open Raster > open GDAL supported Raster dataset.



- Now open DEM file to create Aspect.

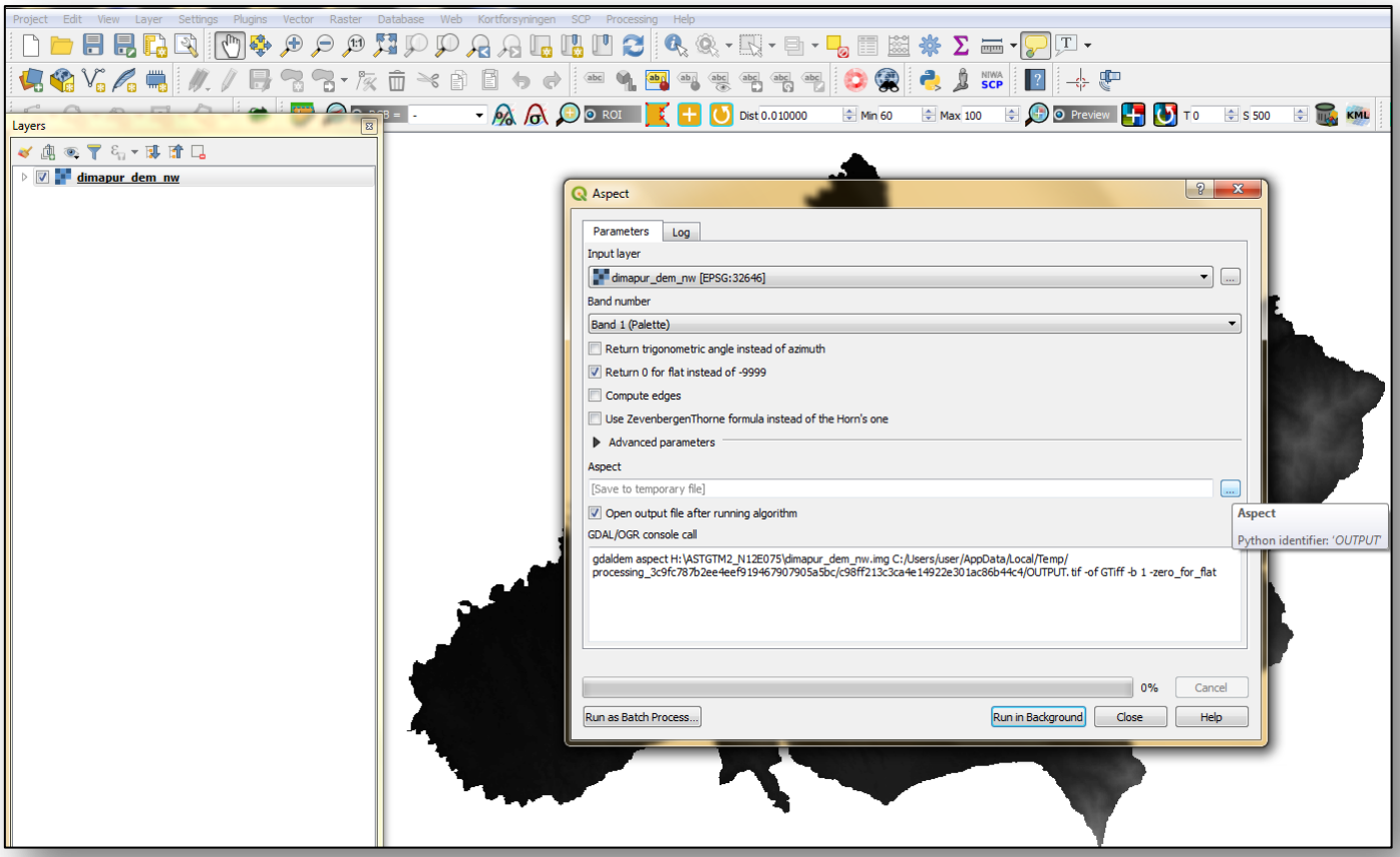
- Click on Layer > go to open Raster Tab >or either directly Click on add Raster tool to open DEM file to create Aspect.
- Go to Raster and in Analysis tab select Aspect option.



- If we select the Aspect option, the following dialog box will be shown.

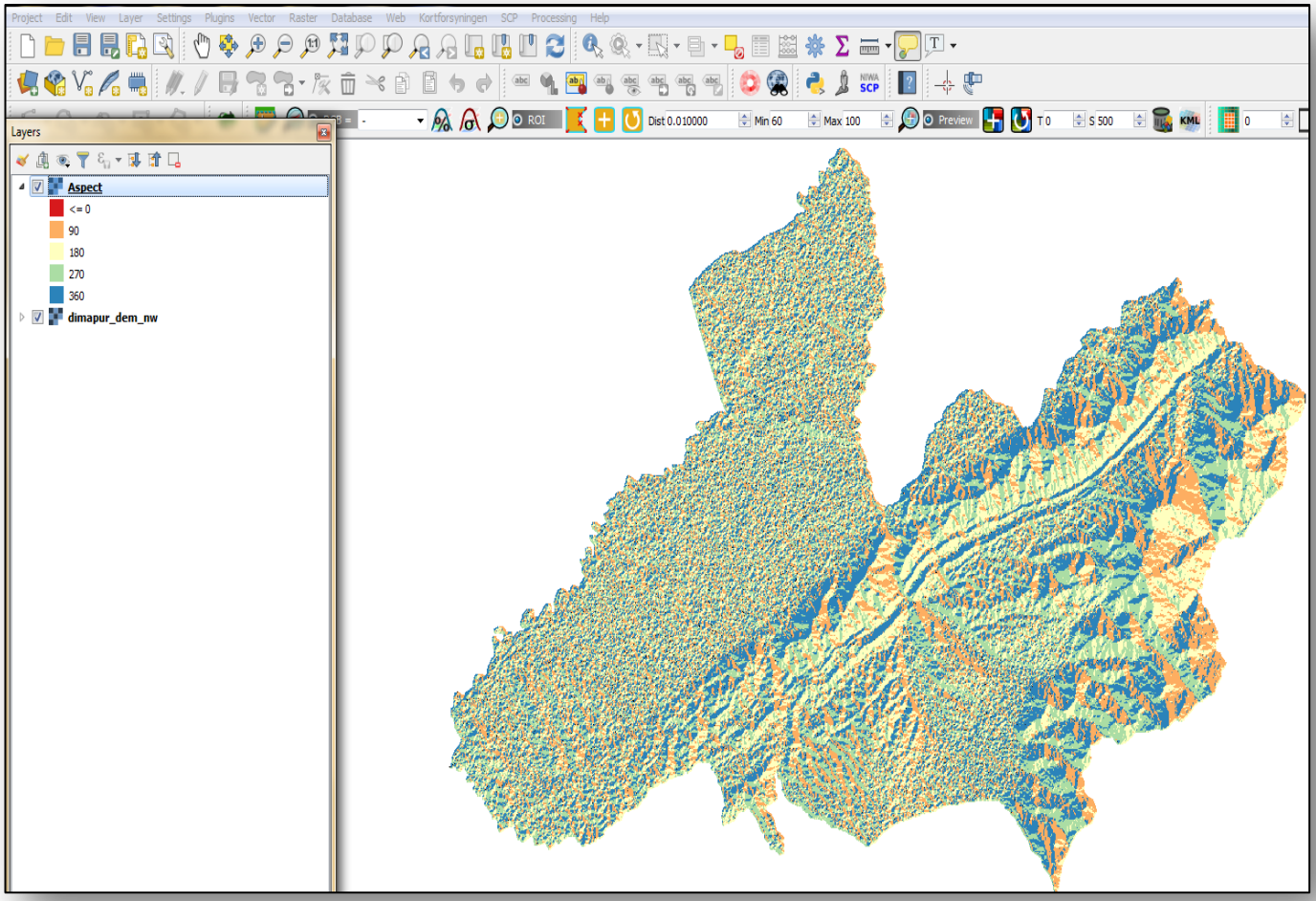
- In the Aspect dialog box, choose DEM file as the Input file, name the Output file as Aspect.tif and leave all other options as it is. Make sure to check the option of Load computed file into canvas when finished.

- In band number set Return 0 for flat instead of -9999 and Click OK.



- In the Layers Panel, right click on Aspect file and repeat the styling steps, as already mentioned in earlier section.
- Select Properties or double click on file and directly go to Layer properties, then click on Style on the left hand side. Select Single band pseudocolor in Render type tab and in Interpolation option select Linear and now select color ramp in min. max. value setting.

- Open output file after running algorithm.Once, selected color ramp in min. max. value setting of Layer properties, the generated Aspect file appears in the classifier window as per the selected color ramp.



- Select Identity icon to check the information about Aspect of each and every pixel by clicking inside the file and that will provide the Aspect value of particular selected location.

Chapter 5:Change Detection by Cross Tabulation Tool

5.1 What is Change Detection ?

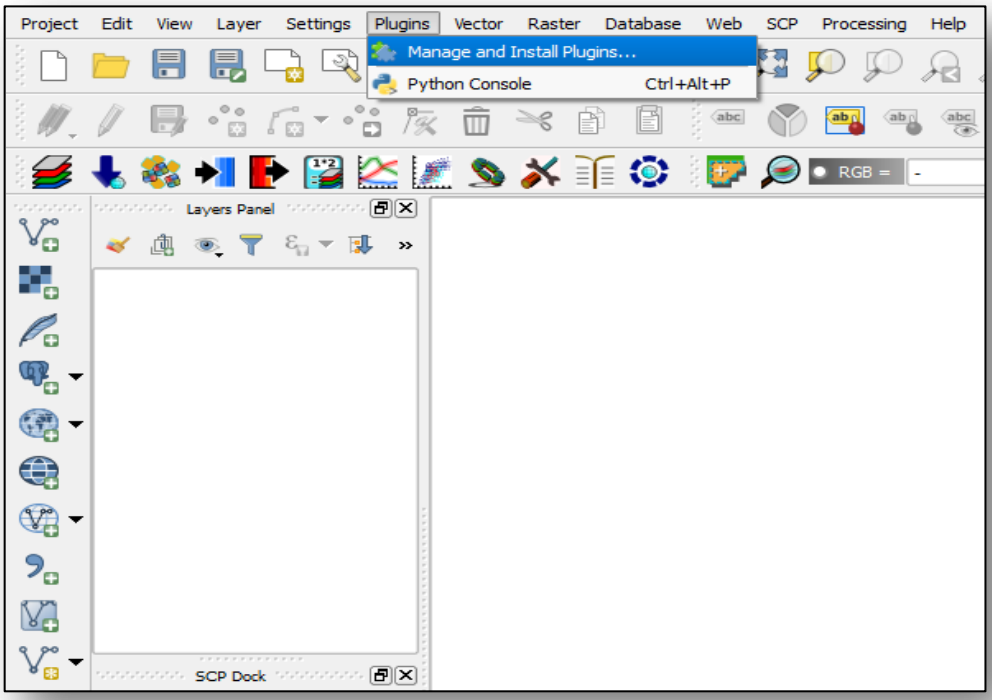
Change detection is a process of extracting changes between time series window (different time) over similar place. The classified imagery of two different times should have the same number of classes which uses the same ID and interpretate the types of changes (improvement, degradation in the forest and no change in the forest),i.e. get information on the changes between classes. Furthermore, can calculate area for these changes (to be able to see which class has experienced the most change).

- To identify the change in features over time.
- Change detection can be used to track feature's location over time.
- Change of a feature's geometry/shape over time. Change detection can be used to understand shrinkage or spread of a specific ground feature, Example flooded or drying condition of river or lake over particular time period.
- Change in a feature's size over time. Change detection can measure and calculate area of a feature.

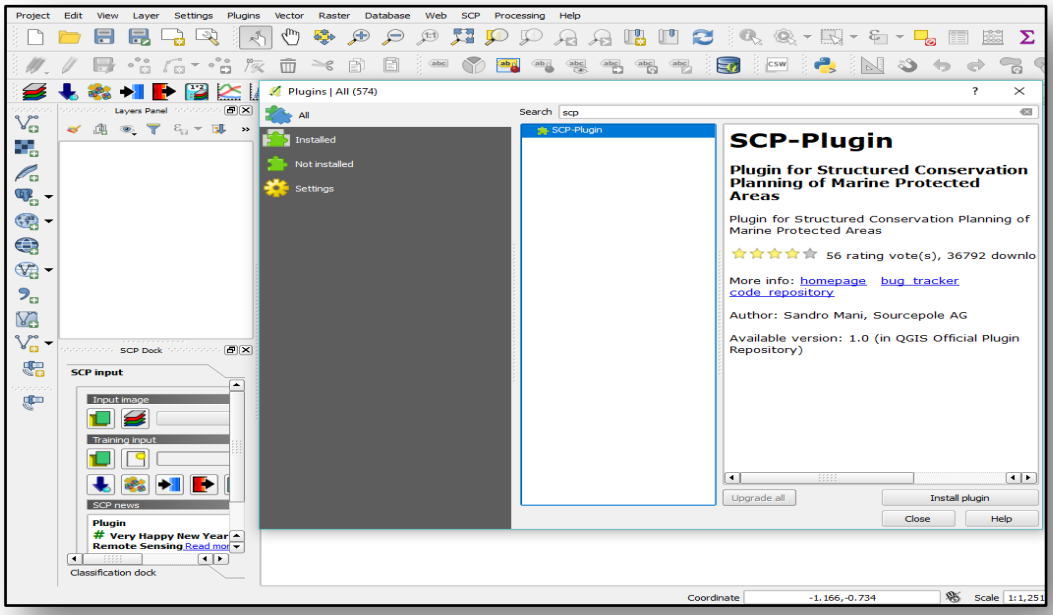
In the SCP (Semi-automatic Classification Plugin) tool and in SAGA toolbox of QGIS there is a tool called **Cross-classification and tabulation** used to detect the Changes in feature and allow to compare two classified images in cross tabulation called a contingency table.

The process allow to compare two classified images is cross tabulation or a contingency table that calculate change in class values.

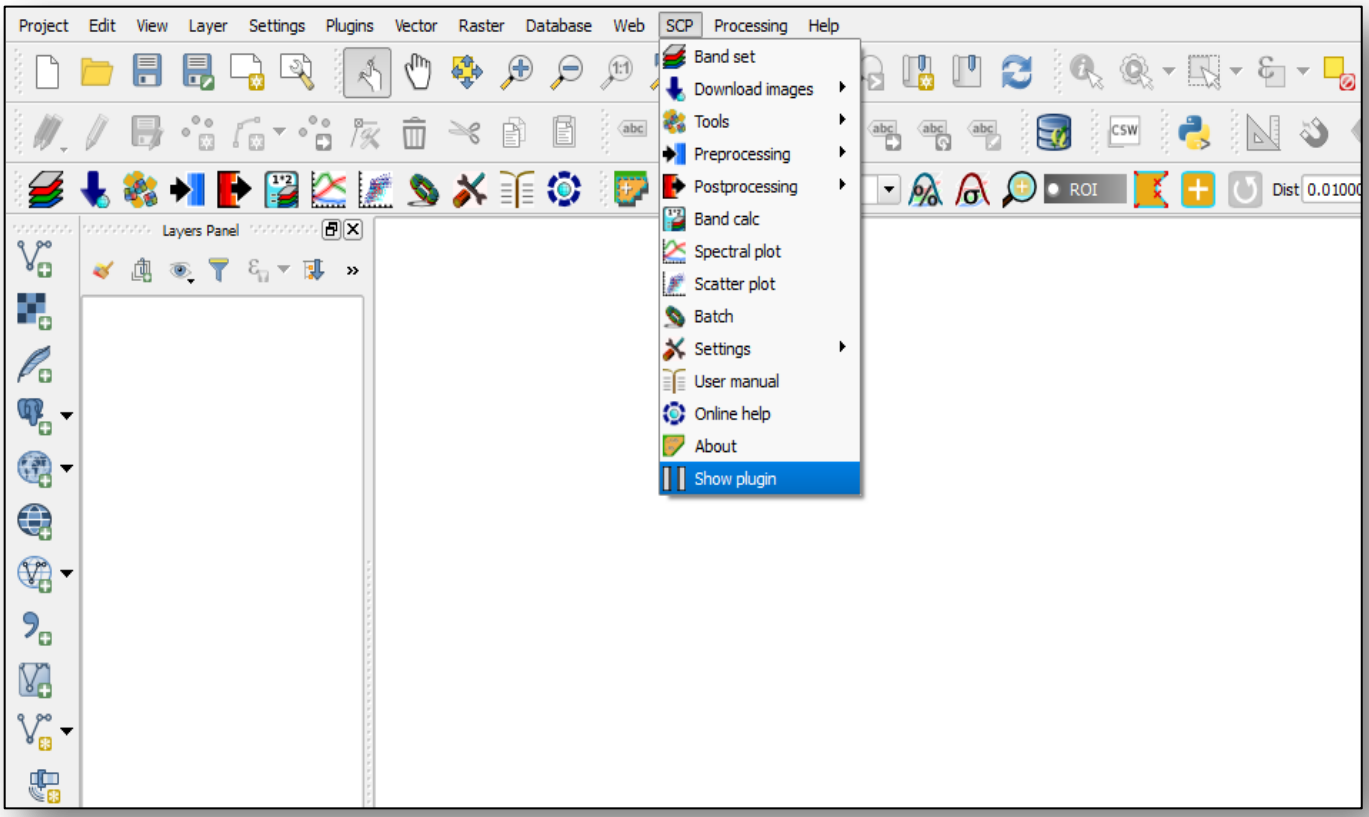
- To open Cross Tabulation tool, firstly install SCP. Go to Plugin and select Manage and Install Plugins.



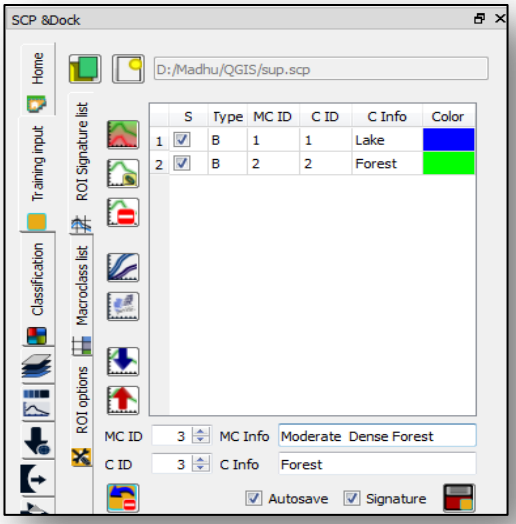
- In search option type SCP or Semi automatic classification and now select SCP Plugin.
- Go to install Plugin.



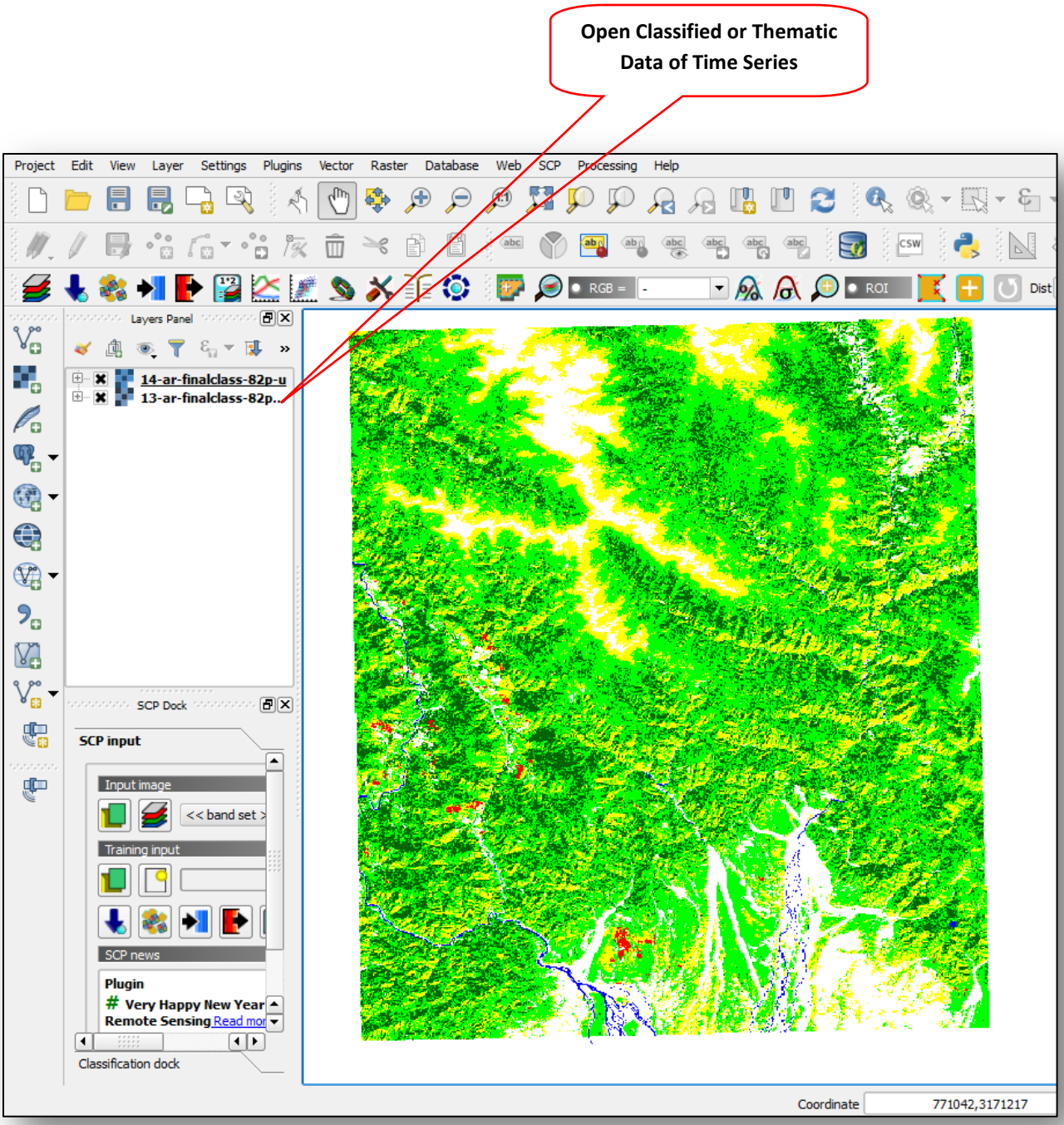
- Now the SCP tool is activated on the screen.
- To show the SCP Dock or Classification window > go to SCP > and select Show Plugin by going down the list of options.



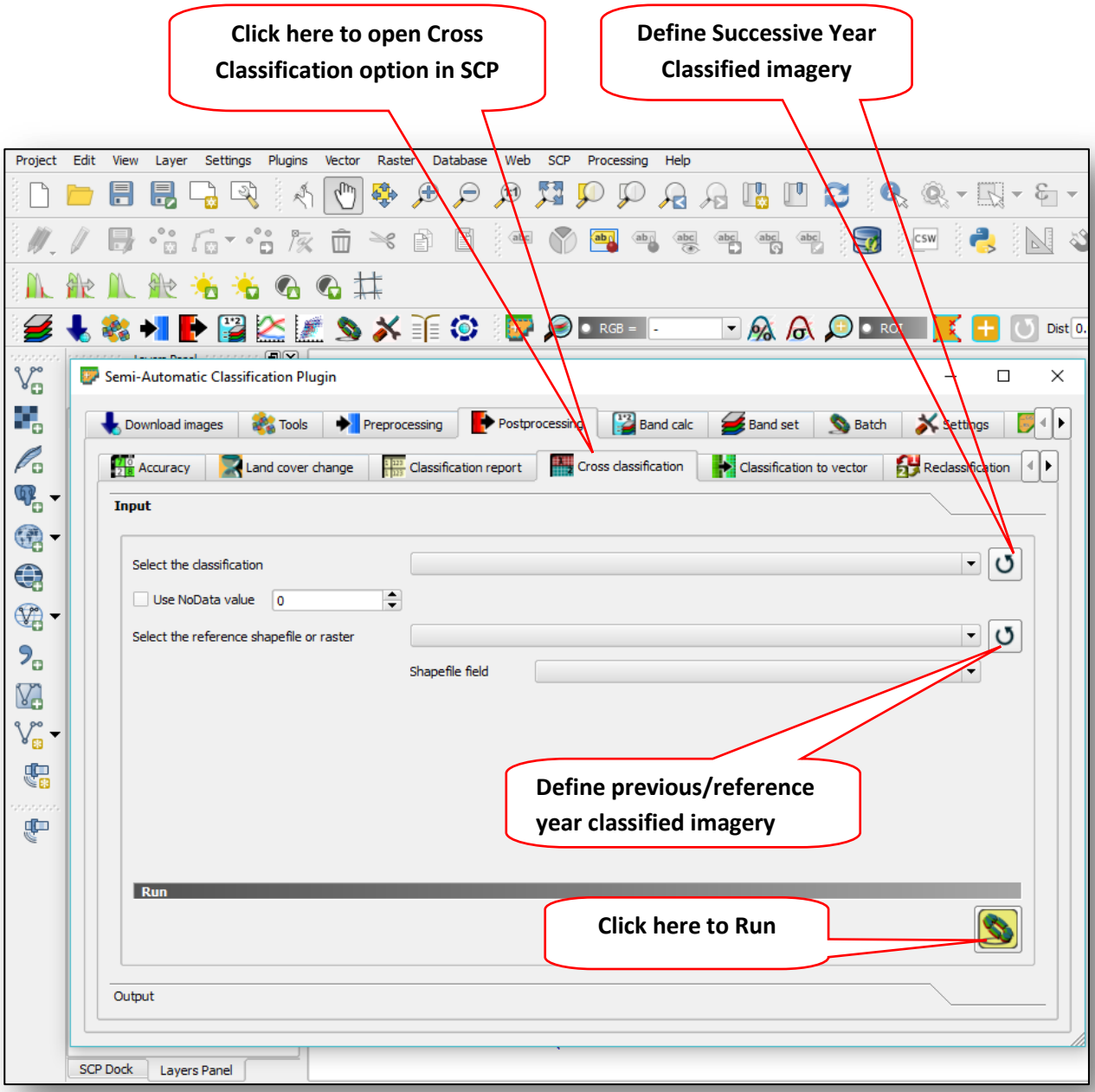
- SCP Dock window will appear on the Map canvas as showing in the Figure.



- Next, make sure to open time series images on the Map Canvas before running the change detection process.

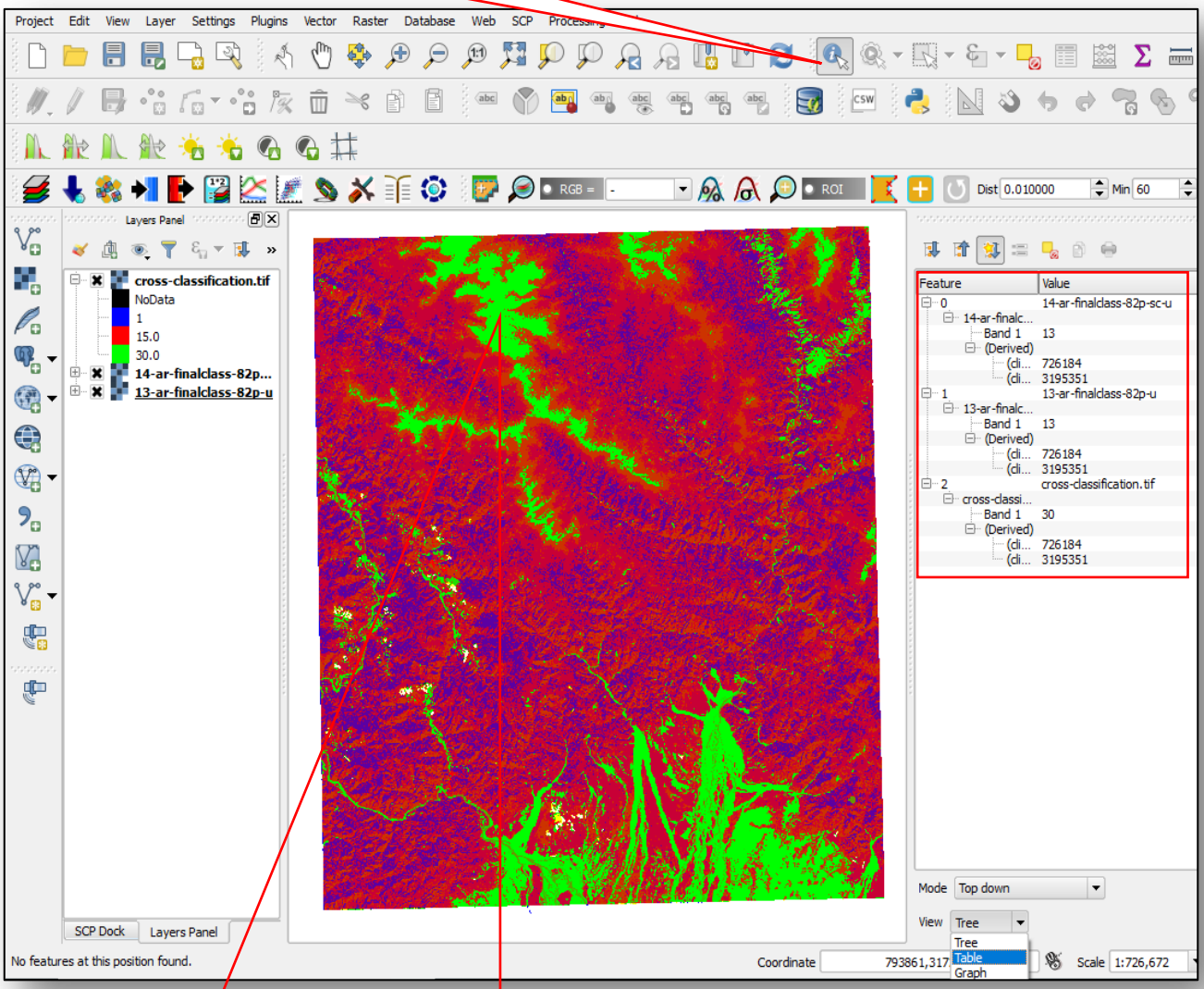


- In SCP Dock tool click Band Set Button by clicking on Icon.
- Go toCross Classification Tab under Postprocessing option in Semi-Automatic Classification Plugin.



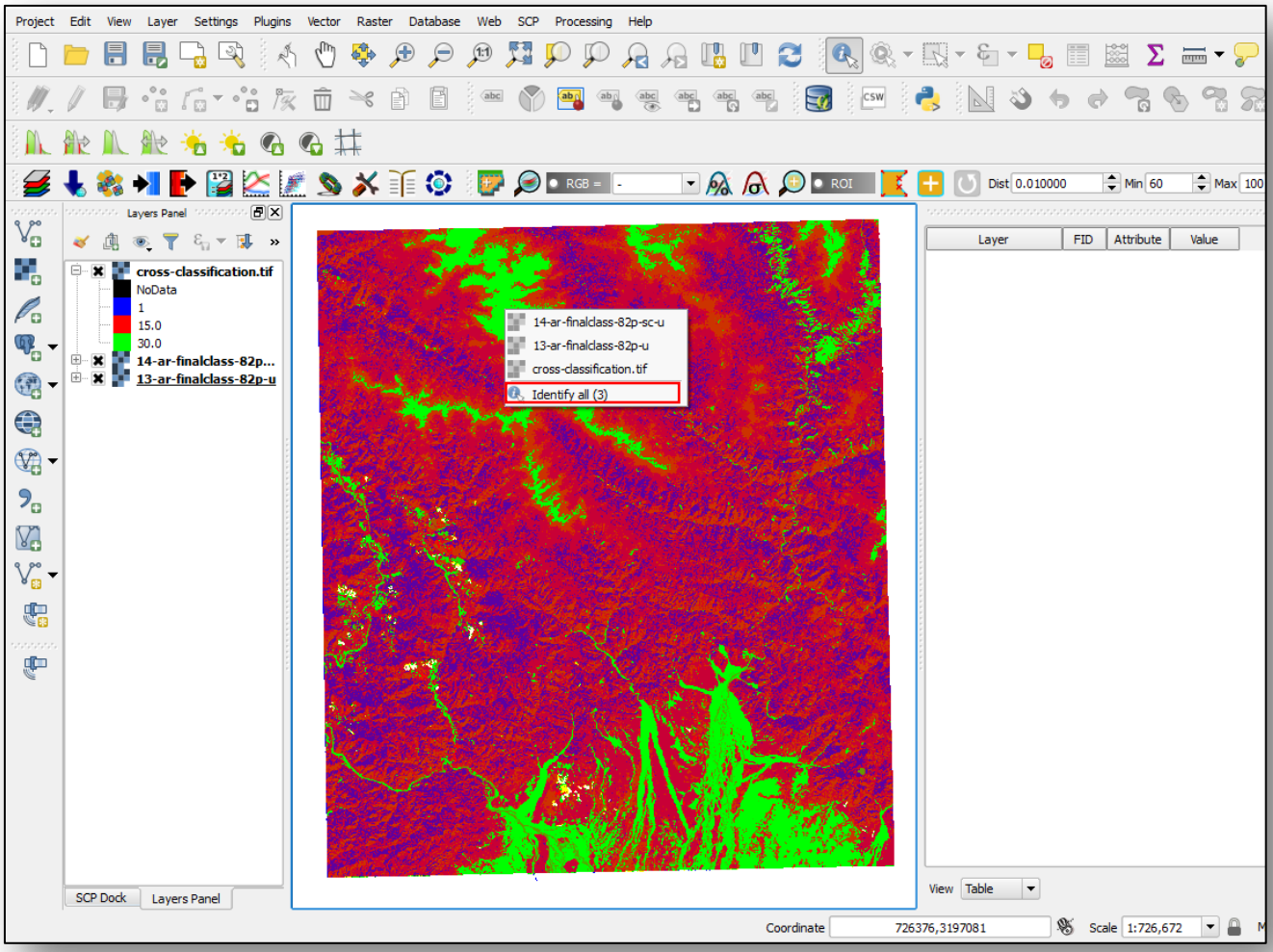
- After running the Cross Classification algorithm, Change file will appear on Map Canvas.
- Change file displays different change classes with different colors.
- Select Table option in Right down side of the window so that change attribute table can be visible.

Select Identity Feature to open the Feature Info in Right side of the window



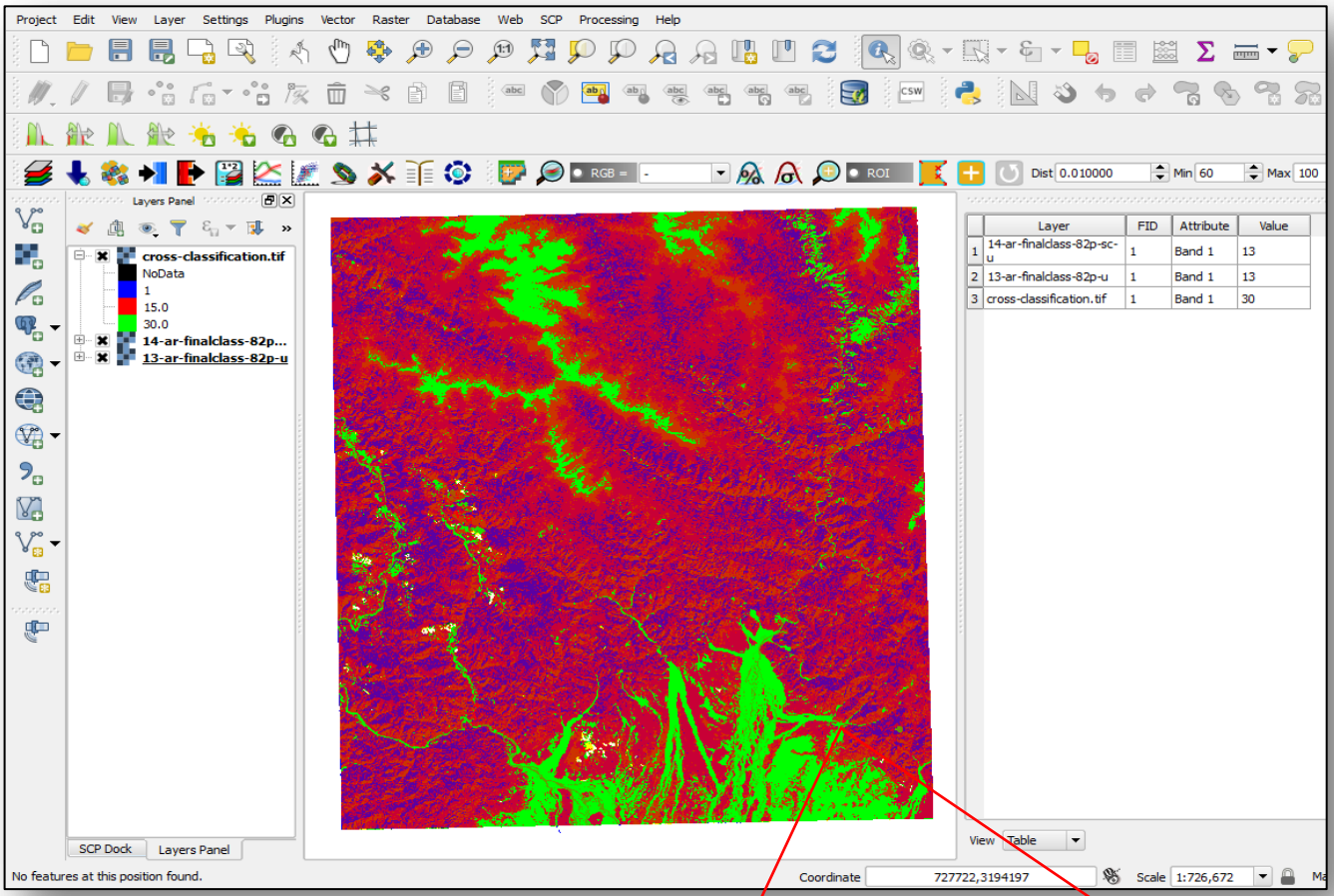
Class13 is Non Forest, as these areas showing Class 13 in both time series window, i.e no Change .

- Right click inside the Map Canvas on image and Select Identify all three.
- The moment we choose this option, attributal information about the previous (Reference) year cycle, successive year cycle and Change file (Cross Classification) will be open in right side of the Classification window.



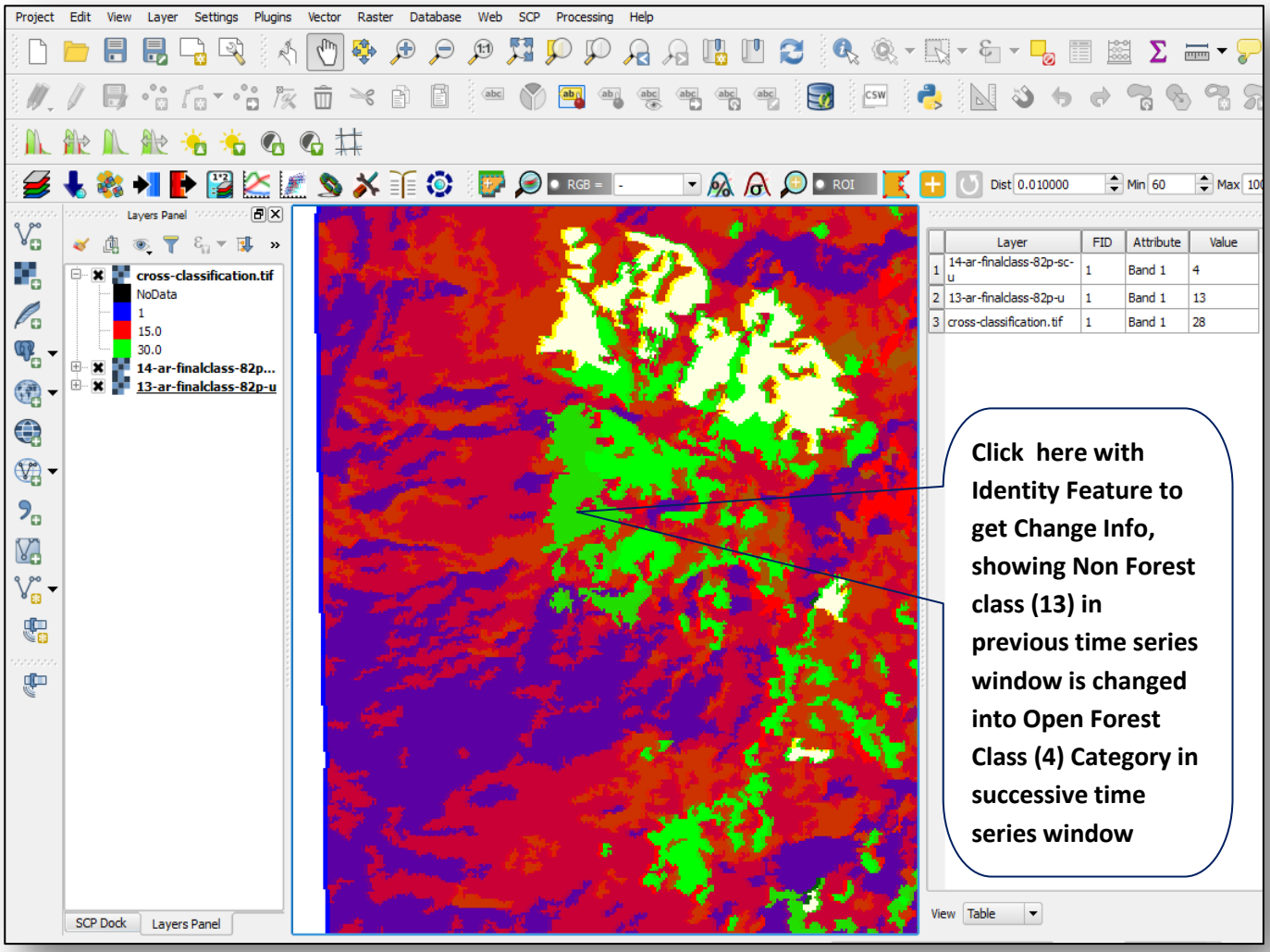
Note: Class2=VDF(Very Dense Forest), Class3=MDF (Moderate Dense Forest), Class4=OF (Open Forest), Class5=Scrub, Class12=Water, Class13=Non Forest

- In the given Figure, Right side of the Classification window is showing Class 13 in both time series file.
- Class 13 is denoted to NF (Non Foret) Class, i.e in previous cycle clicked area was in NF and still showing NF in fresh cycle, i.e. no change found in these areas.



The given patch is showing No Change in imagery, as Non Forest (13) Changed into NonForest Class (13)

- In this case, in attribute table, the selected Class is showing Non Forest (Class 13) in previous year cycle and Open Forest (Class 4) in successive year cycle, i.e the present Change Class is showing improvemnet of the Forest, as Change Class is showing the change of Non Forest class to Open Forest class.

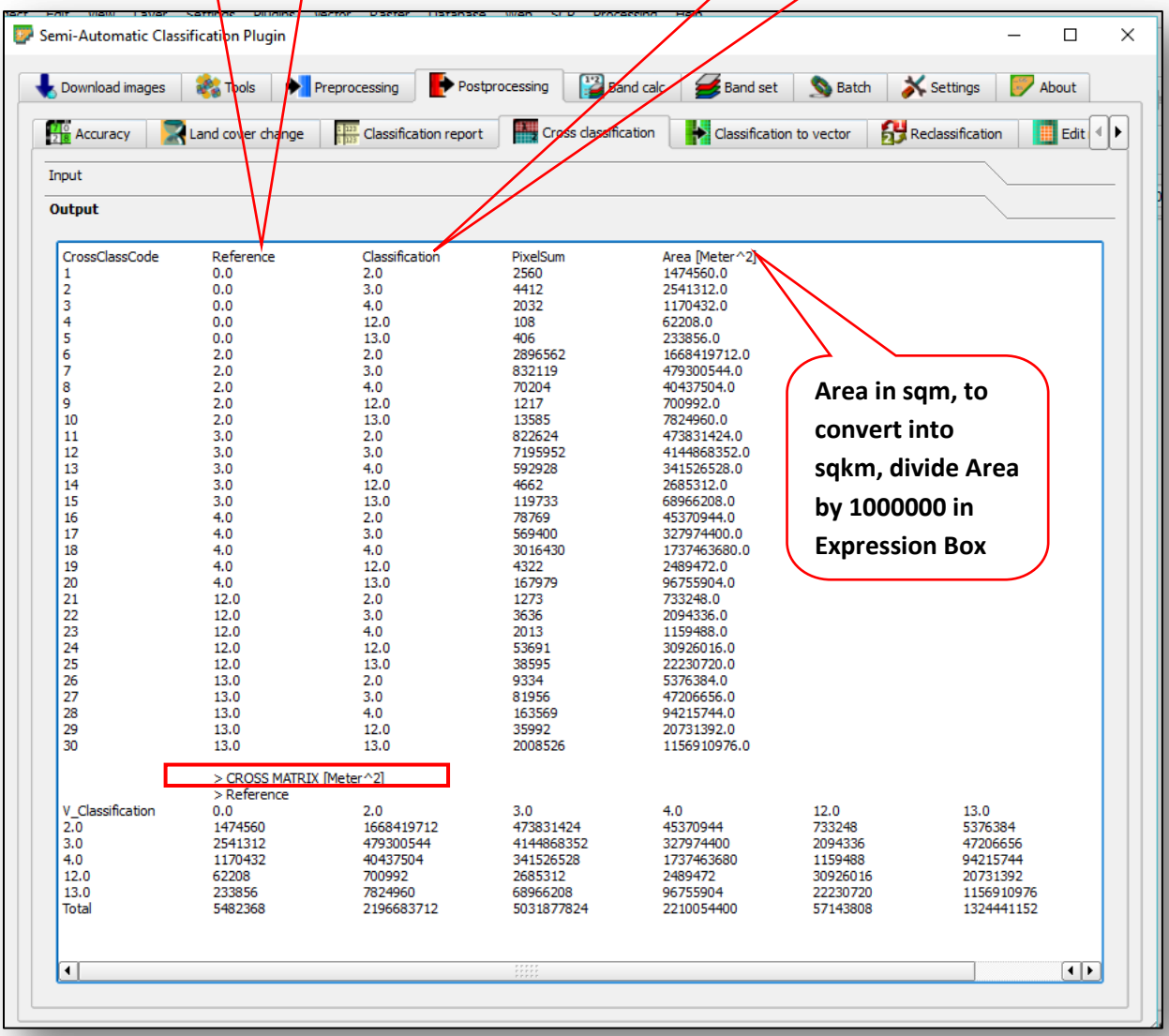


The given patch is showing Positive Change in imagery, as Non Forest (13) Changed into Open Forest Class(4)

5.2 Cross Classification Table

Previousy year classified Image from classes 2-13 as Forest & Non forest Classes

Successive year classified Image from classes 2-13 as Forest & Non forest Classes



CrossClassCode	Reference	Classification	PixelSum	Area [Meter^2]
1	0.0	2.0	2560	1474560.0
2	0.0	3.0	4412	2541312.0
3	0.0	4.0	2032	1170432.0
4	0.0	12.0	108	62208.0
5	0.0	13.0	406	233856.0
6	2.0	2.0	2896562	1668419712.0
7	2.0	3.0	832119	479300544.0
8	2.0	4.0	70204	40437504.0
9	2.0	12.0	1217	700992.0
10	2.0	13.0	13585	7824960.0
11	3.0	2.0	822624	473831424.0
12	3.0	3.0	7195952	4144868352.0
13	3.0	4.0	592928	341526528.0
14	3.0	12.0	4662	2685312.0
15	3.0	13.0	119733	68966208.0
16	4.0	2.0	78769	45370944.0
17	4.0	3.0	569400	327974400.0
18	4.0	4.0	3016430	1737463680.0
19	4.0	12.0	4322	2489472.0
20	4.0	13.0	167979	96755904.0
21	12.0	2.0	1273	733248.0
22	12.0	3.0	3636	2094336.0
23	12.0	4.0	2013	1159488.0
24	12.0	12.0	53691	30926016.0
25	12.0	13.0	38595	22230720.0
26	13.0	2.0	9334	5376384.0
27	13.0	3.0	81956	47206656.0
28	13.0	4.0	163569	94215744.0
29	13.0	12.0	35992	20731392.0
30	13.0	13.0	2008526	1156910976.0

> CROSS MATRIX [Meter^2]
> Reference

V_Classification	0.0	2.0	3.0	4.0	12.0	13.0
2.0	1474560	1668419712	473831424	45370944	733248	5376384
3.0	2541312	479300544	4144868352	327974400	2094336	47206656
4.0	1170432	40437504	341526528	1737463680	1159488	94215744
12.0	62208	700992	2685312	2489472	30926016	20731392
13.0	233856	7824960	68966208	96755904	22230720	1156910976
Total	5482368	2196683712	5031877824	2210054400	57143808	1324441152

Area in sqm, to convert into sqkm, divide Area by 1000000 in Expression Box

Chapter 6: Working with Vector Data

QGIS supports vector data in a number of formats, including shapefiles, MapInfo (mif), Delimited Text (CSV), KMZ, MapInfo (TAB), AutoCAD (dxf) files and PostGIS layers in a PostgreSQL database.

Vector data is a coordinate-based data structure commonly used to represent point, linear and enclosed map features. Each linear feature is represented as x, y coordinates. Attributes stored in a database are associated with the features. Vector data includes:

1. Point features (Temple, Monuments, Forest Chowkies, Forest Fire Point, etc.)
2. Line features (Roads, Railways, Fences, Cart-tracks, Pack-Tracks, etc.)
3. Polygon features (Land Parcels, Wetlands, Forests, etc.)

QGIS supports easy-to-navigate cartography and mapping functionalities.With the vector drawing and editing functionalities, users can create, edit geospatial data, as already mentioned in Map Composition Chapter.

