Tutorial

An Introduction to GIS concepts and usage using QGIS

June 2020

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Note: This tutorial has an accompanying dataset for examples illustrated and for exercises. Please follow instruction given in the Appendix to locate the dataset for purposes of using this tutorial.

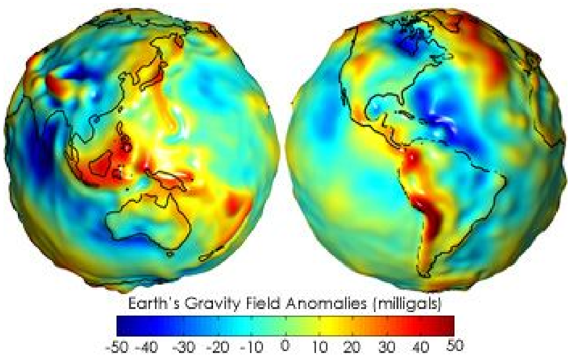
1. Introduction to Geographic Information System

A geographic information system is a system designed to store, represent and manipulate geographical data. A GIS stores spatial data (location information) and optionally a function value or data associated with each spatial data item, e.g., the elevation information for a district map.For storing geographical data we need a conceptual framework to define geographic data elements and their interrelationship.

1.1. Geospatial data

Spatial data, also known as geospatial data, is information about a physical object such as roads, houses, lakes, and countries, and their respective locations. In addition to location, each of these objects also possesses certain attributes, such as a name, number of people, depth, or population.

Every location is a point on the curvature of earth thus it's important to know the shape of earth. We know that earth is spherical but its not perfect sphere, earth is squashed over the poles thus we can say earth shape is ellipsoid, other factor that we can consider is the variation in topology but this variation is negligible in comparison with size of earth.The highest peak Mount Everest is 8848 meter and the diameter of earth is 1,27,56,200 meter.But we cannot ignore the fact that earth is “lumpy” due to different gravitational pull at different location.



The model of earth shown in Figure 1.1 is called Geoid. But this cannot be used for determining the location of objects on earth due to complex mathematical computations required to take the irregularities into account.

Figure 1.1. 3D visualization of gravity anomalies units of Gal [1.1]

Another model that we can use is oblate spheroid (Figure 1.2) due to its close approximation to shape of earth,it has rotational symmetry around an axis from pole to pole.Using this model earth position can be expressed in combination of three-dimensional geographic coordinate systems such as latitude, longitude and elevation.

We can use it as a reference ellipsoid with given origin and orientation that best fit the need for the area to be mapped.

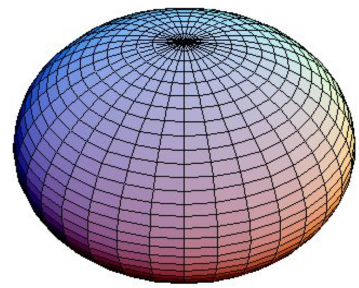


Figure 1.2. oblate spheroid [1.2]

1.1.1. Geographic coordinate system

A geographic coordinate system is a coordinate system used to locate the position of a physical object on Earth.Common coordinate systems are the cartesian system,the polar coordinate system and the cylindrical or spherical coordinate system.

A coordinate reference system (CRS) or geodetic reference system or geodetic reference datum defines, with the help of coordinates, how the two-dimensional, projected map in your GIS is related to real places on the earth.