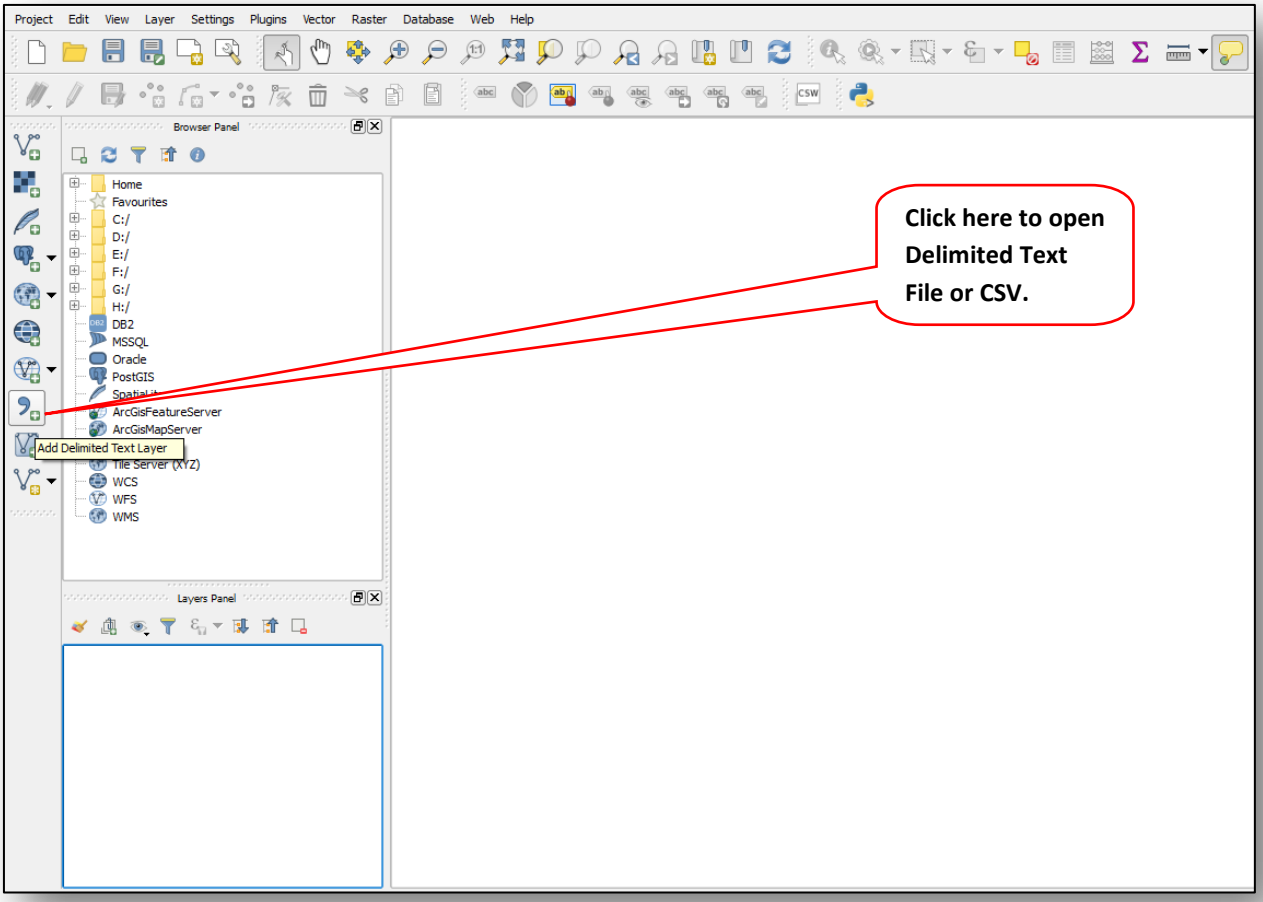
Furthermore, it provides the ability to perform an action based on the attributes of a feature. This can be used to perform any number of actions by working with Query Builder function. We can run an external application or view a web page based on one or more values in your vector layer.

In a Nutshell, QGIS run advanced spatial analysis methods through Query Builder, convert Excel table to GIS format, generate Heat Map/ Hot Spot areas and access data through Web Map Services (WMS) and Web Feature Services (WFS) and utilized best out of technology.

6.1 Convert Comma Separated Values (CSV) file to GIS Platform (Shapefile)

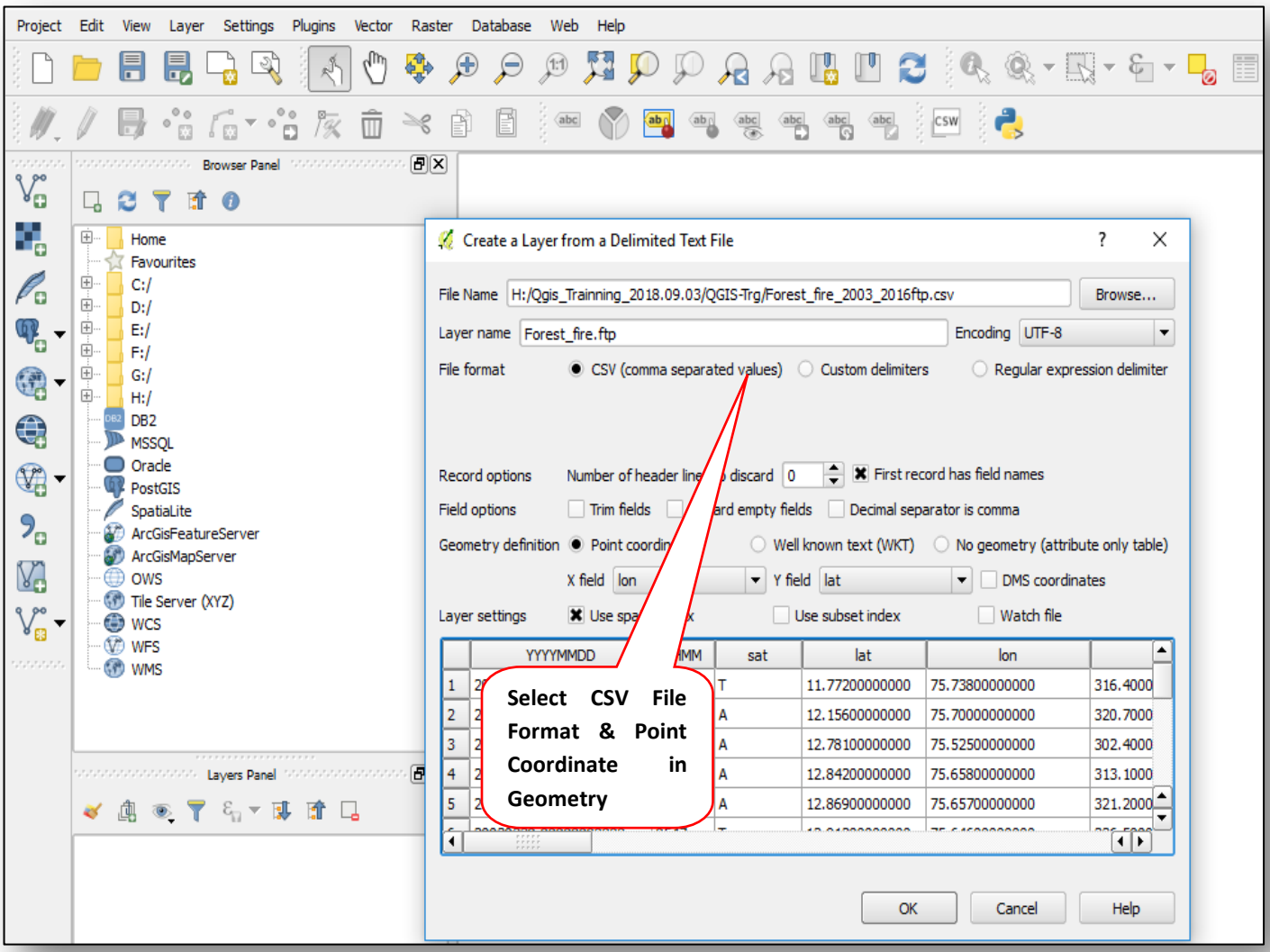
- To generate heat map we will use the forest fire point (CSV format) of Uttarakhand / Dehradun for the period of last 12 years.

- To import the CSV file into QGIS, first save the file as a text file in which at least 2 columns should contain the X and Y coordinates. Save file by SaveAs function in your program to save it as a Delimited File or a Comma Separated Values (CSV) file.



- Go to Layer > Add Layer > and select Add Delimited Text File or directly go to Add Delimited Text File Icon .

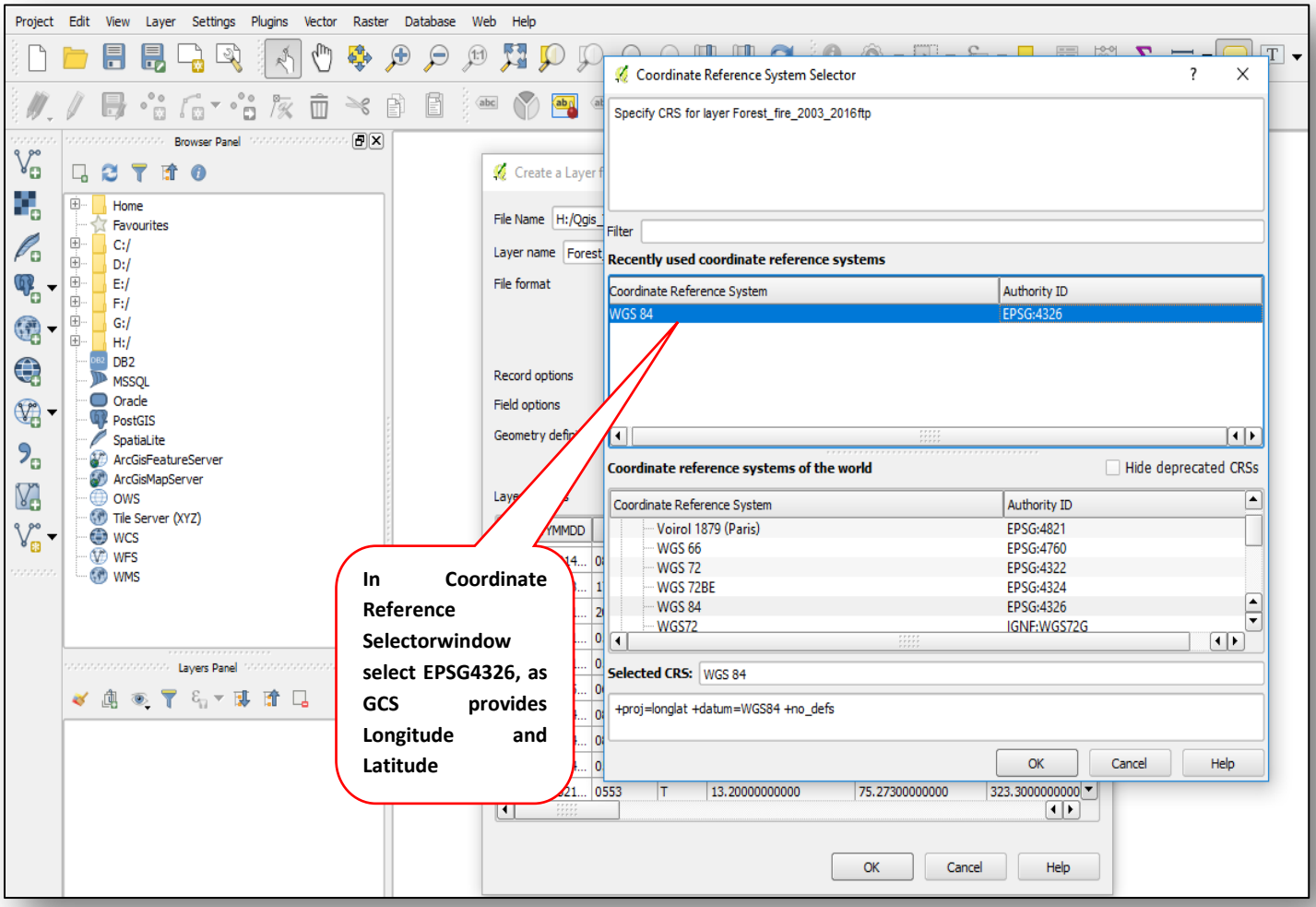
- Next, create a layer from a Delimited Text File dialog box > click on Browse > and specify the path to the text file you downloaded. In the File format section, select CSV (Comma separated values) Tab.
- Make sure to check first record has field names that will show the label fields, otherwise CSV file will open without field name.



- Ensure to check the Use spatial index option as that will speed up the operations on this layer. In the Geometry definition section it will be auto-populated as suitable X (Longitude) and Y (Latitude) coordinate fields.

- Click OK.

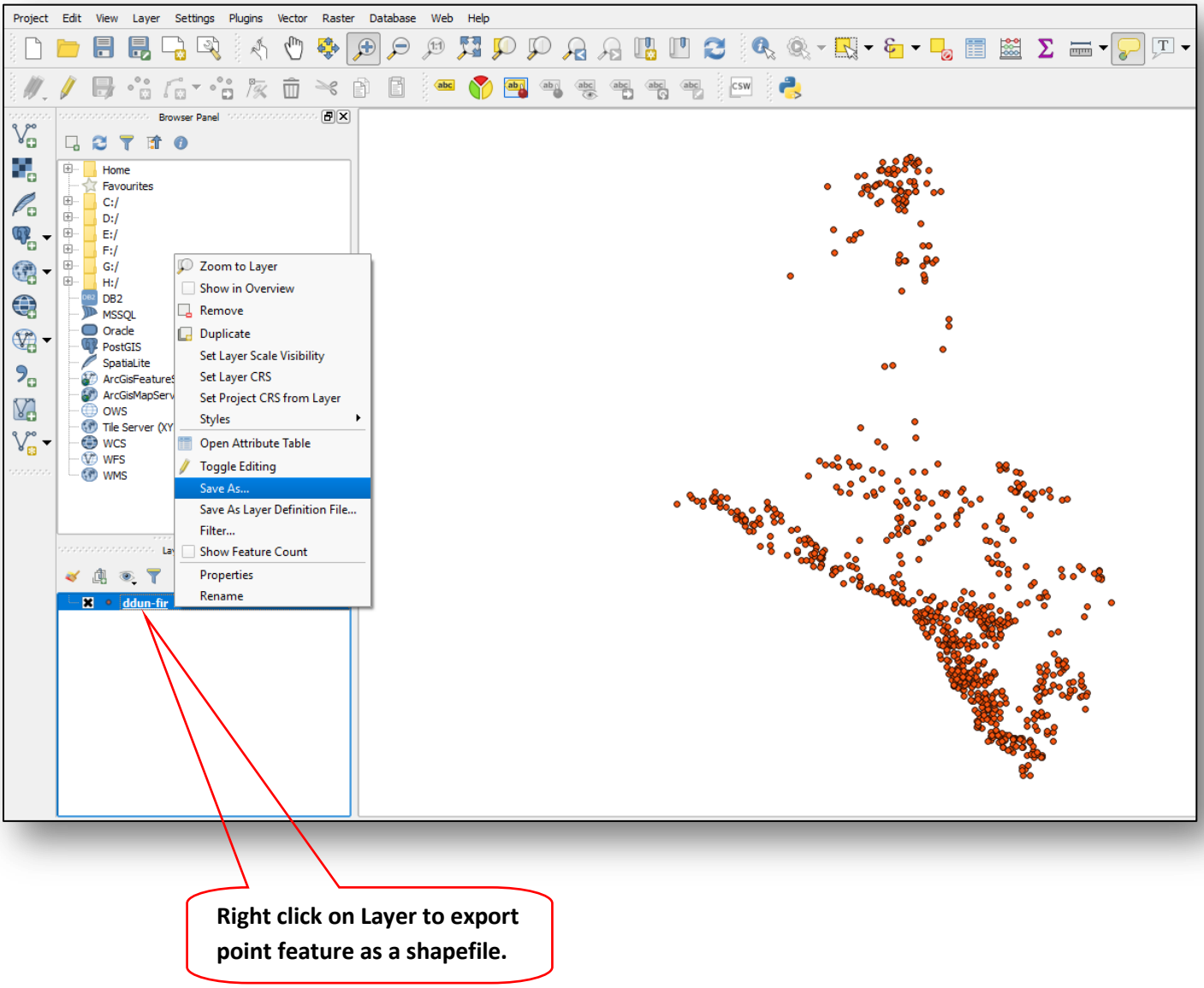
- In the Coordinate Reference Selector window, select a coordinate reference system as CRS EPSG:4326. Since the forest fire coordinates are in latitudes and longitudes, so should select WGS 84.



- Click OK.
- As the data layer is loaded in QGIS > Right click on imported CSV file in Legend Bar > and go to save as shapefile option.

Note: Latitude specifies the north-south position of a point and hence it is a Y coordinate. Similarly Longitude specifies the east-west position of a point and it is a X coordinate, but generally it creates confusion.

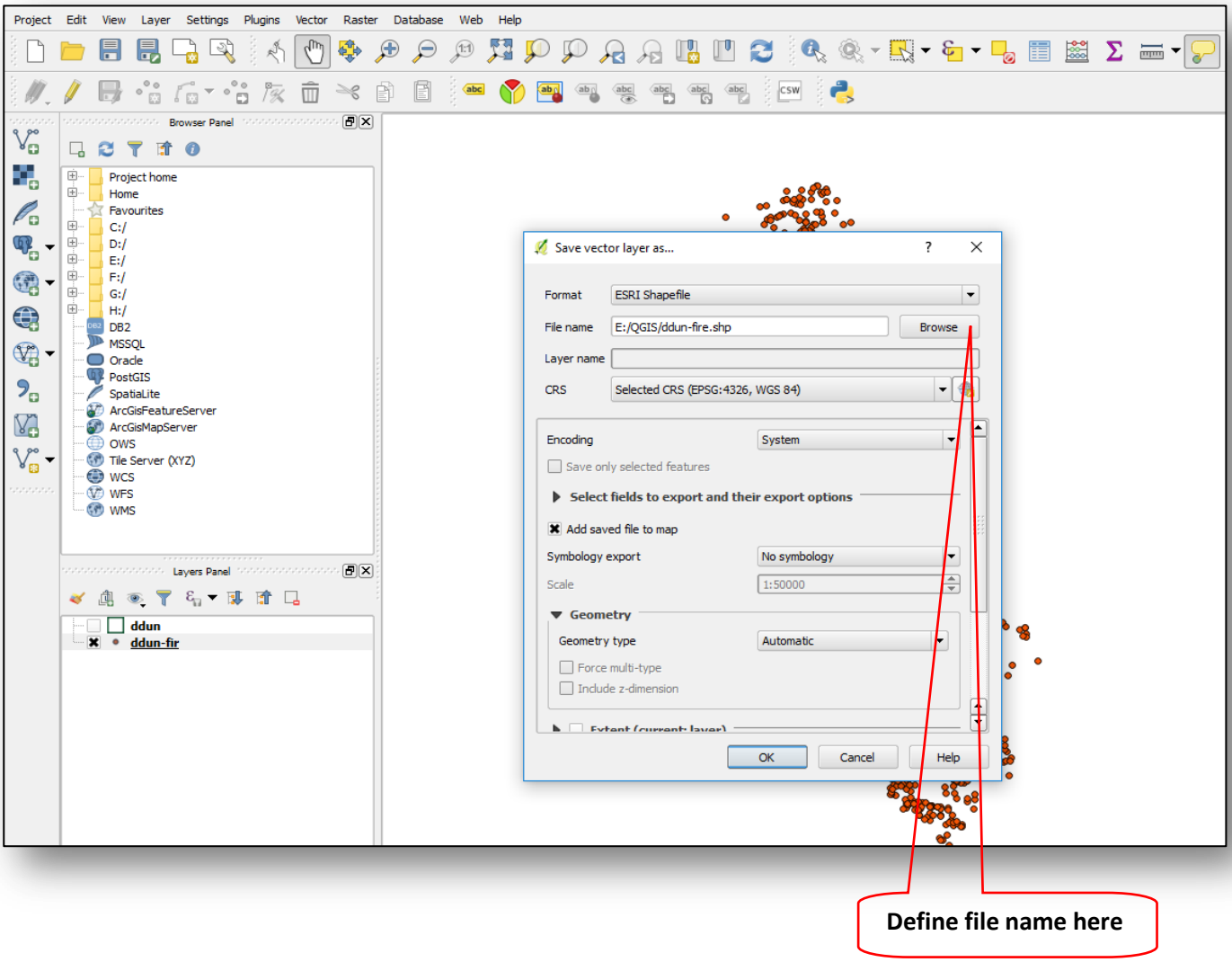
- As the CSV file has to be converted/ exported to shapefile, Right Click on forest fire points (opened CSV file) > go to Save as > and save the CSV file as Shapefile .



- Click ok.

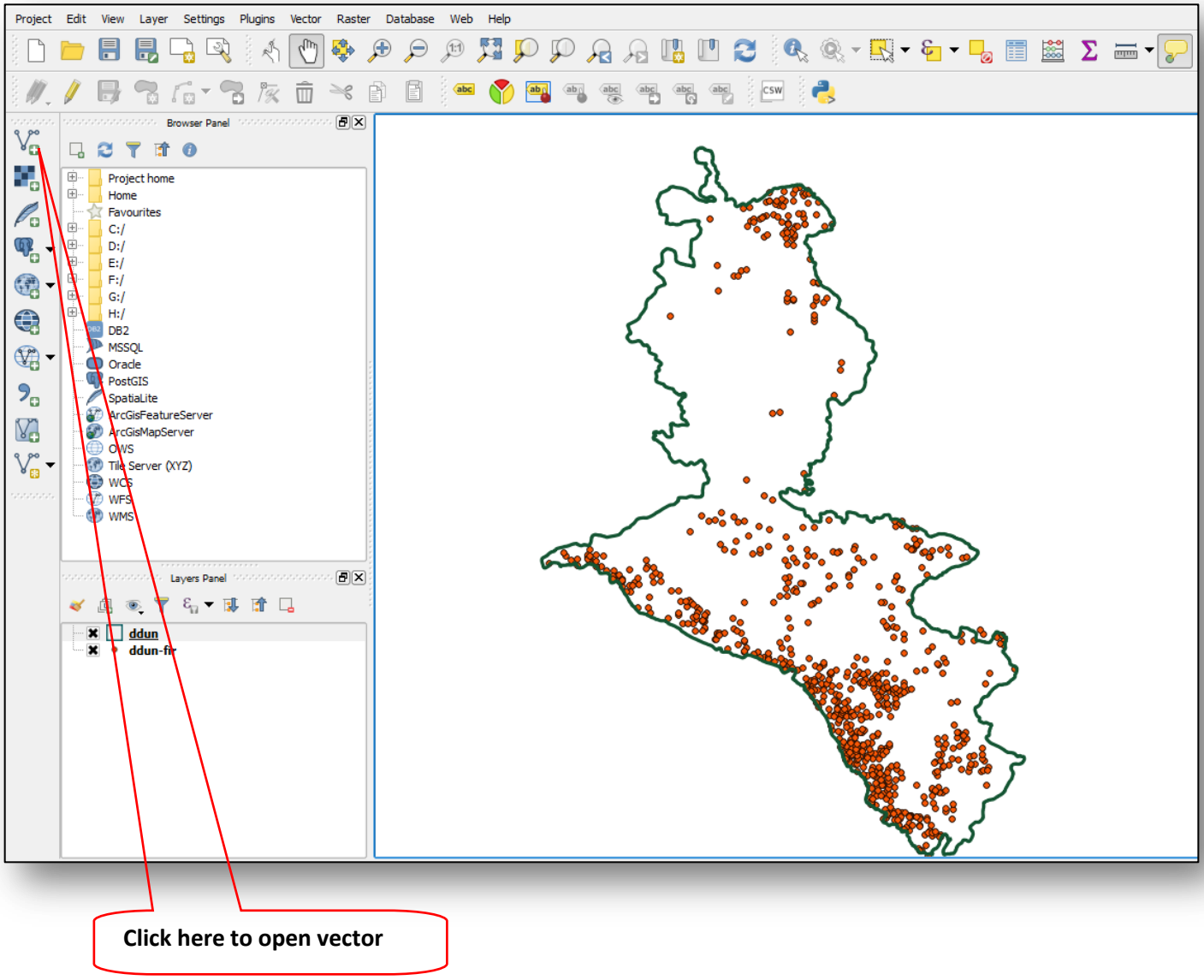
- Next, for saving the file in format Tab select ESRI Shapefile and specify path to save the file through Browse Tab.

- Now select the coordinate reference system as CRS EPSG:4326.



- Check add saved file to map > click ok .

- It will automatically opened Forest Fire point in Map Canvas, with the highly concentrated, dense forest fire point of Dehradun, Uttarakhand.
- In this case, as these are the reported fire points for the period of last 12 years and hence the data is highly dense, it is not suitable for analysis and to locate the vulnerable areas. So to overcome this, we can generate heat map for further analysis.



- To overlay district boundary on forest fire points, go to open vector tool > Browse for the shapefile to open > click Apply > OK.

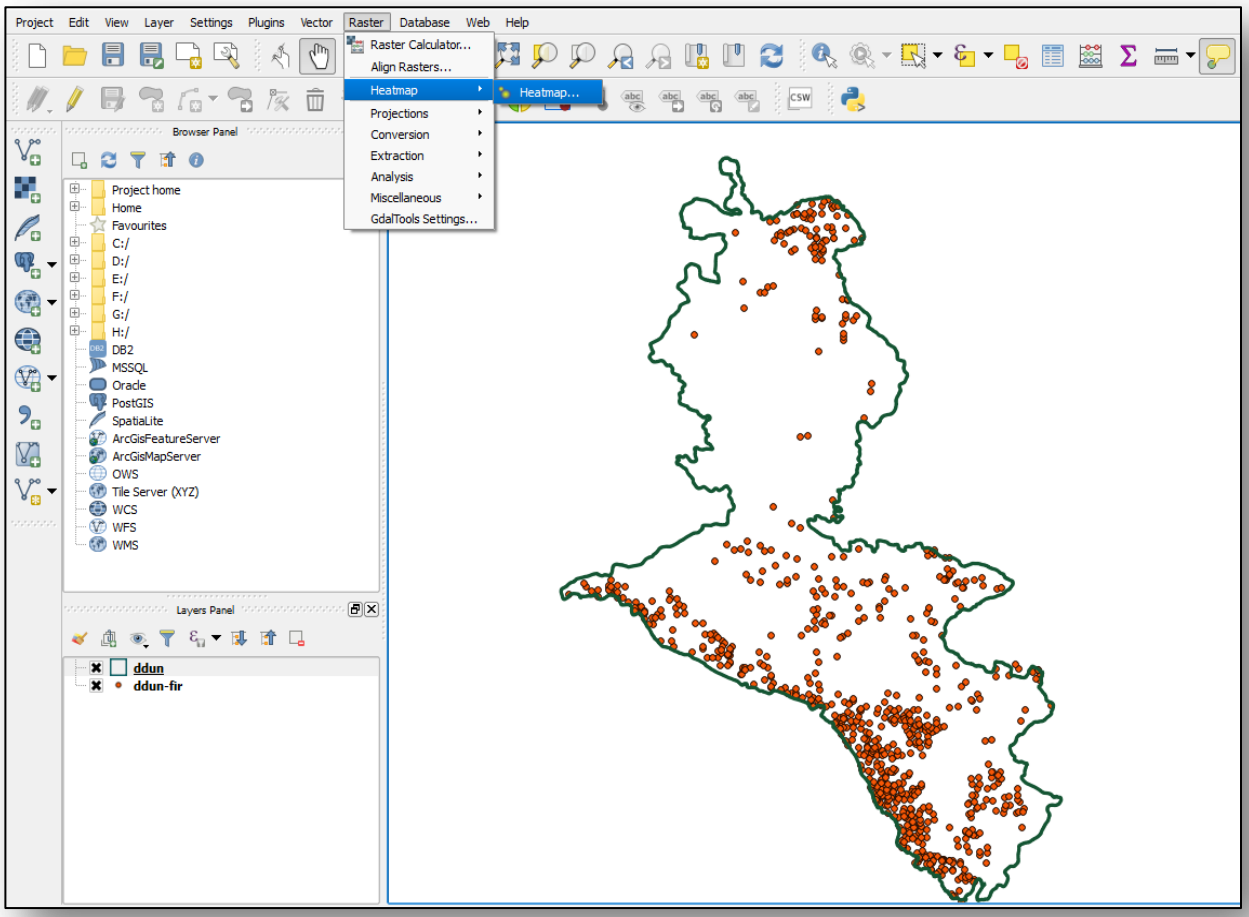
Chapter7: Forest Fire prone/Density Map using Heat Map Plugin

7.1 What is Heat Map??

The term "heat" in GIS term is referred as a high concentration of geographical objects in a particular place. Heat map plugin in QGIS is used for creating heat map or density map by using a kernel density estimating algorithm. The algorithm creates raster file from the point files (vector). The density is calculated based on the number of points in a location, with larger number of clustered points resulting in larger values. Heatmaps can be viewed as the surfaces of densities and illustrates the location of concentration of points or linear objects (Mitchell, 2000).

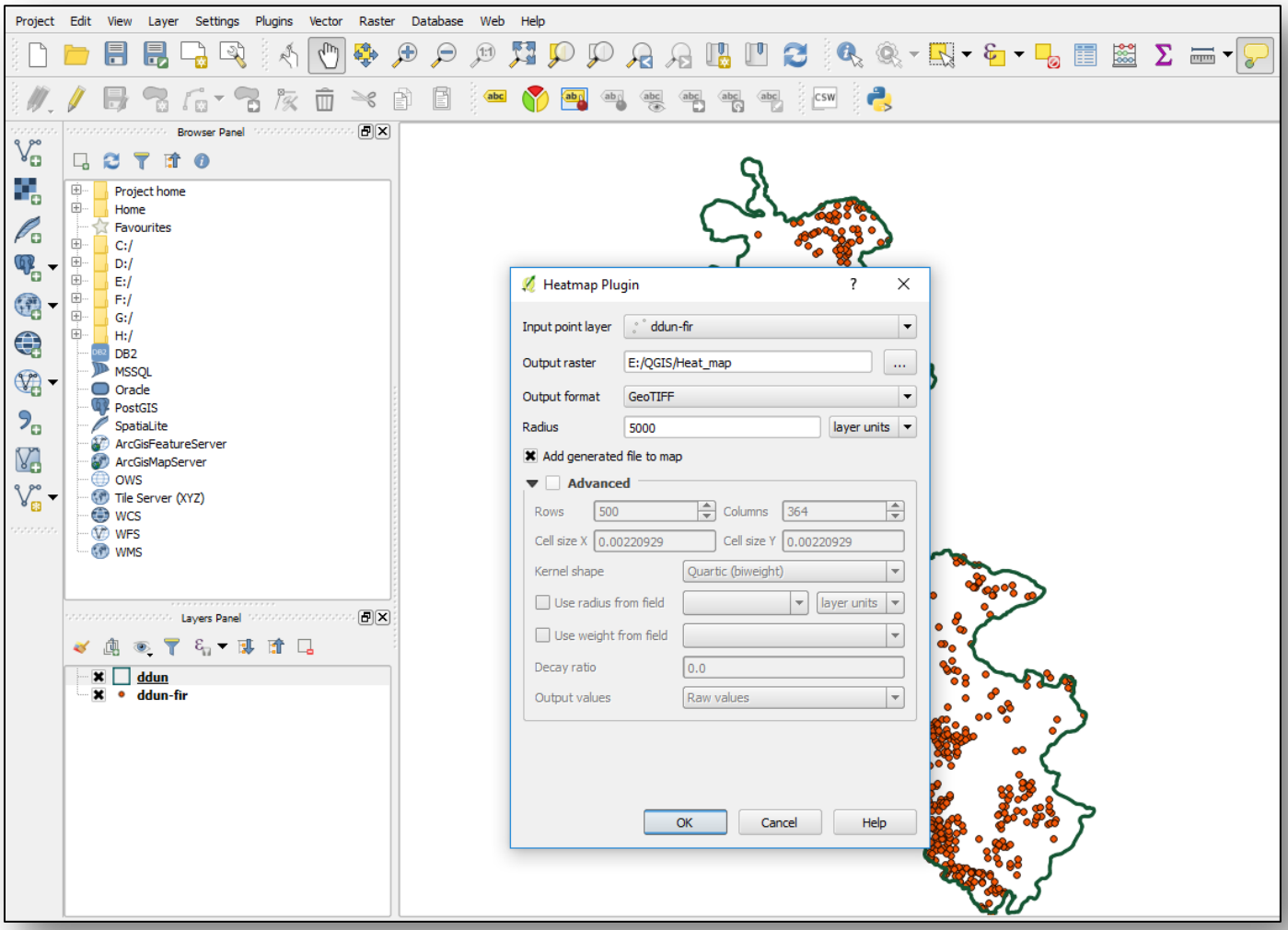
- To activate the Heatmap plugin, first the plugin needs to be activated using the Plugin Manager. After activation, the heatmap icon can be found in the Raster Toolbar.

- Go to Raster and select Heatmap menu. If the Raster toolbar is not visible then select the menu View, Toolbars and select Raster to show the Raster Toolbar.



- Select the Heatmap tool button to open the Heatmap dialog. In the Input point layer field, select exported shapefile of forest fire points.

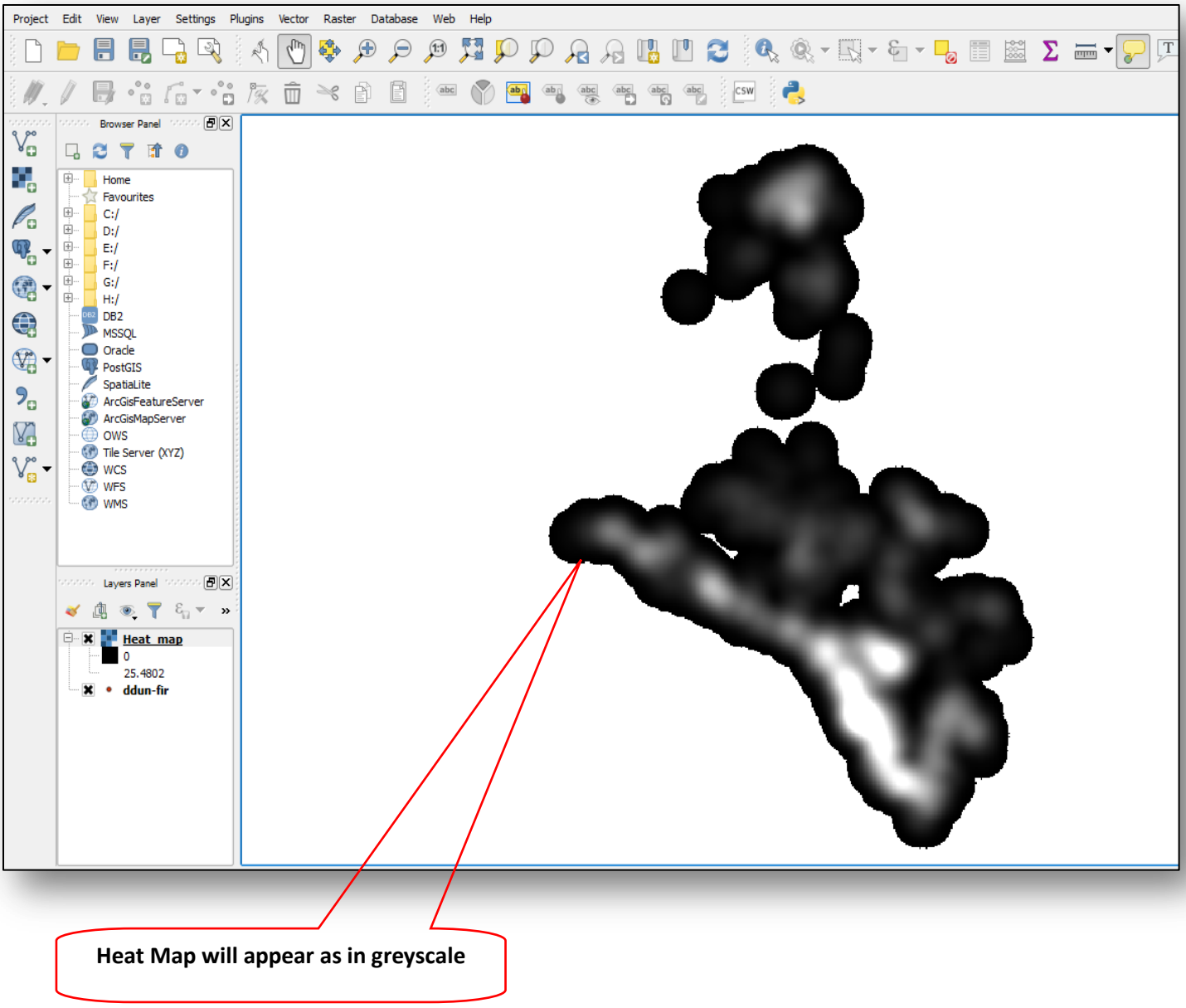
- Specify an output filename by clicking the button next to the Output raster field > Enter the filename heatmap > and leave the Output format as the default format, ie. GeoTIFF > change the Radius to 1000 meters > Click on OK to create and load the forest fire heatmap.



- To create a heatmap by interpolation of discrete points that leads to the creation of a surface. For this process it is necessary to define the following three main criteria:

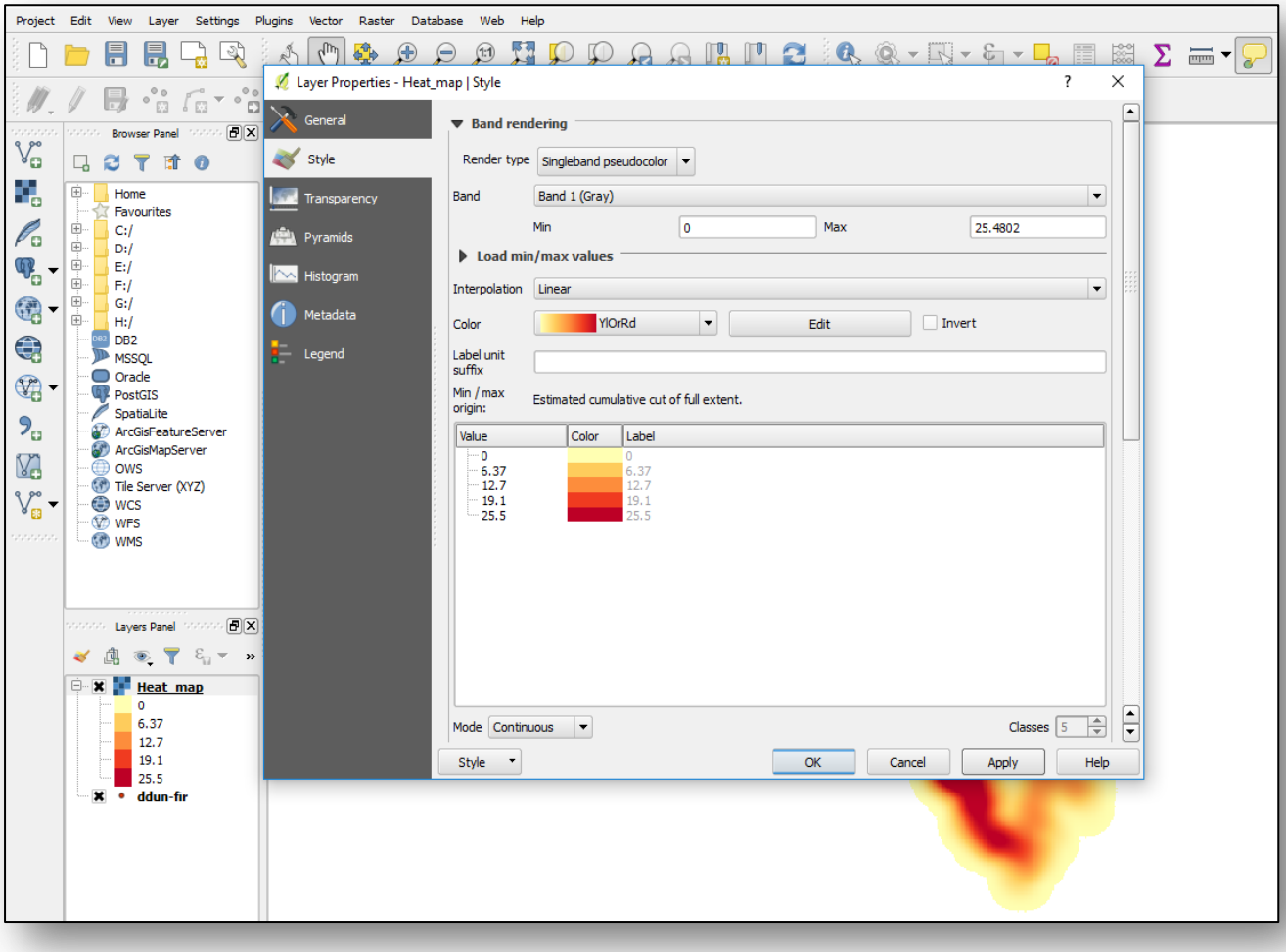
- The size of the cell in the raster layout (determines the level of precision of the constructed surface);
- The search radius around each cell (determines the coefficient of density); the type of calculations (which is used in the interpolation of surface density) (Gis lounge, 2017).

- QGIS will generate the heatmap and add the results to map window. The heatmap is shaded in greyscale, by default. In the given Figure, the lighter areas showing higher concentrations of forest fire points, whereas darker areas showing low concentration of forest fire points.



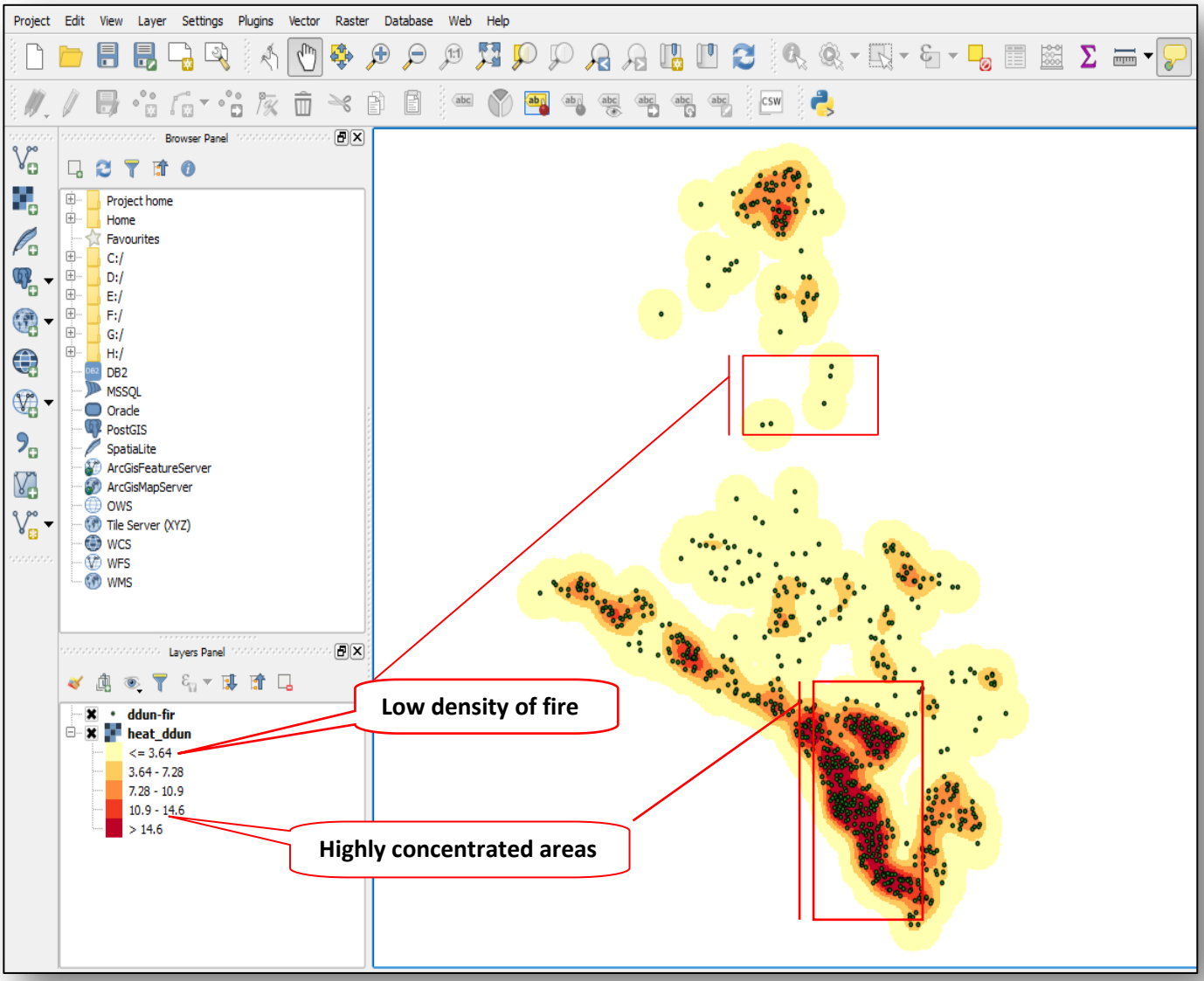
The heatmap can now be styled with different shades of colors to improve its appearance.

- In the Layers Pane > right click on Heat Map file > and select Properties > or double click on file > directly go to Layer properties > click on Style on the left hand side. Change the single band pseudocolor in Render type tab and in Interpolation option select Linear and now select a suitable color ramp , i.e. choosen YlOrRed in min. max. value setting.



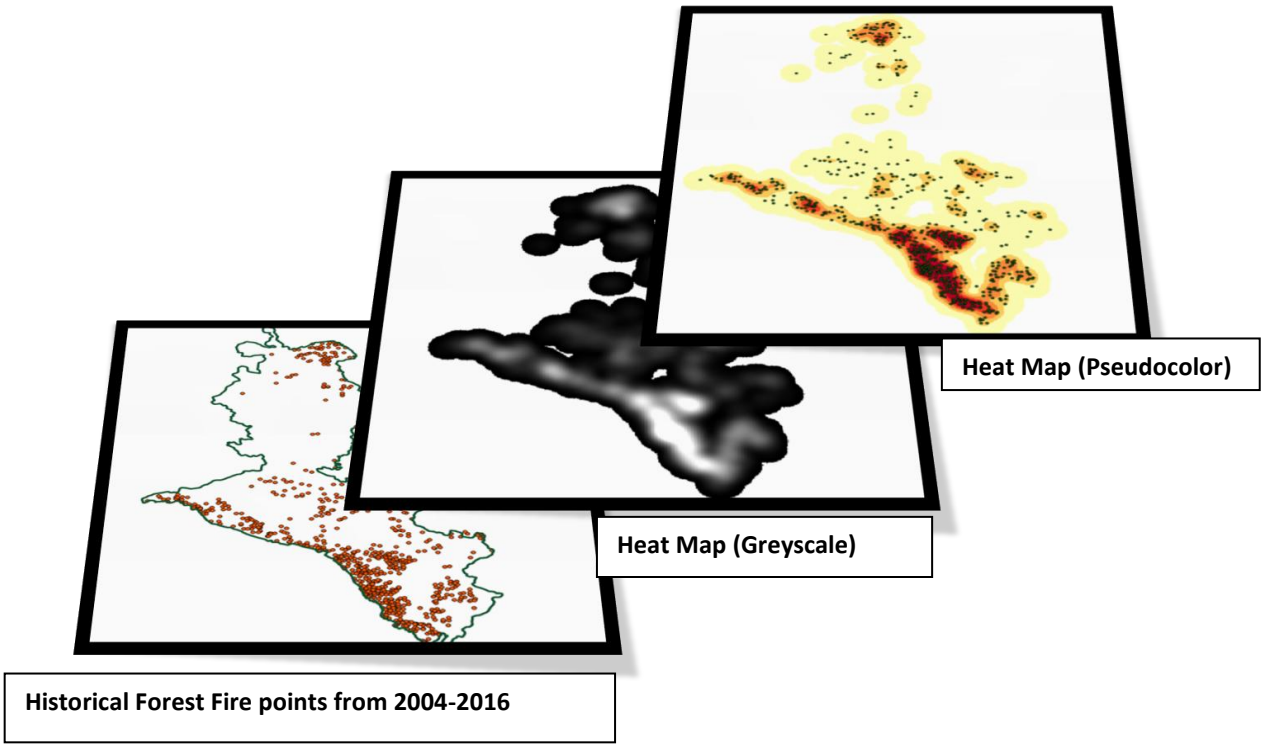
- Click classify button and press OK.

- Now, after styling the heatmap, it will be styled with different shades of colors as showing in the Figure.



- The final result is already shown in Figure, where 3.64 is the minimum threshold, i.e. low density of fire points and 14.6 & above showing higher concentration (density) of forest fire points.

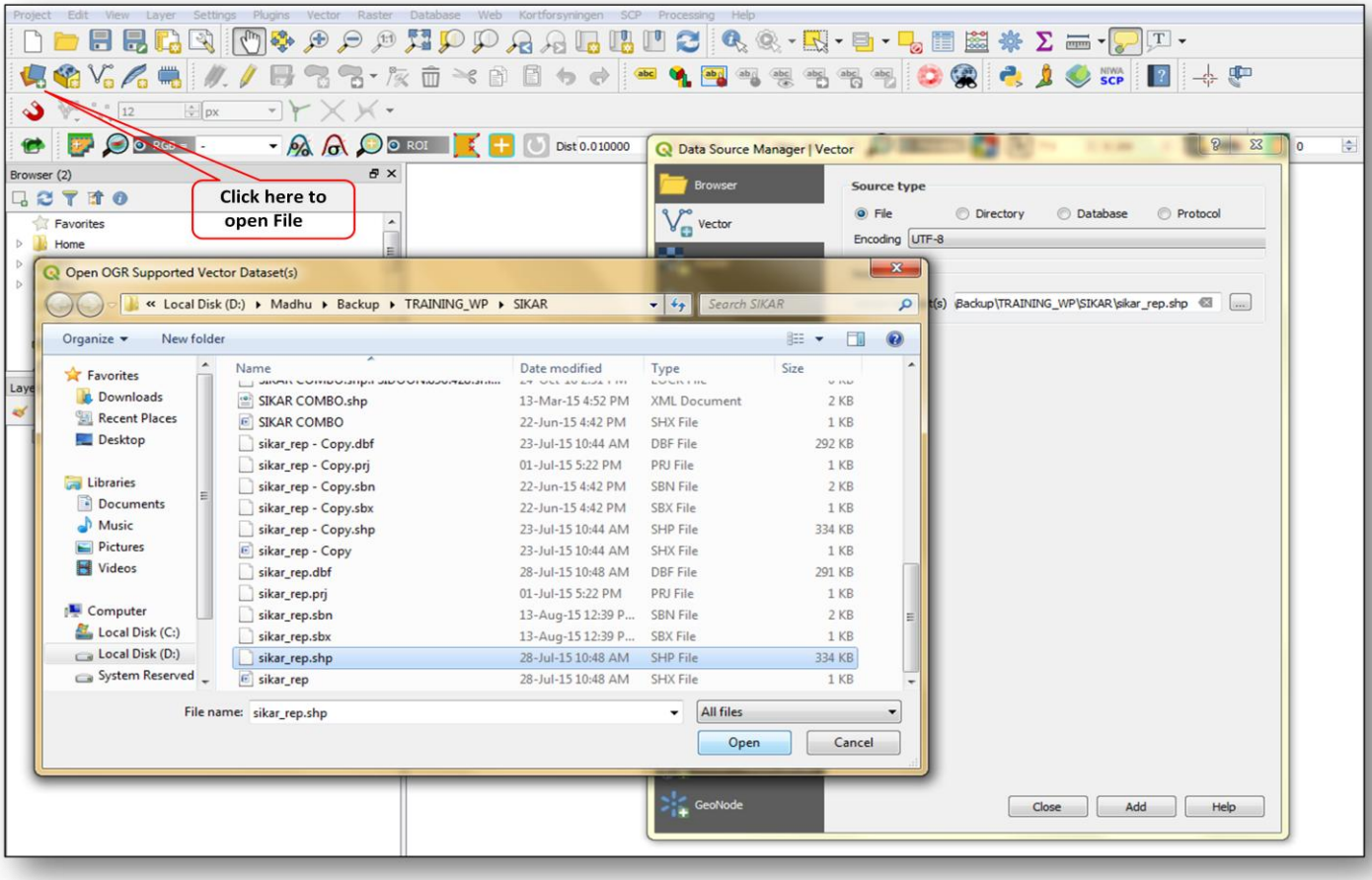
Final product produced by Heat Map



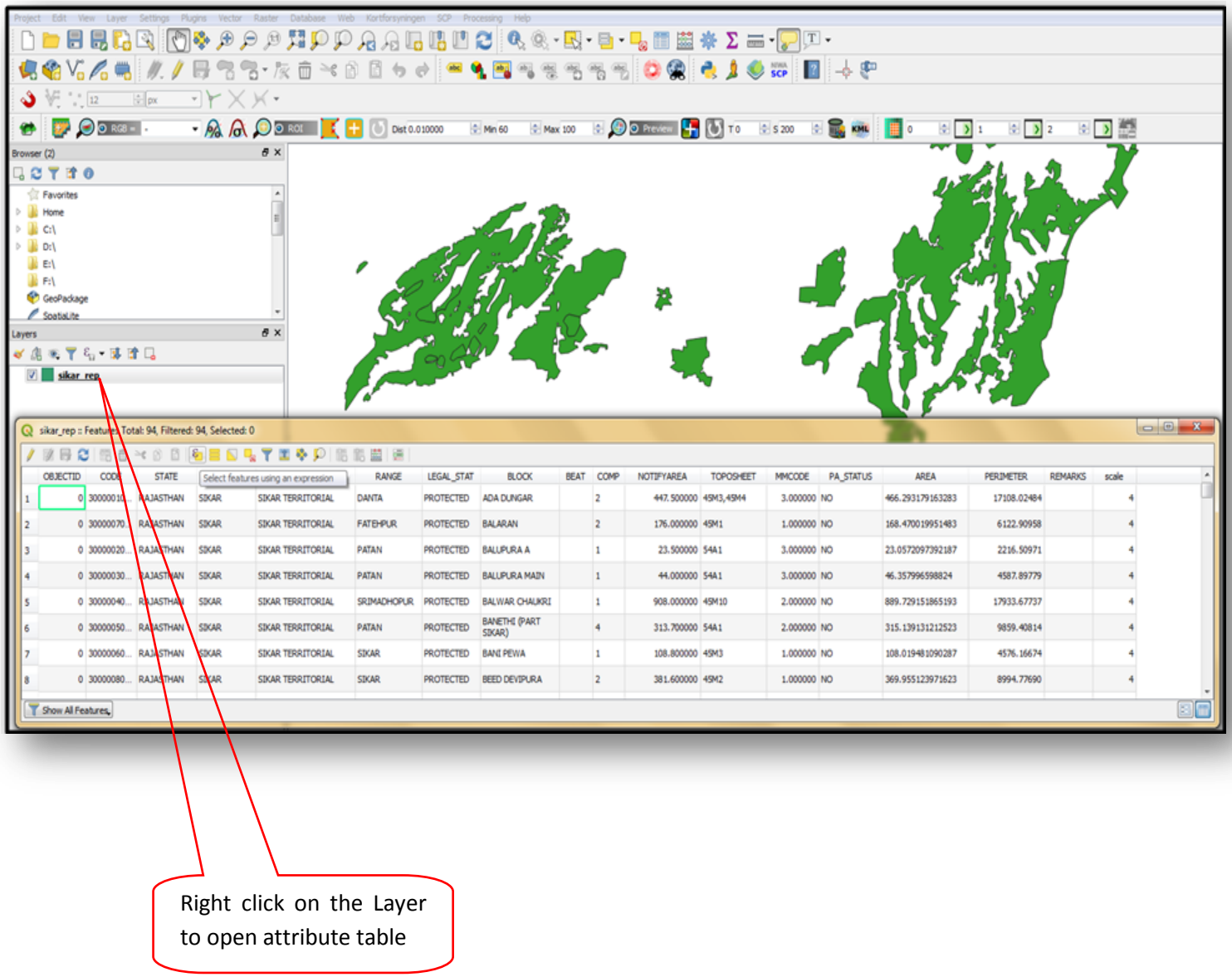
Chapter 8: Query builder in QGIS

Query builder allows to define an expression to create a subset of the data or table by using a SQL-like WHERE clause and to display the desirable result. When working with Query builder, we can delete certain features, extract objects or feature as per area of interest and can run query on a subset of features from a layer. Therefore, select a large number of features easily and can save processing time.

- Open the vector file by Clicking on Open Vector file Icon > and Browse for the file to open > Click Open > and Add option.



- The vector/shapefile will appear on the Map Canvas as shown in Figure, provided with the information about District, Division, Block, Beat, Compartment, Legal Status of forests in government records.

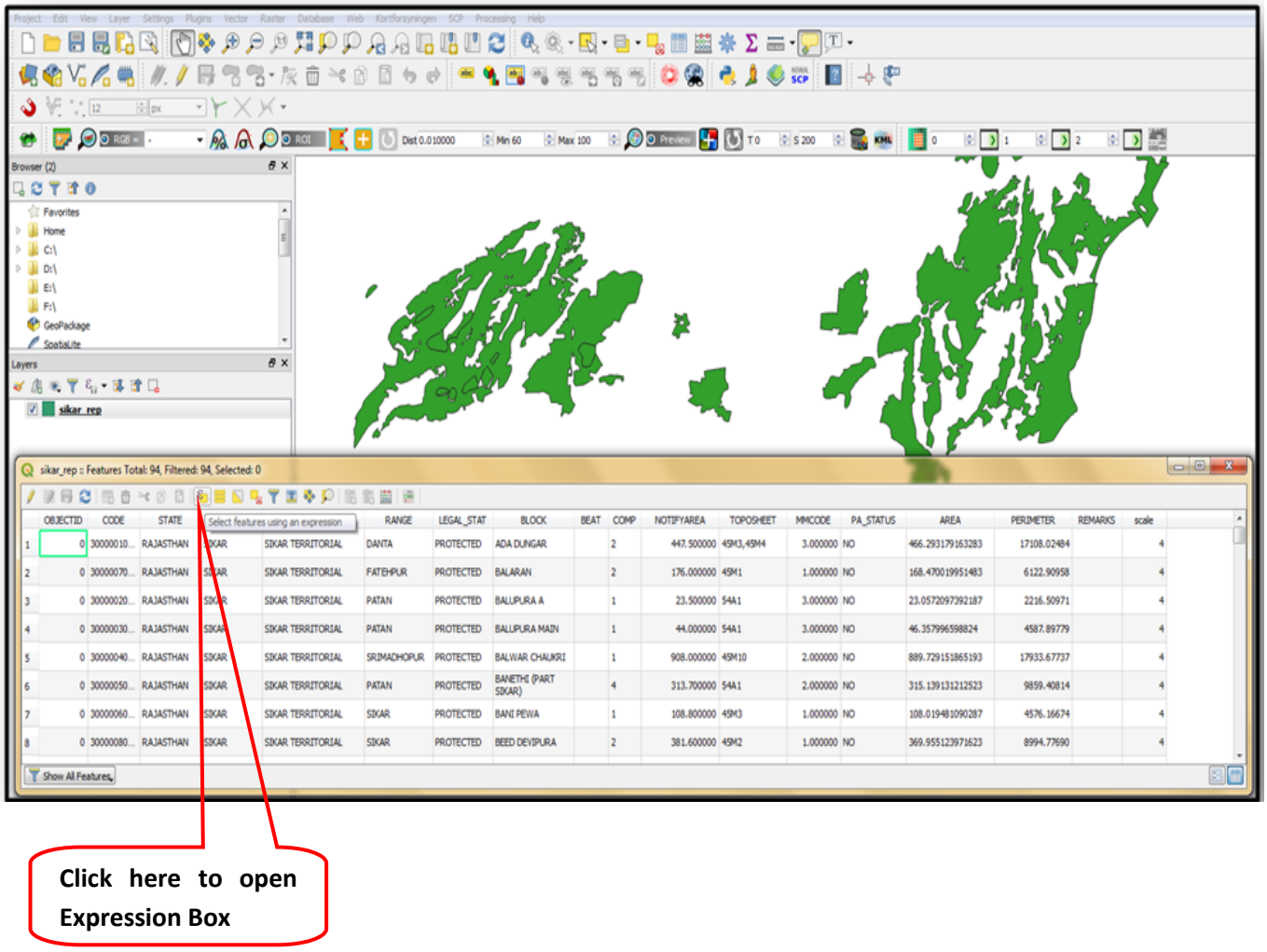


	OBJECTID	CODE	STATE			RANGE	LEGAL_STAT	BLOCK	BEAT	COMP	NOTIFYAREA	TOPOSHEET	MMCODE	PA_STATUS	AREA	PERIMETER	REMARKS	scale
1	0	30000010...	RAJASTHAN	SIKAR	SIKAR TERRITORIAL	DANTA	PROTECTED	ADA DUNGAR		2	447.500000	45M3,45M4	3.000000	NO	466.293179163283	17108.02484		4
2	0	30000070...	RAJASTHAN	SIKAR	SIKAR TERRITORIAL	FATEHPUR	PROTECTED	BALARAN		2	176.000000	45M1	1.000000	NO	168.470019951483	6122.90958		4
3	0	30000020...	RAJASTHAN	SIKAR	SIKAR TERRITORIAL	PATAN	PROTECTED	BALUPURA A		1	23.500000	54A1	3.000000	NO	23.0572097392187	2216.50971		4
4	0	30000030...	RAJASTHAN	SIKAR	SIKAR TERRITORIAL	PATAN	PROTECTED	BALUPURA MAIN		1	44.000000	54A1	3.000000	NO	46.357996598824	4587.89779		4
5	0	30000040...	RAJASTHAN	SIKAR	SIKAR TERRITORIAL	SRIMADHOPUR	PROTECTED	BALWAR CHAUKRI		1	908.000000	45M10	2.000000	NO	889.729151865193	17933.67737		4
6	0	30000050...	RAJASTHAN	SIKAR	SIKAR TERRITORIAL	PATAN	PROTECTED	BANETHI (PART SIKAR)		4	313.700000	54A1	2.000000	NO	315.139131212523	9859.40814		4
7	0	30000060...	RAJASTHAN	SIKAR	SIKAR TERRITORIAL	SIKAR	PROTECTED	BANI PEWA		1	108.800000	45M3	1.000000	NO	108.019481090287	4576.16674		4
8	0	30000080...	RAJASTHAN	SIKAR	SIKAR TERRITORIAL	SIKAR	PROTECTED	BEED DEVIPURA		2	381.600000	45M2	1.000000	NO	369.955123971623	8994.77690		4

Right click on the Layer to open attribute table

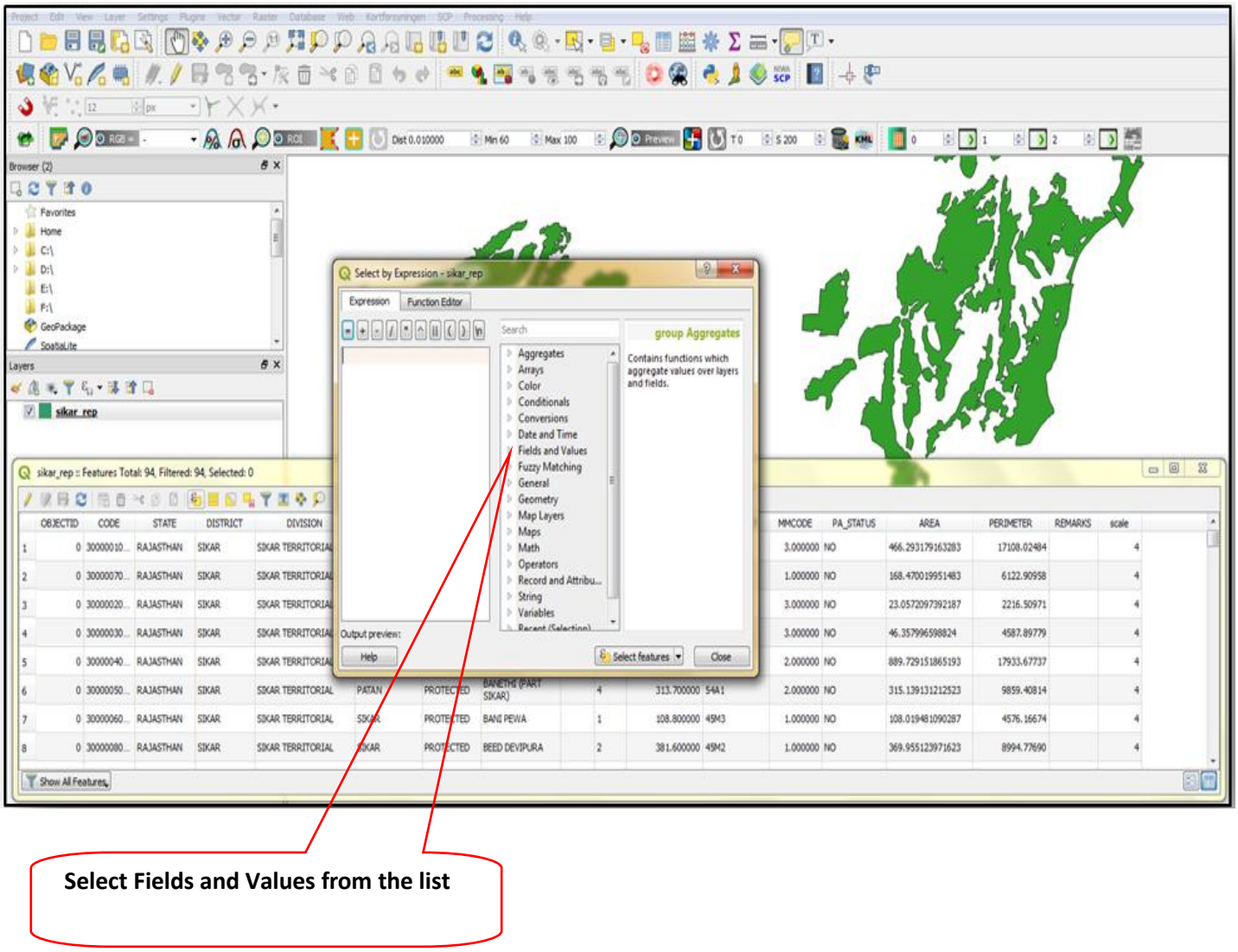
8.1 Calculate area of Forest under RF,PF,UF

- Select feature using an expression Icon on the top of the table to open the expression box of the Query Builder.
- To segregate forested areas inside protected, Reserved Forest and Unclassed Forest, we will type the syntax in query expression window for the same.



Click here to open Expression Box

- The Expression box contains all Fields and attribute columns of the attribute table to be searched.
- Click and expand Fields and Values option and select all unique, that will open the Label Name of attribute.



Select Fields and Values from the list

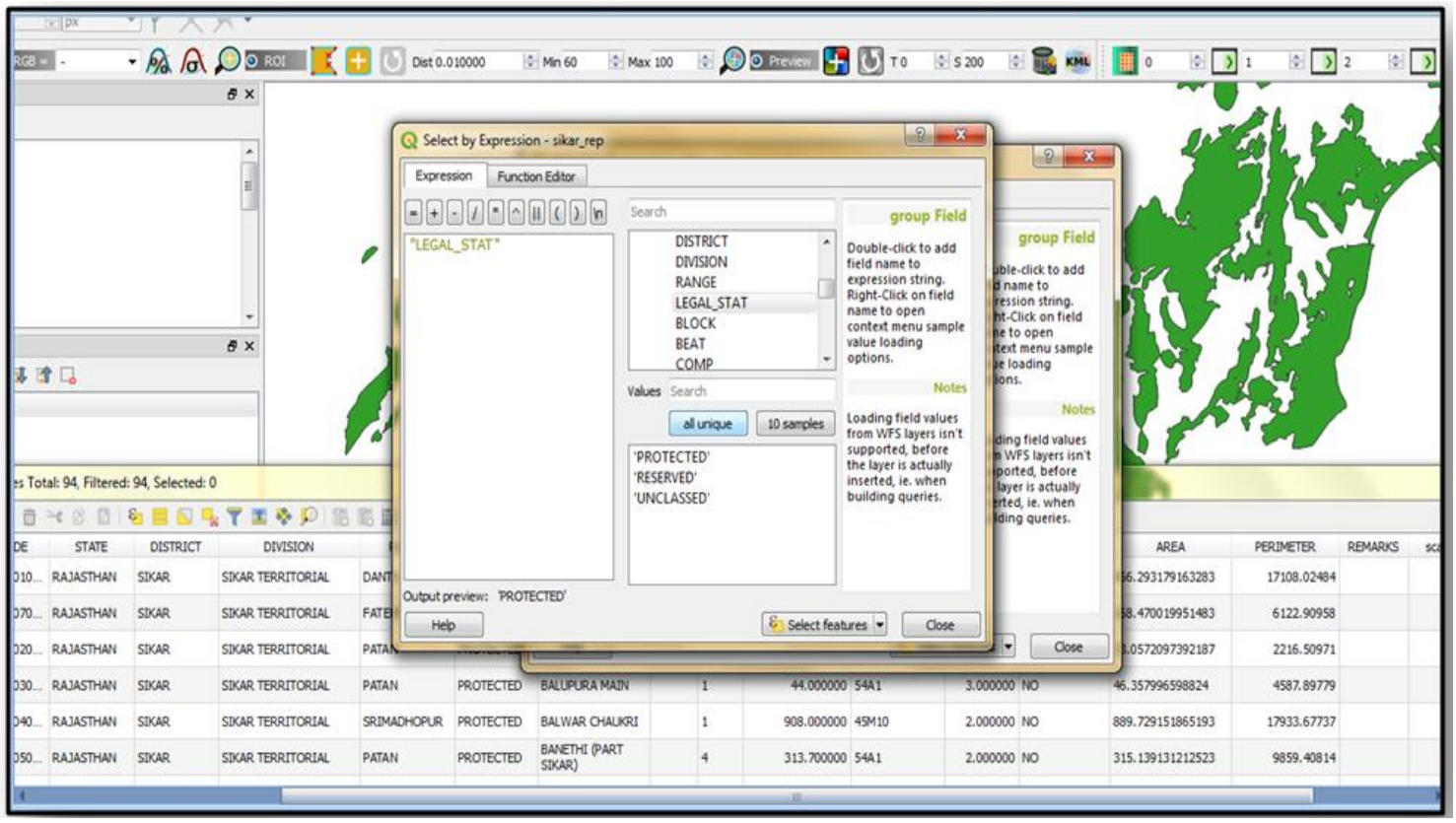
- To add an attribute column to the SQL Query box, double click its Label name in the Fields list and can use the various fields, values and operators to construct the query, or directly can type search query into the SQL box.

- The **Operators section** contains all usable operators. Relational operators (=, >, <), string comparison operator (LIKE) and logical operators (AND, OR) are available.

- To add an operator to the SQL WHERE clause field, click the appropriate button.

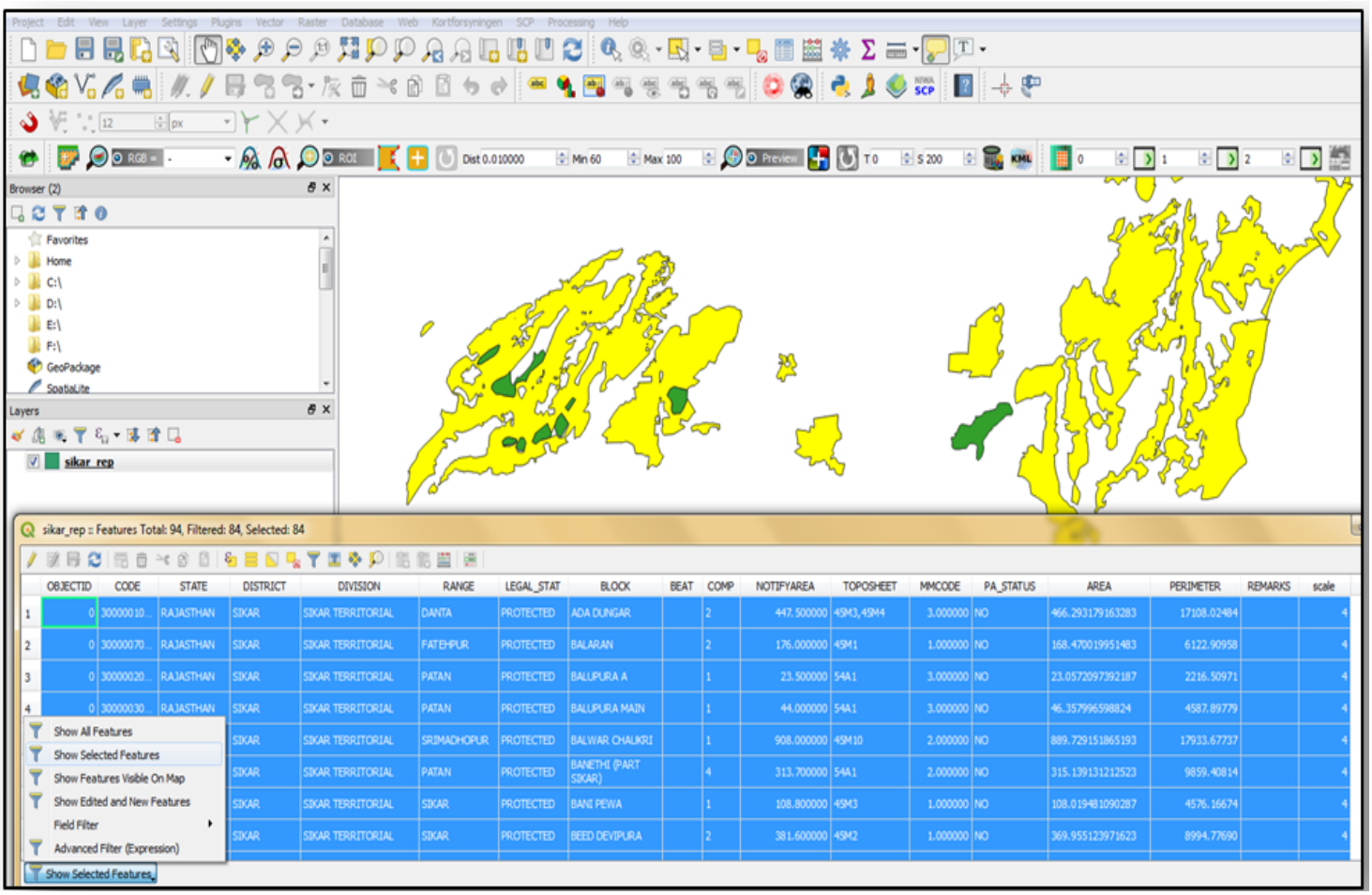
- **Type the Expression1.**

  Example: "LEGAL_STAT" = "PROTECTED"



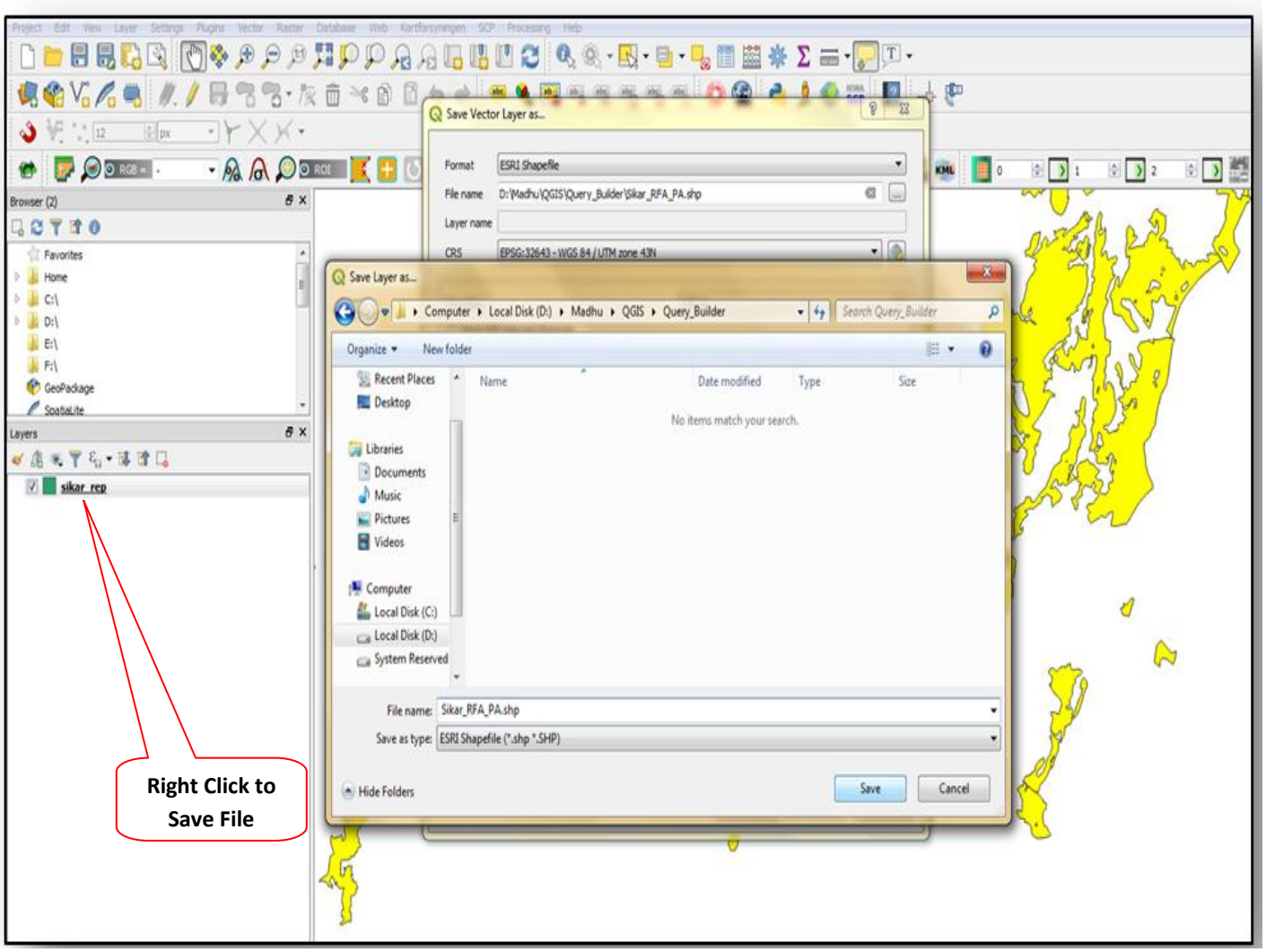
- Query with a logical expression selects and displays only the features or the forested areas classified as “PROTECTED FOREST” by defining the criteria in query builder.

- The query result opened as a new selected layer highlighting features with yellow color in Map Canvas. Now, select Show Selected Feature option in lower extreme left corner of the table.



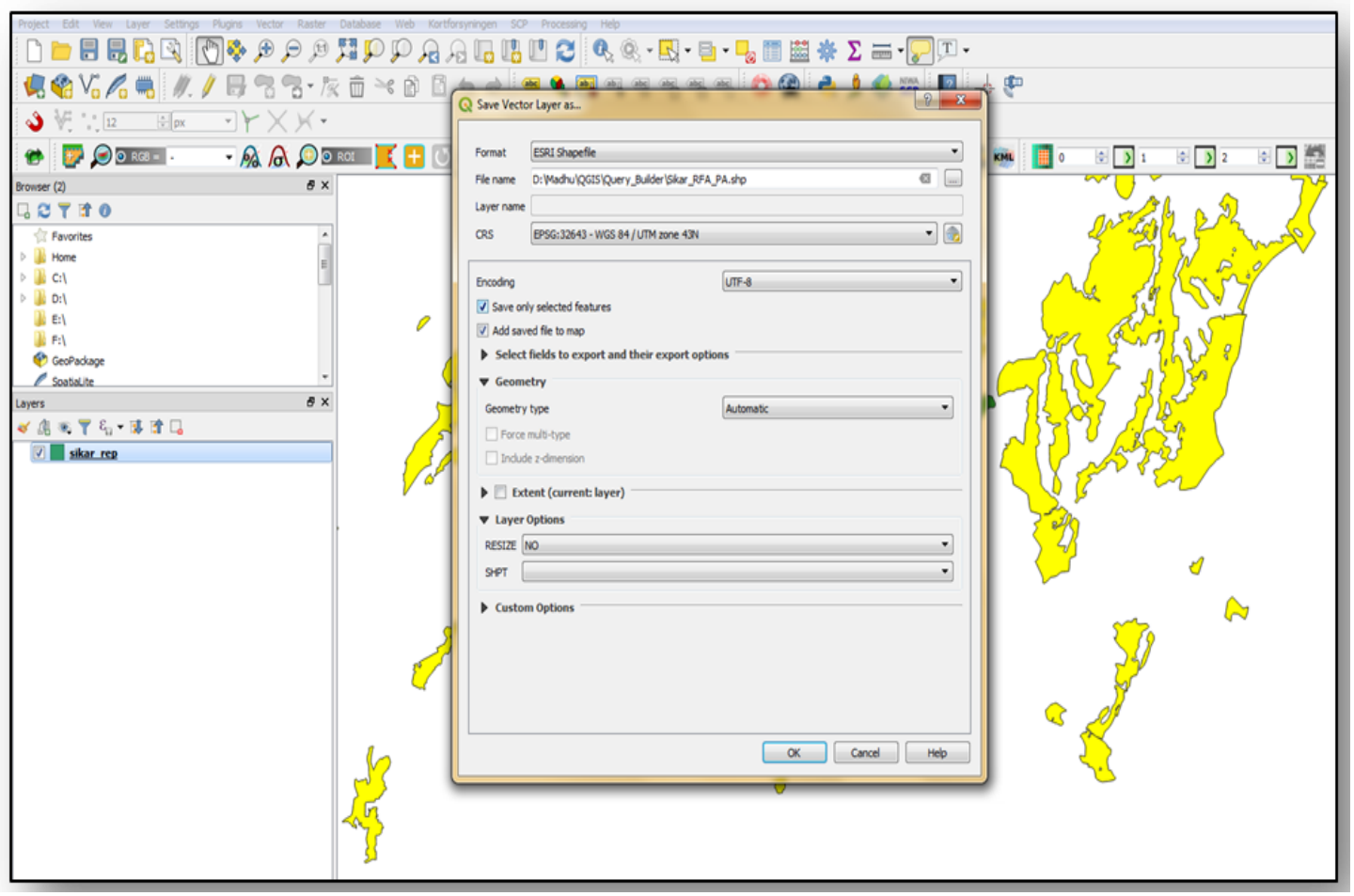
- It will select and highlighted all the features or fields (area along with other fields) that is related to Protected Forest (PF) and by this way can segregate PA from RF and UF.

- The selected features can be saved as any supported vector format and also transformed into another Coordinate Reference System (CRS).
- Next, Right Click on Layer in Legend bar then save it as a new vector layer (shapefile) with new name.



Note: The layer created after running SQL query is temporary and will not continue after session ends until we save the document.

- It will Save file under ESRI shapefile format, choose CRS as depends on the study area.
- Make it sure that Save only Selected option is checked and that is mandatory and now, select desired name and location using 'Browse'.

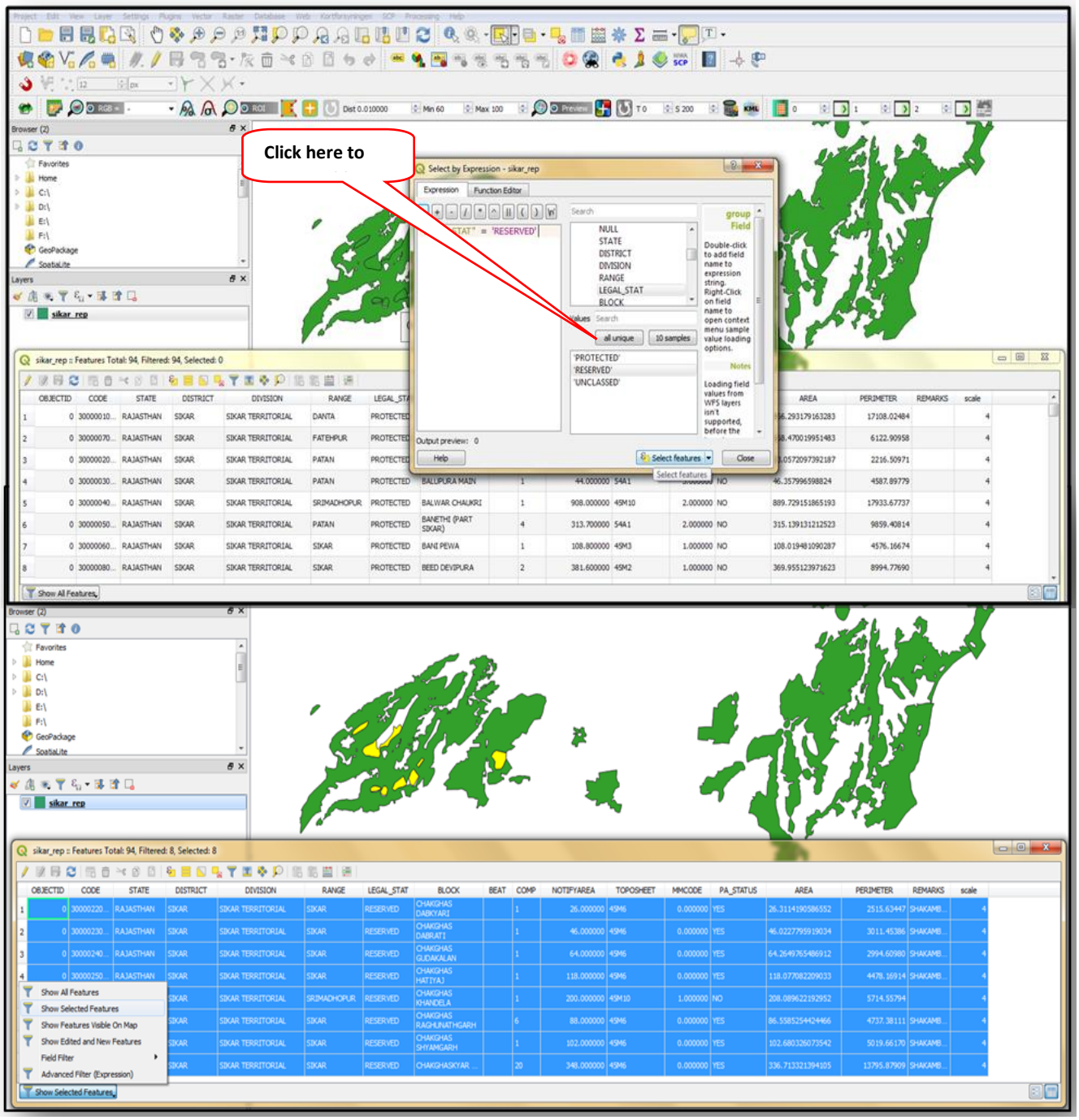


- Click on 'OK' to finish.
- Go to Fields and Values that lists the values of an attribute table. To list all possible values of an attribute, select the attribute in the Fields list and click the **[all unique]** button. Now, it will appear all unique values of an attribute column, select the attribute column in the Fields list and click the **[Sample]** button. To add a value to the SQL WHERE clause field, double click its name in the Values list.
- In order to type the next expression, again follow the same steps as mentioned in earlier section. Make sure to unselect the selected portion before typing syntax for the next expression. Select unselect Icon to unselect selected features.

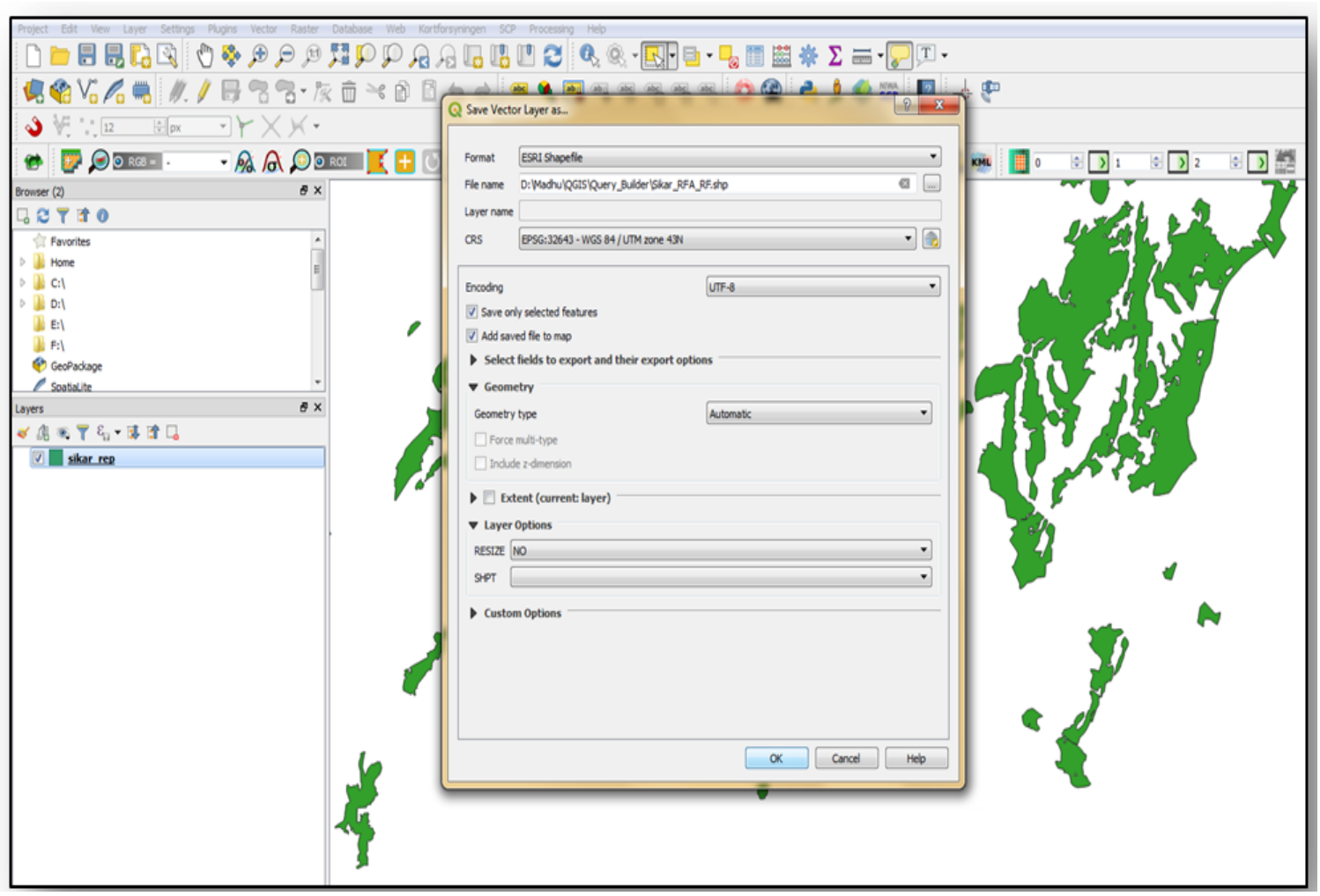
- To add an attribute column to the SQL Query box, double click in its Label name in the Fields list and can use the various fields, values and operators to construct the query, or directly type search query into the SQL box.

- **Type the Expression2.**

  Example: "LEGAL_STAT" = "RESERVED"

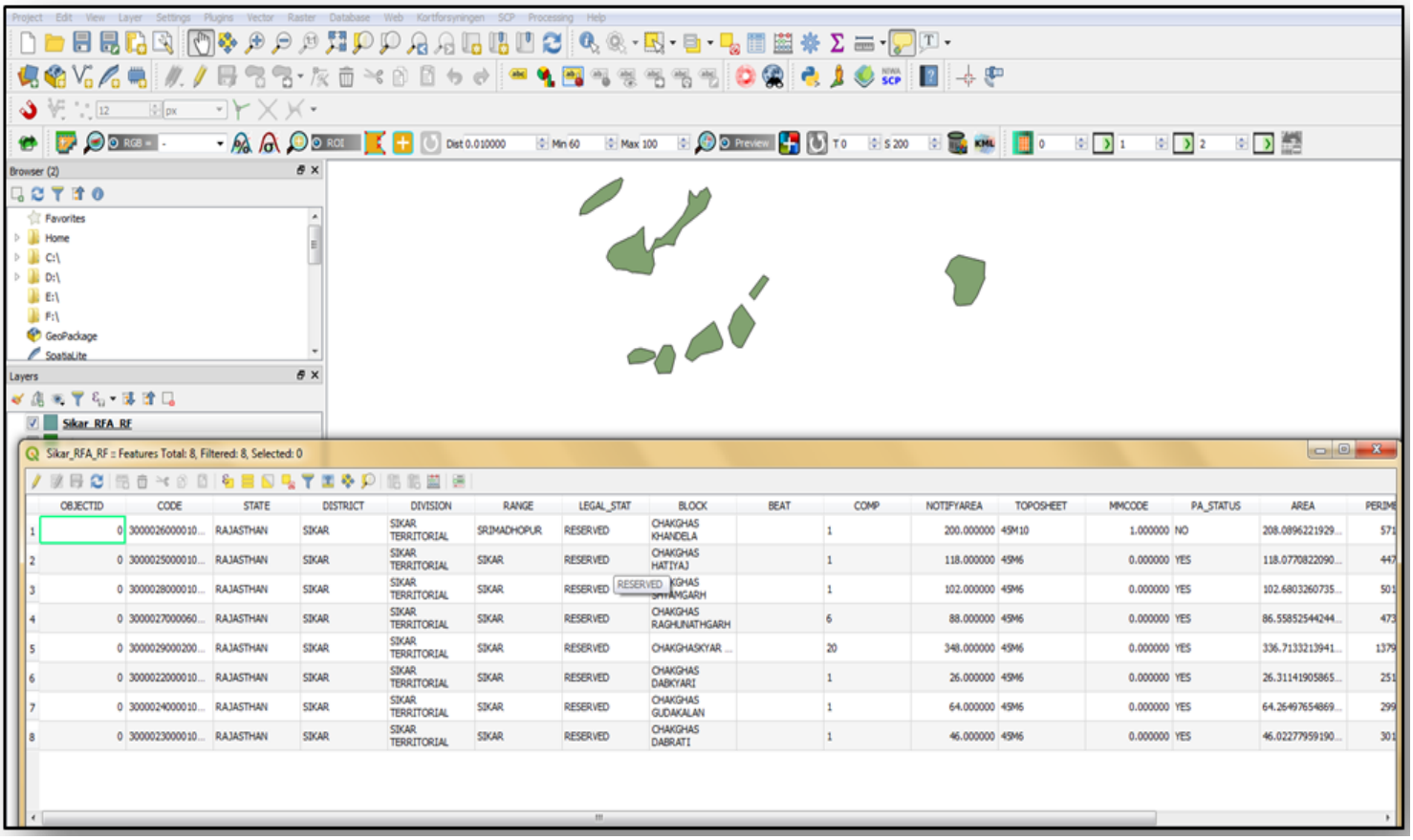


- Next, Right Click on Layer in Legend bar then save it as a new vector layer (shapefile) with new name.



- The selected features can be saved as any supported vector format and also transformed into another Coordinate Reference System (CRS).

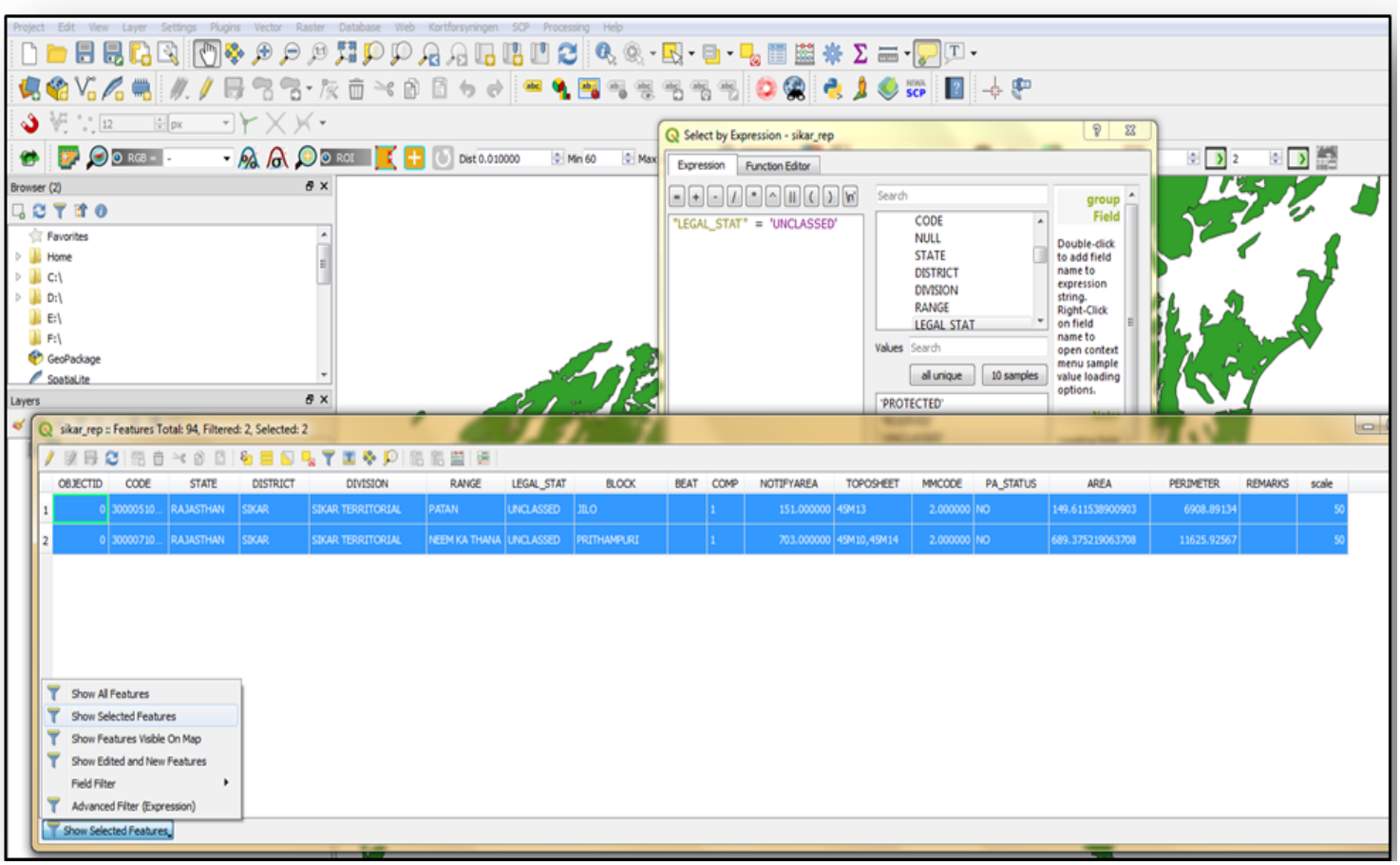
- It will Save file under ESRI shapefile format, choose CRS as depends on the study area.



- After fetching the forested areas under Reserved Forest Category , the output will appear in the Map Canvas window as showing in the Figure.

- **In a similar manner, Type the Expression3.**

  Example: “LEGAL_STAT” = “UNCLASSED”



- The query result opened as a new selected layer highlighting features with yellow color in Map Canvas. Now, select Show Selected Feature option in lower extreme left corner of the table.

- Query with a logical expression selects and displays only the features or the forested areas classified as “UNCLASSED FOREST” by defining the criteria in query builder.

- Next, Right Click on Layer in Legend bar then save it as a new vector layer (shapefile) with new name and that will produce output in a similar manner as displaying in earlier session.

  Note: In a Query session, there is 'AND' ‘OR’ operators to select the features as per the Syntax. Open the Attribute table and Click on ‘Show All Feature’ tab at the left bottom of the table and then click on ‘Advance Filter Expression to type Query as already described in previous session.

Chapter 9: Web Services in QGIS

The Open Geospatial Consortium (OGC) (http://www.opengeospatial.org/,2001) is a leading body in standards development in GIS, consisting of members across diverse scientific backgrounds. OGC has defined several Open Web Services for accessing usually geographical georeferenced data.

There are three basic web services-

- Web Feature Services (WFS): The WFS is concerned with direct access to your data – reading, writing and updating features and returns feature data (vector data) in XML based on GML format
- Web Map Services (WMS: Raster as well as Vector data): The WMS is concerned with transforming data into a map (image).
- Web Coverage Service (WCS): coverage data, especially as raster data

9.1 Working with Web Map Services (WMS)

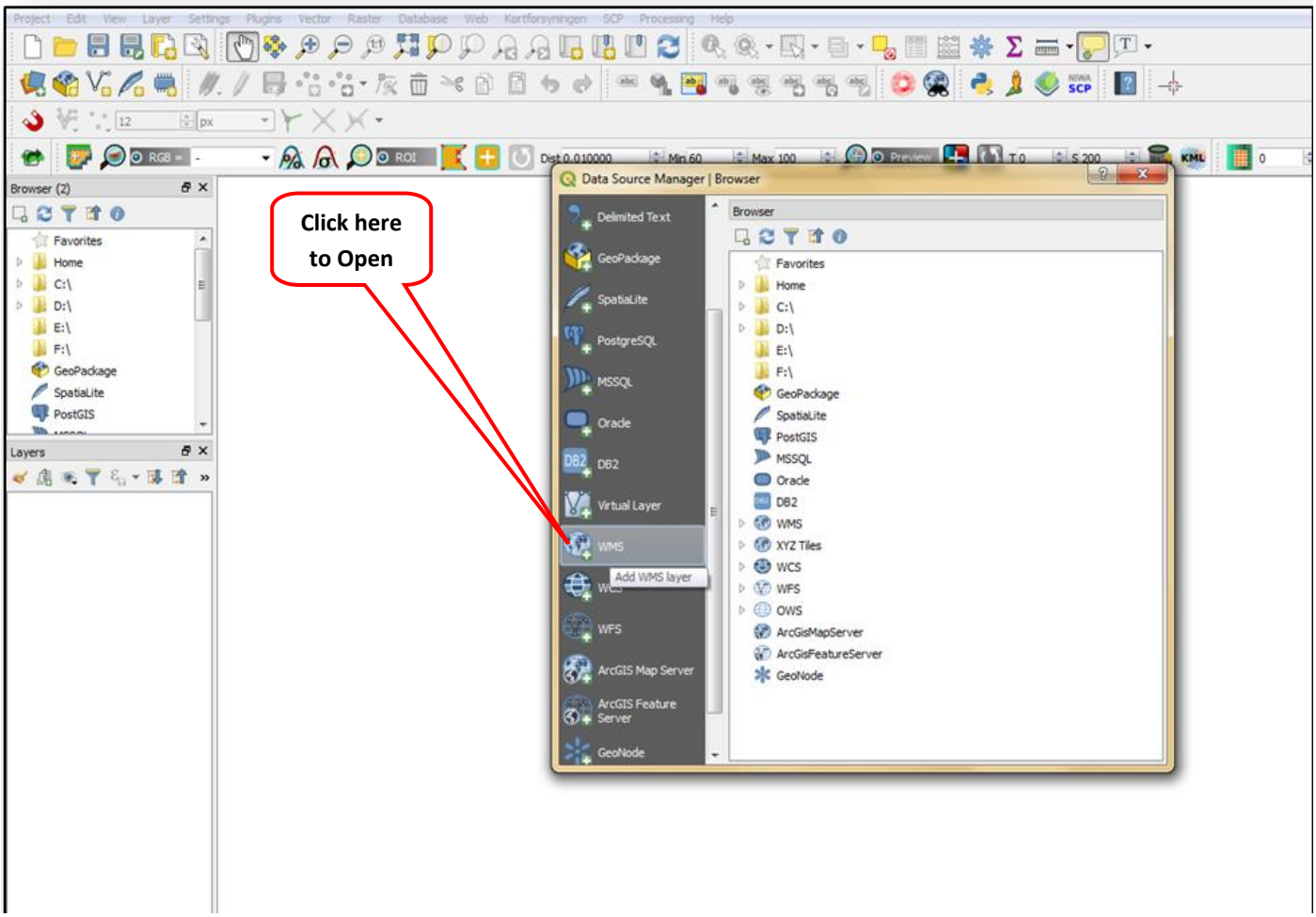
WMS deals with reference data and any users publish datasets online that can be readily used in GIS at other end. A popular standard for publishing maps online is called **WMS (Web Map Service)**.