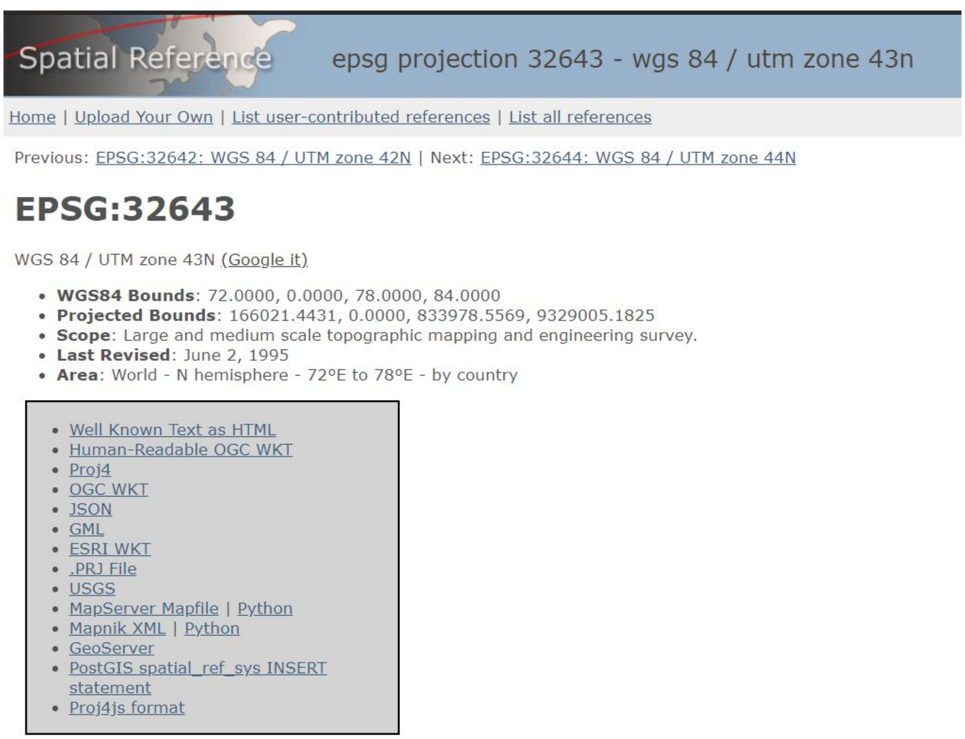


Figure 1.3. Maharashtra EPSG code [1.3]

Some datums are global for providing average accuracy around the world as the benefits of a the global system outweighs
greater accuracy, the global WGS 84(also known as WGS 1984, EPSG:4326) datum is becoming increasingly adopted.

- WGS 84: A projection system, World Geodetic System, from the U.S. Military in 1984. This system is mostly used in our examples. The World Geodetic System is a standard for use in cartography, geodesy, and navigation.

Because the Earth is an imperfect ellipsoid, localised datums can give a more accurate representation of the area of coverage than WGS 84.
Visit the following link and search different datums, Figure 1.3 shows the EPSG code for Maharashtra state.

- https://spatialreference.org/ref/epsg/
- https://epsg.io/

1.1.2. Projection system

Earth is a 3D object i.e,a sphere. But maps are in two dimensions . Even 3D mapping tools are simulations,there is no depth . Thus, map projection is used for creating maps. Let's understand the concept of a map projection by placing a light bulb at the centre of the globe having an opaque land area and transparent ocean(Figure 1.4a). This globe is placed at the middle of a cylindrical room.When we turn the light bulb on, the outline of the continents will be “projected” as shadows on the wall, ceiling, or any other nearby surface. This is what is meant by map “projection.”

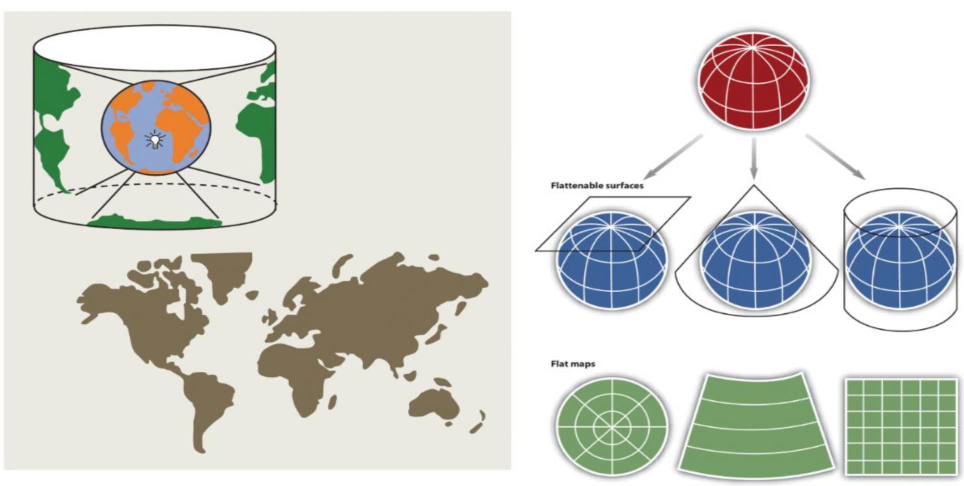
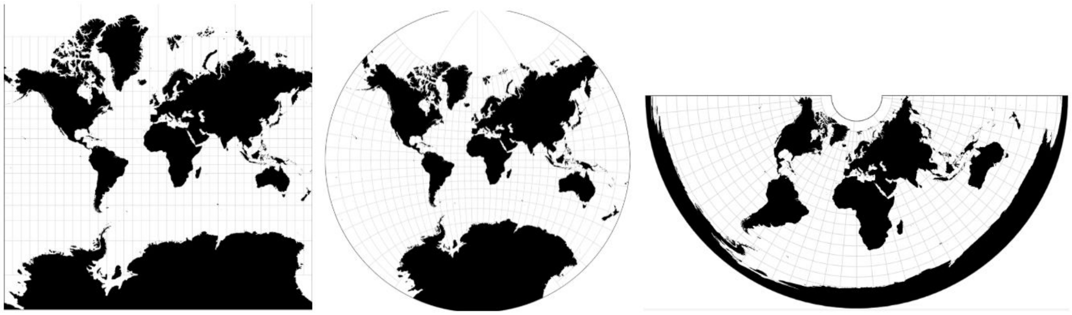