To specify the projection information by CRS Button in QGIS.

- WGS 84: The projection used in GCS/GPS systems with longitude/latitude measurement. Select either ESPG code 4326 or CRS ID 3452.
- Google Mercator: Used in case of online mapping services, including Google, OpenStreetMap and other online services. Its ESPG code is 900913, while CRS ID 3644;
- UTM zone system: UTM system is used in PCS (Projected Coordinate System) and presenting area measurements to perform analysis.

- To add a WMS layer to QGIS, Open QGIS and either click on the Add WMS/WMTS Layer button as shown in the image below > or go to the Layer menu > select Add Layer > Add WMS/WMTS Layer.

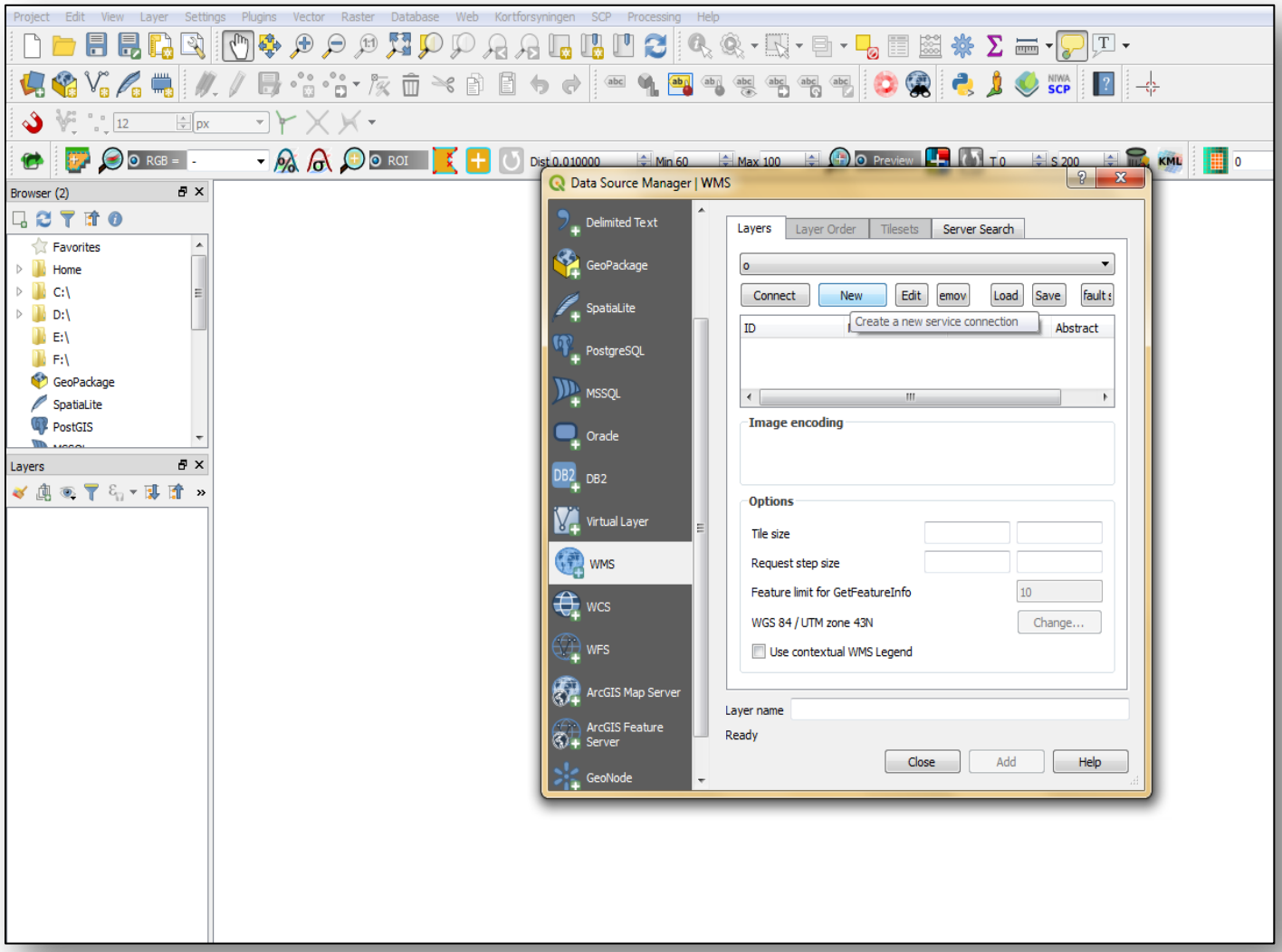
- Make sure your internet should be connected to access the services. Click Settings, Options and in Network option check the connections.



Note: WMS cant allow the users to change the symbology (styling) of the data inspite Feature Service (WFS) gives vector layers separately with writing, updating permission.

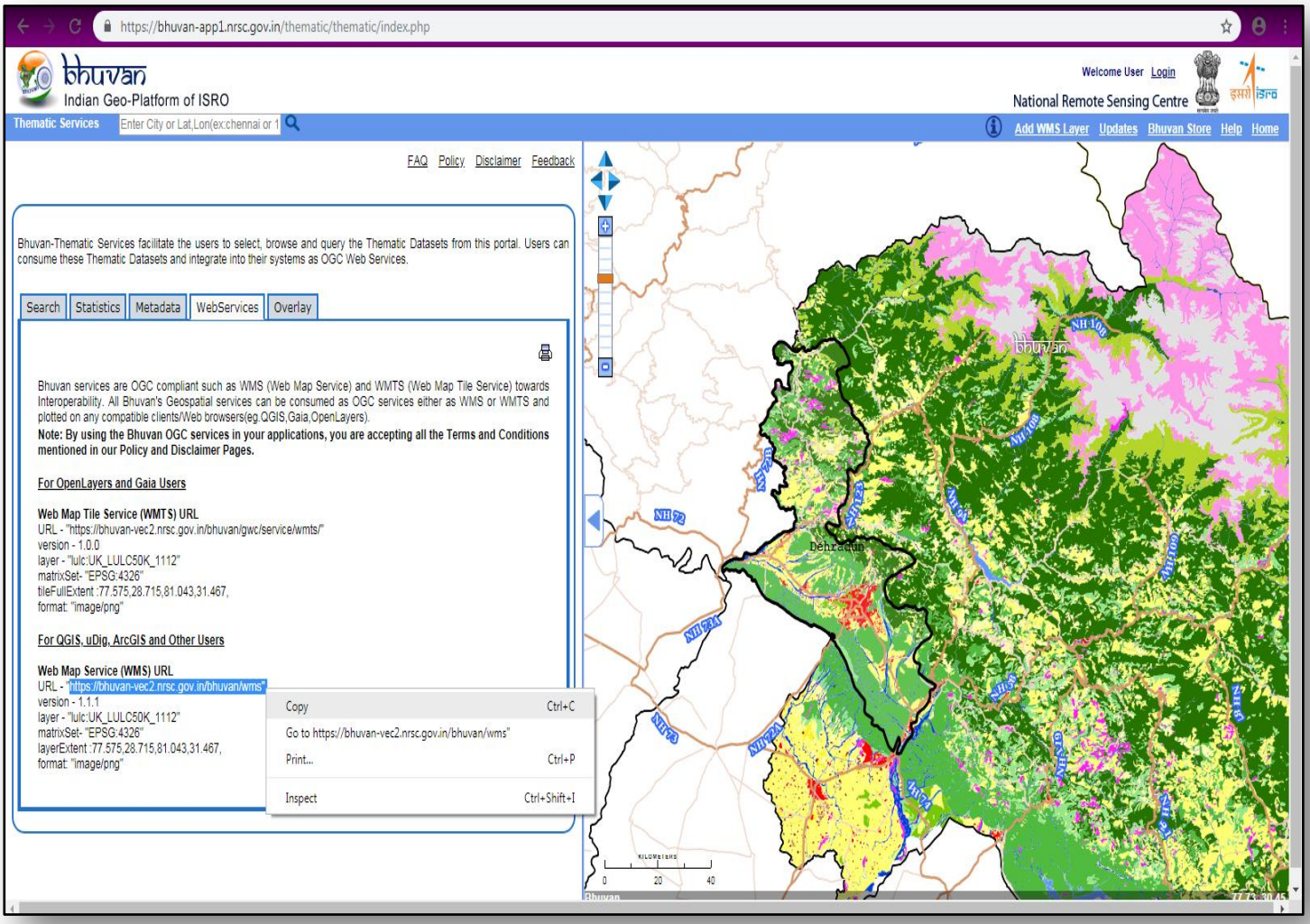
- Select New to create a service connection from the web in the Add Layers tab from a WMS dialog box.

- To open WMS, firstly we require URL Link from the web.



- Next, open Bhuvan portal or any other portal to fetch the services > Go to Web Services Tab > and it will show URL Link to fetch the provided free services by Bhuvan.

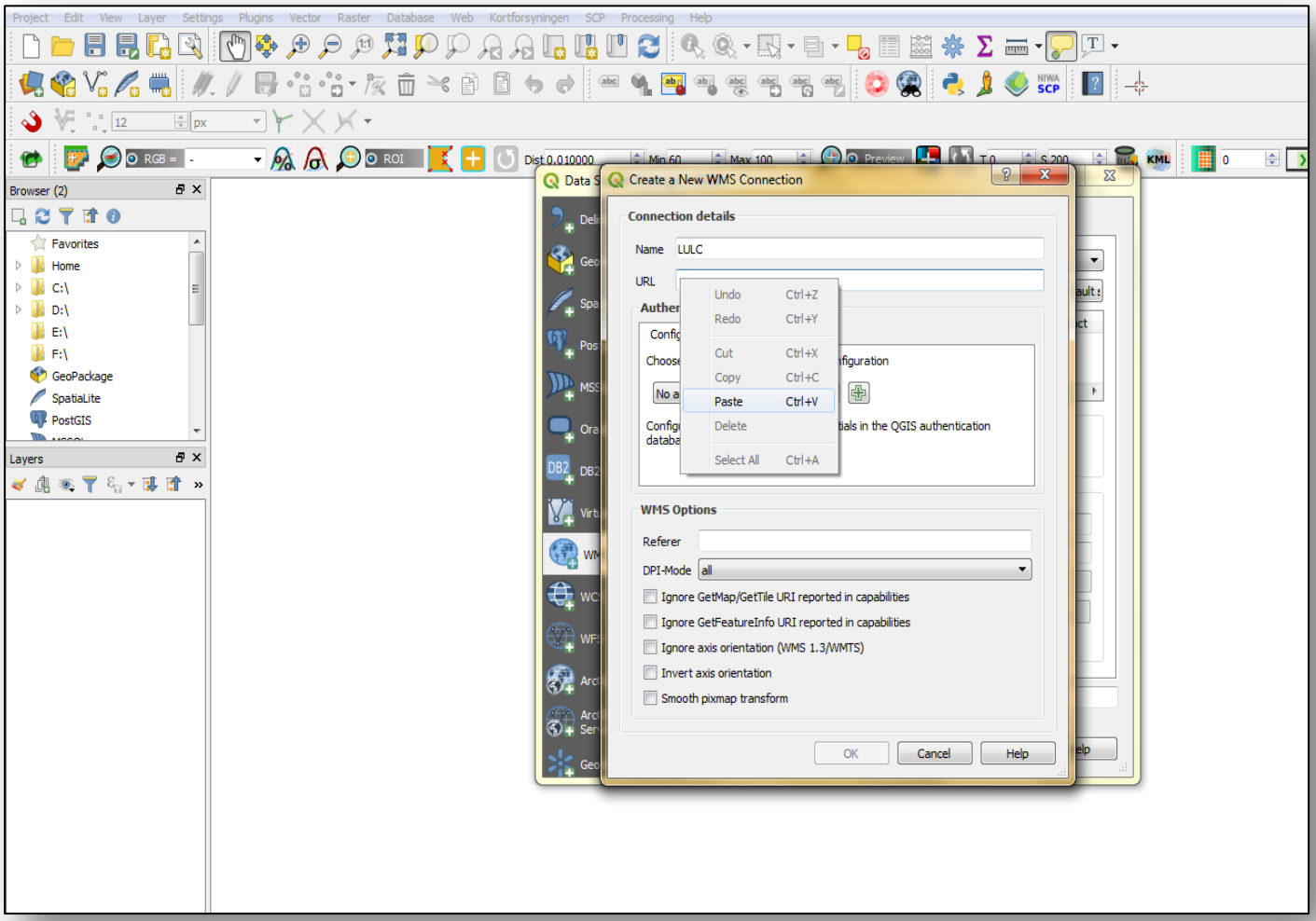
- Copy the link of URL address to paste it in **URL tab** as described in next Figure.



Note: Bhuvan services are OGC provides services such as WMS (Web Map Service) and WMTS (Web Map Tile Service) for Interoperability purpose. All Bhuvan's Geospatial services can be consumed as OGC services either as WMS or WMTS

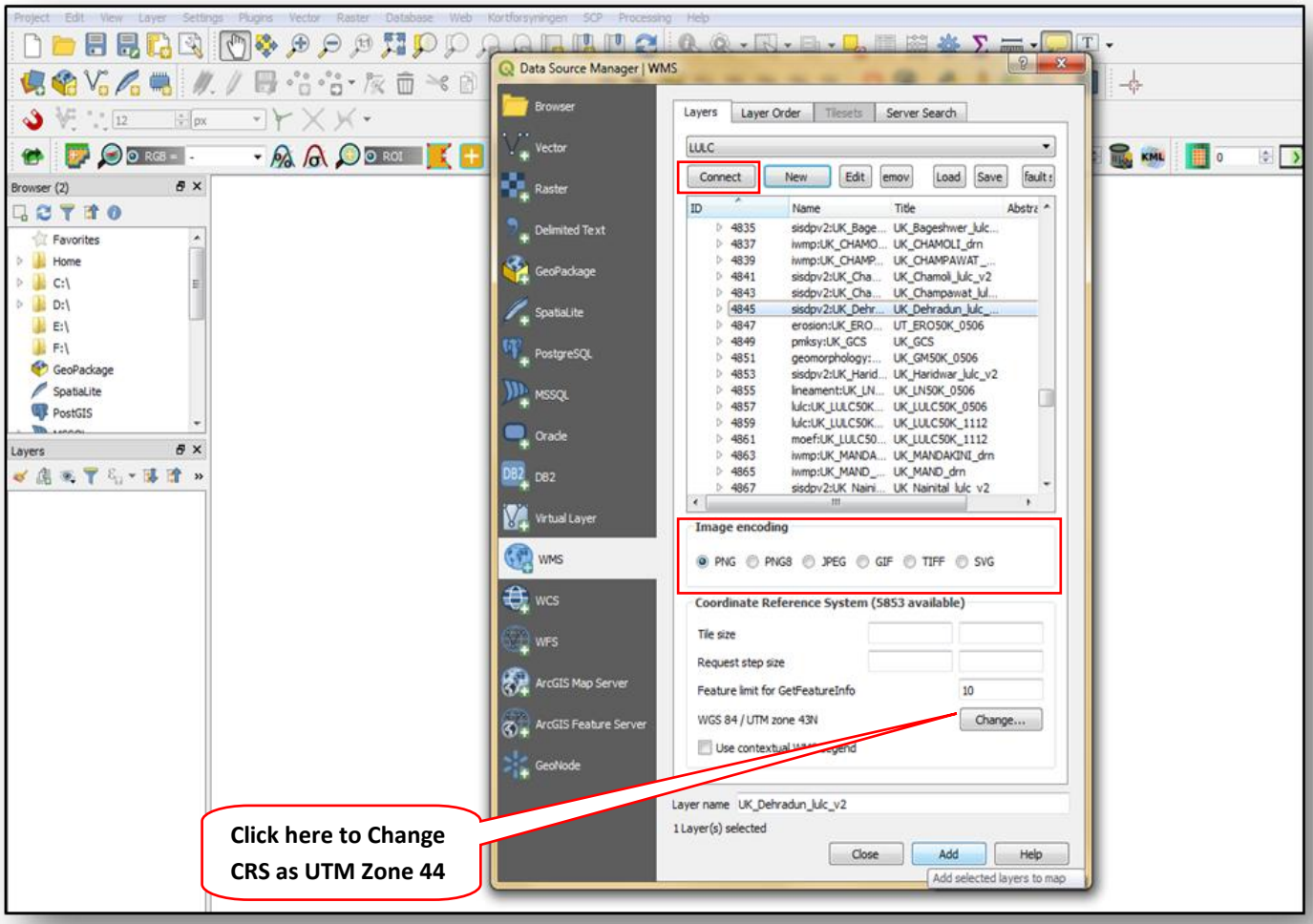
- In the Create a new WMS connection dialog box, type a name of URL connection in the Name text box then paste URL from the Bhuvan portal for the desired WMS layers.

- In a new WMS connection dialog box, enter a name for the connection and the WMS URL.



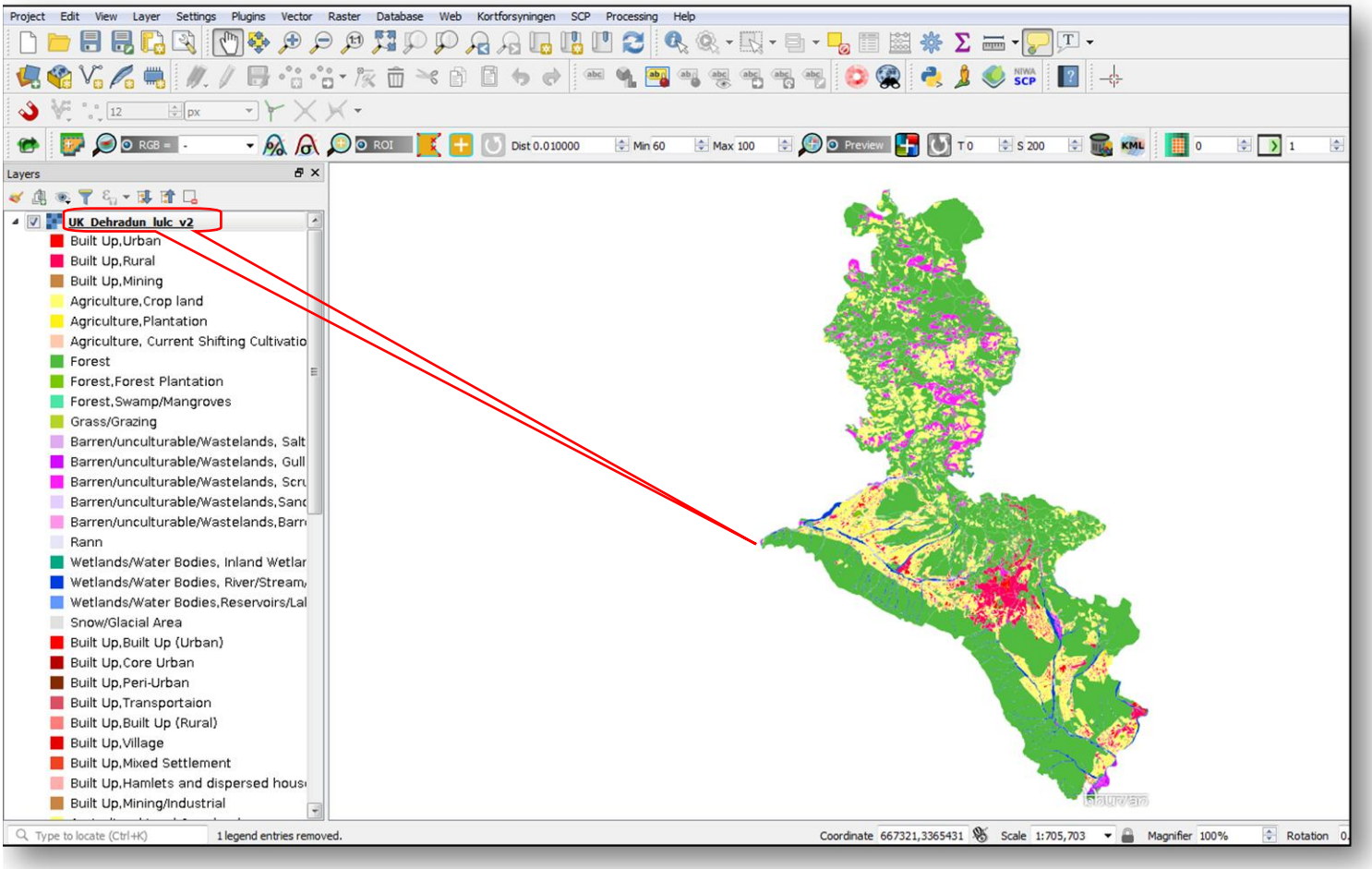
- Click OK.

- In the Add Layer from a Server dialog box > click Connect to load new entries.
- While accessing WMS server with defining web address in the URL, it gives a list of available layers.
- In the Image encoding Tab, choose any image format depends on the types of dataset and other requirements. Select the WMS layer that you want to add, select the Image encoding format to save WMS file into JPG, PNG and in some other available formats.
- Select the Coordinate Reference System, in this case we will select UTM Zone 44 for Dehradun District.
- Click Add.



Note: The quality of PNG images will be better as compared to JPEG. Therefore, to print a map PNG is the better option. To deal with vector data, PNG will be the better choice while in case of Raster JPEG usually takes less time to zoom in/ out, pan the image as compare to uncompressed, larger size of PNG.

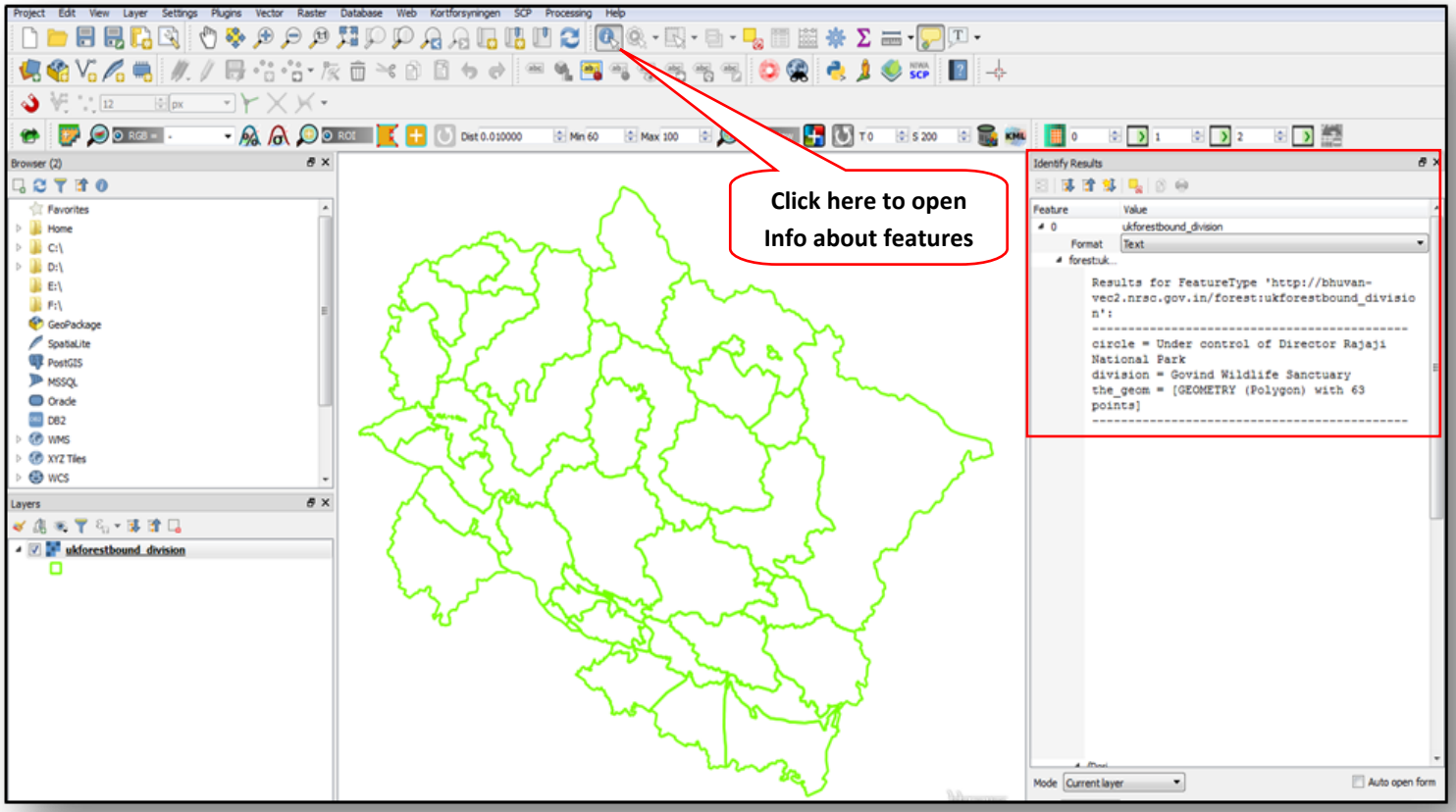
- Now, it will show the layer loaded in the QGIS canvas. While zooming/pan the layer, WMS services sends viewport coordinates to the server for each and every zoom/pan and the server creates an image for that viewport and send it back to the users. Therefore, the whole process usually takes some time to access the web services.



Note: We will notice that selected layers are located correctly on the Map Canvas as "on the fly" projection is Enabled with the same projection as the OSM-WMS layer (WGS 84 / Pseudo Mercator).

- Furthermore, to see the information about the Division boundary, Click on Identity Feature tool > and Click on the boundary that will give some information about the layer such as:

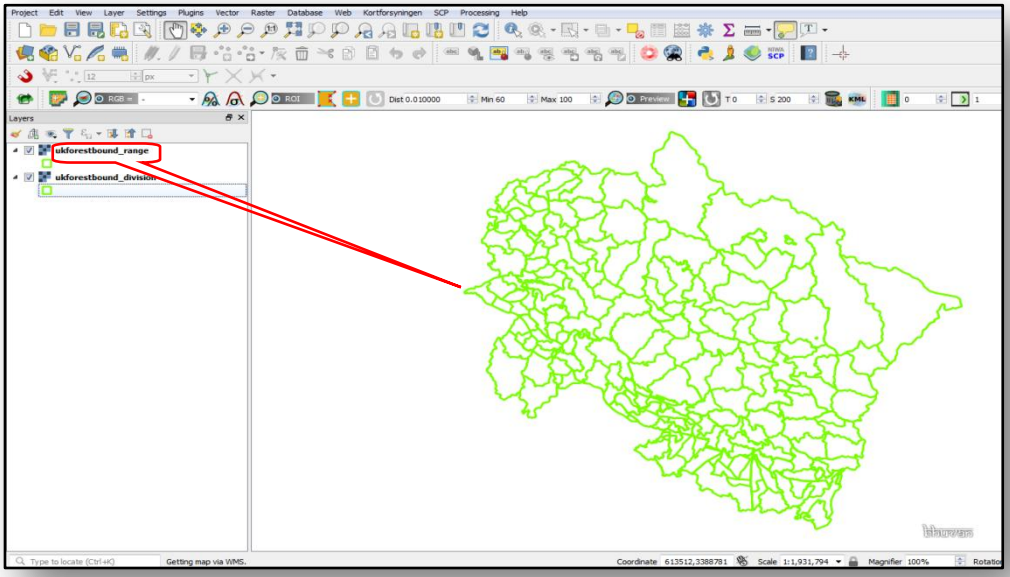
Division: Govind Wildlife Sanctuary
Circle : Under control of Director of Rajaji National Park.



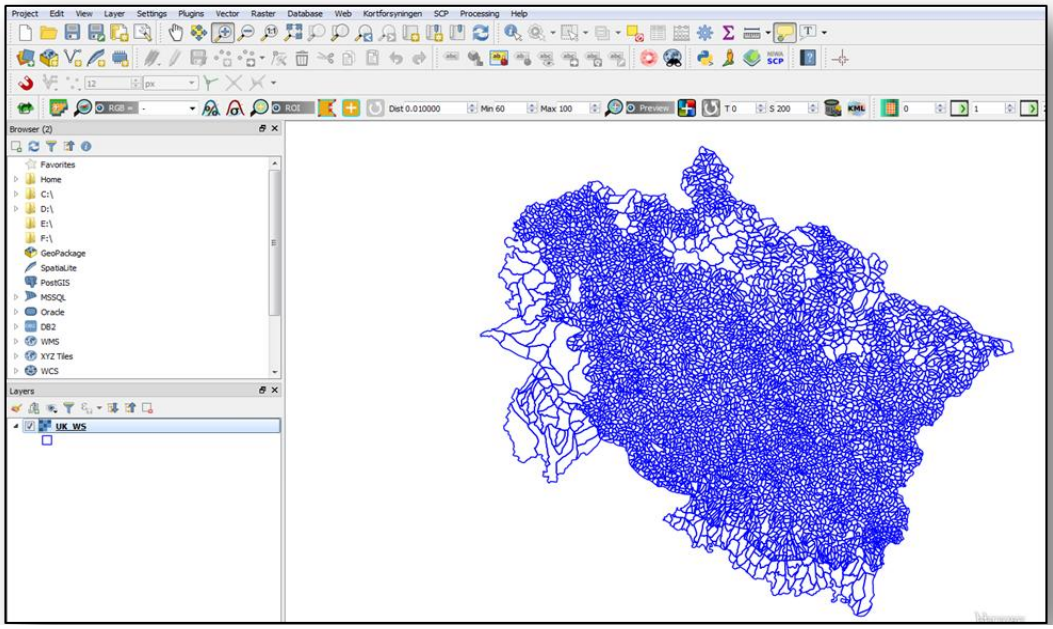
Forest Division Boundary of Uttarakhand

- Likewise, we can load some other new maps by selecting the list of available **WMS** layers as well as **WFS**.

  Example, Go to UK-forestbound-division, UK-forestbound-range, UK-forestbound-circle and Watershed boundary as UK-WS.

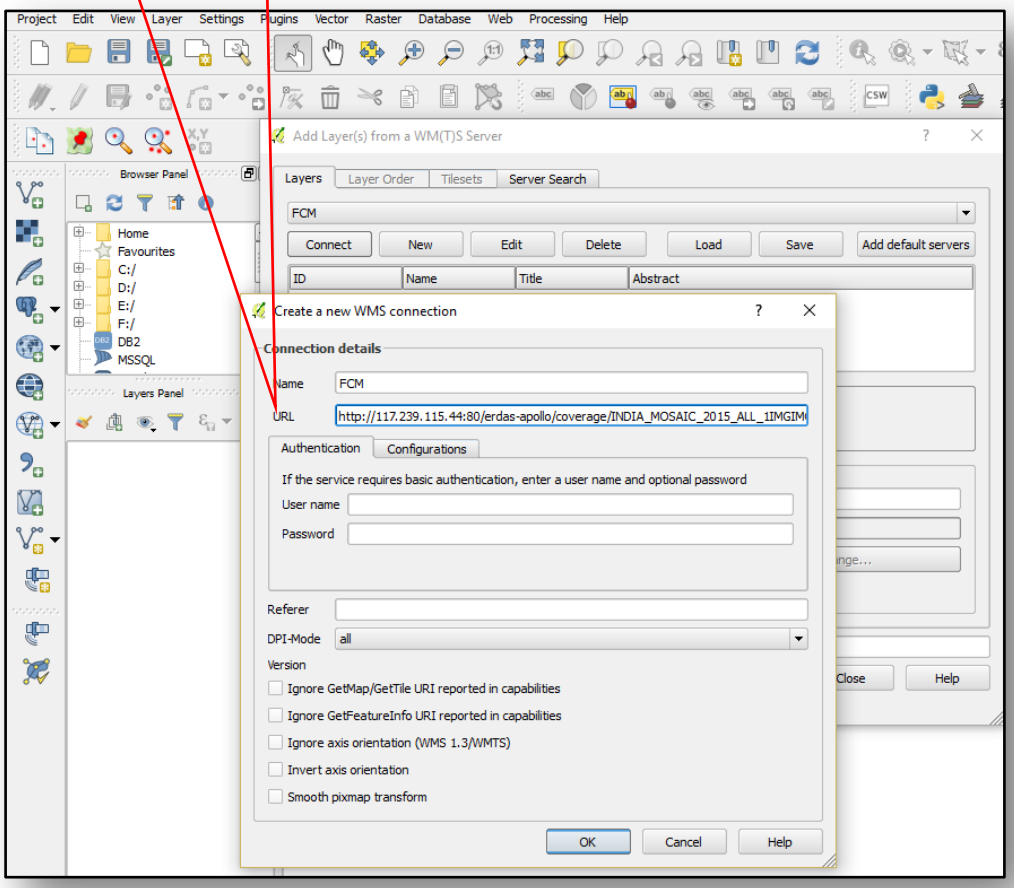


Forest Range Boundary of Uttarakhand

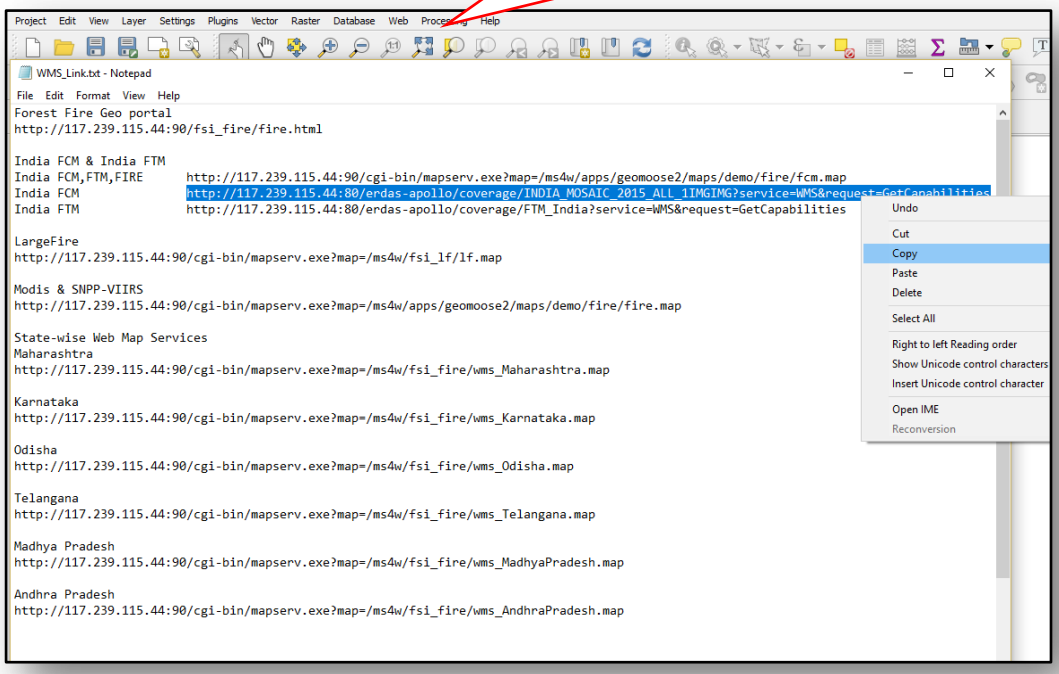


Watershed Boundary of Uttarakhand

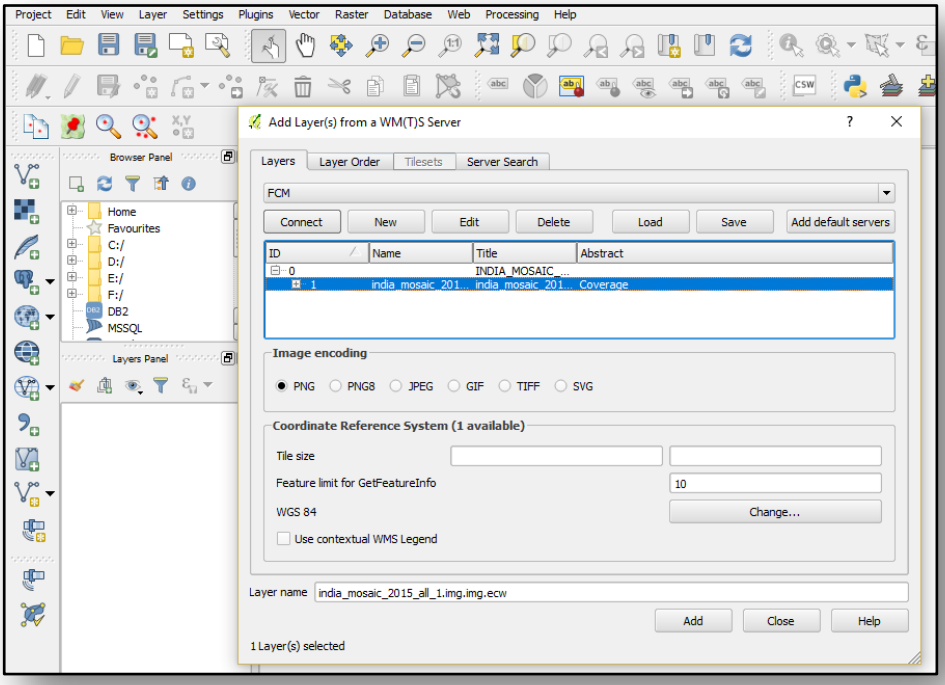
WMS Services (FCM) provided by FSI,
To visualize the data, copy link to URL



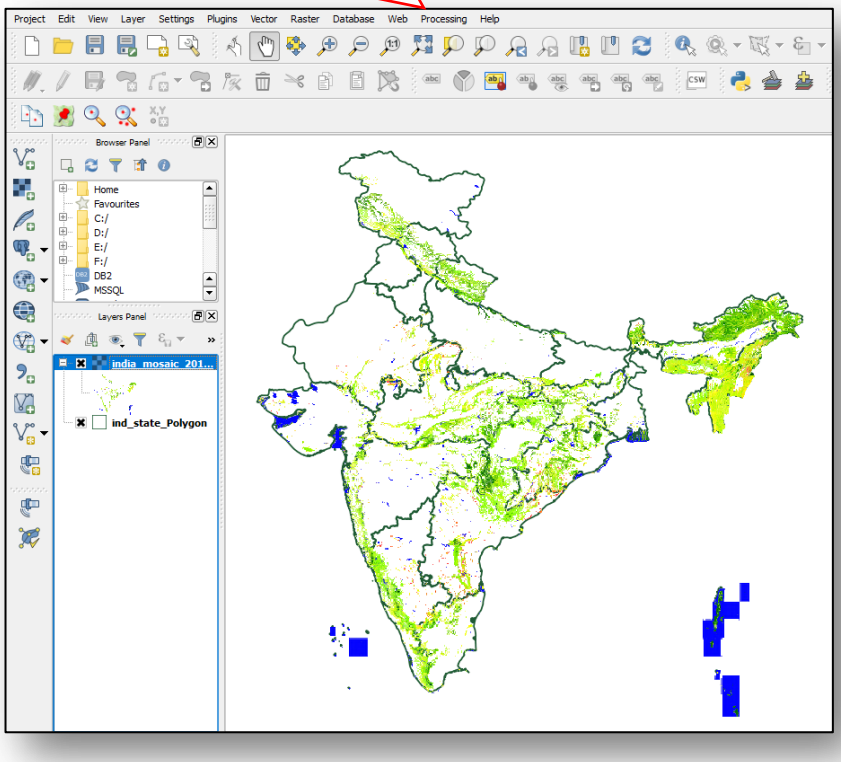
Different WMS link provided by FSI



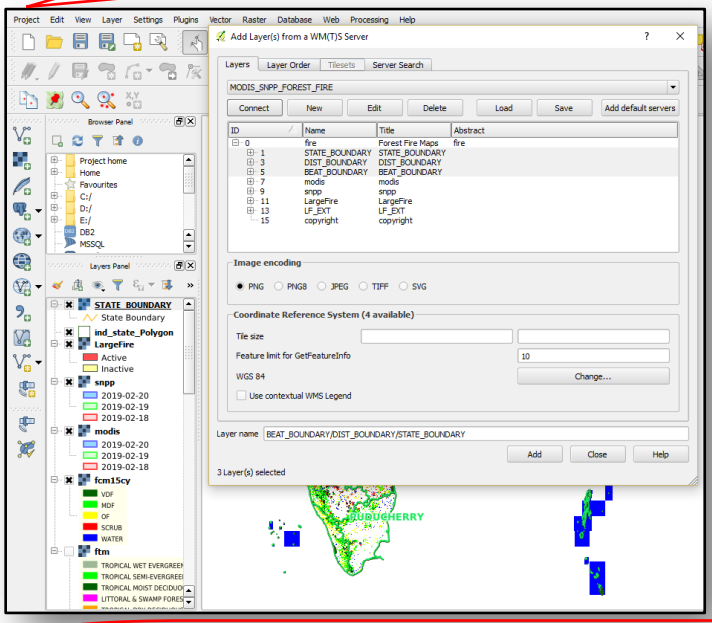
- Now, follow the same steps as mentioned in earlier sessions of WMS.



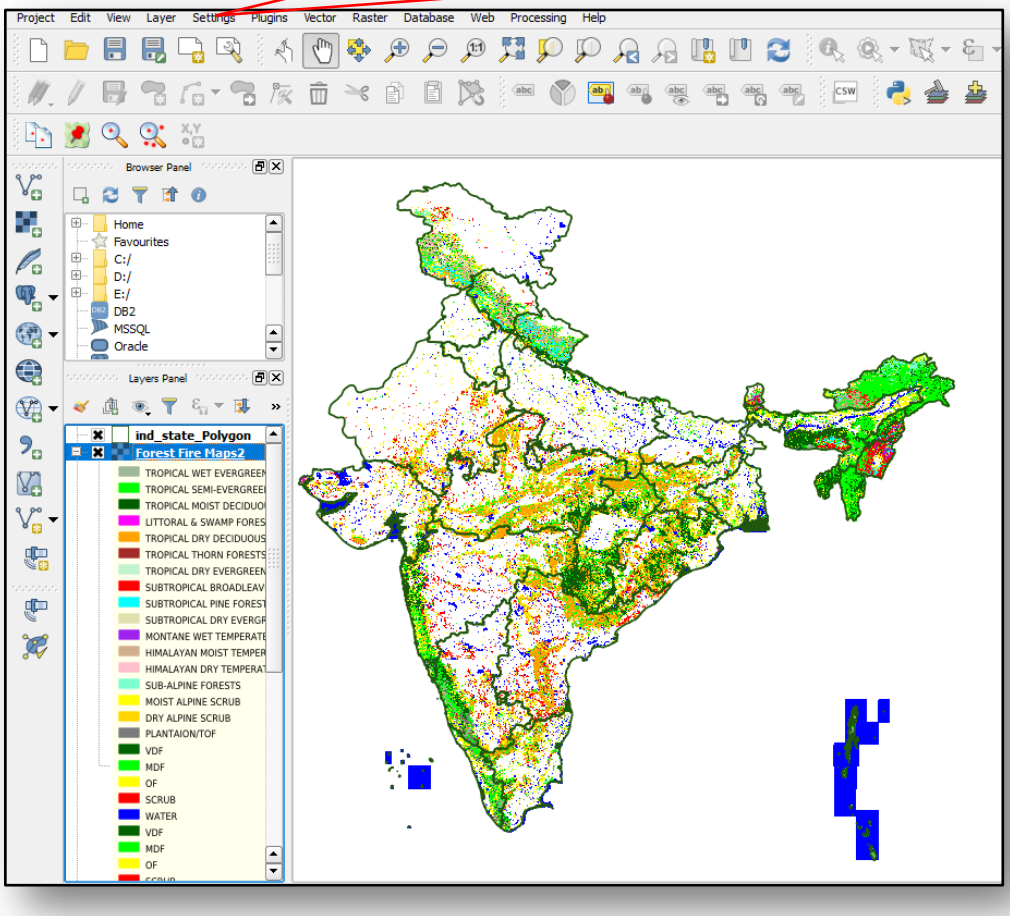
WMS Layer (FCM) loaded in the QGIS canvas

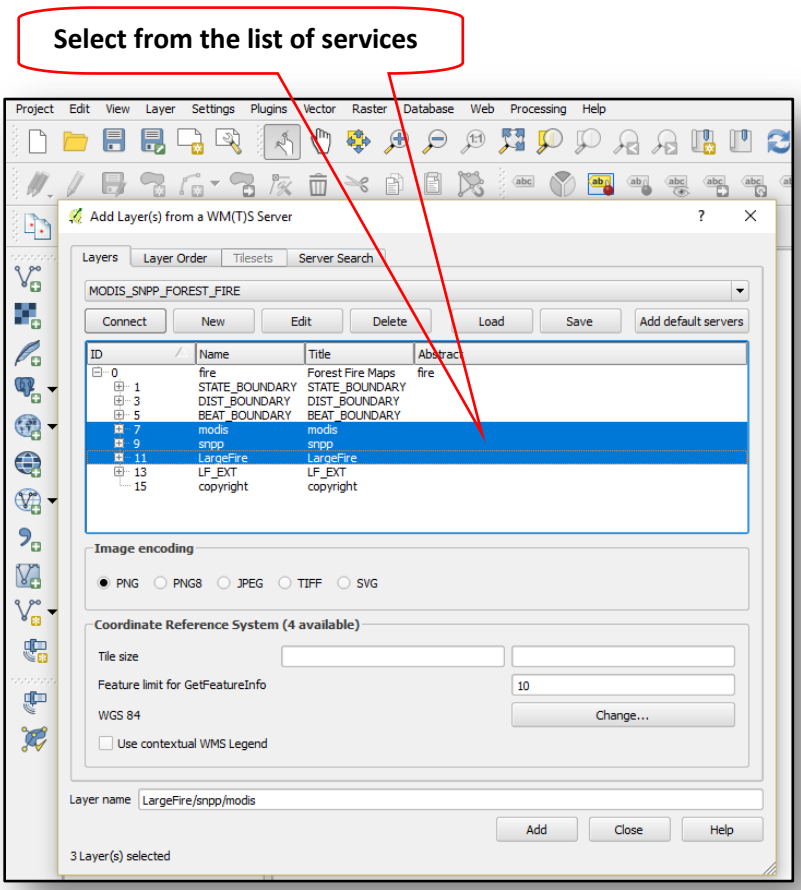


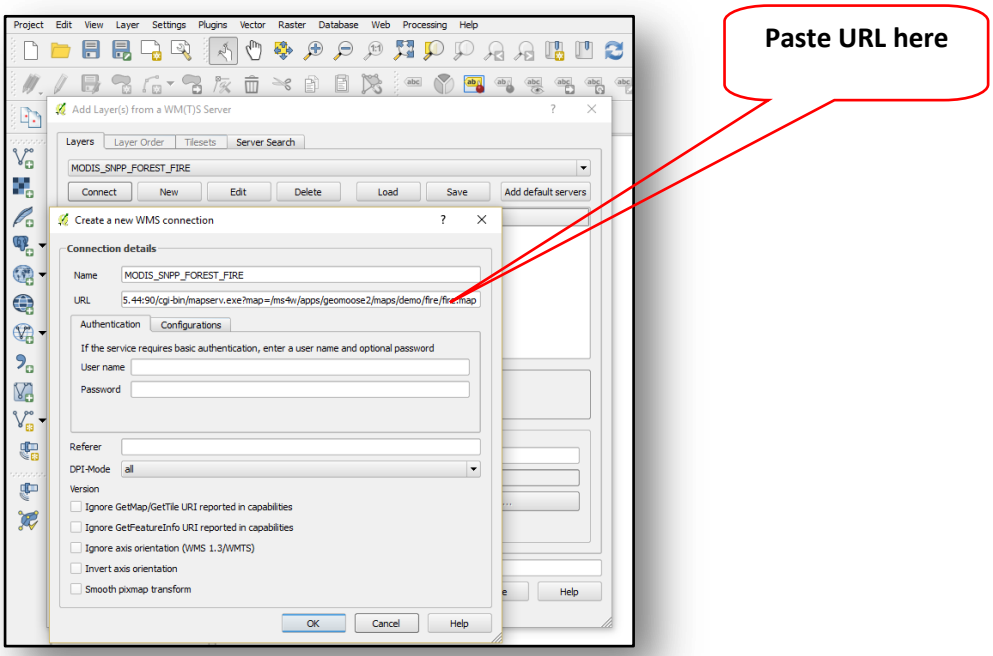
Likewise, other layers canalso be fetched from FSI portal