Figure 1.4. a. Projection concept ***b.Projection of sphere on different surfaces [1.4]***

Features of 3D spherical earth are projected onto different shapes such as Cone, Cylinder, even flat surfaces or planes or other shapes.(Figure 1.4b)These shapes then flattened into 2D maps or digital data sets used in GIS.

The projection system used by the GIS defines the measuring units.We are mostly familiar with Mercator projection since it is best for navigation . Figure 1.5 shows some of the available projections.

But no matter what shape is used the resulting flat surface is distorted. Therefore there is no such thing as perfect map projection .For example, In Mercator Projection,Antarctica appears to be a huge continent and Greenland appears to be just as large as South Africa.although, Greenland is one eighth of the size.



Mercator projection *Lagrange projection* *Conic Equidistant projection*

Figure 1.5. Some of the World Map Projections [1.5]

1.1.3. GIS Layers

A GIS layer is a view of a spatial area with information elements, e.g., a layer of roads, or a layer of village boundaries etc. Each layer has geographical context and hence multiple layers can be superimposed to view aggregate details of a region, e.g., a road layer and a village layer when viewed together can help understand road connectivity details.(Figure 1.6)

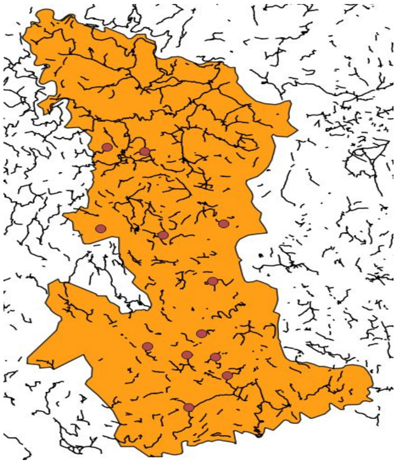


Figure 1.6. 'tribal roads' layer overlay over 'block boundary' layer

1.2. Data Representation

The spatial data are represented in raster and vector data formats :

1.2.1. Raster Data

Raster data is based on a (usually rectangular, square-based) tessellation of the 2D plane into pixels (also known as cells). Each pixel represents a small portion of the spatial area and has an associated value for some attribute (Figure 1.7), e.g., the DEM (data elevation model) raster dataset associates the elevation of a small region to a pixel, grid-based satellite image.

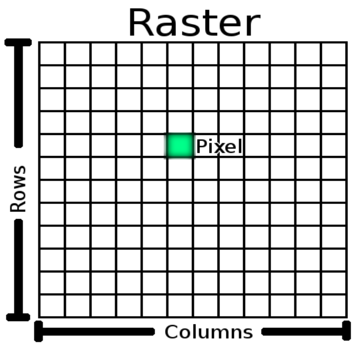


Figure 1.7. Rows and columns of pixels[1.6]

Raster data is not only good for images that depict the real world surface (e.g. satellite images and aerial photographs), they are also good for representing more abstract ideas(Figure 1.8).

Figure 1.8. a. Raster satellite image *b. Rainfall variation*

Figure 1.9. a. More resolution *b. Less resolution raster image*

The relationship between pixel size and the number of pixels is expressed as the resolution of the raster. Lesser the resolution, more pixelated image will be produced(Figure 1.9).