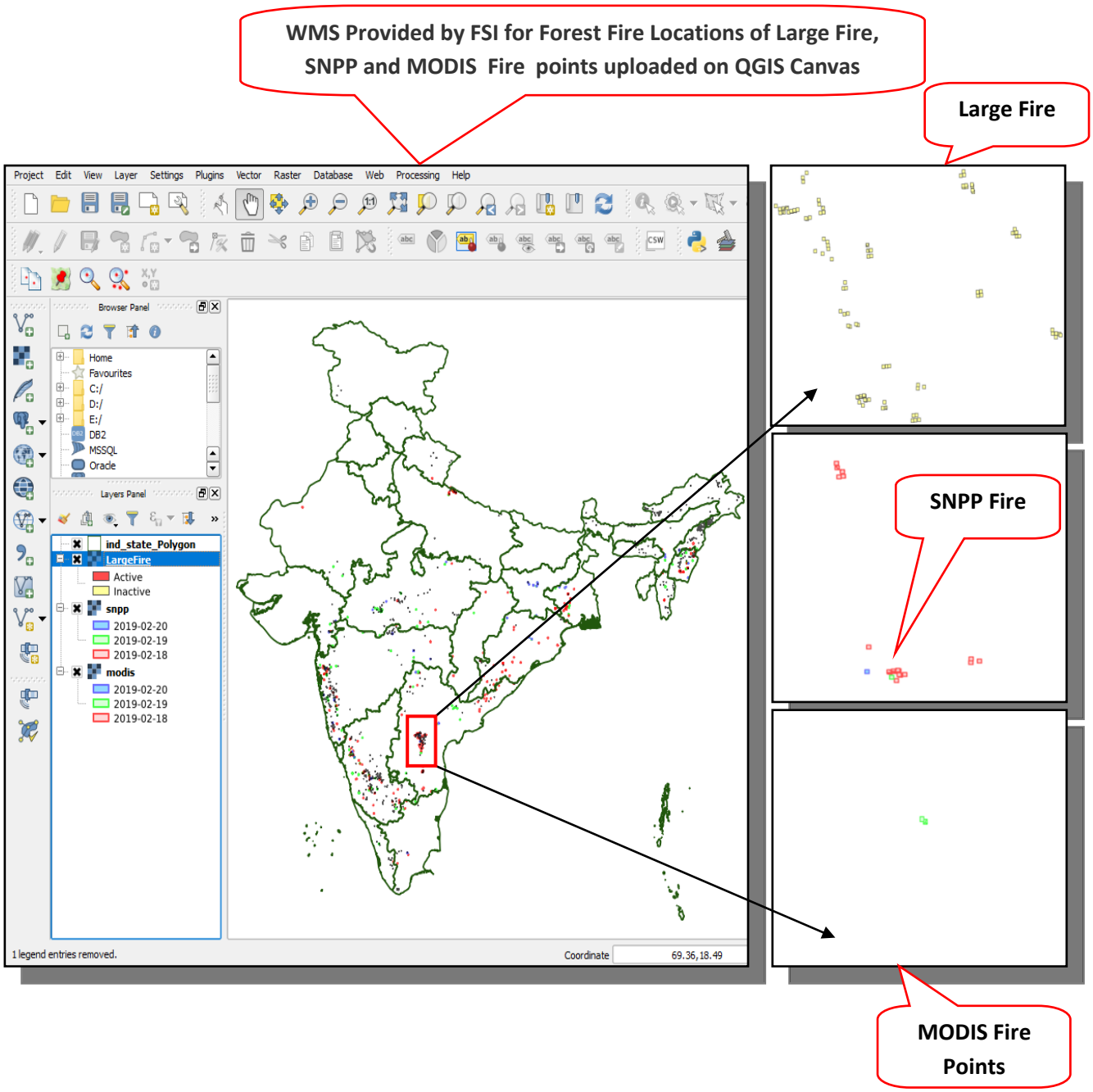


WMS Layers (FCM, FTM) loaded in the QGIS Canvas



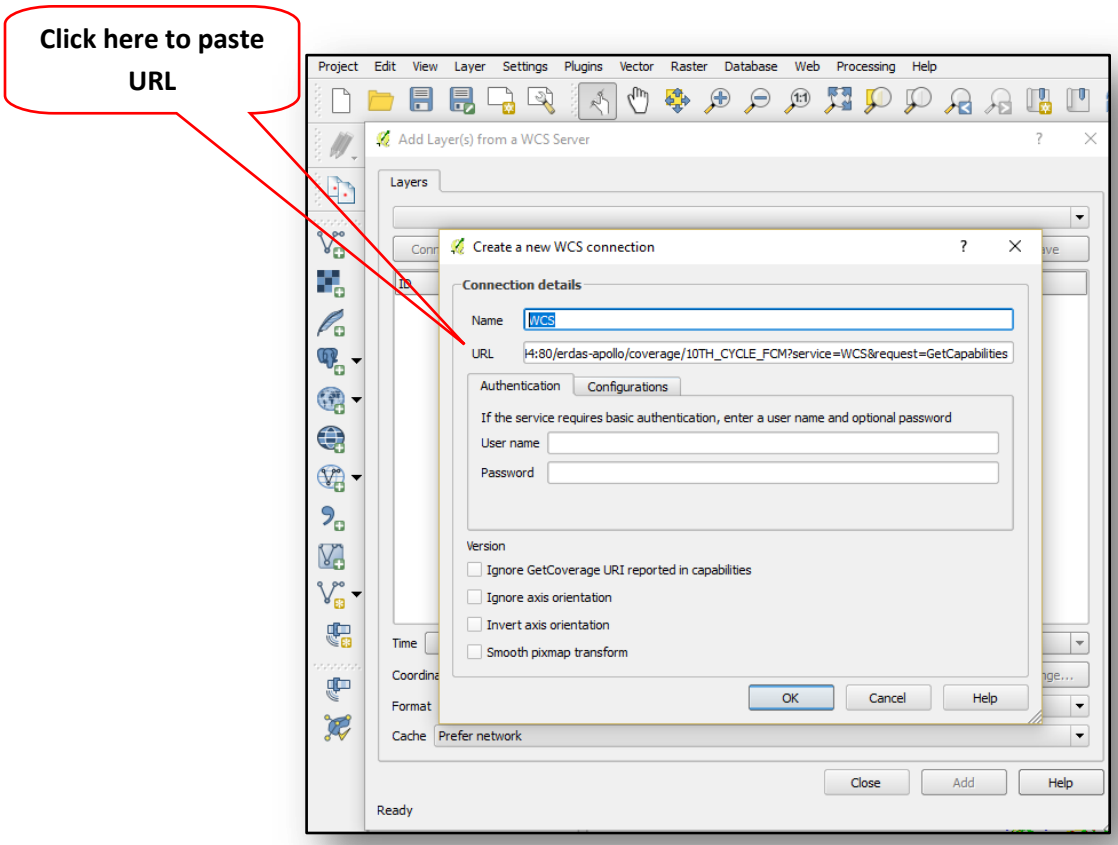

Select from the list of services
Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Help
Add Layer(s) from a WM(T)S Server
Layers
Layer Order
Tilesets
Server Search
MODIS_SNPP_FOREST_FIRE
Connect
New
Edit
Delete
Load
Save
Add default servers
ID
Name
Title
Abstract
0 fire Forest Fire Maps fire
1 STATE_BOUNDARY STATE_BOUNDARY
3 DIST_BOUNDARY DIST_BOUNDARY
5 BEAT_BOUNDARY BEAT_BOUNDARY
7 modis modis
9 snpp snpp
11 LargeFire LargeFire
13 LF_EXT LF_EXT
15 copyright copyright
Image encoding
PNG
PNG8
JPEG
TIFF
SVG
Coordinate Reference System (4 available)
Tile size
Feature limit for GetFeatureInfo
10
WGS 84
Change...
Use contextual WMS Legend
Layer name
LargeFire/snpp/modis
Add
Close
Help
3 Layer(s) selected

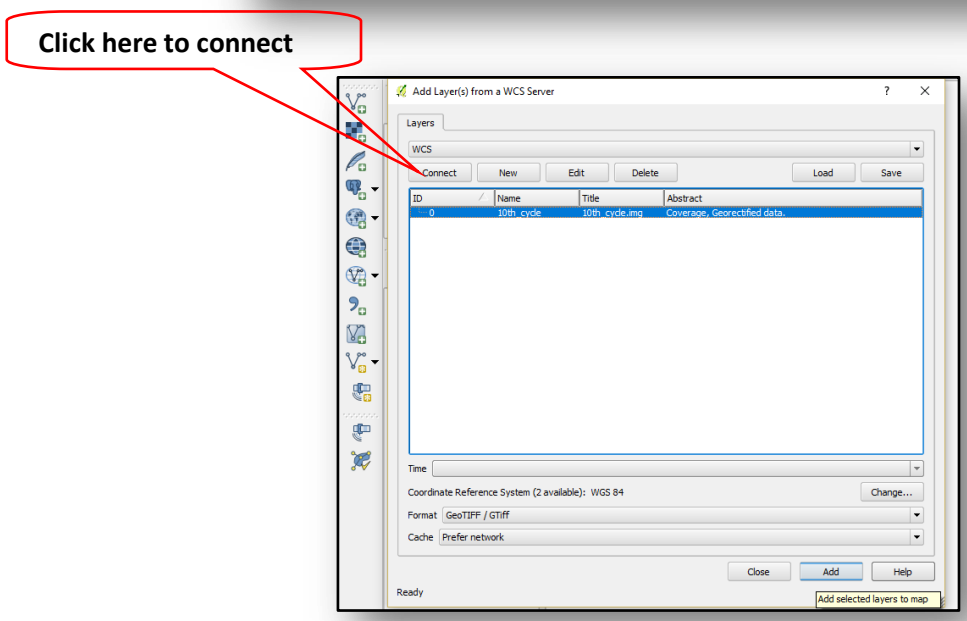

Paste URL here
Create a new WMS connection
Connection details
Name
MODIS_SNPP_FOREST_FIRE
URL
Authentication
Configurations
If the service requires basic authentication, enter a user name and optional password
User name
Password
Referer
DPI-Mode
all
Version
Ignore GetMap/GetTile URI reported in capabilities
Ignore GetFeatureInfo URI reported in capabilities
Ignore axis orientation (WMS 1.3/WMTS)
Invert axis orientation
Smooth pixmap transform
OK
Cancel
Help


WMS Provided by FSI for Forest Fire Locations of Large Fire, SNPP and MODIS Fire points uploaded on QGIS Canvas
Large Fire
SNPP Fire
MODIS Fire Points
Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Help
Browser Panel
Home
Favourites
C:/
D:/
E:/
DB2
MSSQL
Oracle
Layers Panel
ind_state_Polygon
LargeFire
Active
Inactive
snpp
2019-02-20
2019-02-19
2019-02-18
modis
2019-02-20
2019-02-19
2019-02-18
1 legend entries removed.
Coordinate
69.36,18.49

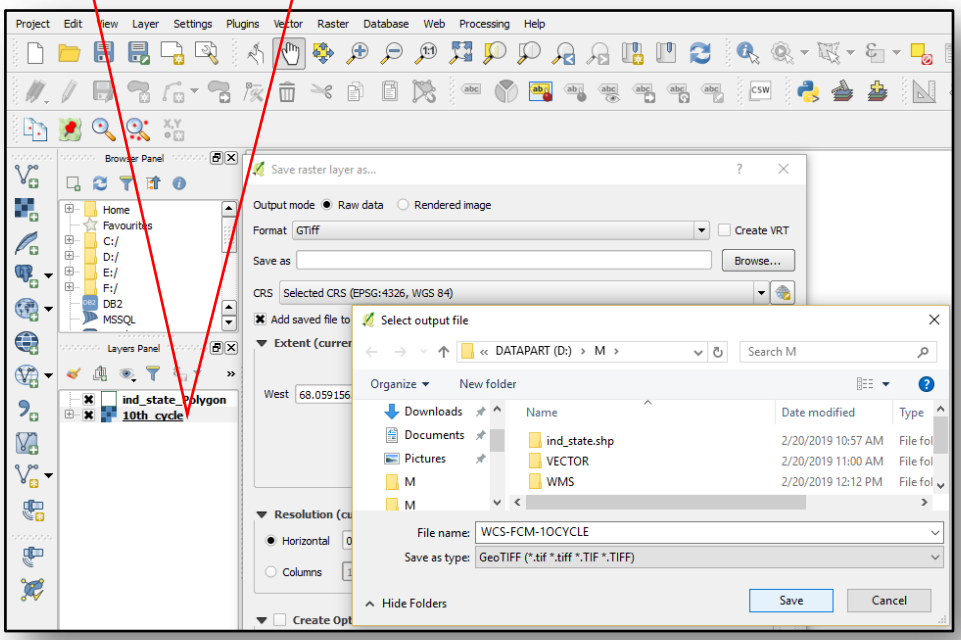
9.2 Web Coverage Service (WCS)

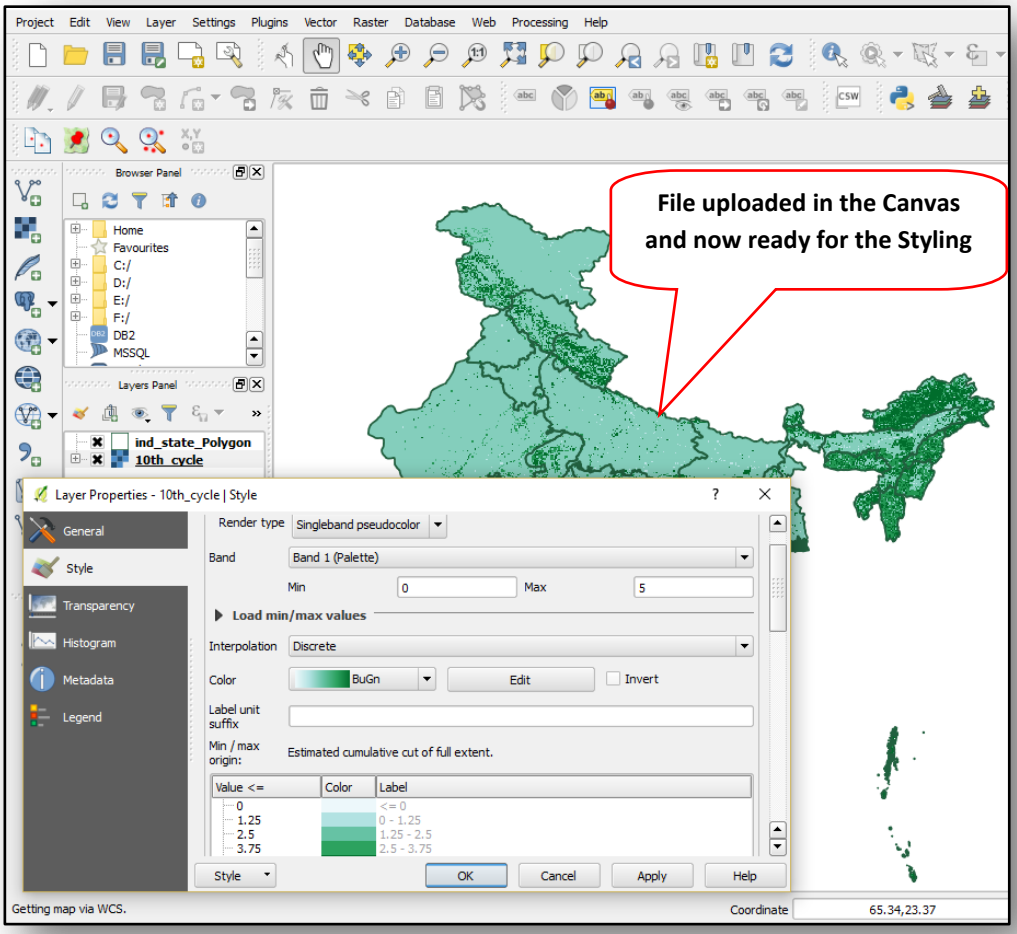
- WCS is used to publish the raster data, i.e. satellite imagery in image or TIFF, GeoTIFF formats.
- To open WCS window Click on WCS tool in extreme Left side of the window.
- Create a new WCS connection > and Paste address of a link in **URL Tab** >and Click OK.





To save the file as Geotiff, Right Click on Layer in Legend Bar

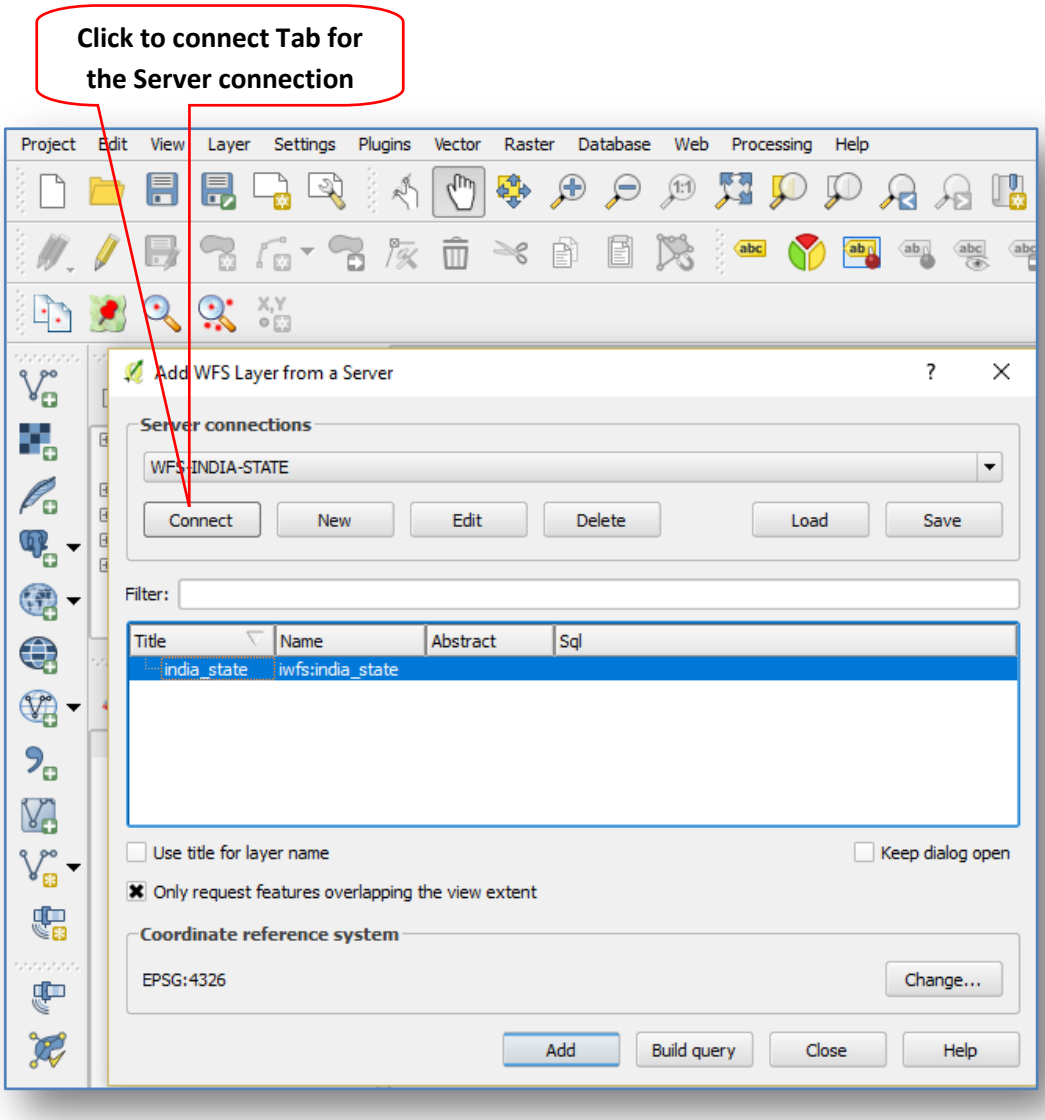


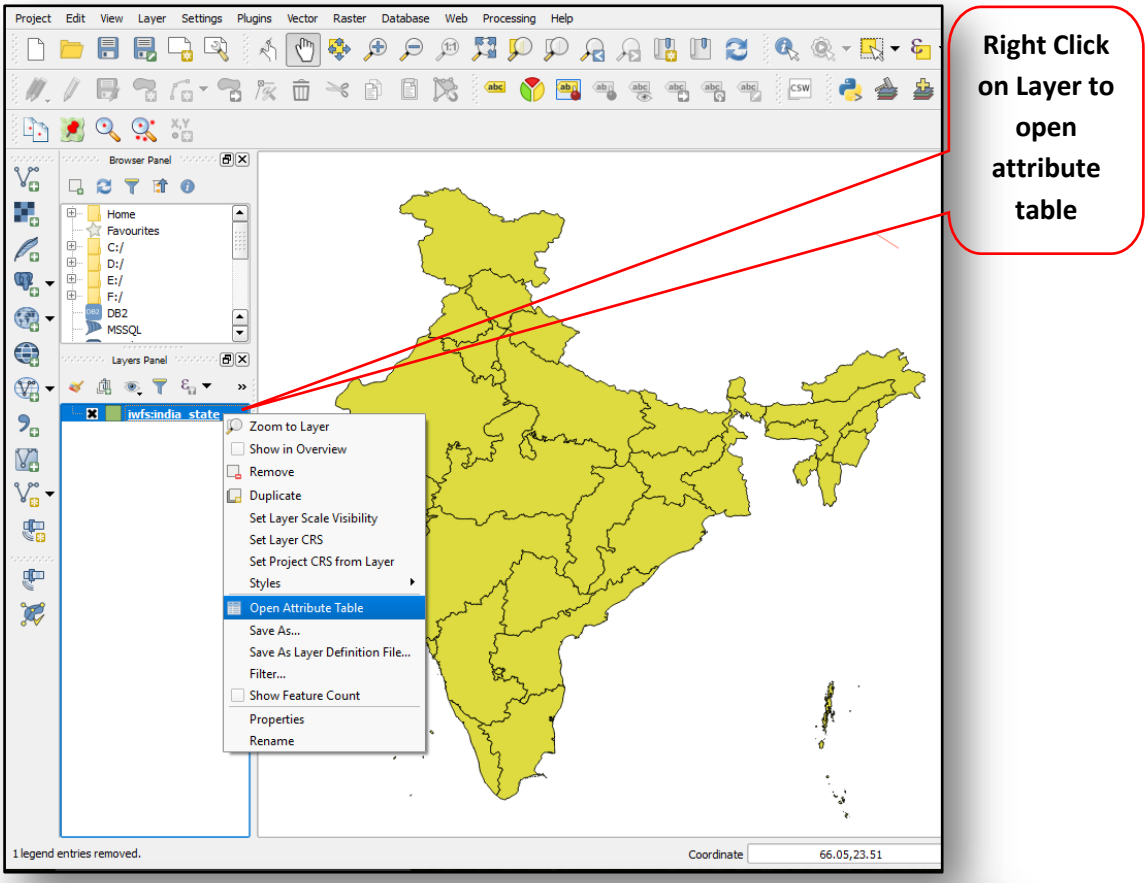


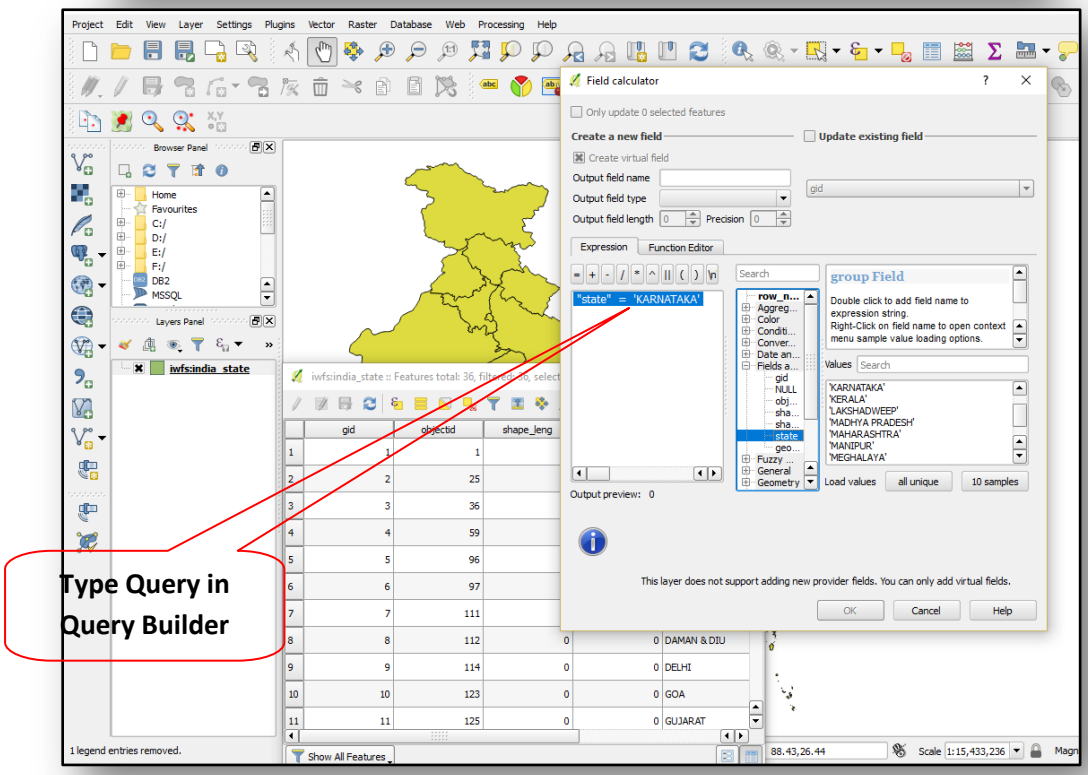
9.3 Web Feature Service (WFS)

WFS is used to query, update, delete the data of the map that is used to share the vector data or metadata of the map over the web.

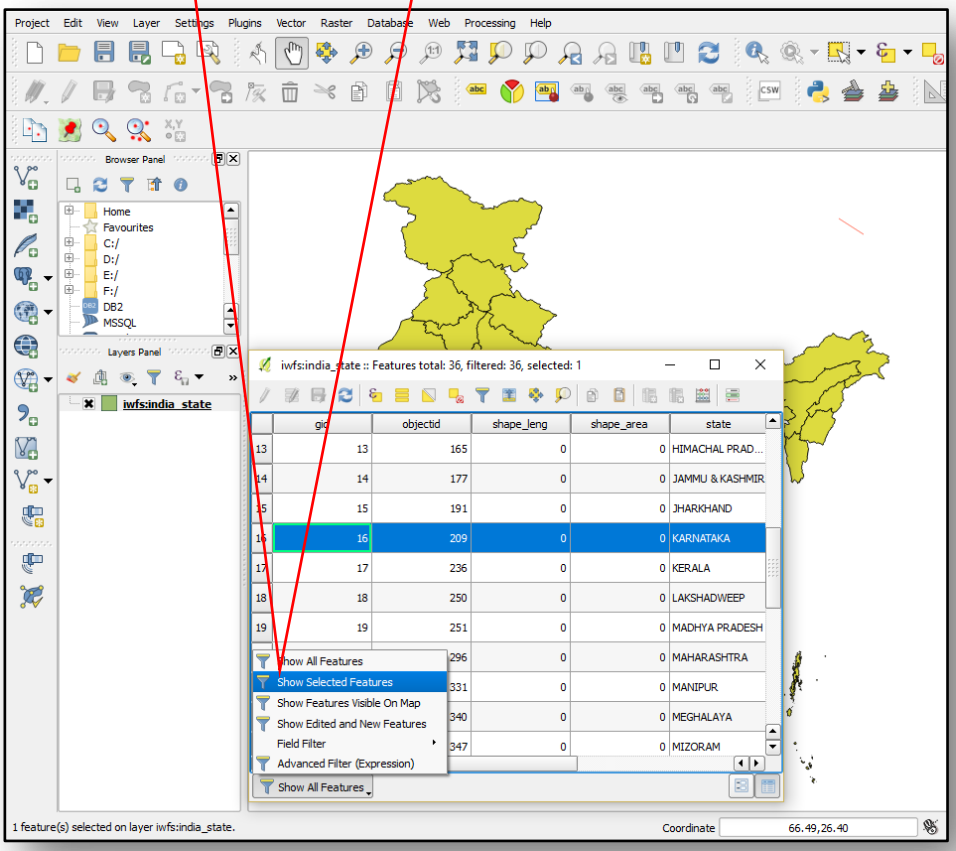
- To open WFS window > Click on WFS tool in extreme Left side of the window.
- Create a new WCS connection > and Paste address of a link in URL Tab > Click OK.

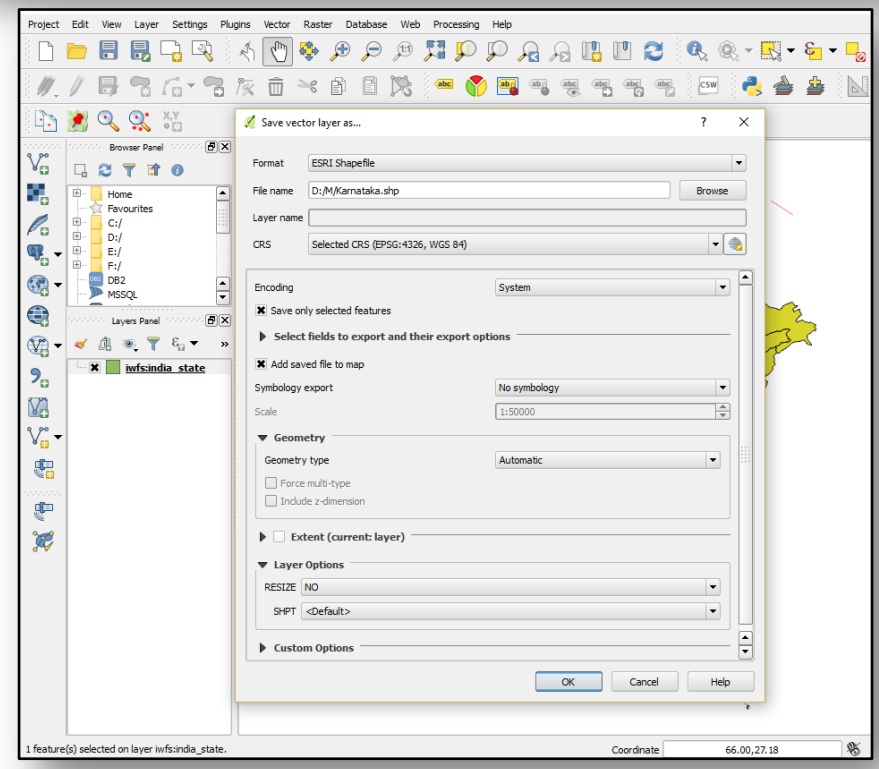



Right Click on Layer to open attribute table
Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Help
Browser Panel
Home
Favourites
C:/
D:/
E:/
F:/
DB2
MSSQL
Layers Panel
iwfs:india_state
Zoom to Layer
Show in Overview
Remove
Duplicate
Set Layer Scale Visibility
Set Layer CRS
Set Project CRS from Layer
Styles
Open Attribute Table
Save As...
Save As Layer Definition File...
Filter...
Show Feature Count
Properties
Rename
1 legend entries removed.
Coordinate
66.05,23.51

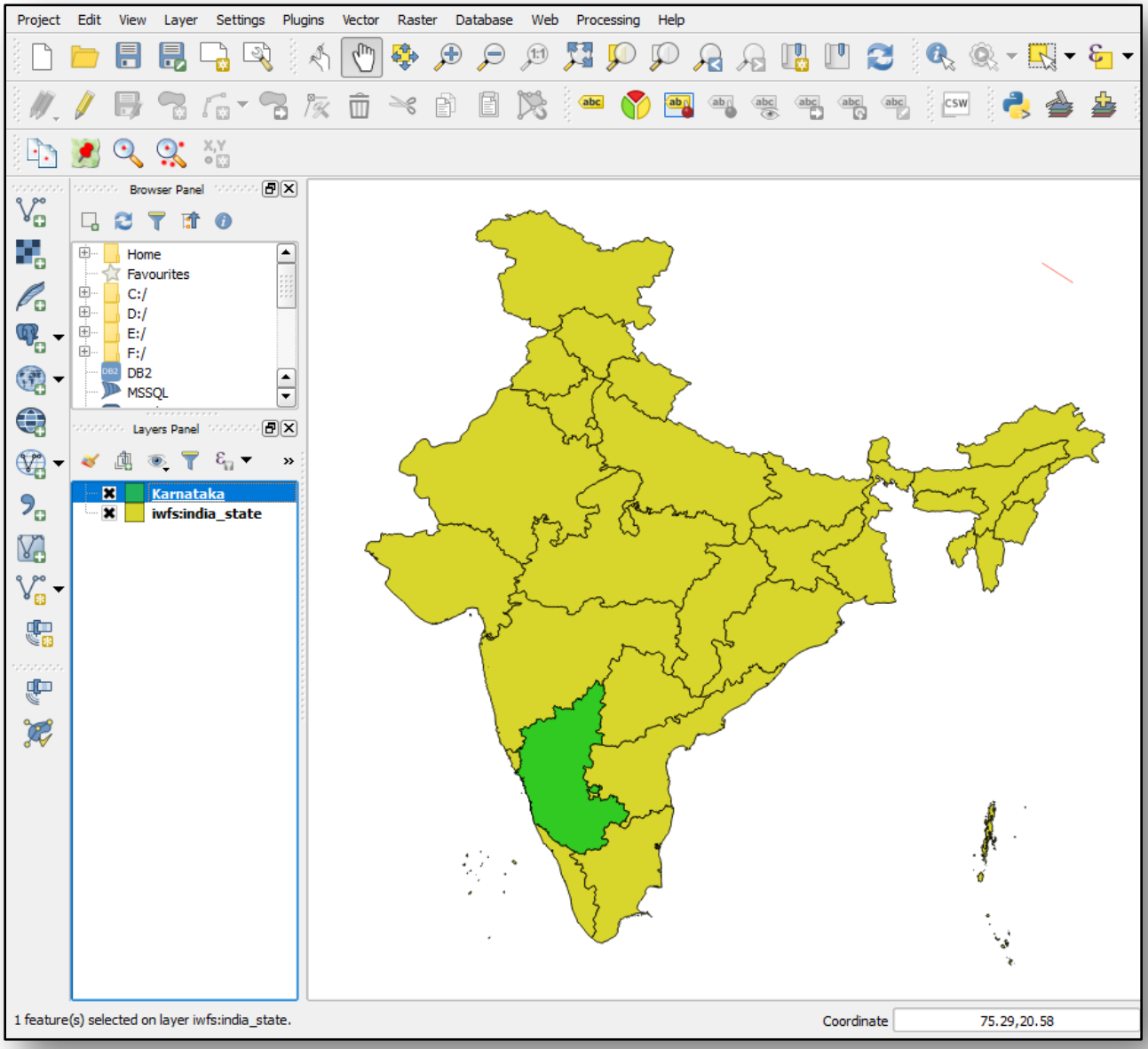

Type Query in Query Builder
Field calculator
Only update 0 selected features
Create a new field
Update existing field
Create virtual field
Output field name
Output field type
Output field length
Precision
Expression
Function Editor
"state" = 'KARNATAKA'
group Field
Double click to add field name to expression string.
Right-Click on field name to open context menu sample value loading options.
Values
'KARNATAKA'
'KERALA'
'LAKSHADWEEP'
'MADHYA PRADESH'
'MAHARASHTRA'
'MANIPUR'
'MEGHALAYA'
Load values
all unique
10 samples
Output preview: 0
This layer does not support adding new provider fields. You can only add virtual fields.
OK
Cancel
Help
iwfs:india_state :: Features total: 36, filtered: 36, selected
gid
objectid
shape_leng
DAMAN & DIU
DELHI
GOA
GUJARAT
Show All Features
1 legend entries removed.
88.43,26.44
Scale
1:15,433,236

Click here to show selected State as per Query written in Expression box and Save it as Shapefile of selected feature only





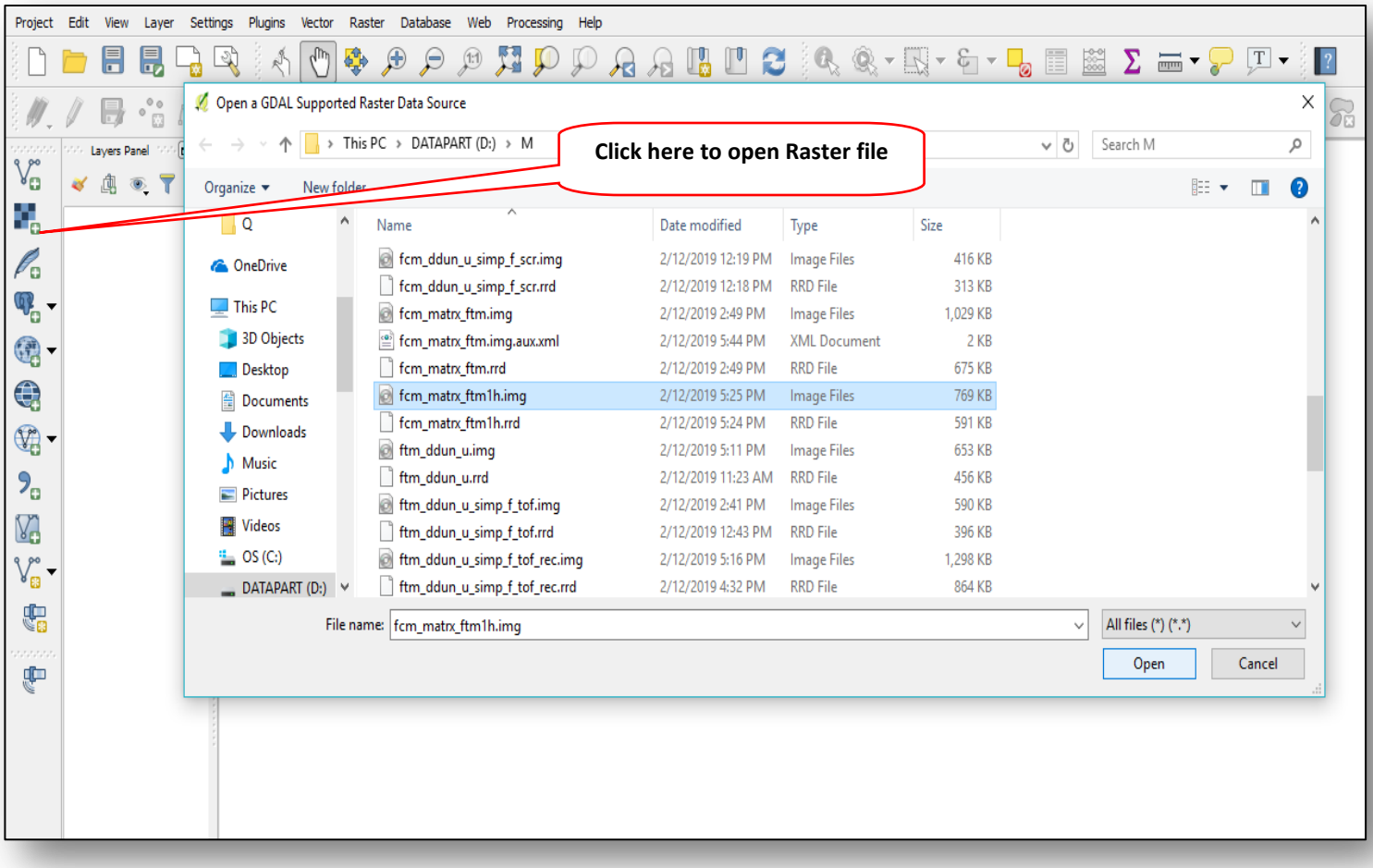
- Once the shapefile is saved, it will appear as a separate shapefile and opened on the map canvas and as it is a WFS layer, we can update and delete features accordingly.



Chapter 10: Grid-based Analysis and Sampling the Data

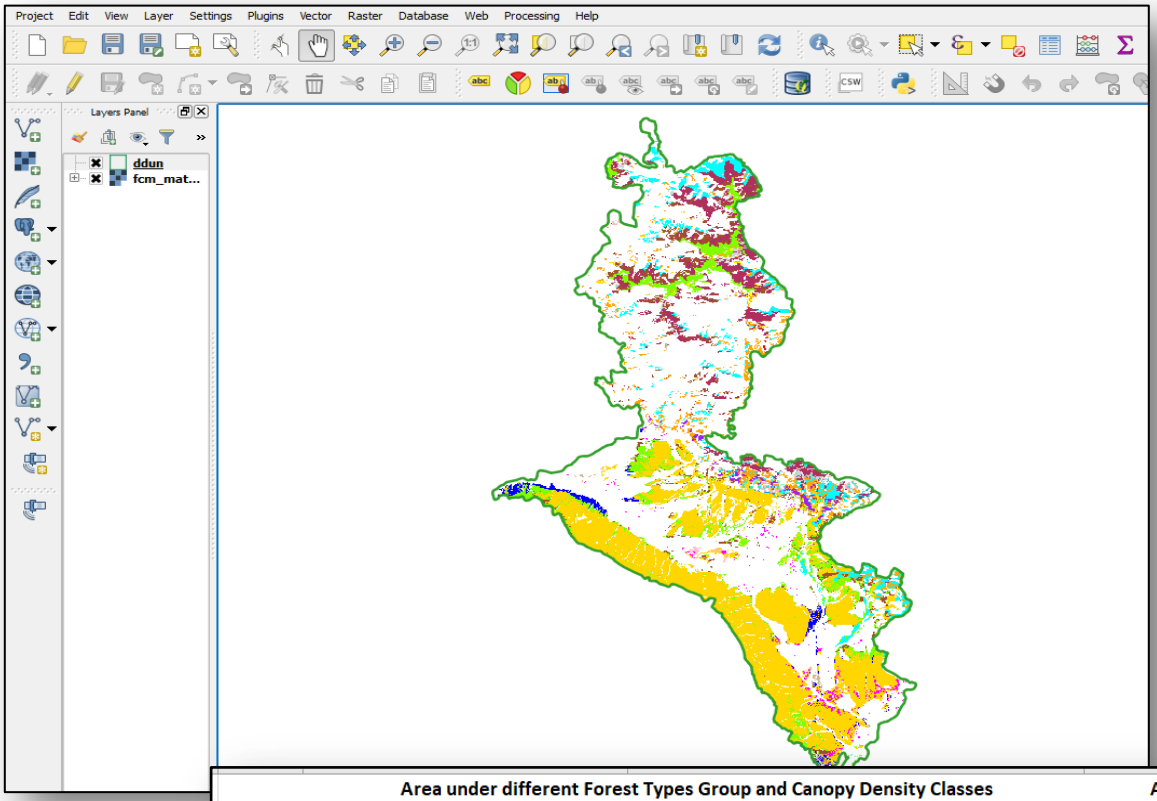
- To create a 5x5 Km grid for creating sampling points on loaded file (Canopy density class-wise Forest Types) of Dehradun in Map canvas, first load file.

- To upload file either go to Layer > open Raster/Vector file > or directly open it by clicking on open Raster/ Vector button.



- Select the file > and click open.

- It will load selected layer on Map Canvas > next create grid of 5x5km for the further analysis.

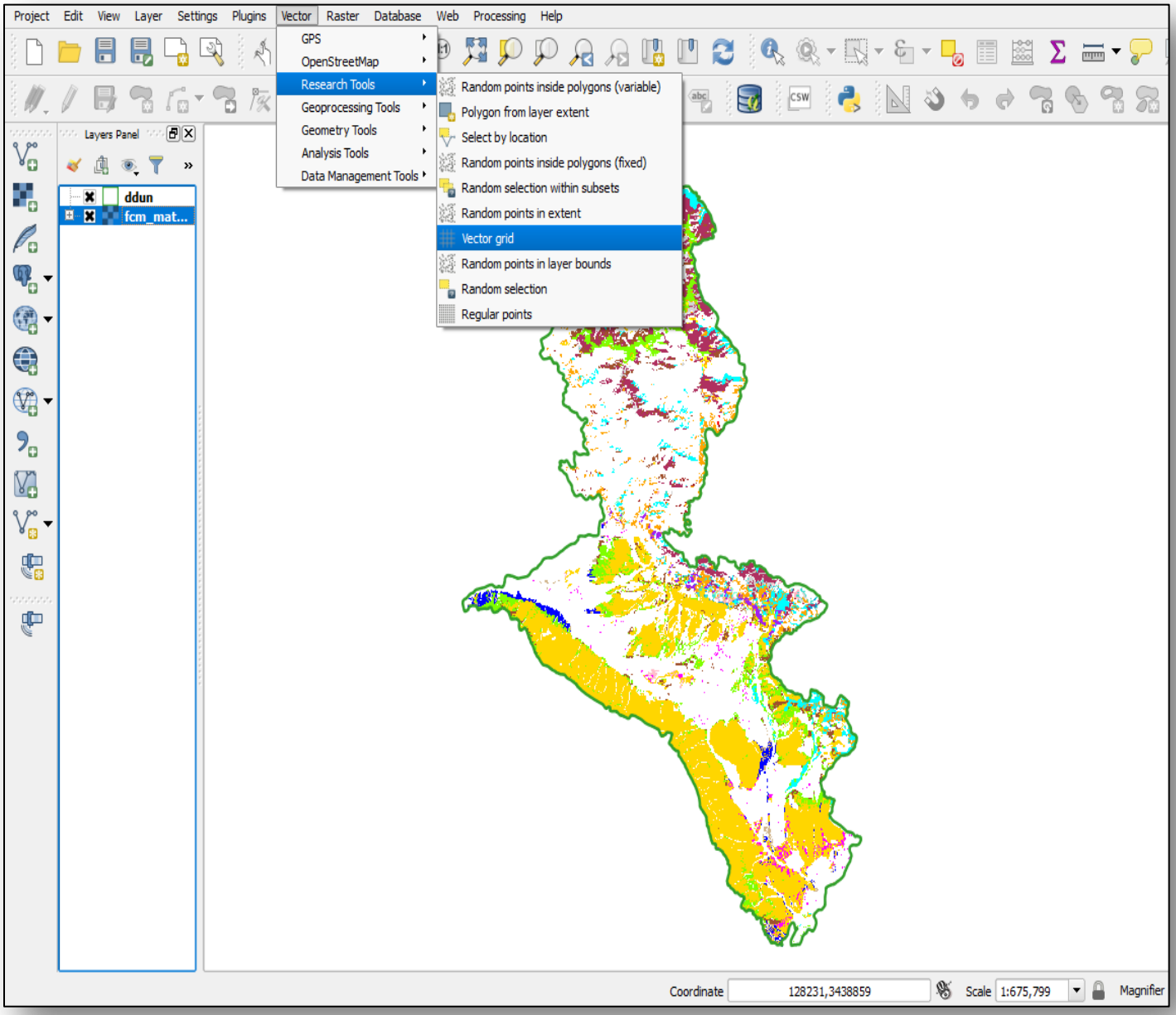


Area under different Forest Types Group and Canopy Density Classes			Area (sqkm)		
Group	**Type Group**	**Forest Types**	**Dense**	**Open**	**Scrub**
		3C/C2a Moist Siwalik Sal Forest	639.10	18.83	0.90
Group3	**Tropical Moist Deciduous Forest**	3C/C3a West Gangetic Moist Mixed Dec. Forest	26.77	10.32	0.00
		5B/C1a Dry Siwalik Sal Forest	104.51	35.41	2.59
		5B/C2 Northern Dry Mixed Deciduous Forest	17.45	12.43	3.32
		5/1S2 Khair-Sissu Forest	8.72	5.07	0.00
Group5	**Tropical Dry Deciduous Forest**	5/DS1 Dry Deciduous scrub	0.03	0.04	0.00
		9/C1b Upper or Himalayan Chir Pine Forest	100.30	58.45	5.59
		9/C1/DS2 Subtropical Euphorbia Scrub Forest	2.53	8.13	3.66
		9/C1/DS1/Himalayan Subtropical Scrub Forest	0.00	0.00	0.01
Group9	**SubTropical Pine Forest**	9/C1a Lower or Siwalik Chir Pine Forest	0.46	0.00	0.00
		12/C1c Moist Deodar Forest	54.98	2.84	0.20
		12/C1d Western Mixed Coniferous Forest	53.79	2.14	0.00
		12/C1a Ban Oak Forest	145.41	23.82	1.03
		12/C1/D52 Himalayan Temperate Secondary Scrub	2.99	4.14	0.26
		12/C1b Moru Oak Forest	0.10	0.00	0.00
Group12	**Himalayan Moist Temperate Forest**	12/C2b West Himalayan Upper Oak /Fir Forest	0.02	0.00	0.00
	TOF/PLN.	**TOF/PLN.**	22.76	22.38	3.05
Total			**1179.91**	**204.00**	**20.61**

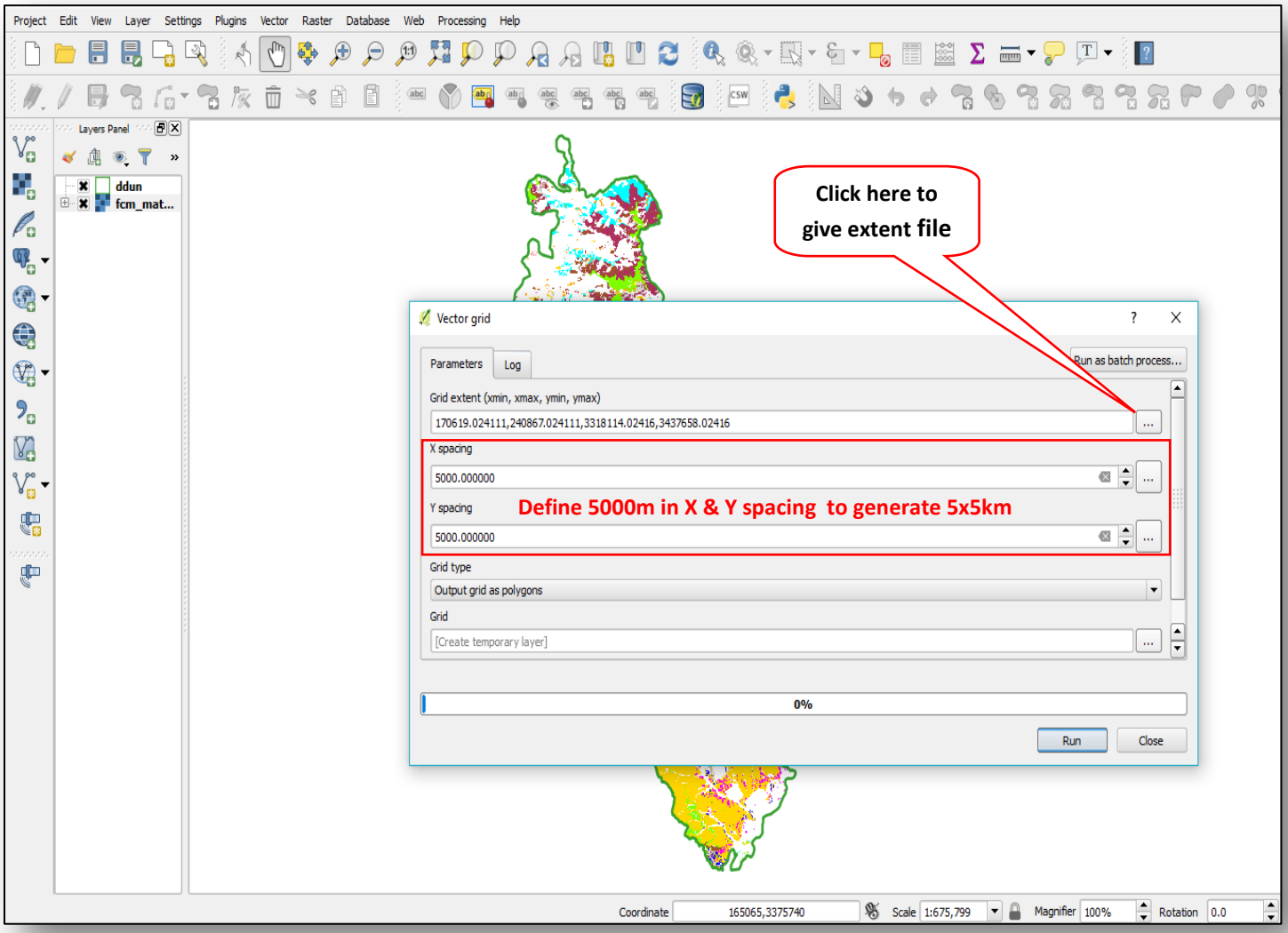
Attribute Table of a Forest Types Group-wise Canopy Density Classes

10.1 Create 5x5 Km Grid

- Next, go to Vector > Research Tools followed by Vector grid.