Rasters can represent a wide variety of data. The data can be continuous(Figure 1.10) or categorical(Figure 1.11).

Continuous Data:

- Elevation
- Temperatures
- Precipitation
- Reflectance (light)

Categorical Data:
- Land Cover Type
- Soil Type
- Vegetation Type

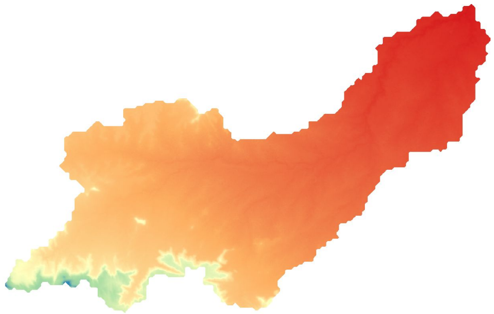
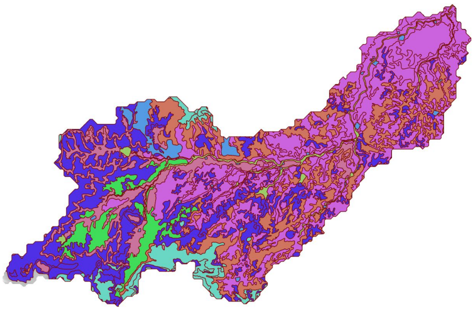


Figure 1.10. Elevation variation is represented by continuous variation in colour



Raster Data can be represented using following file formats
- Image (.img)
- GeoTIFF (.tif)

Figure 1.11. Soil type is a discrete value represented by different colours

1.2.2. Vector data

Vector data uses geometry (polygons, polylines and points) to represent (spatial) objects(Figure 1.12). Additionally, each object can be associated with attributes.Geometry are stored by simply recording the coordinates of its starting and ending points.Each point would be expressed as two or three numbers (depending on whether the representation was 2D or 3D, often referred to as X,Y or X,Y,Z coordinates(Figure 1.13)

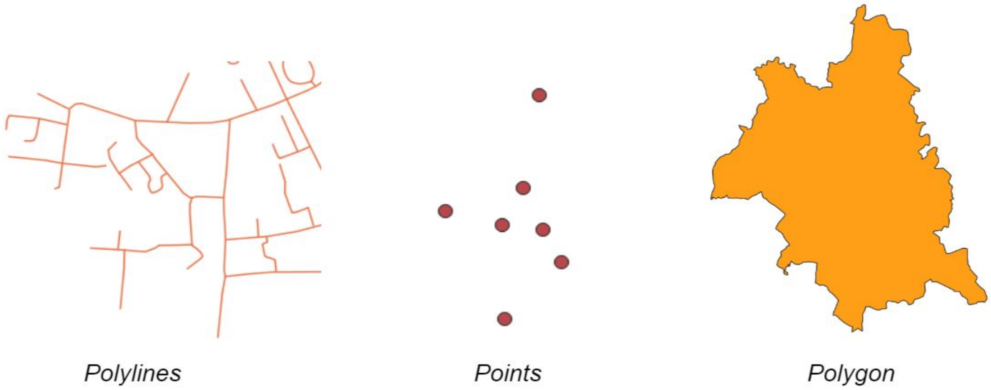


Figure 1.12. Vector geometry is used for representation of roads ,locations or geographical boundaries

Vector Data File Formats
- Shapefile (.shp)
- GeoJSON (.geojson)
- KML (.kml)

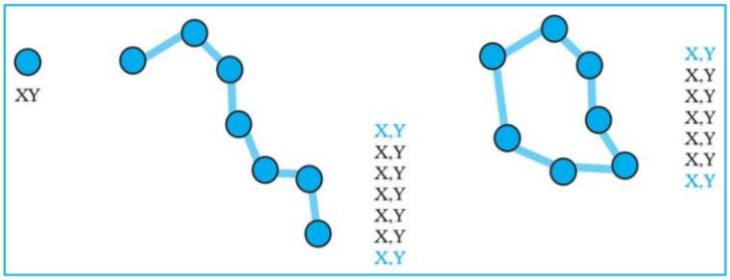


Figure 1.13 The Vector Data Model is based around Coordinate Pairs[1.7]

1.3. GIS Softwares

GIS Software includes the application that provides geospatial data viewing, editing and analysis capabilities.