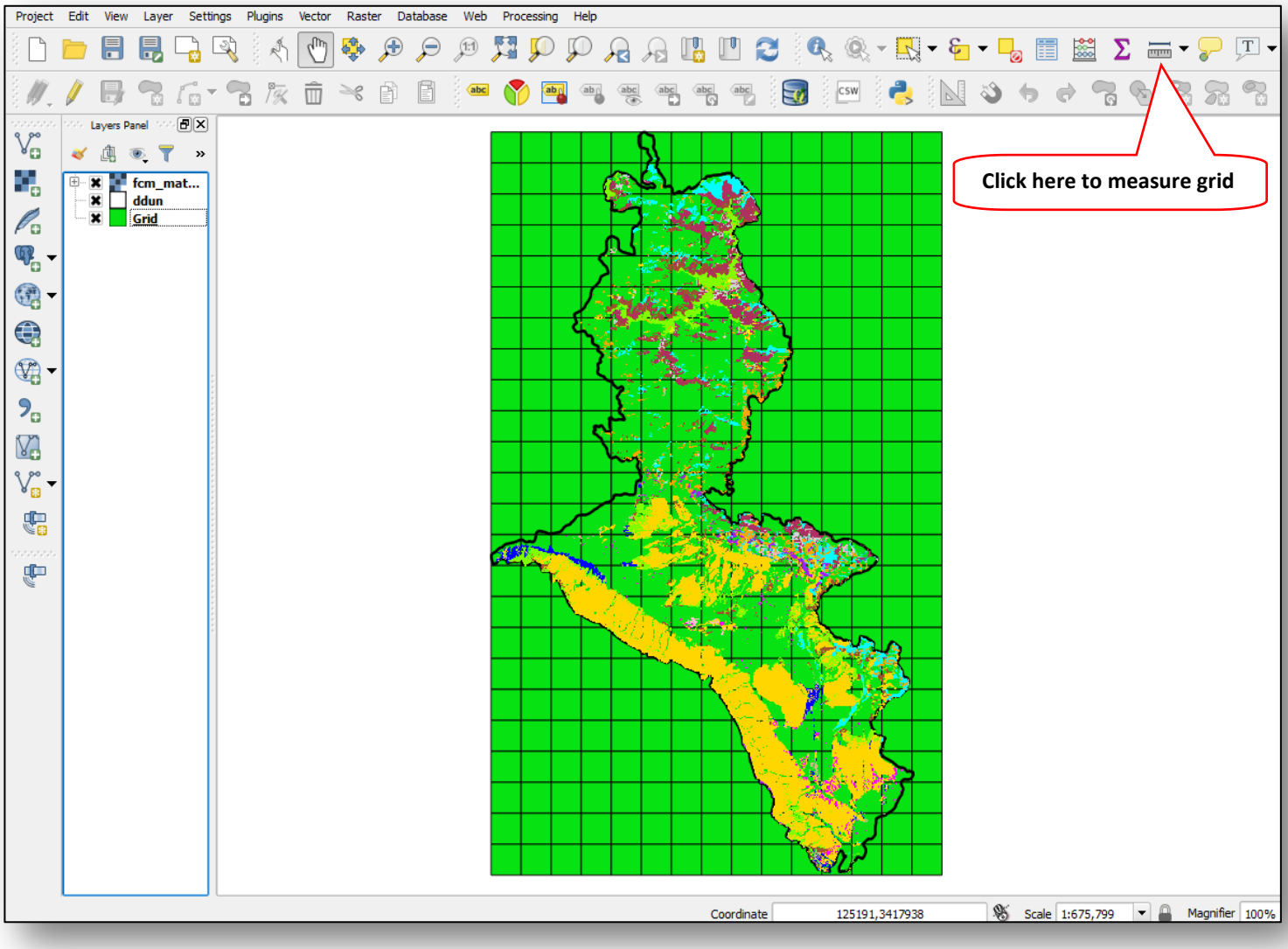


- Now, Vector grid window will appear on the Map canvas > next set the parameters in the window.
- Click on Right side of Grid extent field > and select the reference file to create a grid.
- In X & Y spacing define the size of grids (5000m=5km, i.e. 5x5km)
- Set Grid Type as Output Grid as Polygon > and Click on Grid option to save file, otherwise it automatically save the file.



- Click Run.

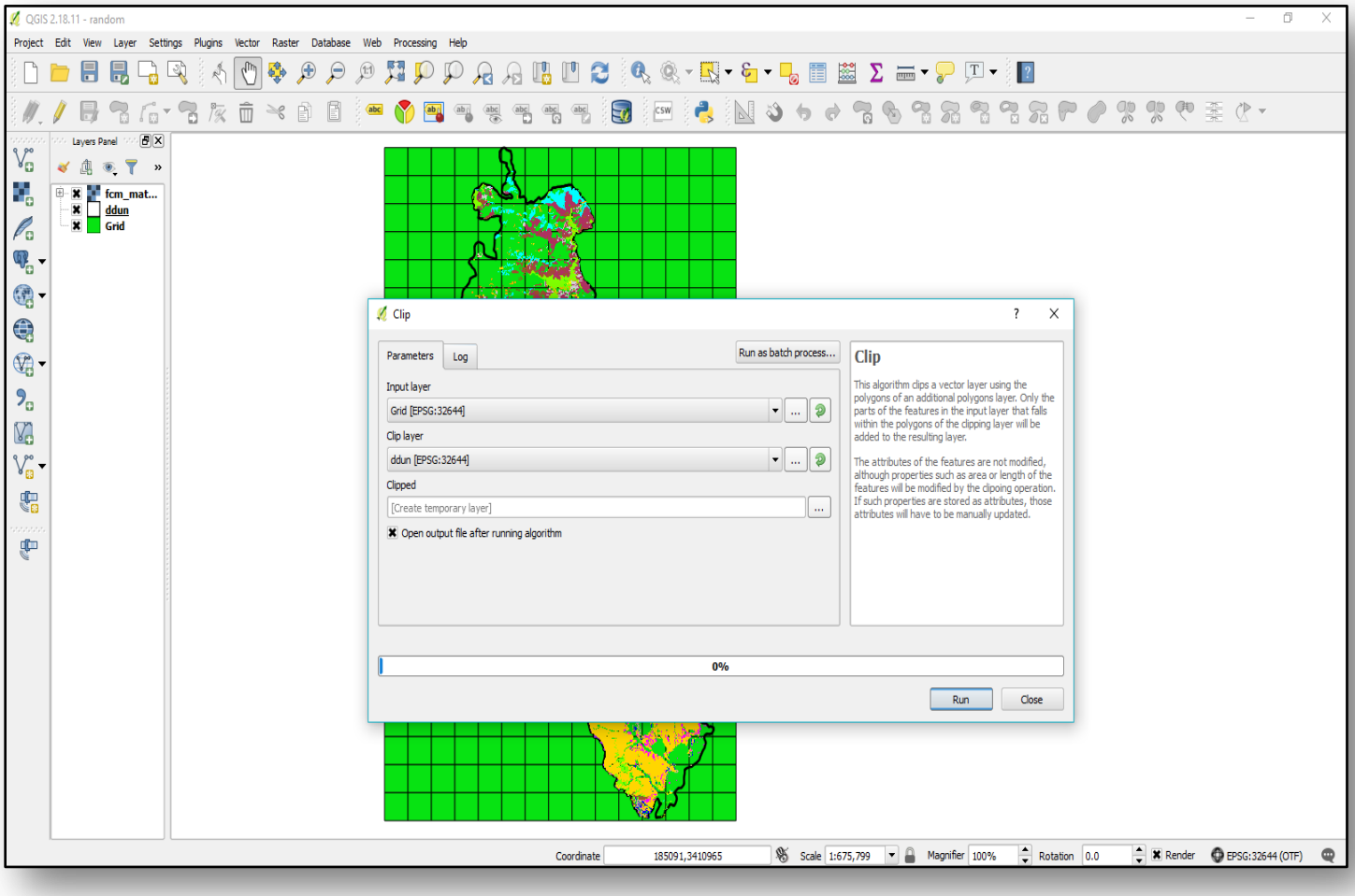
- Open output Vector grid file after running algorithm and that will appear on Map Canvas as shown in Figure.
- Now, can measure the generated grid dimension by clicking on measurement tool as highlighted in Figure.



- Now we will observe that grid of 5x5km generated as per the map extent, i.e. going out of extent of boundary of Vector/ Raster Layer. Therefore, to clip the extent of grid as per the reference of imported Layer **>** Go to Vector Tab **>** and select Clip option from the list of options.

- In Clip window > select the extent of the grid by clicking Right side of Input Layer option > and set the name of the extent/boundary file in clip Layer.

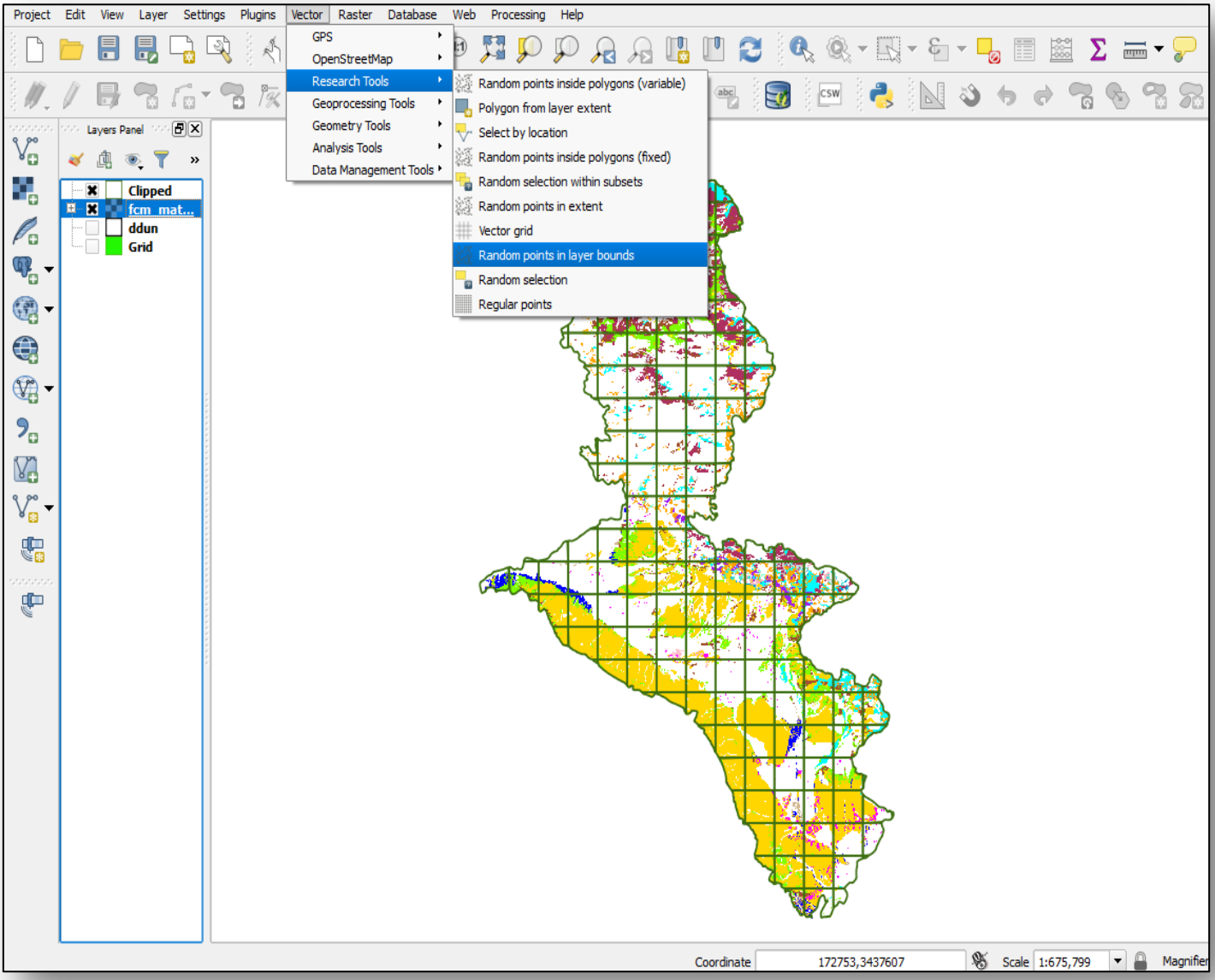
- Before clicking Run, make sure to check Open output file after running algorithm to open file automatically.



10.2Creating Random Points

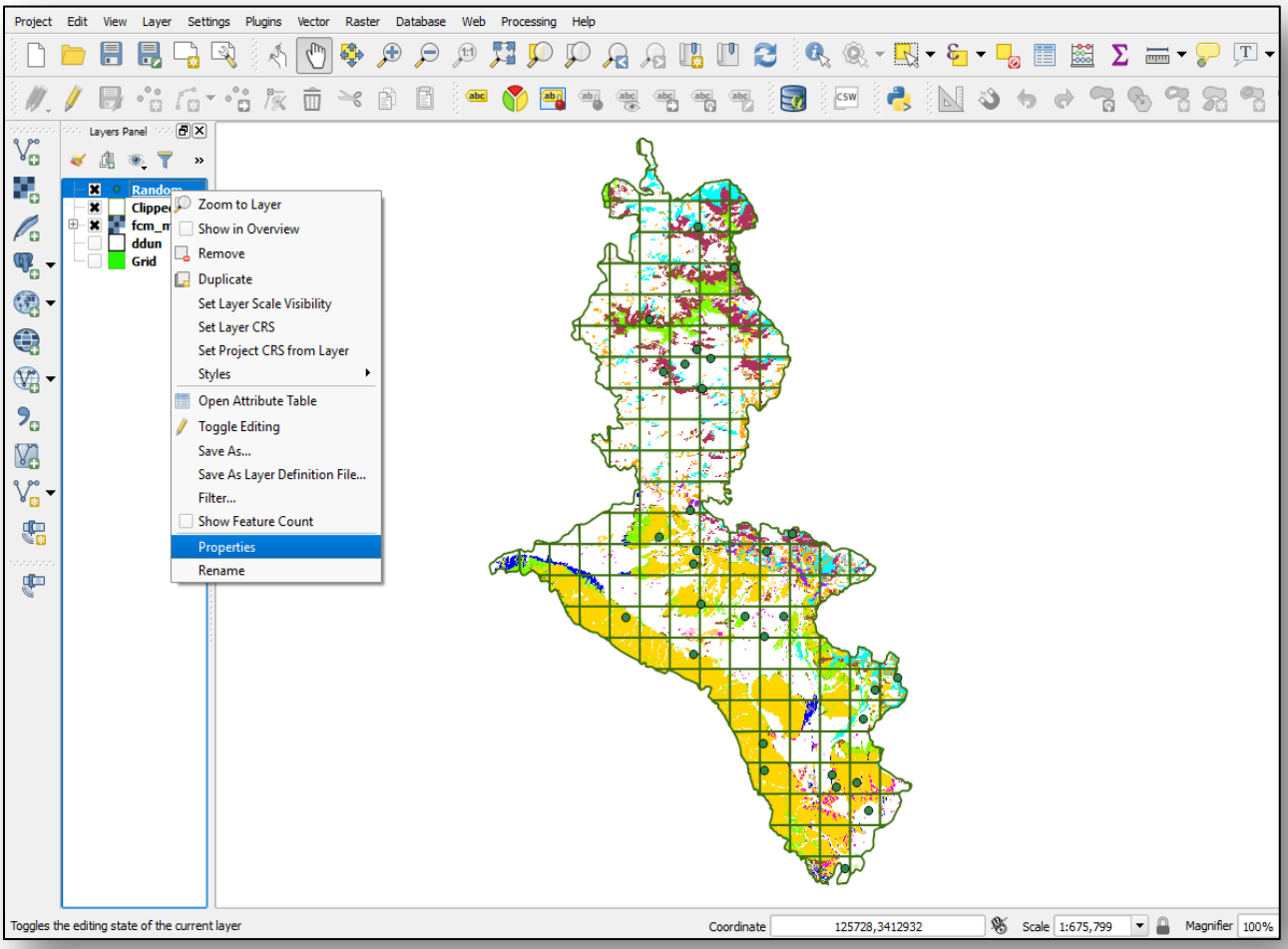
- Now, after running algorithm grid file uploaded on the Map Canvas. At this time it is showing clipped extent of grid as per area of interest.

- In the Menu Bar **>** select Vector **>** and click Research Tools **>** navigate to Random points in layer bounds.

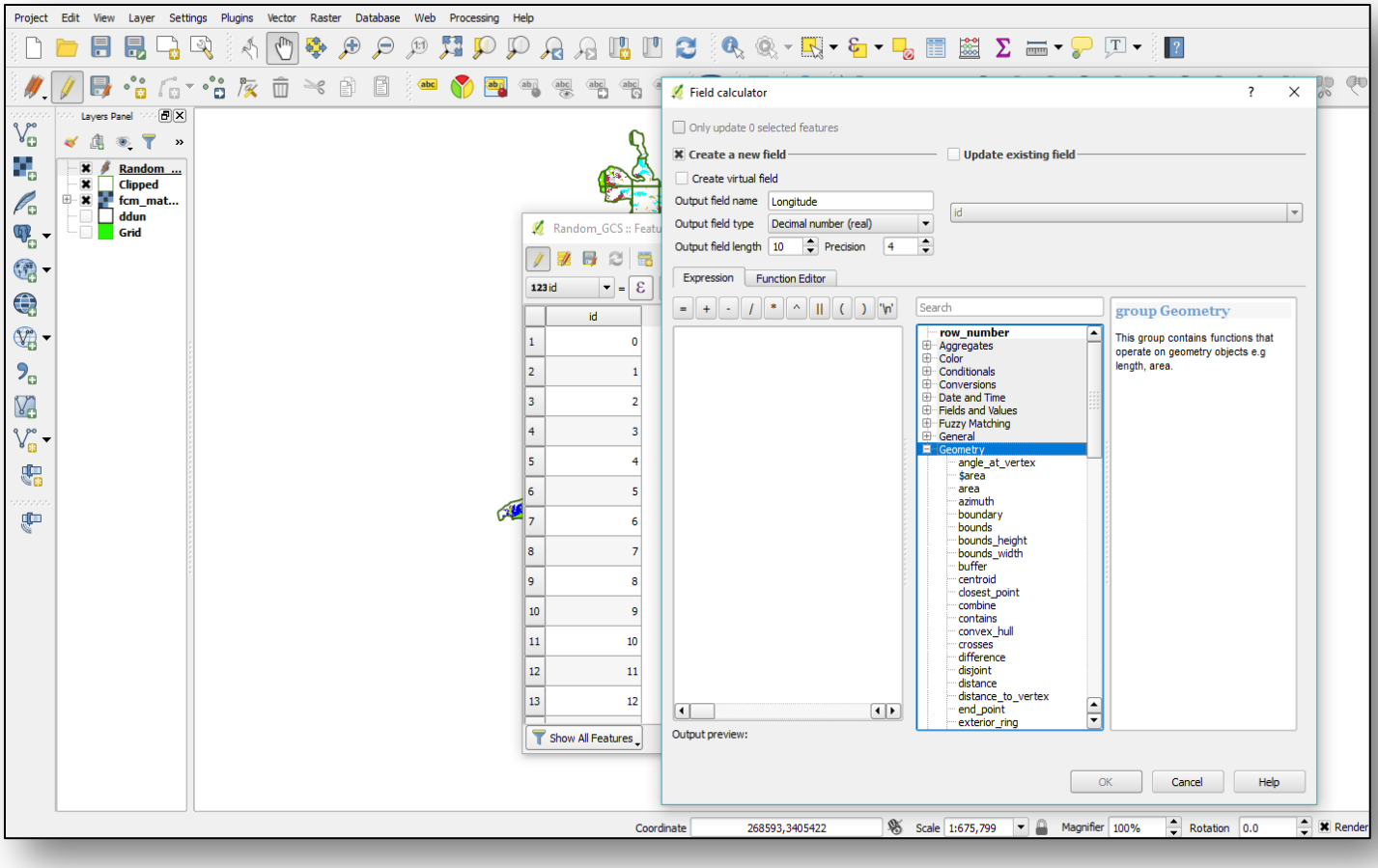


- When the process is completed, the random points will be added to QGIS Map Canvas. A total 30 Random points have been generated as per defined parameters in generation of Random points.

- Right click on Layer **>** and go to Properties **>** set coordinate Reference System as EPSG:4326 WGS 84, Geographic Coordinate System (GCS) defined Longitude and Latitude in Degree units inspite of meters .

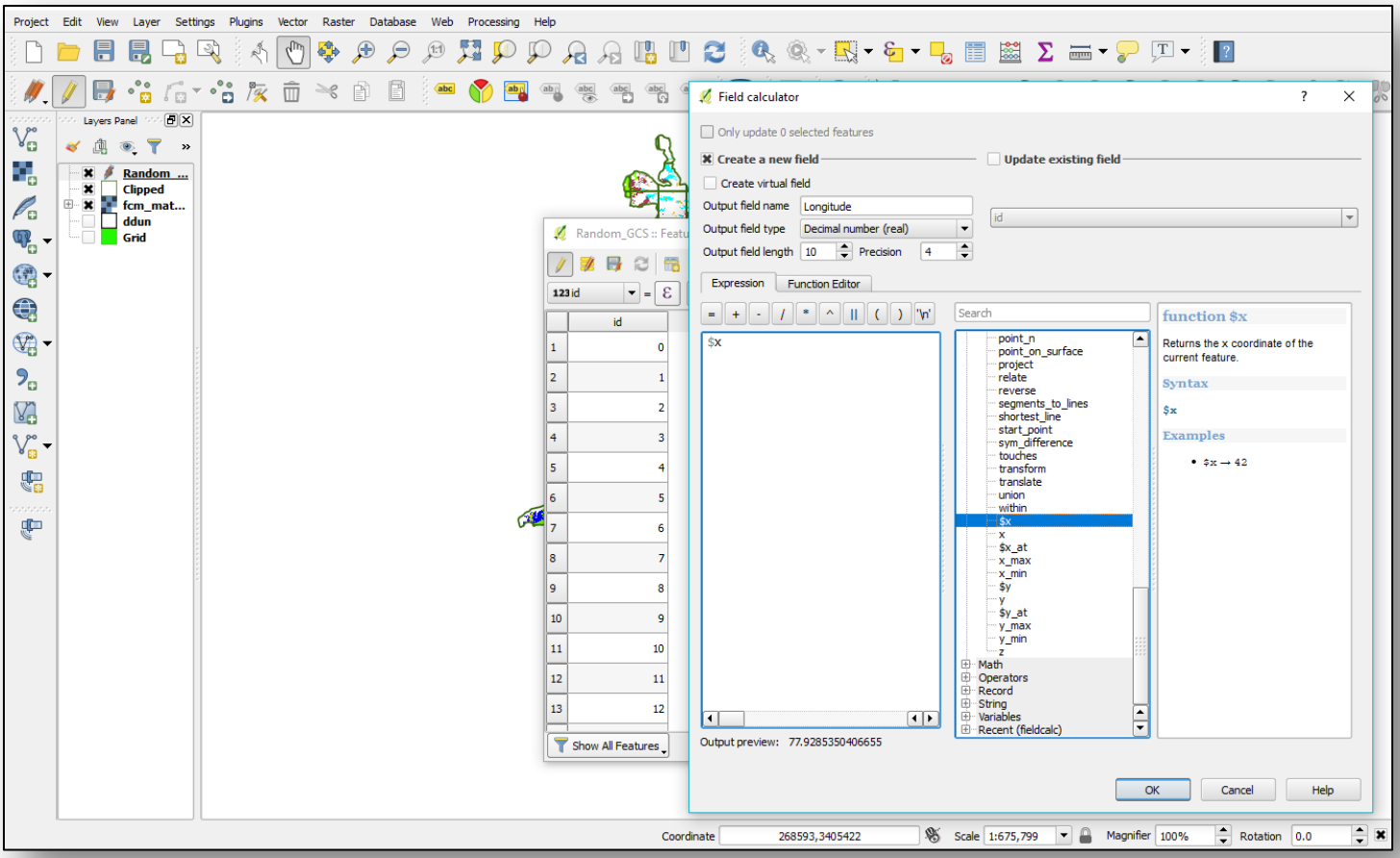


- Right Click on Random Point on Legend Bar and Open the attribute table for the same. There are 30 Random Points in the attribute table with Feature Id.
- Now, we want to generate Longitude and Latitude Id's for each and every point.
- In Field Calculator, make sure to check create a new field, define output field name as "Longitude" and in Output field Type define Decimal number (real) and set Output field length as 10 and precision as 4, i.e. show values after 4 decimal place.



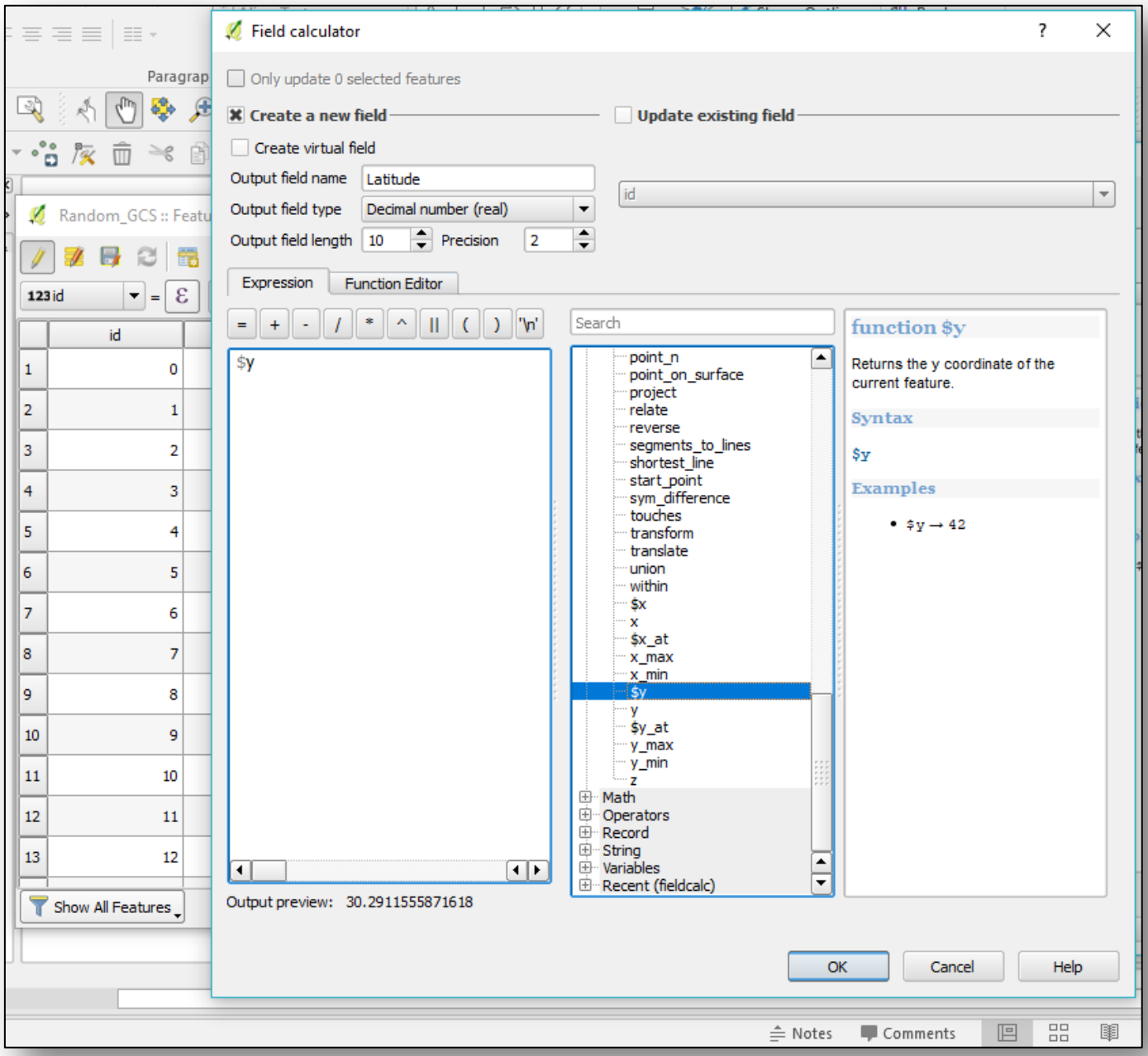
- Now select Geometry in row_number column to set the expression in expression box.

- Double click on $x so that it will appear in expression box and representing Longitude of each and every Id.



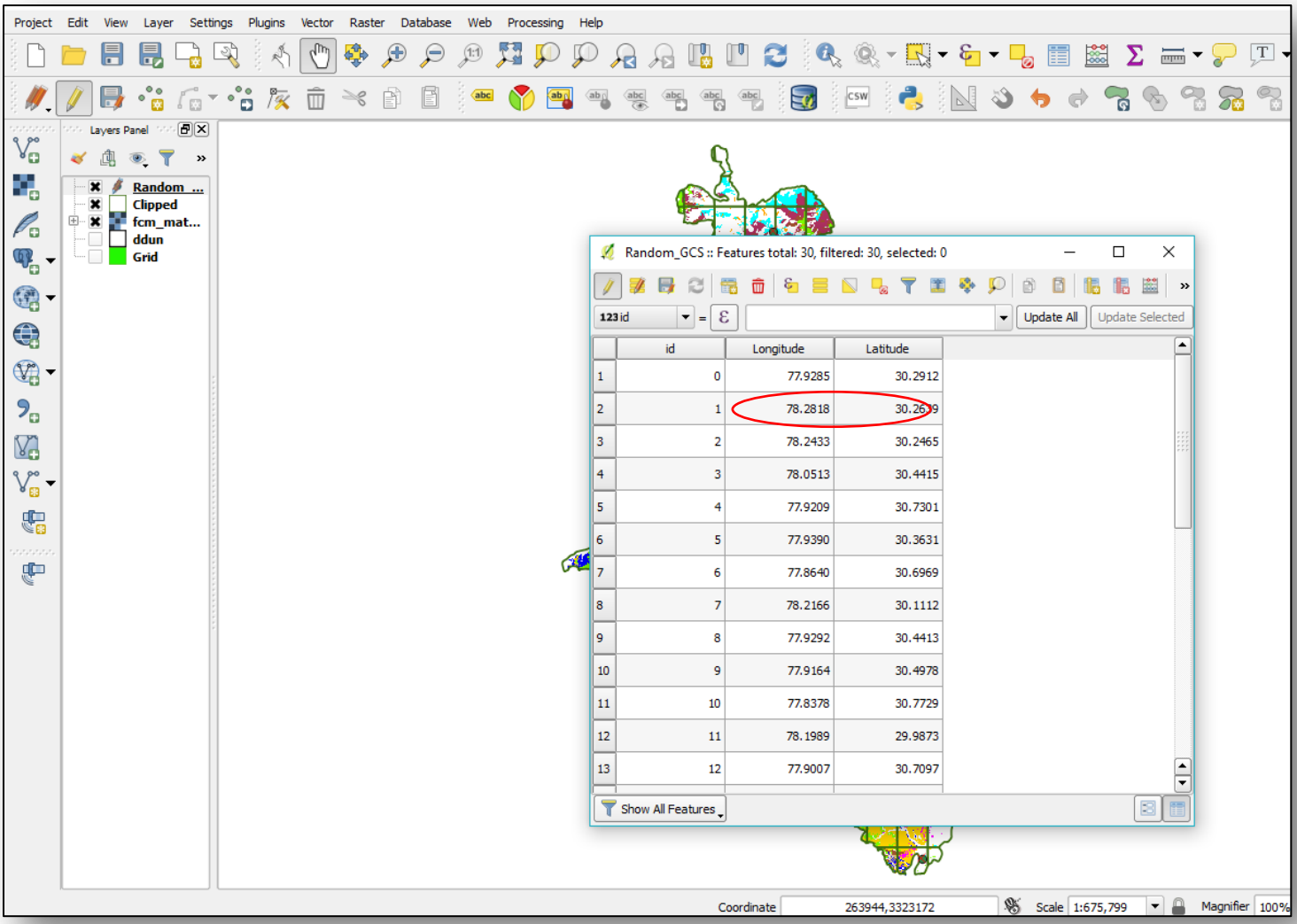
- Next, select $x **>** and click ok.

- Similarly, double click on $y so that it will appear in expression box and representing Latitude of each and every Id.



- Now, select $y **>** and click ok.

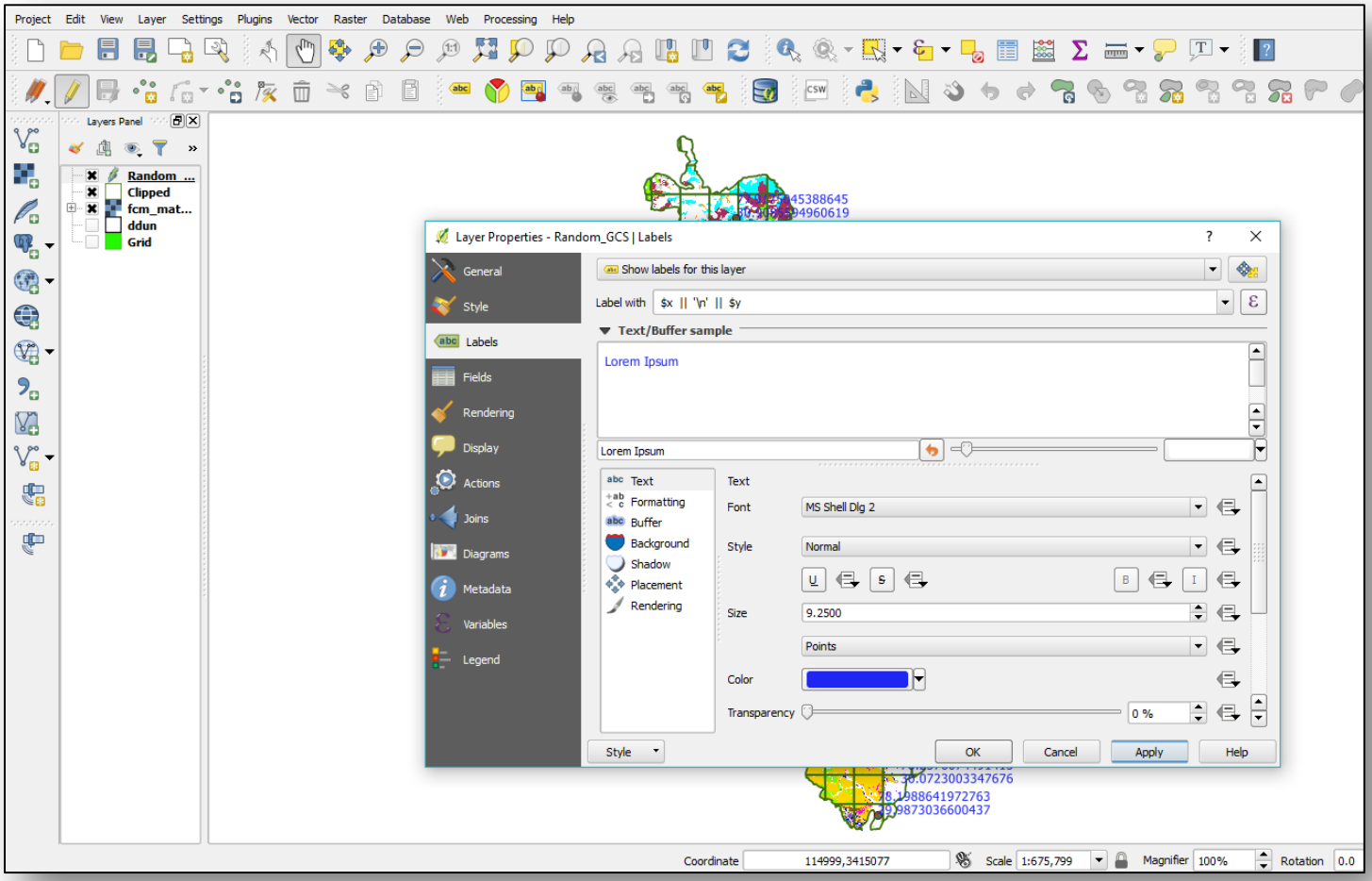
- When the Geometry calculation process is complete, it will load Random points denoting Longitude and Latitude values at generated points. Now, Right Click on Random Points Layer and this time table is showing newly added fields with the name Longitude and Latitude.



	id	Longitude	Latitude
1	0	77.9285	30.2912
2	1	78.2818	30.2619
3	2	78.2433	30.2465
4	3	78.0513	30.4415
5	4	77.9209	30.7301
6	5	77.9390	30.3631
7	6	77.8640	30.6969
8	7	78.2166	30.1112
9	8	77.9292	30.4413
10	9	77.9164	30.4978
11	10	77.8378	30.7729
12	11	78.1989	29.9873
13	12	77.9007	30.7097

- In the Layers Panel > right click on Random points Layer > and select Properties or either double click on file > and directly go to Layer properties > then click on Labels on the left hand side Panel.

- Select Show labels for this layer > and Click on expression Icon on Right side of Label with option.



- Type the following Expression in Expression box:

  $x || '\n' || $y

  Where,

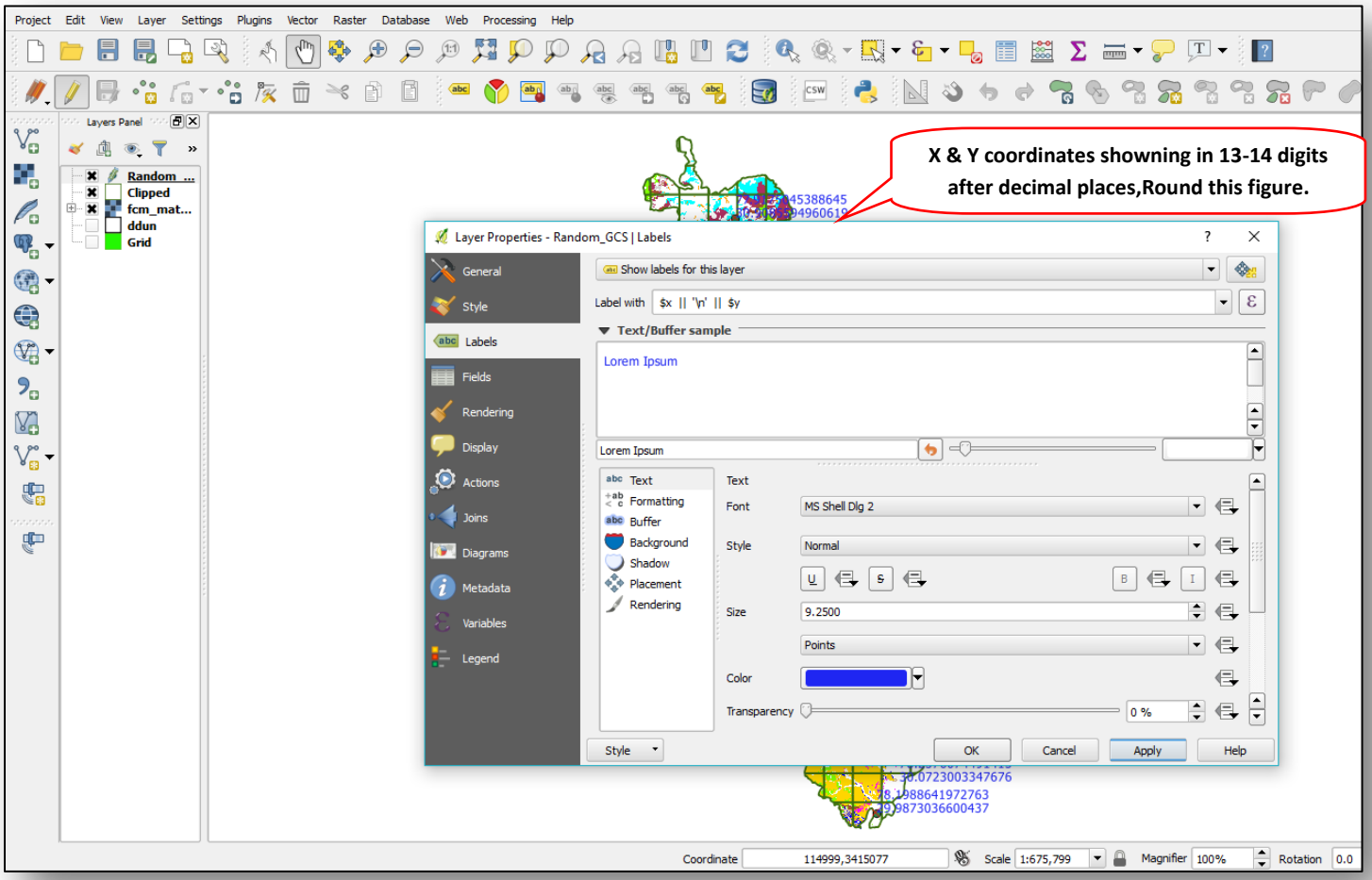
  $x:Longitude

  $y:Latitude

  ||:String Concatination (for space)

  '\n': New Line

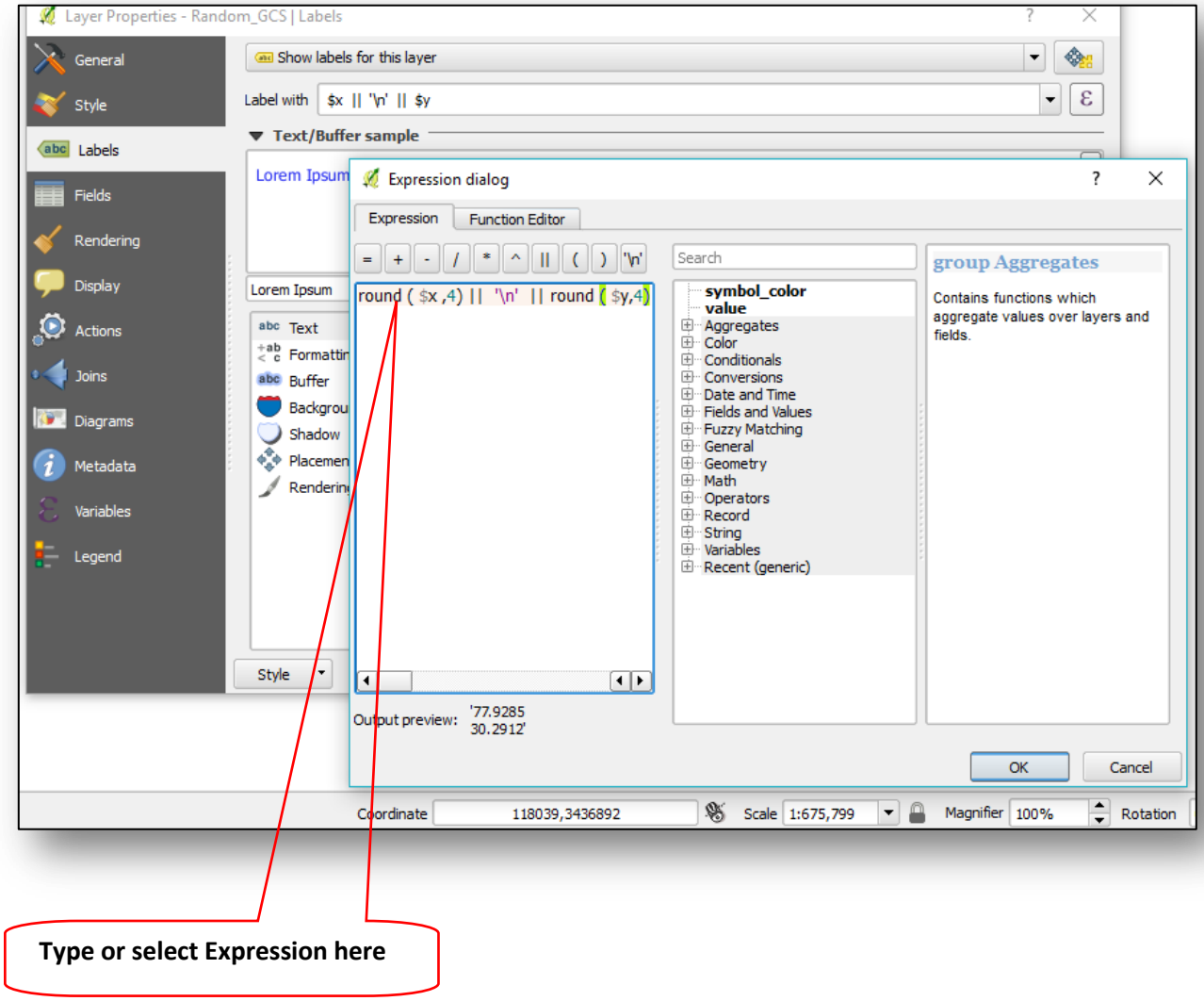
- When the execution of expression is complete, it will display random points file with Longitude, Latitude Labels on QGIS Map Canvas, but the values of X & Y coordinates showing in 13-14 digits after decimal place, so for this we can round this Figure in the Expression box.



- To display Longitude, Latitude labels of random points with 4 digits after decimal place, go to Expression dialog and select Math > select Round or type the expression in expression box.

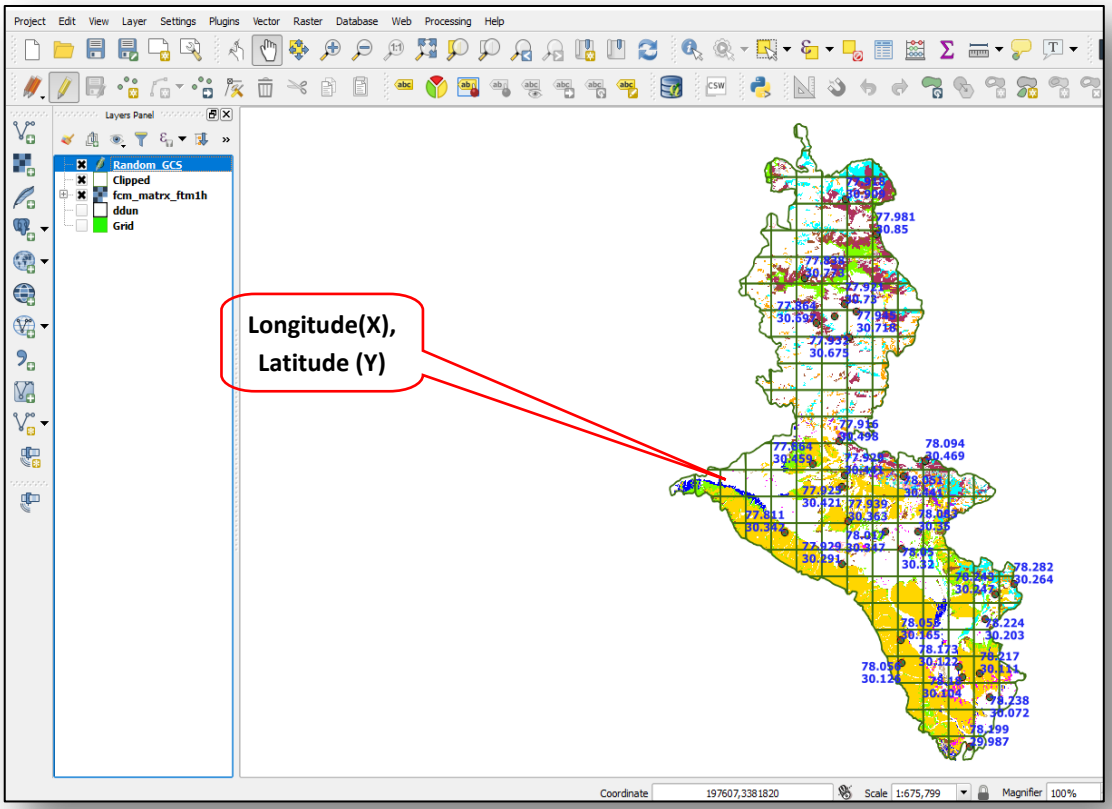
- Type the following Expression in Expression box:

  round($x,4) || '\n' || round($y,4)

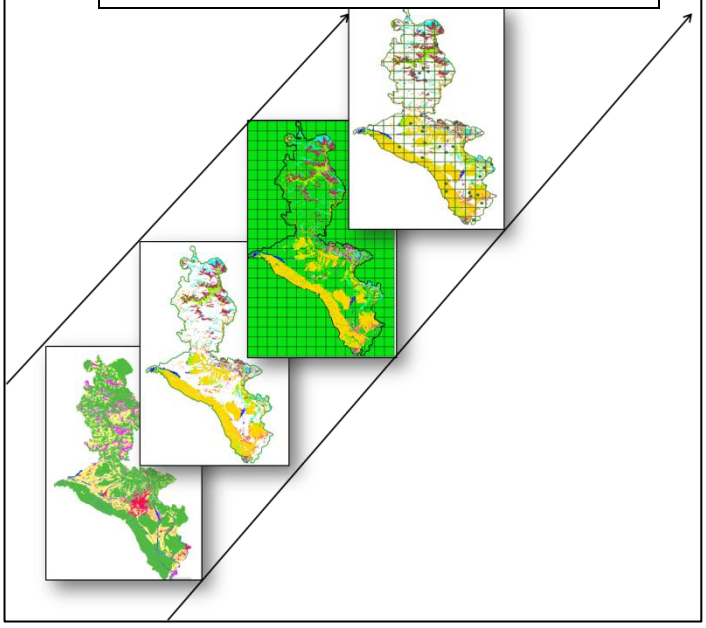


- Type expression in expression dialog box and press ok.

- Once the expression is executed, the random points will be added on QGIS Map Canvas as depicting in Figure with Longitude and Latitude values with 4 decimal place.



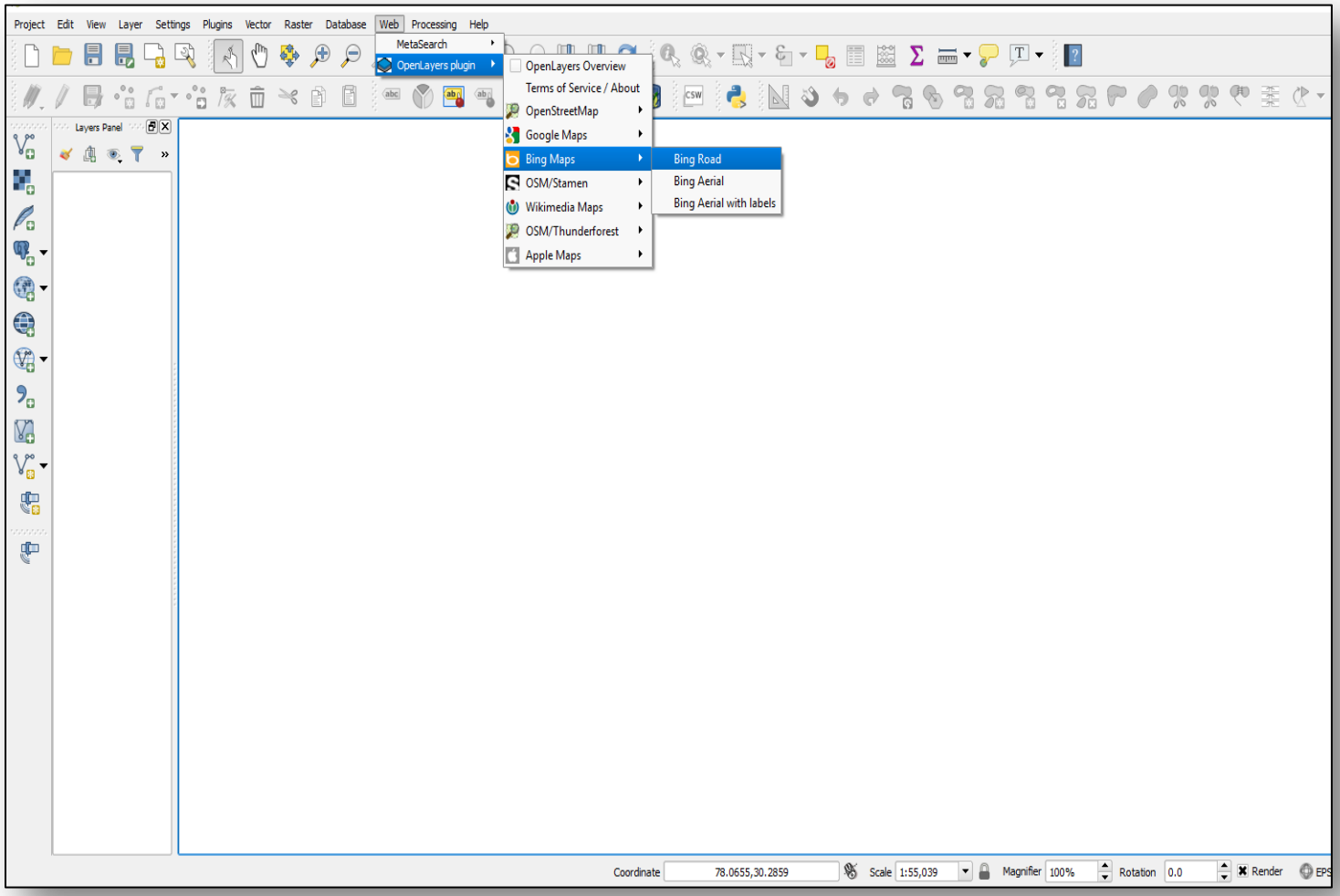
Random Points Generated on 5x5km Grid



Chapter 11. Bing Maps/Base Maps/Street Map in QGIS

- To open Bing Maps > go to Web > and Select OpenLayers plugin > go to Bing Road under Bing Maps options.

- If the Openlayers Plugin is already loaded to QGIS, load it using the Web option. In OpenLayers plugin menu select any one of the provided services such as, Google Maps (Google Maps Streets), Bing Maps (Road, Aerial), Street Map etc.

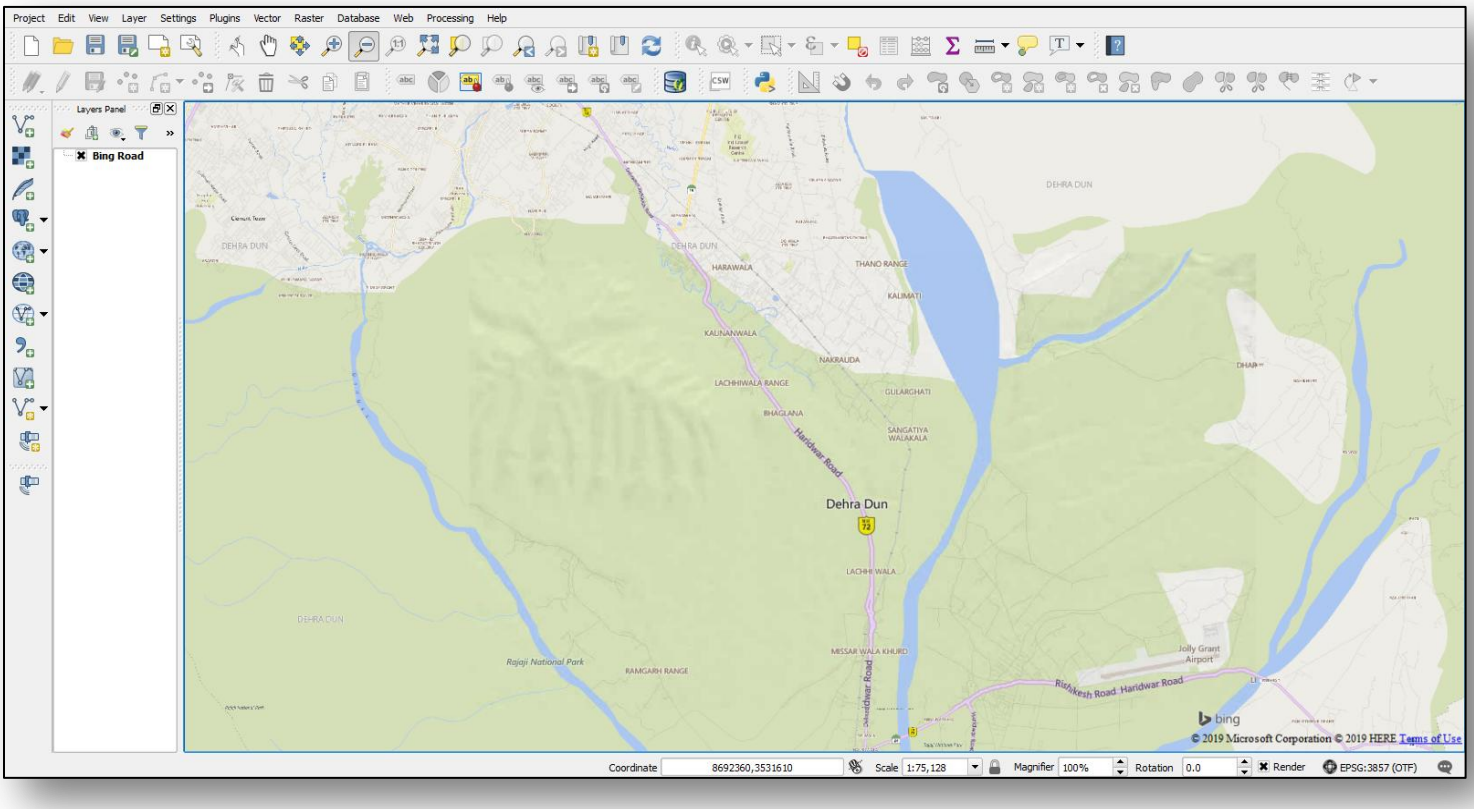


.

- Add the Bing Maps services as basemap to QGIS Map Canvas by clicking the **Bing map** gallery > Choose the Bing Map you want to add as a basemap.

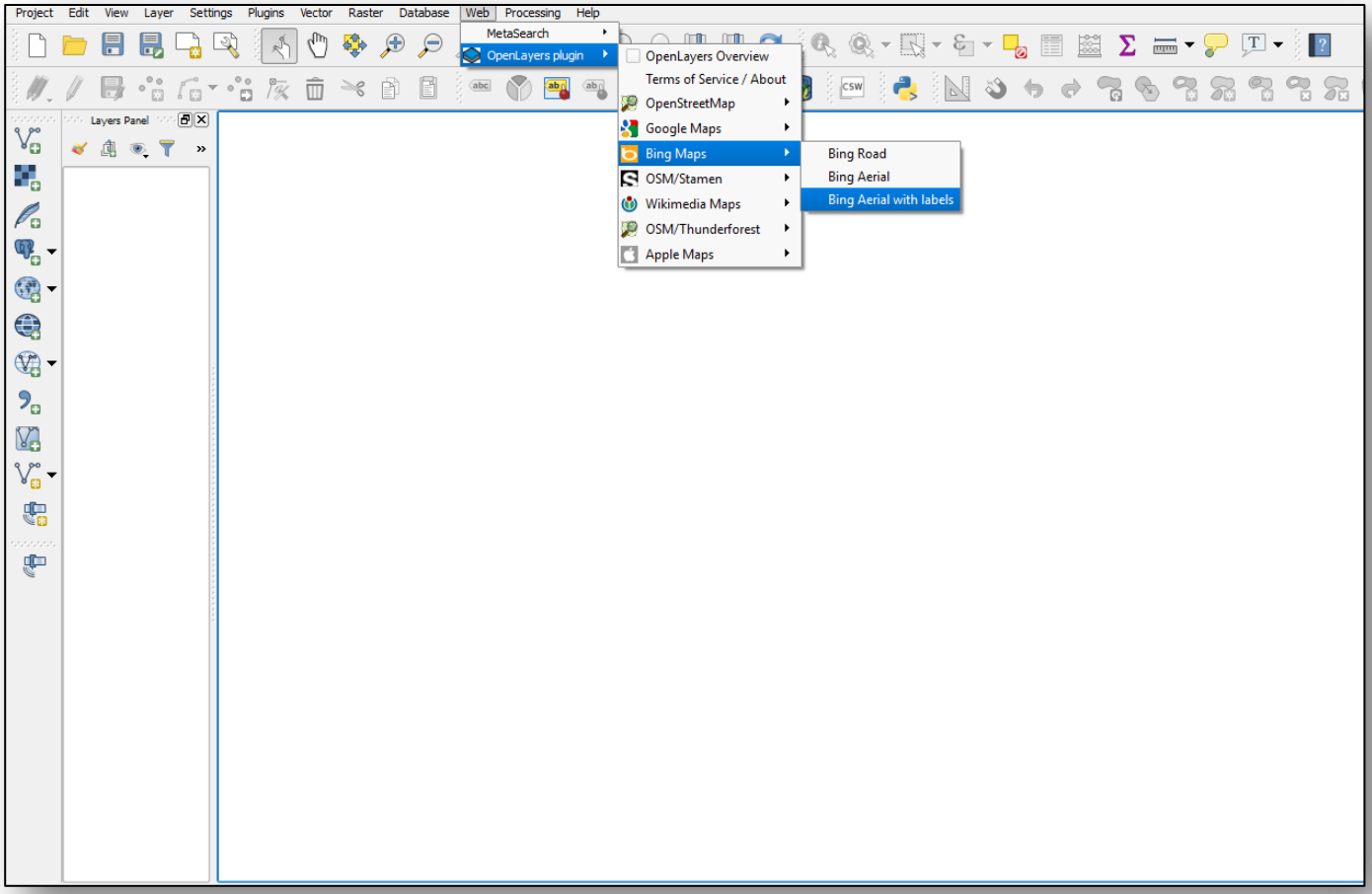
- Now, Bing Map will appear in Task Bar.

- While dealing with Bing Maps/ OSM, there is no need to store or manage data at users end, instead anyone accesses or visualize the Bing Maps server directly.



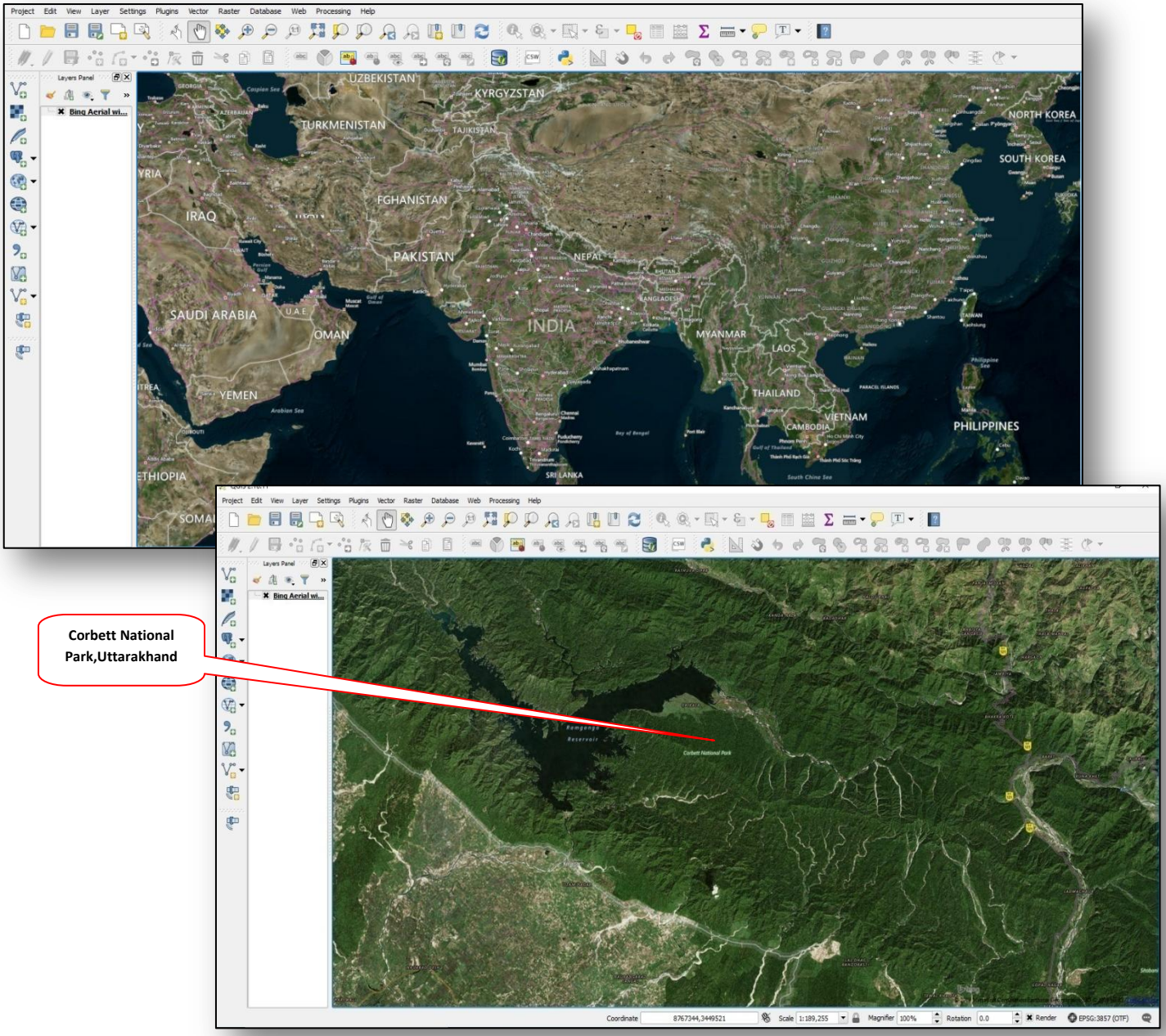
- The Bing Maps web service projects on the fly and can be transformed to match as per working data. However, Bing Maps services uses a projected coordinate system, Mercator Auxiliary Sphere, based on GCS_WGS_1984 as geographic coordinate system.

- Next, add the Bing Aerial with Labels services as base layer to QGIS Map Canvas by clicking the **Bing map** gallery. Choose the Aerial Bing Map to add as value aided for Geospatial analysis.



Note: QGIS also supports OpenStreet Map (OSM) plugin to download, edit, create & upload data (.osm files) to support the OSM project.

- Now, we can visualize the data as per the selected area of interest by introducing Bing Map Services and OpenStreetMap (OSM) services as a source of freely available data globally that enables the QGIS user to download OSM data.



Note: See Bing Maps (http://www.bing.com/maps) for more information about the Bing Maps mapping system.

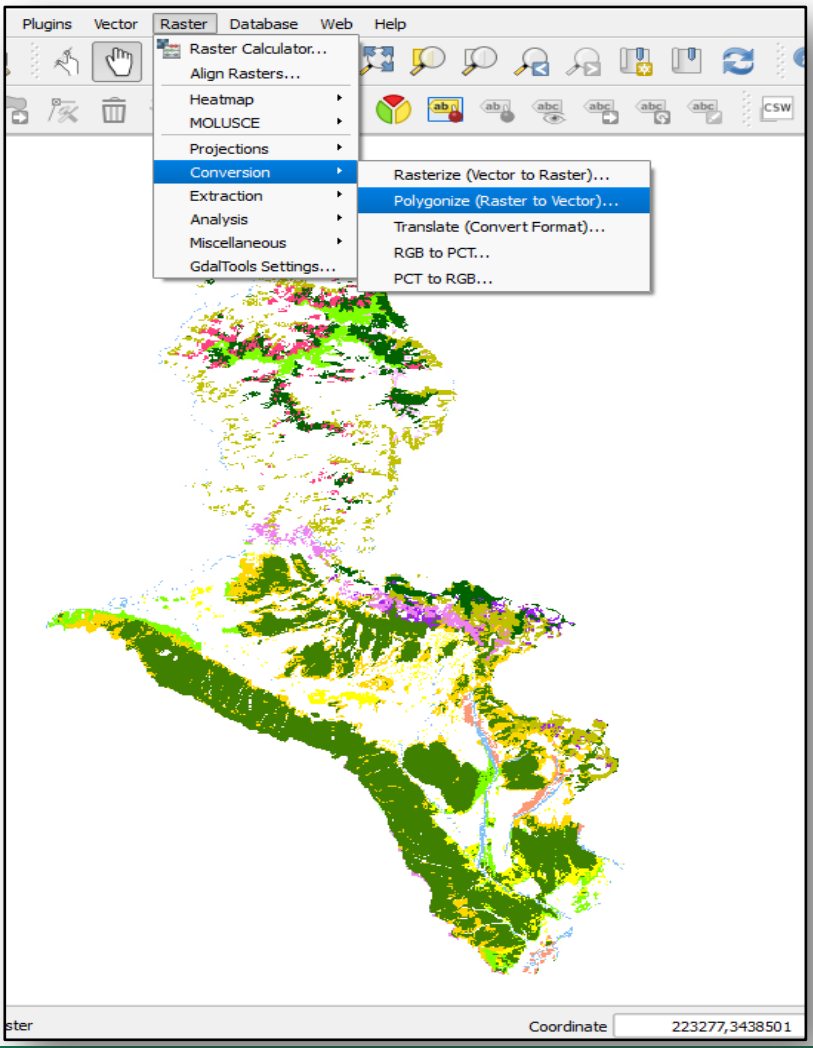
Chapter 12 Conversion of Data: Raster and Vector Data Formats

In RS/GIS world, we have two formats of the data, i.e. Raster and Vector data. To Converting between raster and vector formats allows users to make use of both raster and vector data when solving a GIS problem, as well as using the various analysis methods. Furthermore, it increases the flexibility of considering data sources, processing methods for solving a GIS problem.

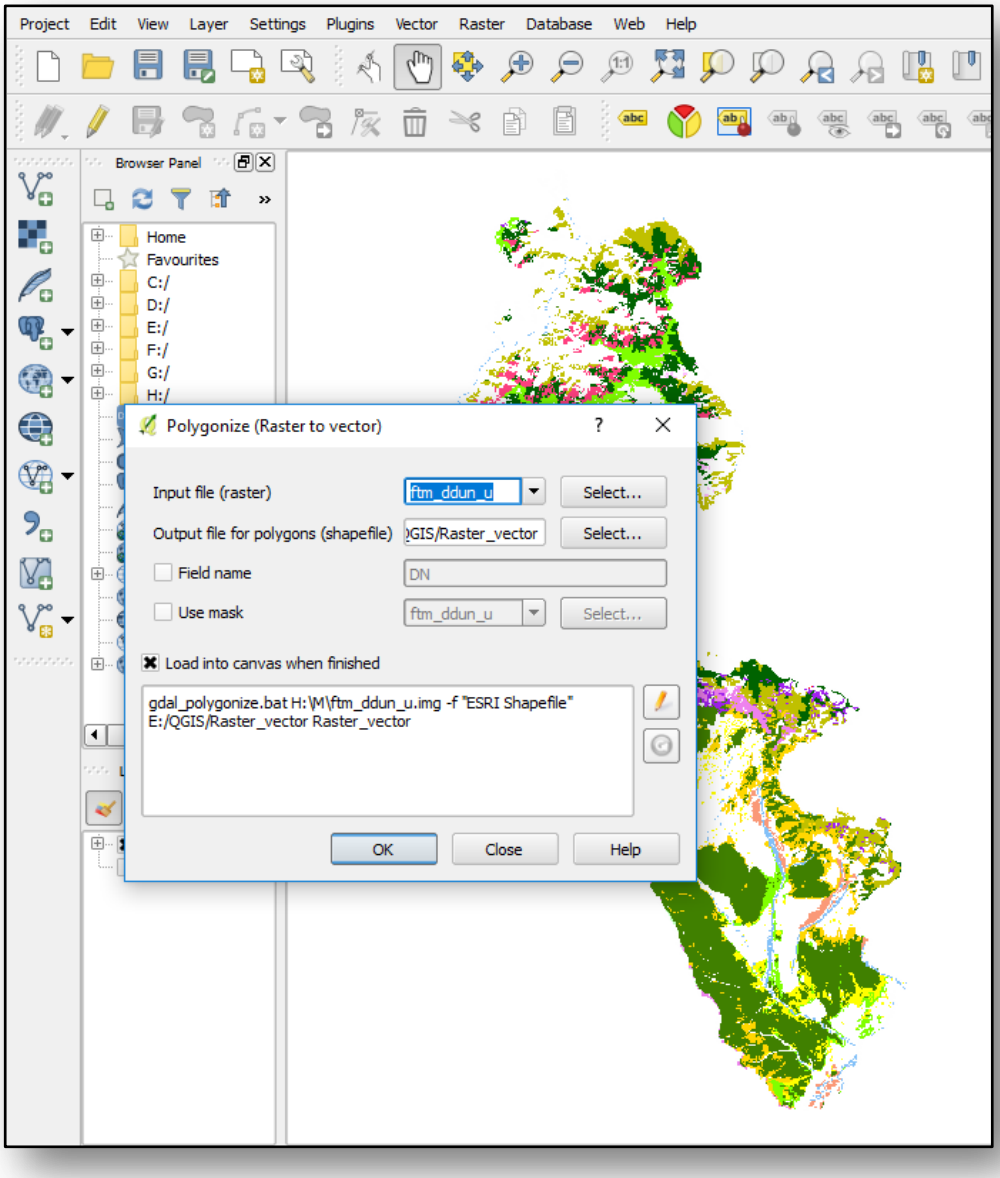
Rasters are made up of pixels or grid cells**,** usually regularly spaced and square. While, vector data represents in points, lines and polygons in shapefiles, geodatabases and various other GIS file formats. As per the requirement we can convert Raster data to Vector data and vica-versa.

12.1 Raster to Vector Conversion

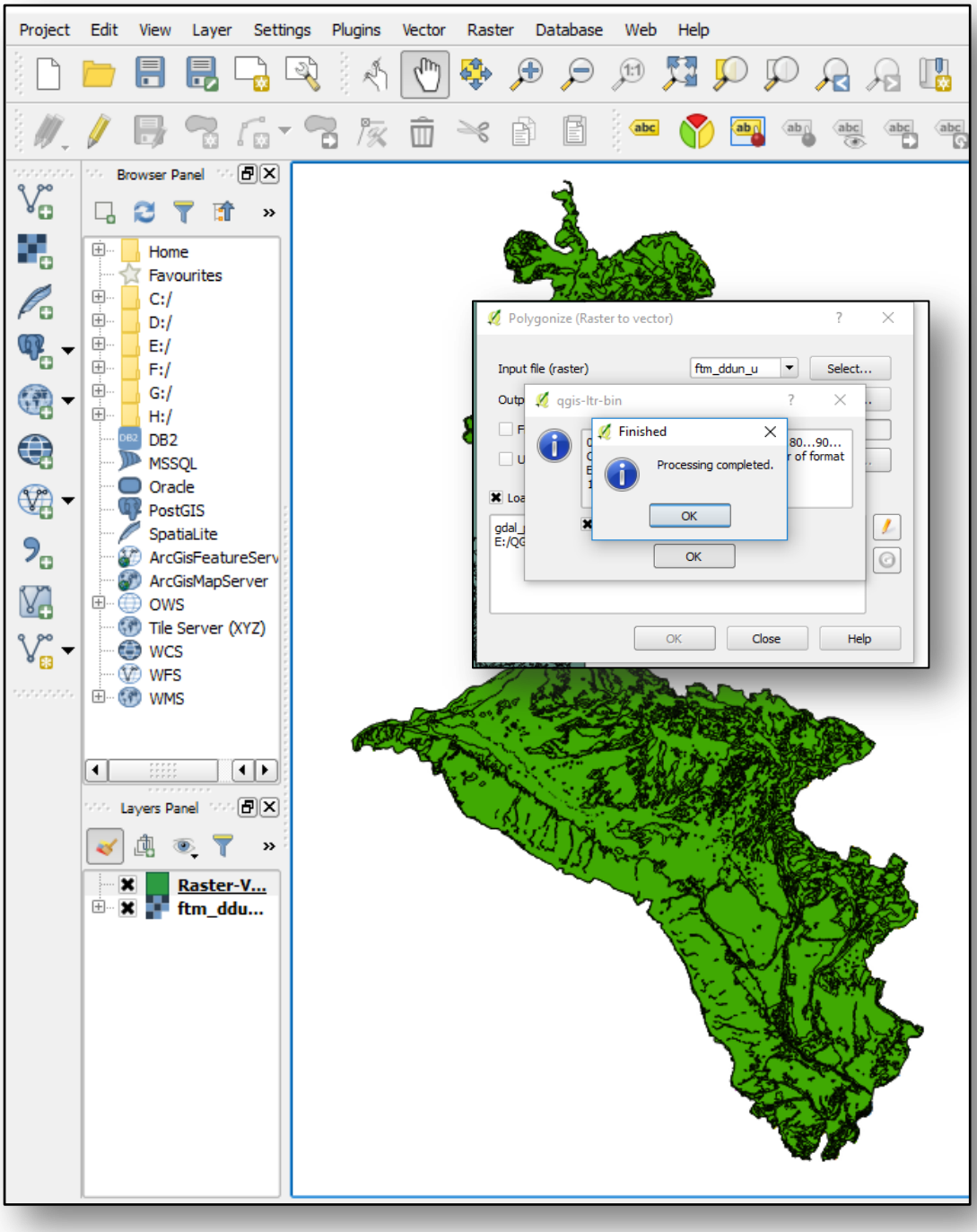
- To convert > Go to Open Raster Tab as shown in earlier Chapters.
- Go to Raster > Select Conversion > and finally Select Polygonize (Raster to Vector)



- Now, Polygonize (Raster to Vector) window will appear on the Map Canvas.
- In Input file, define the Raster file to convert and in Output file option accordingly define the name of shapefile.
- Make sure to check Load into canvas when finished, if want to open file on Map Canvas automatically after running the process.
- Click Ok.

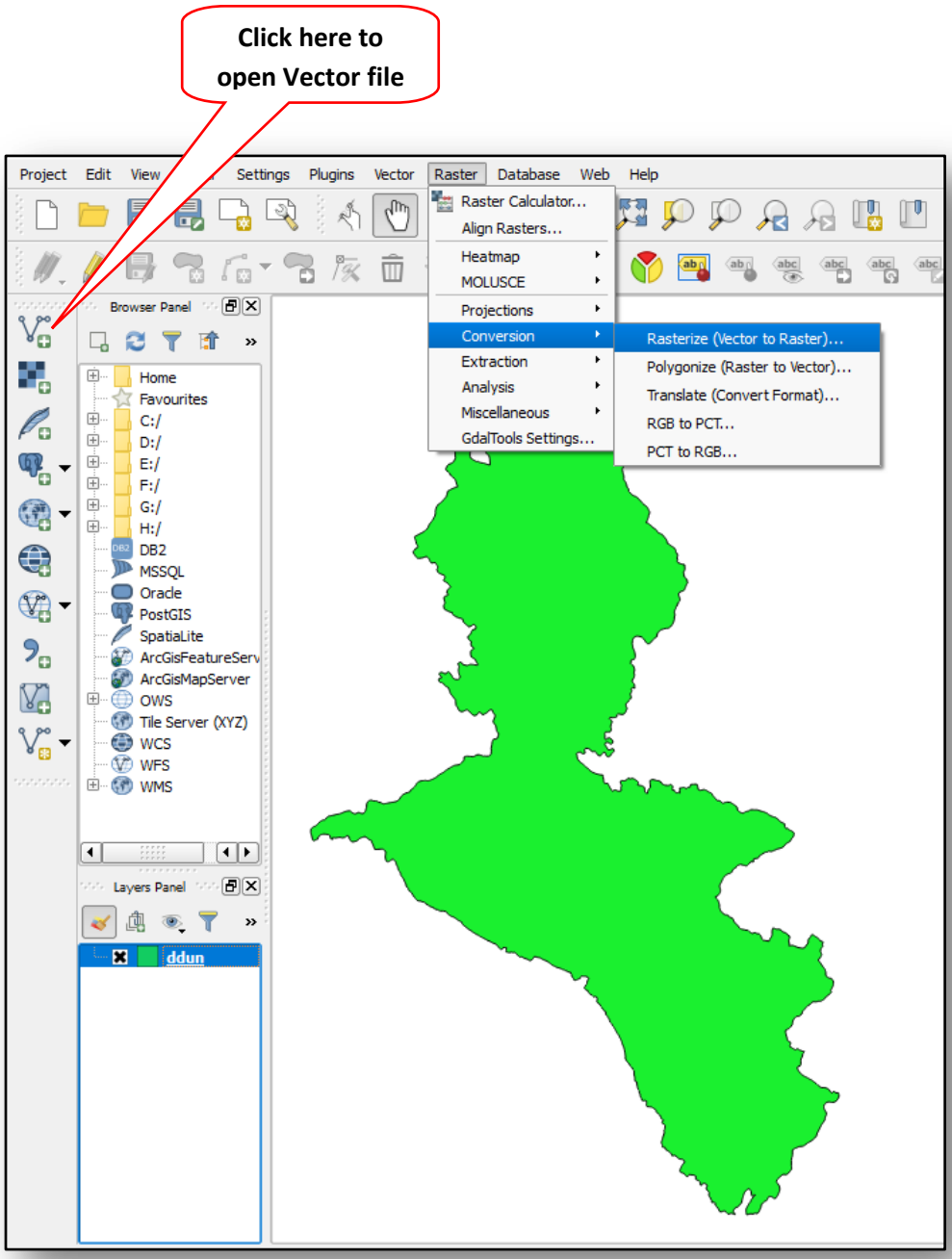


- After running algorithm, the shapefile (in converted format) will be appear on the window. It will create outer bounding box and we can delete the same while selecting it after Toggle Editing and Delete outer Bounding Box.
- Now, Shapefile will be appear on window as showing in Figure.

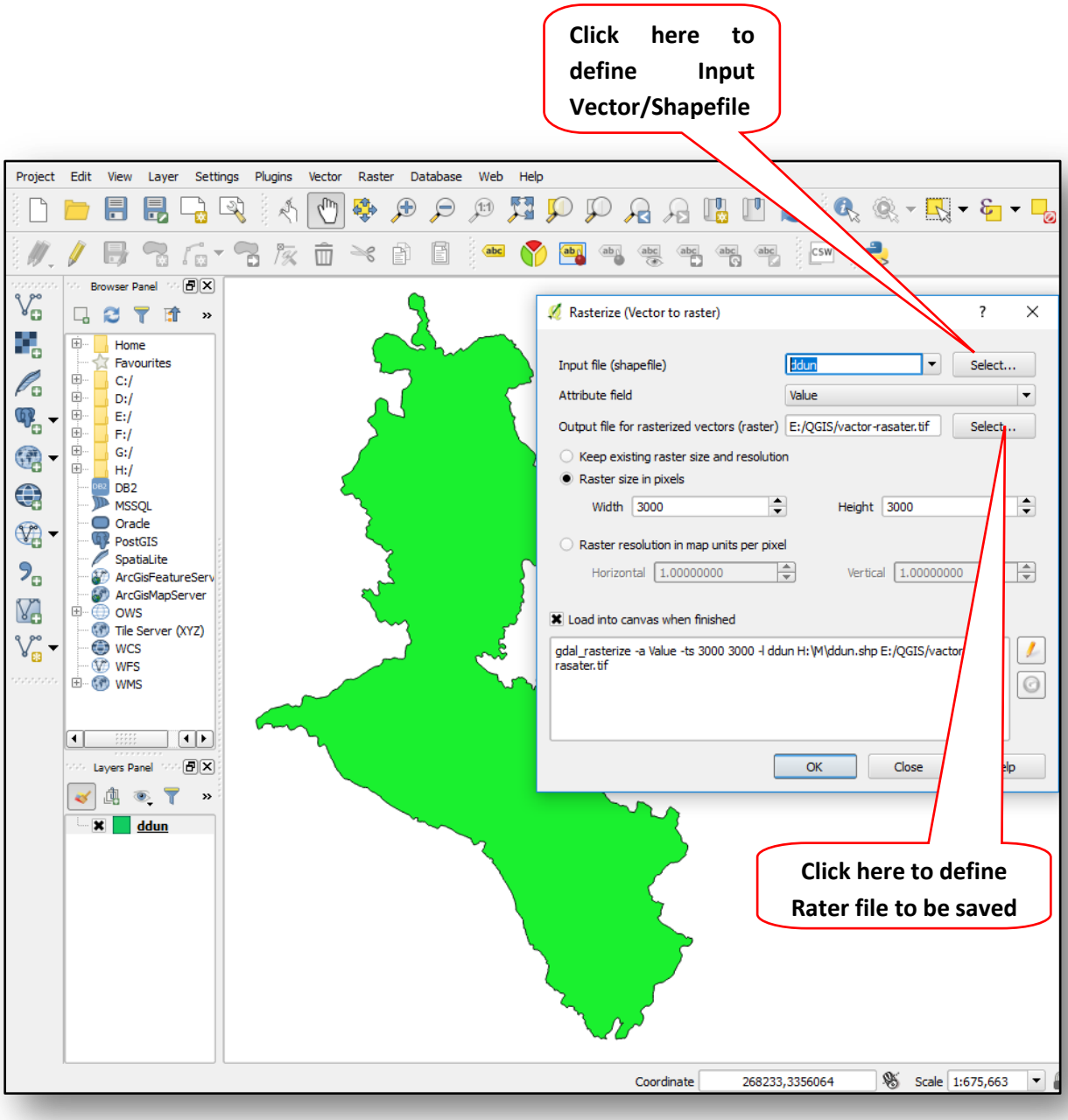


12.2 Vector to Raster Conversion

- To convert Vector to Raster, Open Vector File by Clicking on Open Vector Button in Left Side of window.
- Go to Raster > Conversion > and Select Rasterize (Vector to Raster)

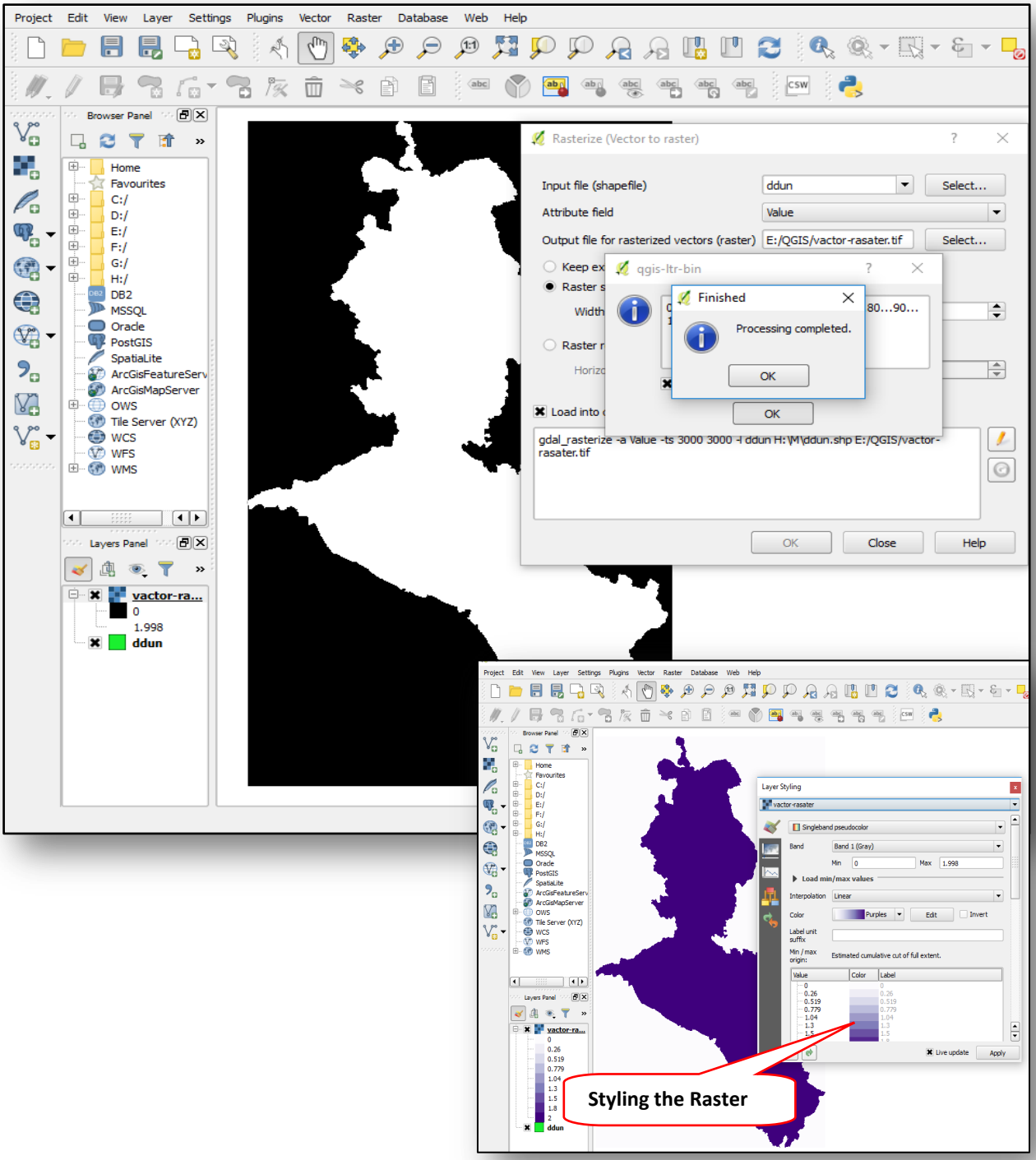


- Now, Rasterize window will appear. In Input file option define Input file while in Output define Name of Raster file to be saved as output in Geotiff format.



- After running the algorithm converted file in the Geotiff format will be appear on the window.
- Now, Shapefile will be appear on window as showing in Figure.
- In the Layers Panel > right click on file > and select Properties.

- Go to Layer properties > click on Style on the left hand side > Select Single band pseudocolor in Render type tab > and now select any color ramp.



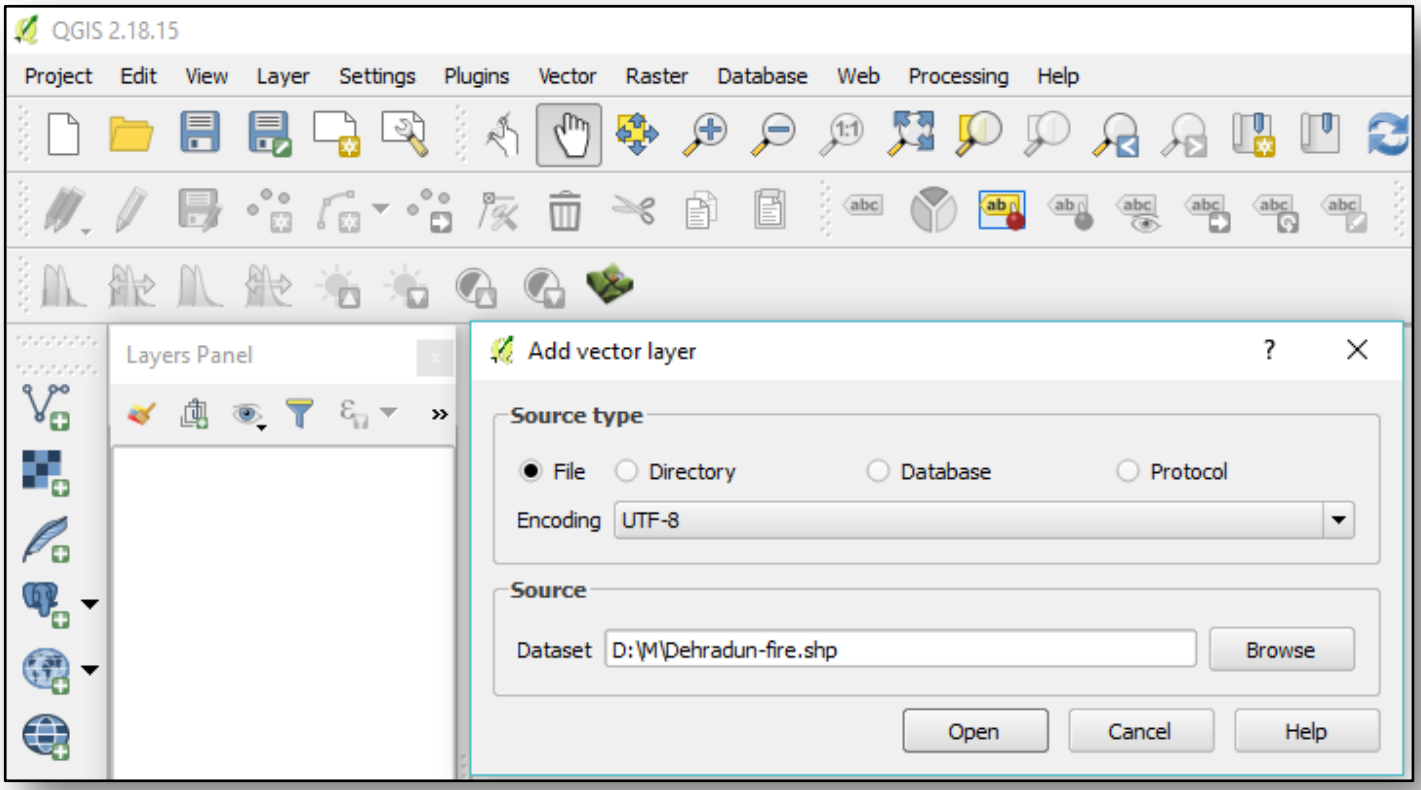
Chapter 13: Join between a Spatial and Non-Spatial Layers

Join between a spatial layer (shapefile) and a non-spatial table (Excel Table/CSV file)

Sometimes the data would available as a table or a spreadsheet, in that case there could be a need to link non spatial table (Excel) with existing spatial data (shapefile) by performing the operation known as a Table Join. To join a table with the shapefile, we need a unique and common attribute for each feature.

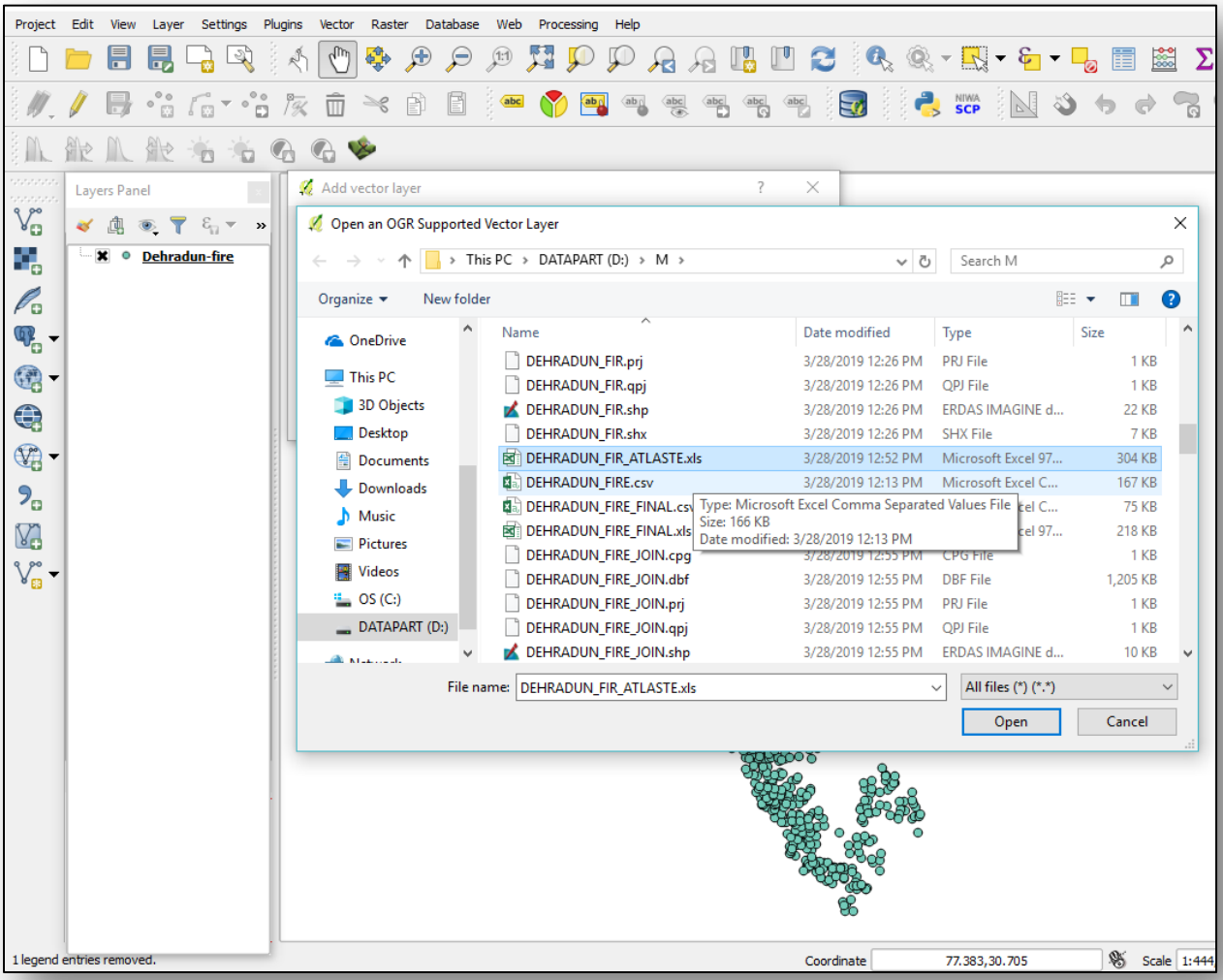
Join with non-spatial table (Excel Table/CSV)

- We will first load shapefile, in which new fields to be joined, now go to Layer > add vector layer.



- Browse to the shapefile and select open. QGIS can open file directly to map canvas

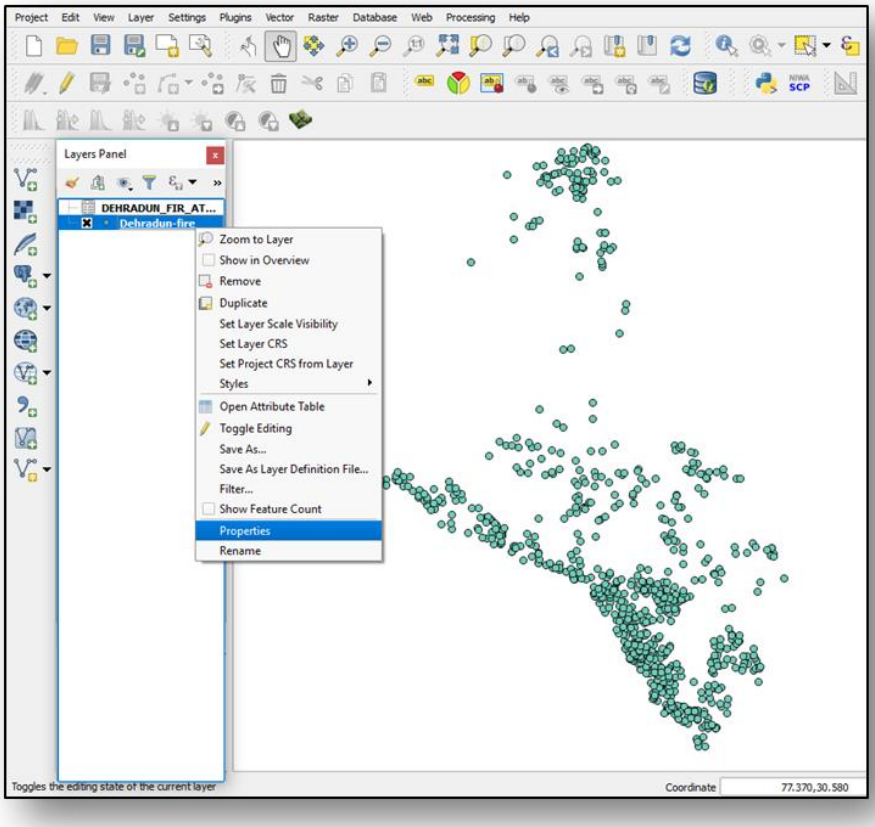
- Next, to load excel table in Map Canvas **>** go to Load Vector Layer button.



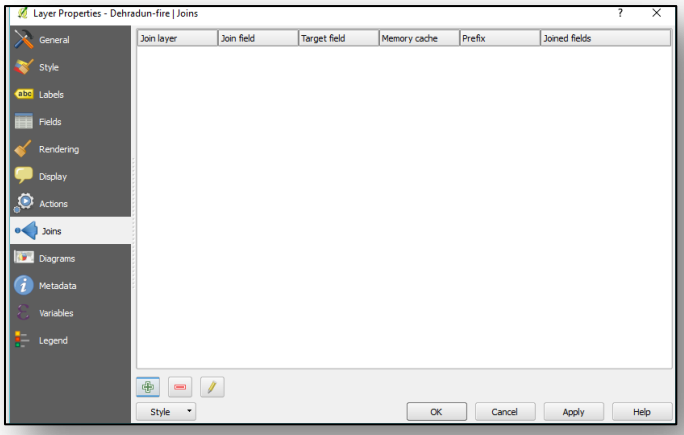
- Check that all files option is selected, otherwise you will not see Excel files.

- The Excel table then appears in the list of layers. Now, open the table in the similar way as other tables and files to open on map canvas.

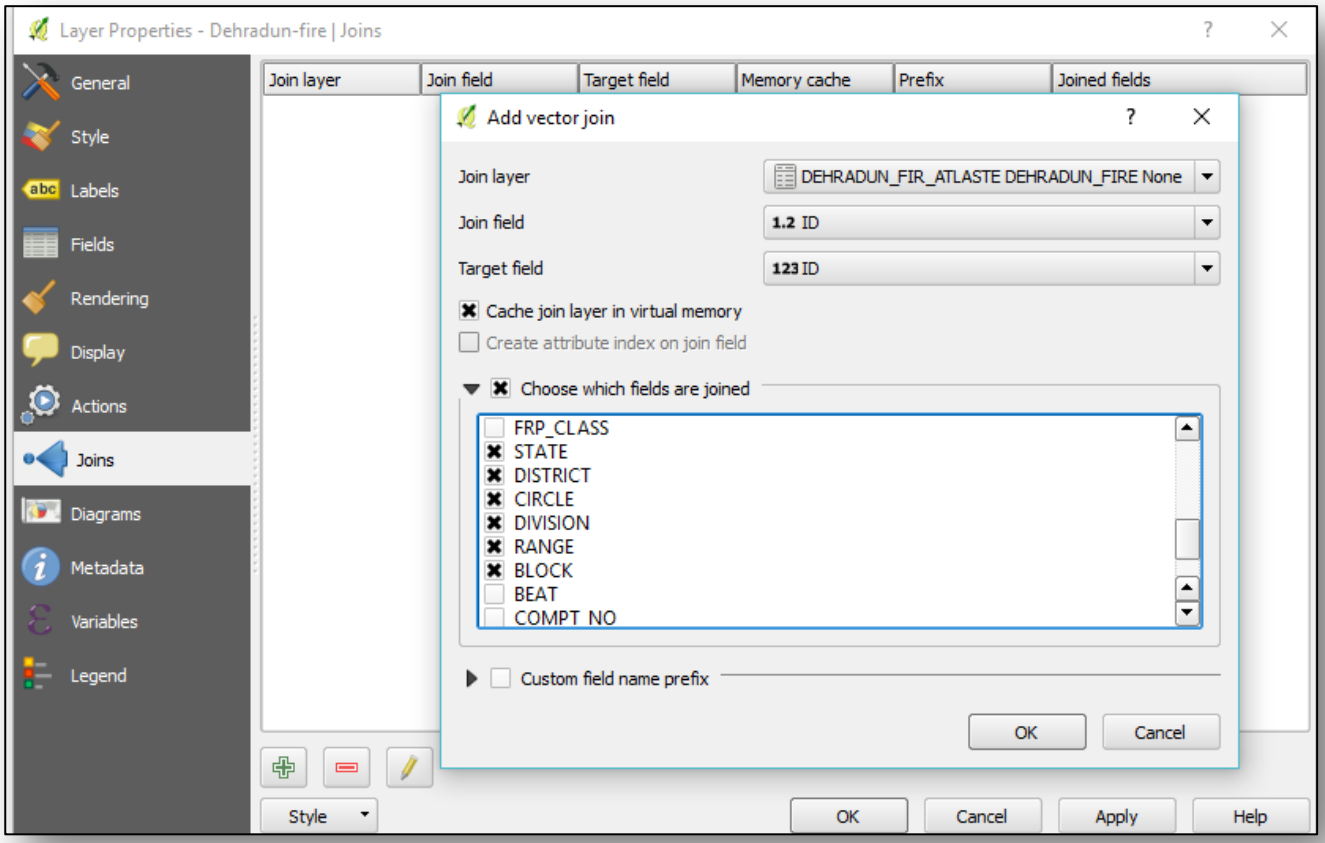
- Double-click the shapefile layer in the Layers panel, otherwise Right click on shapefile and go to properties.



- The properties window of the layer opens. Select **Joints** tab and click on the + symbol to add a join.
- InJoin Layer select the Excel table/.csv file.



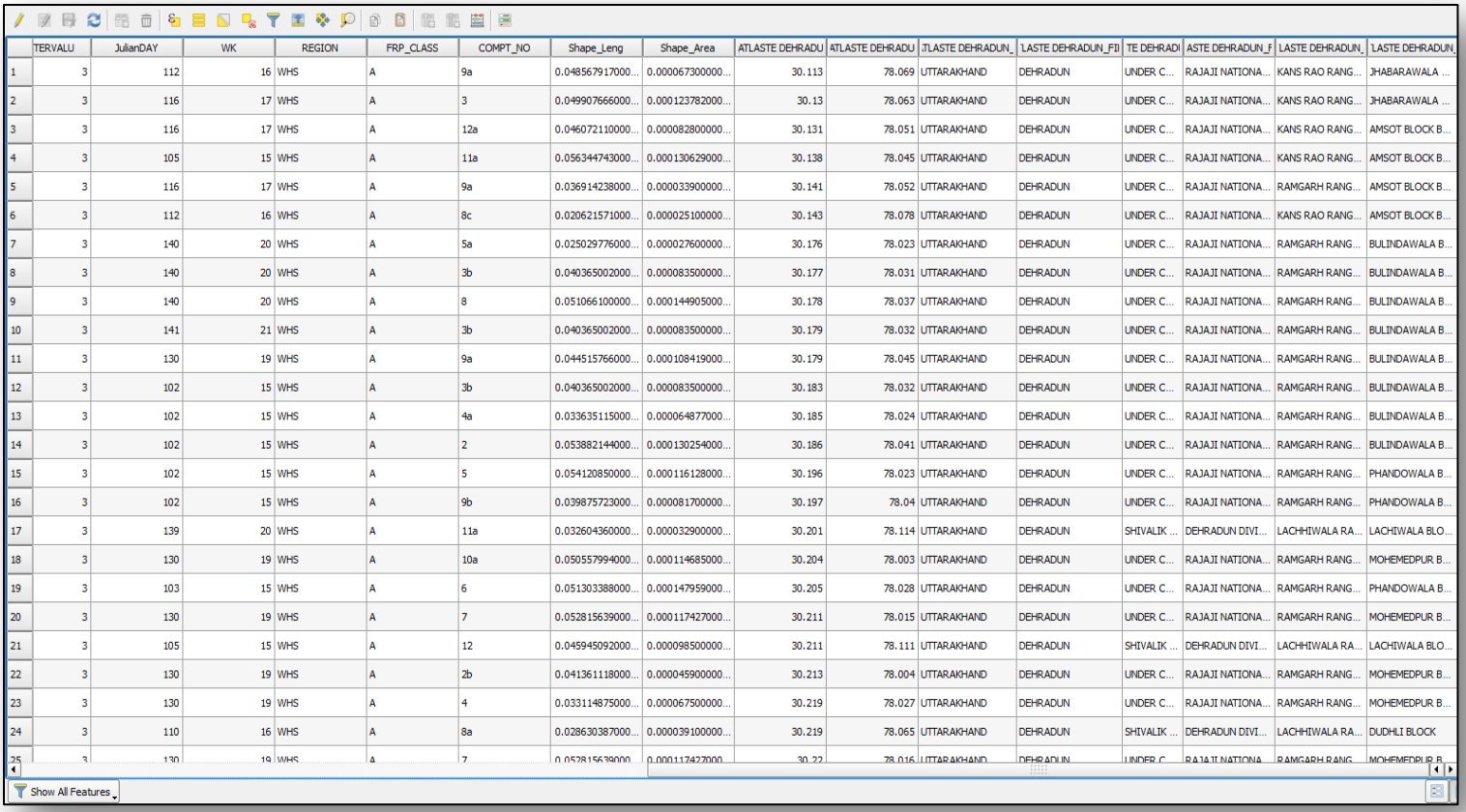
- In join field,select the key field of your Excel table/.csv file
- In Join field in the target layer select the key (unique key) of shapefile,we need a unique and common attribute for each feature.
- In choose fields select fields to joined.



- Click OK

Note: For this operation, you can use the ID as a unique field to join. However, it will not allow to join the fields. ID are the unique codes for the feature for joining process.

- After running the process, joined table will appear with above selected fields participated in join.



	TERVALU	JulianDAY	WK	REGION	FRP_CLASS	COMPT_NO	Shape_Leng	Shape_Area	ATLASTE DEHRADU	ATLASTE DEHRADU	JTLASTE DEHRADUN_	LASTE DEHRADUN_FII	TE DEHRADI	ASTE DEHRADUN_F	LASTE DEHRADUN_	LASTE DEHRADUN_
1	3	112	16	WHS	A	9a	0.048567917000...	0.000067300000...	30.113	78.069	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	KANS RAO RANG...	JHABARAWALA ...
2	3	116	17	WHS	A	3	0.049907666000...	0.000123782000...	30.13	78.063	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	KANS RAO RANG...	JHABARAWALA ...
3	3	116	17	WHS	A	12a	0.046072110000...	0.000082800000...	30.131	78.051	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	KANS RAO RANG...	AMSOT BLOCK B...
4	3	105	15	WHS	A	11a	0.056344743000...	0.000130629000...	30.138	78.045	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	KANS RAO RANG...	AMSOT BLOCK B...
5	3	116	17	WHS	A	9a	0.036914238000...	0.000033900000...	30.141	78.052	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	AMSOT BLOCK B...
6	3	112	16	WHS	A	8c	0.020621571000...	0.000025100000...	30.143	78.078	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	KANS RAO RANG...	AMSOT BLOCK B...
7	3	140	20	WHS	A	5a	0.025029776000...	0.000027600000...	30.176	78.023	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	BULINDAWALA B...
8	3	140	20	WHS	A	3b	0.040365002000...	0.000083500000...	30.177	78.031	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	BULINDAWALA B...
9	3	140	20	WHS	A	8	0.051066100000...	0.000144905000...	30.178	78.037	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	BULINDAWALA B...
10	3	141	21	WHS	A	3b	0.040365002000...	0.000083500000...	30.179	78.032	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	BULINDAWALA B...
11	3	130	19	WHS	A	9a	0.044515766000...	0.000108419000...	30.179	78.045	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	BULINDAWALA B...
12	3	102	15	WHS	A	3b	0.040365002000...	0.000083500000...	30.183	78.032	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	BULINDAWALA B...
13	3	102	15	WHS	A	4a	0.033635115000...	0.000064877000...	30.185	78.024	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	BULINDAWALA B...
14	3	102	15	WHS	A	2	0.053882144000...	0.000130254000...	30.186	78.041	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	BULINDAWALA B...
15	3	102	15	WHS	A	5	0.054120850000...	0.000116128000...	30.196	78.023	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	PHANDOWALA B...
16	3	102	15	WHS	A	9b	0.039875723000...	0.000081700000...	30.197	78.04	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	PHANDOWALA B...
17	3	139	20	WHS	A	11a	0.032604360000...	0.000032900000...	30.201	78.114	UTTARAKHAND	DEHRADUN	SHIVALIK ...	DEHRADUN DIVI...	LACHHIWALA RA...	LACHIWALA BLO...
18	3	130	19	WHS	A	10a	0.050557994000...	0.000114685000...	30.204	78.003	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	MOHEMEDPUR B...
19	3	103	15	WHS	A	6	0.051303388000...	0.000147959000...	30.205	78.028	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	PHANDOWALA B...
20	3	130	19	WHS	A	7	0.052815639000...	0.000117427000...	30.211	78.015	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	MOHEMEDPUR B...
21	3	105	15	WHS	A	12	0.045945092000...	0.000098500000...	30.211	78.111	UTTARAKHAND	DEHRADUN	SHIVALIK ...	DEHRADUN DIVI...	LACHHIWALA RA...	LACHIWALA BLO...
22	3	130	19	WHS	A	2b	0.041361118000...	0.000045900000...	30.213	78.004	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	MOHEMEDPUR B...
23	3	130	19	WHS	A	4	0.033114875000...	0.000067500000...	30.219	78.027	UTTARAKHAND	DEHRADUN	UNDER C...	RAJAJI NATIONA...	RAMGARH RANG...	MOHEMEDPUR B...
24	3	110	16	WHS	A	8a	0.028630387000...	0.000039100000...	30.219	78.065	UTTARAKHAND	DEHRADUN	SHIVALIK ...	DEHRADUN DIVI...	LACHHIWALA RA...	DUDHLI BLOCK
25	3	130	19	WHS	A	7	0.052815639000	0.000117427000	30.22	78.016	UTTARAKHAND	DEHRADUN	UNDER C	RAJAJI NATIONA	RAMGARH RANG	MOHEMEDPUR B

Show All Features

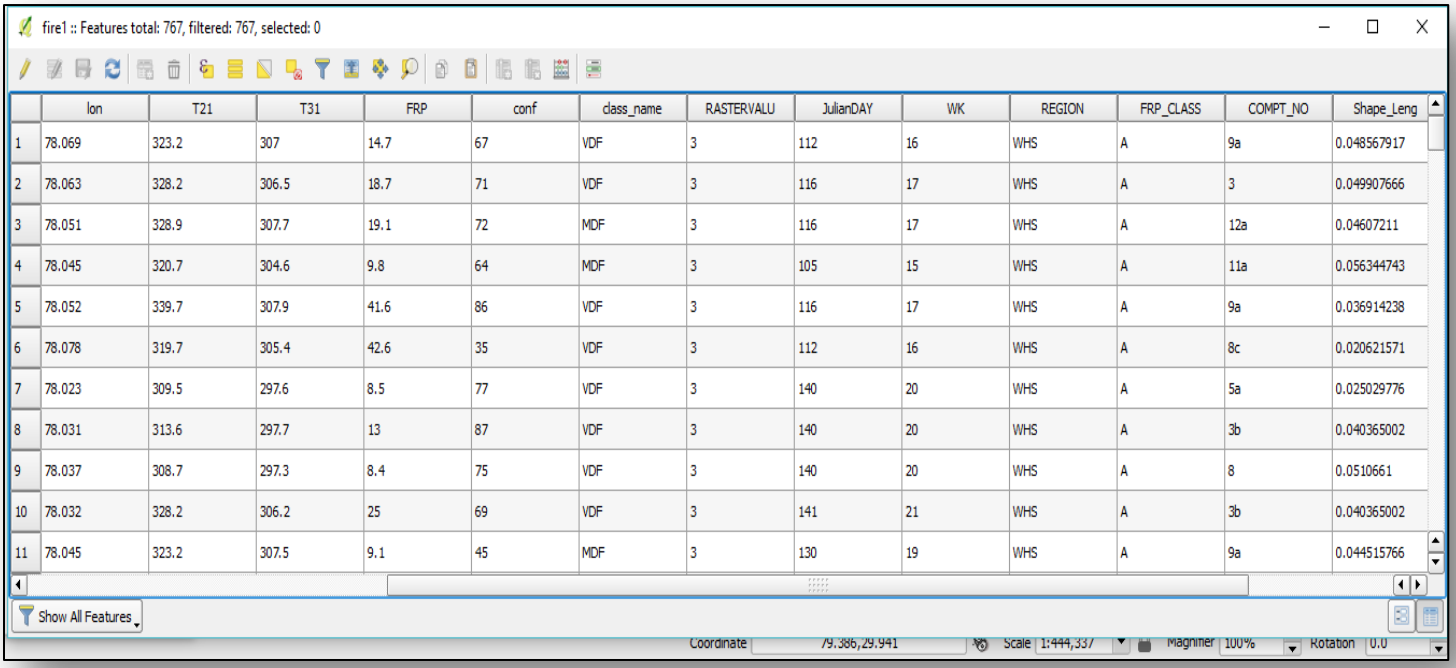
- Right-click on the shapefile in layer panel and select Open Attribute Table, table will appear as showing in Figure.

- Right click on shapefile in layer panel and save it as new shapefile with newly added joined features or save as MS Office open XML spreadsheet format.

Join two spatial layers (shapefiles)

Likewise, we can join two shapefiles also by following the same steps as mentioned in previous section (Join with non-spatial table).

- Right click on shapefile and open attribute table, now in this table we can see that there are some fields that to be added viz.DISTRICT,CIRCLE, DIVISION,RANGE and BLOCK.



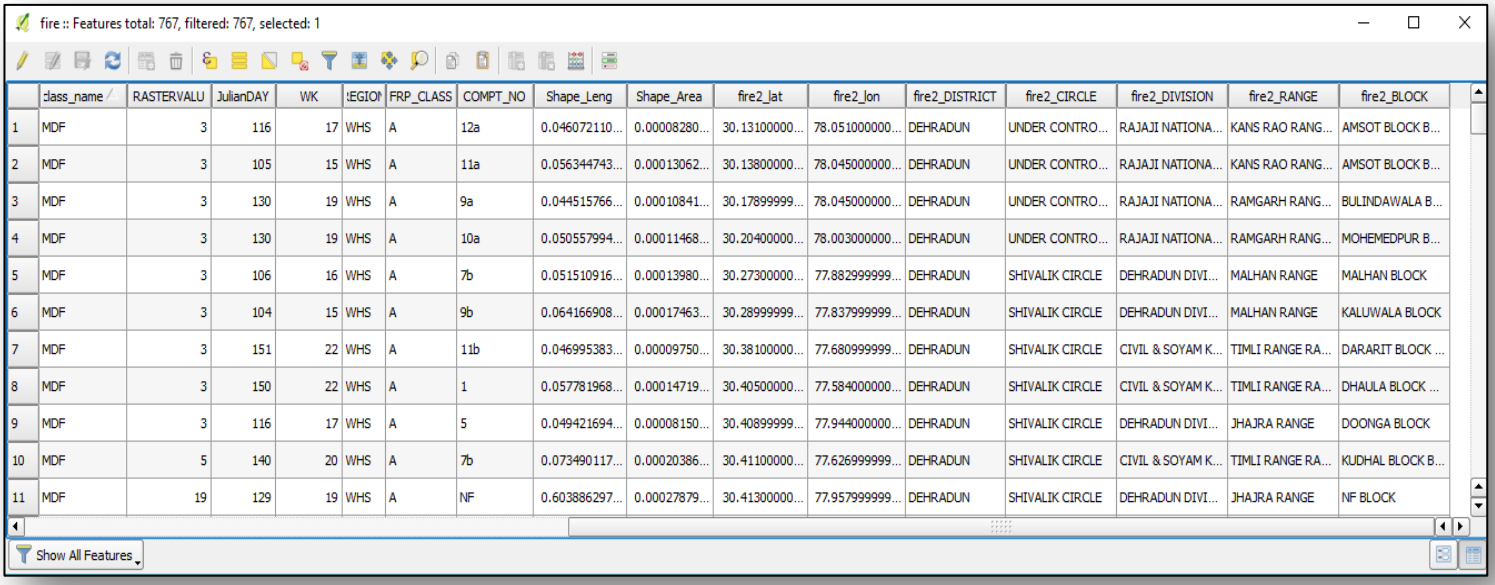
fire1 :: Features total: 767, filtered: 767, selected: 0

	lon	T21	T31	FRP	conf	class_name	RASTERVALU	JulianDAY	WK	REGION	FRP_CLASS	COMPT_NO	Shape_Leng
1	78.069	323.2	307	14.7	67	VDF	3	112	16	WHS	A	9a	0.048567917
2	78.063	328.2	306.5	18.7	71	VDF	3	116	17	WHS	A	3	0.049907666
3	78.051	328.9	307.7	19.1	72	MDF	3	116	17	WHS	A	12a	0.04607211
4	78.045	320.7	304.6	9.8	64	MDF	3	105	15	WHS	A	11a	0.056344743
5	78.052	339.7	307.9	41.6	86	VDF	3	116	17	WHS	A	9a	0.036914238
6	78.078	319.7	305.4	42.6	35	VDF	3	112	16	WHS	A	8c	0.020621571
7	78.023	309.5	297.6	8.5	77	VDF	3	140	20	WHS	A	5a	0.025029776
8	78.031	313.6	297.7	13	87	VDF	3	140	20	WHS	A	3b	0.040365002
9	78.037	308.7	297.3	8.4	75	VDF	3	140	20	WHS	A	8	0.0510661
10	78.032	328.2	306.2	25	69	VDF	3	141	21	WHS	A	3b	0.040365002
11	78.045	323.2	307.5	9.1	45	MDF	3	130	19	WHS	A	9a	0.044515766

Show All Features

Coordinate 79.386,29.941 Scale 1:444,337 Magnifier 100% Rotation 0.0

- After performing Join function we can now see a new set of fields, including fire2_DISTRICT, fire2_CIRCLE, fire2_DIVISION, fire2_RANGE, fire2_BLOCK fields added to shapefile as showing in given Table.



fire :: Features total: 767, filtered: 767, selected: 1

	class_name	RASTERVALU	JulianDAY	WK	REGION	FRP_CLASS	COMPT_NO	Shape_Leng	Shape_Area	fire2_lat	fire2_lon	fire2_DISTRICT	fire2_CIRCLE	fire2_DIVISION	fire2_RANGE	fire2_BLOCK
1	MDF	3	116	17	WHS	A	12a	0.046072110...	0.00008280...	30.13100000...	78.051000000...	DEHRADUN	UNDER CONTRO...	RAJAJI NATIONA...	KANS RAO RANG...	AMSOT BLOCK B...
2	MDF	3	105	15	WHS	A	11a	0.056344743...	0.00013062...	30.13800000...	78.045000000...	DEHRADUN	UNDER CONTRO...	RAJAJI NATIONA...	KANS RAO RANG...	AMSOT BLOCK B...
3	MDF	3	130	19	WHS	A	9a	0.044515766...	0.00010841...	30.17899999...	78.045000000...	DEHRADUN	UNDER CONTRO...	RAJAJI NATIONA...	RAMGARH RANG...	BULINDAWALA B...
4	MDF	3	130	19	WHS	A	10a	0.050557994...	0.00011468...	30.20400000...	78.003000000...	DEHRADUN	UNDER CONTRO...	RAJAJI NATIONA...	RAMGARH RANG...	MOHEMEDPUR B...
5	MDF	3	106	16	WHS	A	7b	0.051510916...	0.00013980...	30.27300000...	77.882999999...	DEHRADUN	SHIVALIK CIRCLE	DEHRADUN DIVI...	MALHAN RANGE	MALHAN BLOCK
6	MDF	3	104	15	WHS	A	9b	0.064166908...	0.00017463...	30.28999999...	77.837999999...	DEHRADUN	SHIVALIK CIRCLE	DEHRADUN DIVI...	MALHAN RANGE	KALUWALA BLOCK
7	MDF	3	151	22	WHS	A	11b	0.046995383...	0.00009750...	30.38100000...	77.680999999...	DEHRADUN	SHIVALIK CIRCLE	CIVIL & SOYAM K...	TIMLI RANGE RA...	DARARIT BLOCK ...
8	MDF	3	150	22	WHS	A	1	0.057781968...	0.00014719...	30.40500000...	77.584000000...	DEHRADUN	SHIVALIK CIRCLE	CIVIL & SOYAM K...	TIMLI RANGE RA...	DHAULA BLOCK ...
9	MDF	3	116	17	WHS	A	5	0.049421694...	0.00008150...	30.40899999...	77.944000000...	DEHRADUN	SHIVALIK CIRCLE	DEHRADUN DIVI...	JHAJRA RANGE	DOONGA BLOCK
10	MDF	5	140	20	WHS	A	7b	0.073490117...	0.00020386...	30.41100000...	77.626999999...	DEHRADUN	SHIVALIK CIRCLE	CIVIL & SOYAM K...	TIMLI RANGE RA...	KUDHAL BLOCK B...
11	MDF	19	129	19	WHS	A	NF	0.603886297...	0.00027879...	30.41300000...	77.957999999...	DEHRADUN	SHIVALIK CIRCLE	DEHRADUN DIVI...	JHAJRA RANGE	NF BLOCK

Show All Features

4.2.1.2. Automatic Conversion to Surface Reflectance (TOA Reflectance)

Atmospheric correction is the process of removing the effects of the atmosphere to produce surface reflectance values. Atmospheric correction can significantly improve the interpretability by converting digital numbers to more significant units like radiance, reflectance or brightness temperature.

These sensor specific information (metadata file that contains the information) is needed to carry out this Radiometric calibration.

Images in radiance can be converted to Top of Atmosphere (TOA) Reflectance (combined surface and atmospheric reflectance) in order to reduce in between-scene variability through a normalization for solar irradiance. This TOA reflectance (ρpρp), which is the unitless ratio of reflected versus total power energy (NASA, 2011), is calculated by:

$$\rho p=(\pi*L\lambda*d2)/(ESUN\lambda*\cos\theta s)\rho p=(\pi*L\lambda*d2)/(ESUN\lambda*\cos\theta s)$$

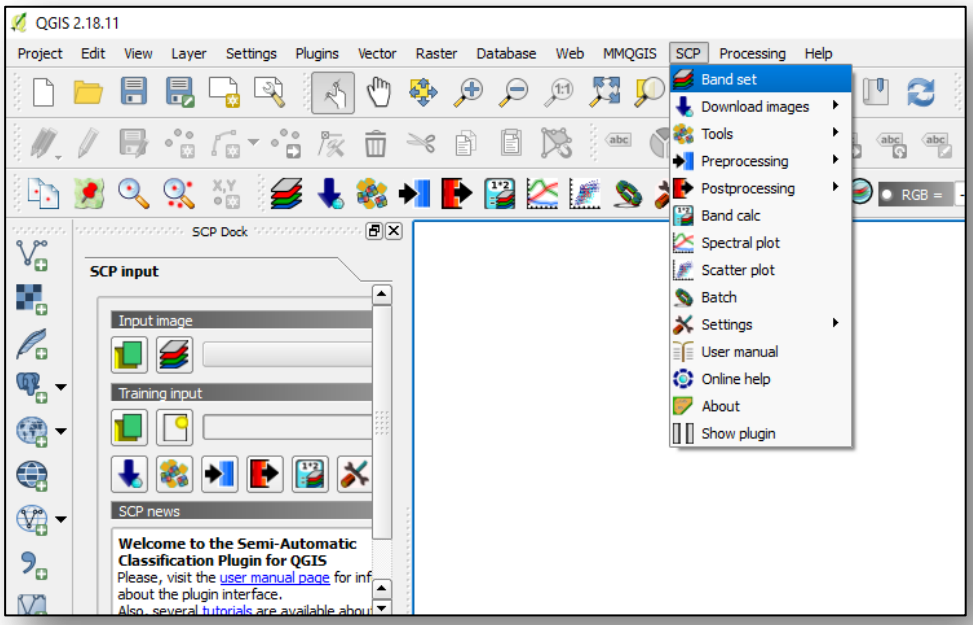
where:

- LλLλ = Spectral radiance at the sensor's aperture (at-satellite radiance)
- dd = Earth-Sun distance
- ESUNλESUNλ = Mean solar exo-atmospheric irradiances
- θsθs = Solar zenith angle in degrees, which is equal to θsθs = 90° - θeθe where θeθe is the Sun elevation

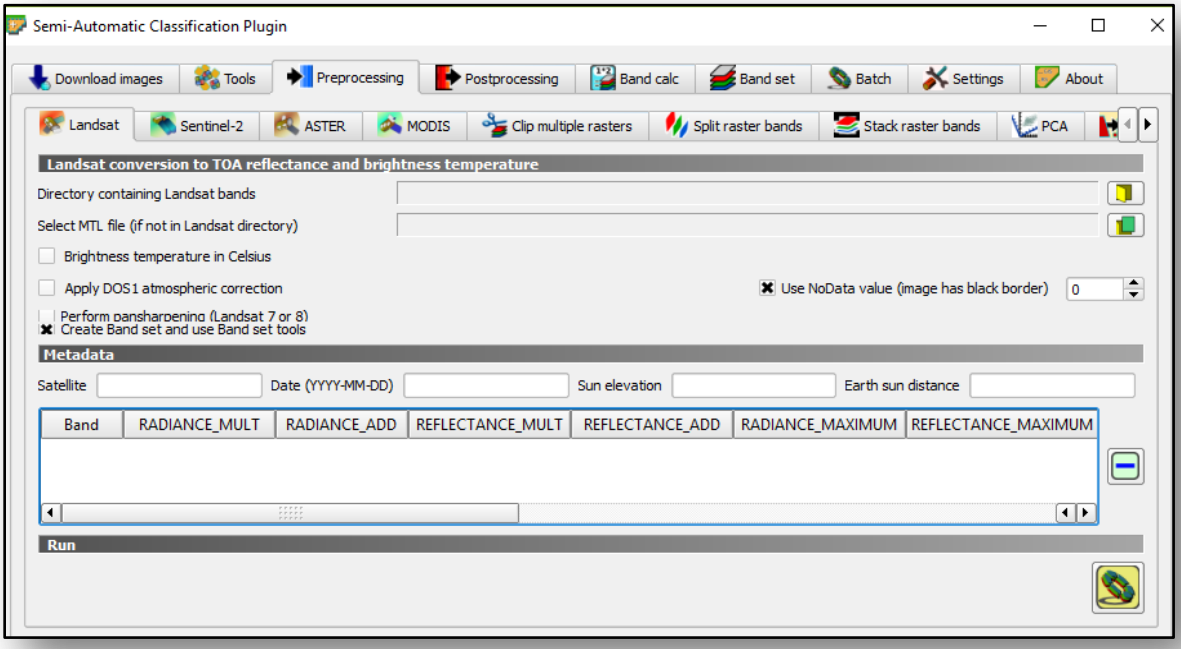
Sentinel-2 are composed of several bands and a metadata filewhich contains information required for the conversion to reflectance.

- Band 2 - Blue;
- Band 3 - Green;
- Band 4 - Red;
- Band 5 - Vegetation Red Edge;
- Band 6 - Vegetation Red Edge;
- Band 7 - Vegetation Red Edge;
- Band 8 - NIR;
- Band 8A - Vegetation Red Edge;
- Band 11 - SWIR;
- Band 12 - SWIR;

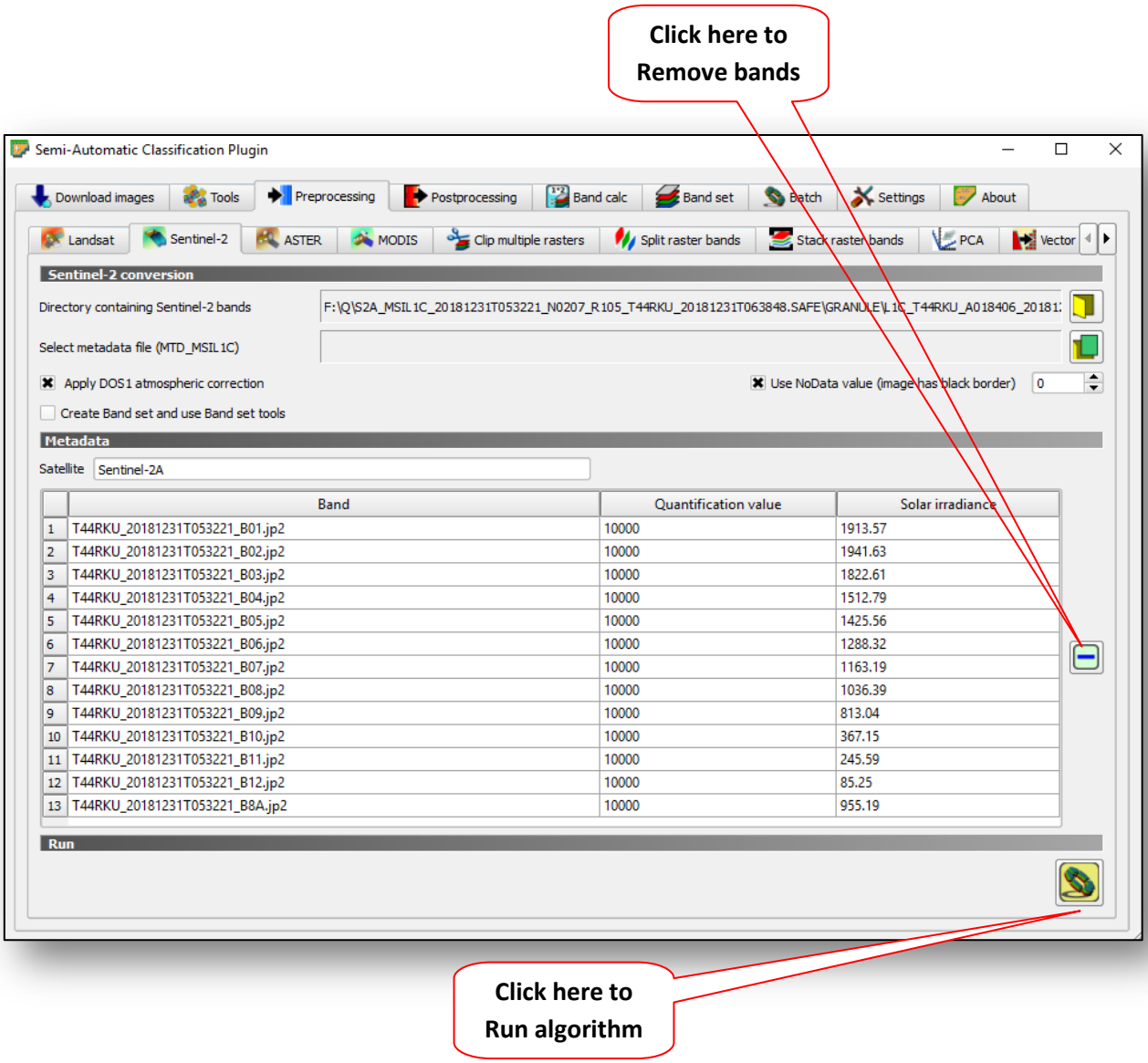
- To convert raw digital numbers (DN) in the image to top-of-atmosphere (TOA) radiance or reflectance, go to SCP in main Toolbar and select Band set.



- Next,after selecting Band set > Semi- Automatic Classification Plugin will appear > now select Preprocessing option by clicking the button in the SCP menu or the SCP Tools.
- In order to convert bands to reflectance, select Sentinel 2 or Landsat as per availability.

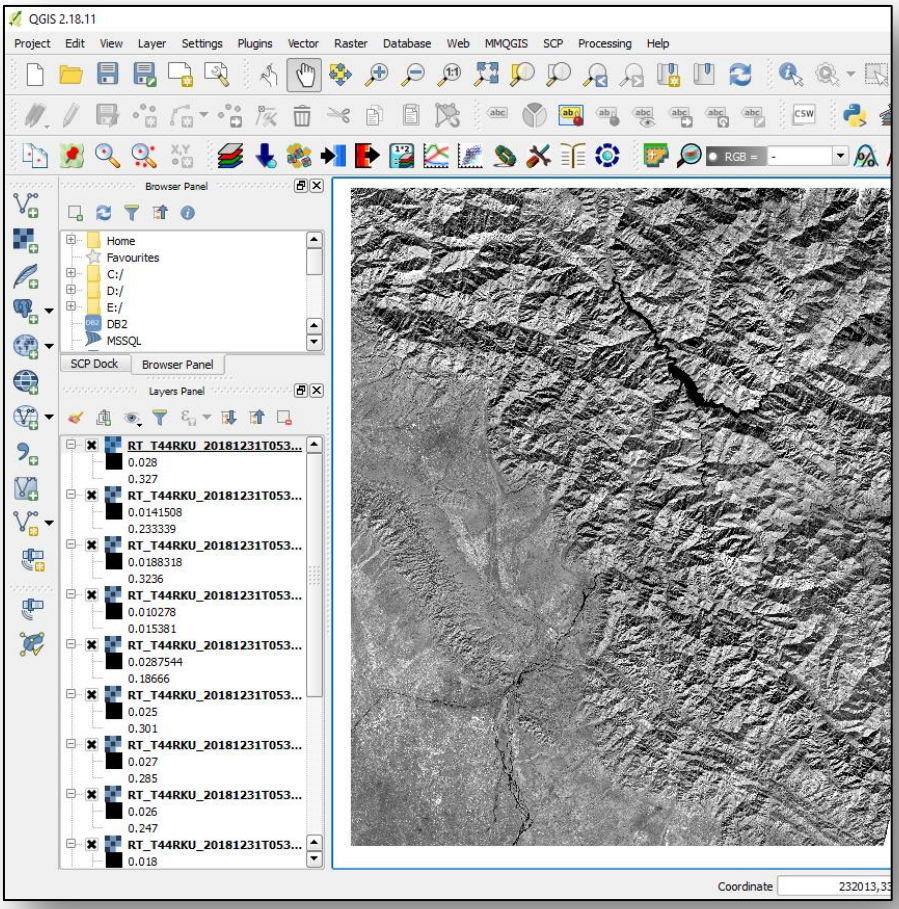


- Click the button Directory containing Sentinel-2 bands and select the available directory. The list of bands is automatically loaded with the metadata information for each band in the Metadata table as metadata file is provided inside the same specified directory.



NOTE : To convert images to reflectance using SCP, one should copy the.xml filecontains MTD_SAFL1C (included in the granule directory) and paste it inside the same directory of bands (files .jp2).

- In order to calculate Surface Reflectance we are going to perform the process by applying the DOS1 Correction, therefore enable the option Apply DOS1 atmospheric correction.
- Click the button to start the conversion process and select the directory where converted bands are saved.
- After running the algorithm converted bands are loaded and displayed on map canvas as showing in the Figure.



NOTE: Dark Object Subtraction (DOS) Method is used when there is no atmospheric measurements available at the time of acquisition. Some pixels within the image are in complete shadow and their radiances received at the satellite are due entirely to atmospheric scattering (path radiance). In order to improve the calculation of parameters based on the image path radiance value is then subtracting from each pixel value in the image. The process improves the interpretability and quality of remote sensed data.

Chapter14: Preparation of Working Plan by using QGIS

- QGIS is one of the most efficient software for working plan (WP) preparation, which involves analysis of several spatial layers.

- A spatial database is a set of geo-referenced layers in which each layer is representing particular theme and features on the ground, such as Forest Cover, Forest Types, Administrative boundary, Road/Rail network, Forest, Compartment, Village boundary and Plantation area. In RS/GIS world, earth features can either be in vector or raster format.

- QGIS is scientific basis for analyzing, synthesizing and efficiently storing or compiling the data for each Compartment, Block, Range and Divisional level.

- Creating Spatial and Non-Spatial Layers in QGIS

- QGIS is fulfilling the basic requirements for creating spatial databases.

(i) QGIS software is used for creating spatial and non-spatial database of the Forest Division in a more consistent way.

(ii) The spatial database will comprise layers on different themes and in each layer, attribute data will be attached with the features in attribute table.

(iii) On screen digitization for creating large scale1:25,000 or higher Maps efficiently.

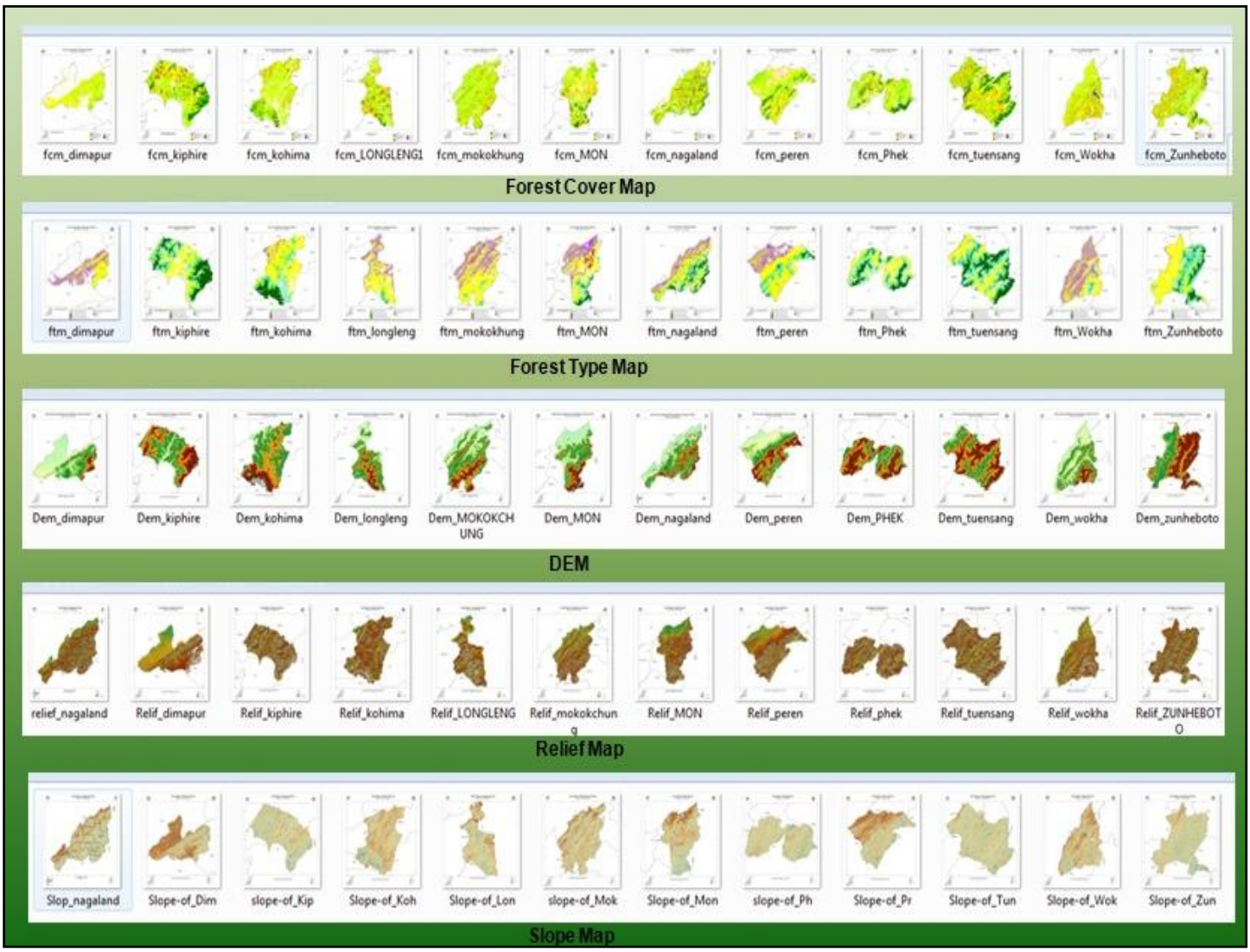
Indicative list of layers in the Spatial Database in GIS as per National Working Plan Code–2014

1 Division boundary* Maps in the division/ department
2 Range boundary* Maps in the division/ department
3 RF and PF boundary* Maps in the division/ department / SOI toposheets/existing digitized boundary
4 National parks and wildlife sanctuaries* Maps in the division/ department/ WII
5 Beat boundary Maps in the division/ department
6 Block* Maps in the division/ department
7 Compartment boundary* Maps in the division/ department
8 Location of all the offices* Maps in the division/ department/GPS
9 Village locations* SOI toposheets /Census
10 Road network* SOI toposheets /Google Earth
11 Railway line SOI toposheets
12 Forest check gates* Maps in the division / department /GPS
13 Rest houses Maps in the division / department /GPS

14 Stream network* SOI toposheets /Satellite Image/ASTER DEM
15 Nurseries* Maps in the division / department/GPS
16 High resolution satellite imagery* NRSC
17 Forest cover* FSI / Self Interpretation
18 Forest type/stock map* FSI/ maps in the division/ department
19 Police station/chowkis SOI Toposheets/ Police Department's Map
20 JFMCs* GPS
21 Plantation locations in the last 15/20 years Maps in the division/ department/GPS
22 Forest depots Maps in the division/ department/GPS
23 Fire locations recorded in the last 5 years FSI's website and conversion of the same in to point coverage
24 Parent geology Maps from GSI
25 Protected areas* Maps in the division/ department/ WII
26 Wildlife corridors Maps in the division/ department/ WII
27 Eco-tourism spots Maps in the division/ department /GPS
28 Soil type NBSS&LUP map on 1:250,000 scale
29 Altitude zones* ASTER DEM
30 Slope ASTER DEM
31 Aspect ASTER DEM
32 Fire affected area Burnt area mapping using IRS P6 LISS III data
33 Fire sensitive spots Grid analysis using FSI's forest fire spots data

Note: * Marked as a Mandatory List

Preparation of Geospatial Layers in QGIS



Annexure1.

Some useful Links and Portals

Data Availability on Bhuwan Portal	
Component Name	Data Availability
Bhuvan 2D / 3D	Resourcesat-1– AWiFS, LISS III & LISS IV, Cartosat 1 & 2 – PAN (merged with LISS IV), Oceansat – 1&2 - OCM
NRSC Open EO Data Archive	Resourcesat-1: AWiFS Ortho and LISS III Ortho, IMS-1: HySI, CartoDEM, Oceansat-2:OCM2: NDVI, VF and Albedo, Tropical Cyclone Heat Potential, Ocean Heat Content, D 26, Wind Products.
Thematic Services	Thematic Maps of 1:10000, 1:50000, 1:250000 – Landuse/Landcover, Wasteland, Geomorphology, Lineament and Urban Landuse, Soil, Salt Affected and Alkalinity
Disaster Services	Drought, Earthquake, Flood, Forest Fire, Landslide and Cyclone.
	Data Support for International Disasters
Projects	Municipal GIS, Tourism GIS, Forestry, Irrigation, Agriculture, Urban etc

Few important Geoportals: **Web Portal**	**URL**	**Specialty**
MapMyIndia	http://www.maps.mapmyindia.com	Rich POI and detailed maps of India.
Indian NSDI	https://nsdiindia.gov.in	Metadata catalogue and policy document.
Biodiversity Information System	http://bis.iirs.gov.in	Biodiversity spatial viewer and data download utility. Rich data contents on plant biodiversity of India.
Indian Bio-resource Information Network	http://ibin.gov.in	Rich data contents for Indian Bio-resource information. System of distributed database.
India-WRIS	http://india-wris.nrsc.gov.in	Rich data contents for water resources of India.
NIC GIS	http://gis.nic.in	Village level tagging of information in GIS domain

Annexure2.

Links for Web Map Services

FSI: Forest Fire Geo portal

http://117.239.115.44:90/fsi_fire/fire.html

India FCM & India FTM

http://117.239.115.44:90/cgi-bin/mapserv.exe?map=/ms4w/apps/geomoose2/maps/demo/fire/fcm.map

LargeFire

http://117.239.115.44:90/cgi-bin/mapserv.exe?map=/ms4w/fsi_lf/lf.map

Modis & SNPP-VIIRS

http://117.239.115.44:90/cgi-bin/mapserv.exe?map=/ms4w/apps/geomoose2/maps/demo/fire/fire.map

Forest Fire locations for Respective States

Maharashtra

http://117.239.115.44:90/cgi-bin/mapserv.exe?map=/ms4w/fsi_fire/wms_Maharashtra.map

Karnataka

http://117.239.115.44:90/cgi-bin/mapserv.exe?map=/ms4w/fsi_fire/wms_Karnataka.map

Odisha

http://117.239.115.44:90/cgi-bin/mapserv.exe?map=/ms4w/fsi_fire/wms_Odisha.map

Telangana

http://117.239.115.44:90/cgi-bin/mapserv.exe?map=/ms4w/fsi_fire/wms_Telangana.map

Madhya Pradesh

http://117.239.115.44:90/cgi-bin/mapserv.exe?map=/ms4w/fsi_fire/wms_MadhyaPradesh.map

Andhra Pradesh

http://117.239.115.44:90/cgi-bin/mapserv.exe?map=/ms4w/fsi_fire/wms_AndhraPradesh.map

BHUVAN

Bhuvan https://bhuvan-vec2.nrsc.gov.in/bhuvan/wms

Annexure3

Abbreviations

DEM	Digital elevation model
GIS	Geographical Information System
NDVI	Normalized difference vegetation index
USGS	United States Geological Survey
TRU	Terrain Ruggedness Index
TPI	Topographic Position Index
ROI	Regions of Interest
OBIA	Object-based image analysis
NIR	Near infrared
OGR	Open GIS Simple Features Reference
SDTS	Spatial Data Transfer Standard
GML	Game Maker Language
GDAL	Geospatial Data Abstraction Library
WMS	Web Map Service
WMTS	Web Map Tile Service
WCS	Web Coverage Service
WFS	Web Feature Service
UMN	Unified Messaging Service
OGC	Open Geospatial Consortium

Annexure4

Glossary of keywords

Digital elevation model (DEM)

Digital elevation model is a 3D representation of a terrain's surface. A DEM can be represented as a raster (a grid of squares, also known as a heightmap when representing elevation) or as a vector-based triangular irregular network (TIN).

Graphical User Interface (GUI)

A computer format/ interface that allows the user to interact with the computer through icons or visual indicators (e.g., menus, buttons, windows, fields).

Point

A shapefile or layer that displays point data.

Polyline

One-dimensional lines, also called polylines, are used to represent geographical features like rivers, roads, railroads, trails, and topographic lines. It can only measure distance.

Polygon

Polygons are two-dimensional geographical features covering a portion of the earth's surface, for example forests, lakes, administrative boundaries. It can measure area as well as perimeter.

Slope

Slope is the incline and steepness of a surface.

Terrain Ruggedness Index (TRI)

The mean difference between a central pixel and its surrounding cells.

Web Map Service (WMS)

To share and render the map on the browser or create a custom map based application, OGC Web Map Service (WMS) is used.

Web Feature Service (WFS)

WFS is used to query, update, delete the data of the map. This is used to share the vector data or metadata of the map over the web.

Web Coverage Service (WCS)

WCS is used to publish the raster data like satellite imagery in image or TIFF or GeoTIFF formats.

NDVI

Normalized Difference Vegetation Index quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).

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Note: The latest release of QGIS is always available from this web page
http://www.qgis.org/en/site/forusers/download.html
Website: http://www.fsi.nic.in

WHY QGIS??????

- RUN QGIS ANYWHERE AND CAN GET BEST OUT OF TECHNOLOGY, AVAILABLE IN 48 LANGUAGES GLOBALLY.

  WE CAN INSTALL IT ON WINDOW,SMAX OS X, LINUX, UNIX,ANDROID BASED TABS AND SMART PHONES.

- GEOPROCESSING
  ROBUST, FAST GEOPROCESSING AND MORE EFFICIENT WITH HANDLING PROCESSING TOOLBOX, BATCH PROCESSING,GRAPHICAL MODELER AND PYTHON CONSOLE.

- BASEMAPS AVAILABILITY, SUPPORTS MORE THAN 2,700 CRS.
  ALMOST 148 READY TO USE BASE MAPS ARE AVAILABLE IN QGIS.

- MOST USER FRIENDLY SOFTWARE WITH PRESENTABLE CARTOGRAPHICAL, DATA VISUALIZATION AND STYLING TOOL.

- SEMI-AUTOMATION CLASSIFICATION PLUGIN HANDLIND DATA DOWNLOADING (LANDSAT, SENTINEL, MODIS), BAND STACKING, CLASSIFICATION (SUPERVIZED AND UNSUPERVIZED) AND CHANGE DETECTION.

- QGIS2THREEJS PLUGIN FOR 3D VIEW IN QGIS.

- IN A NUTSHELL, QGIS IS A COMPLETE PACKAGE OF RASTER, VECTOR,WEB SERVICES,BASE MAP SERVICES, DOWNLOADING PLATFORM, CLASSIFICATION, CHANGE DETECTION 3DSERVICES ANDFEW MORE INFINITE SERVICES……

- LAST BUT NOT LEAST, ITS FREE AND OPEN!!!!!!!

QGIS is an user-friendly software supported with most interactive Graphical User Interface (GUI) and providing some common functions and features as provided by full-fledged licensed softwares. The software is established as a project in June 2002 and is developed using the Qttoolkit (https://www.qt.io) and C++. QGIS is released under the GNU General Public License (GPL). Developing QGIS under this license means that users can modify the source code and have access to a GIS program to freely modified it and is developed using the Qt toolkit (http://www.trolltech.com).

Moreover, the most versatile feature of QGIS is its platform flexibility, as it is currently runs on most Unix, Linux platforms, Windows, and OS X. QGIS supports a number of raster and vector data formats, with some new support added using the plugin architecture.

Users can browse and download the QGIS links (http://www.qgis.org) for further support.

For further queries can connect m.bist83@gmail.com