1.3.1. Open source Softwares

The term open source refers to something people can modify and share because its design is publicly accessible.These are Free to use and anyone can contribute in its development.

Some of the open source GIS software includes:
- QGIS
- GRASS GIS
- MapWindow GIS
- GeoDa
- SAGA GIS etc

1.3.2. Commercial Softwares

Following are some commercially available GIS softwares
- ArcGIS (Esri)
- Geomedia (Hexagon Geospatial)
- MapInfo Professional (Pitney Bowes)
- Manifold GIS (Manifold)

1.3.3. QGIS vs ArcGIS

QGIS	ArcGIS
Open source software	Proprietary software
Freely available	Commercial
Can be installed on different operating systems	Compatible with windows only
Under creative common license	Single user licensed software
Developed by all over the world programmers	Developed and deployed in secure environment of Esri
https://qgis.org/en/site/	https://www.arcgis.com/index.html

Table 1.1. QGIS vs ArcGIS

2. Introduction to QGIS

As we have seen, QGIS is a major Open-Source GIS program,It is free to download and easy to use. Major advantage of using QGIS over other open source tools is its functionality. It provides a diverse toolset integrated from multiple programs. We can import, edit and save most spatial file formats and have significant user base and online documentation.

2.1. Installation

This tutorial is based on QGIS version 1.8.0.

2.1.1. Installation on Linux

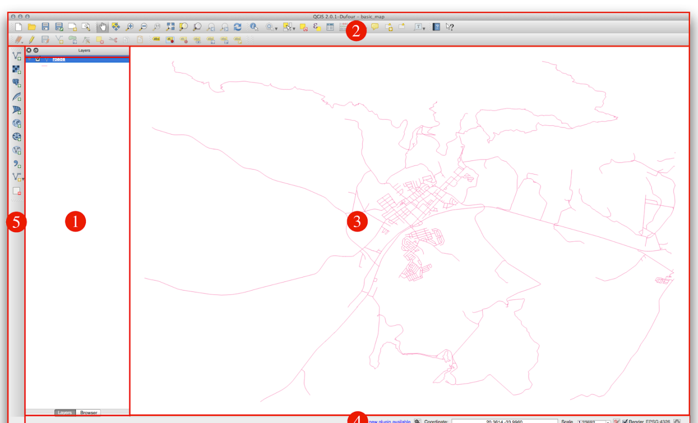
https://qgis.org/en/site/forusers/download.html#linux
Follow the instructions given in the link above to install QGIS on Ubuntu/Debian/Fedora. The instructions include the installation of prerequisites like python, grass etc.

2.1.2. Installation on Windows

https://qgis.org/en/site/forusers/download.html#windows
Download QGIS from the above link:
Run the setup, follow the instructions and install QGIS.

2.2. Interface

The section of the interface identified in the figure above are:



1. Layers List Panel
2. Toolbars
3. Map canvas
4. Status bar
5. Side Toolbar

Figure 2.1. QGIS Interface [2.1]

2.2.1. Layers List Panel

In the Layers list, you can see a list of all the layers added.You can expand the layer for more information and on right clicking there are a lot of options available related to the selected layer. You can also group the layer together for easy handling.

2.2.2. Toolbar

Toolbar contain icon to commons tools for easy access.You can easily customize the interface to see only the tools you use most often, adding or removing toolbars as necessary via the Settings ‣ Toolbars menu.

2.2.3. Map canvas

Loaded layers are displayed over Map canvas.

2.2.4. Status bar

Shows you information about the current map. Also allows you to adjust the map scale and see the mouse cursor’s coordinates on the map.

2.2.5. Side Toolbar

By default the Side toolbar contains the buttons to load the layer and all the buttons to create a new layer.

2.3. Adding world map Tile

2.3.1. OpenStreetMap Tile Layer

- Enable browser panel(Layer ‣ panels ‣ browser panel)
- Right click on Tile Server(XYZ)
- Click on new connection
- Enter this url for OSM tile layer https://tile.openstreetmap.org/{z}/{x}/{y}.png and click OK
- Give suitable name to tile layer in next dialog box and click OK
- Again go to browser panel and click on Tile Server to show dropdown
- Click on the OSM tile layer that you created

2.3.2. Pan map, zoom in , zoom out

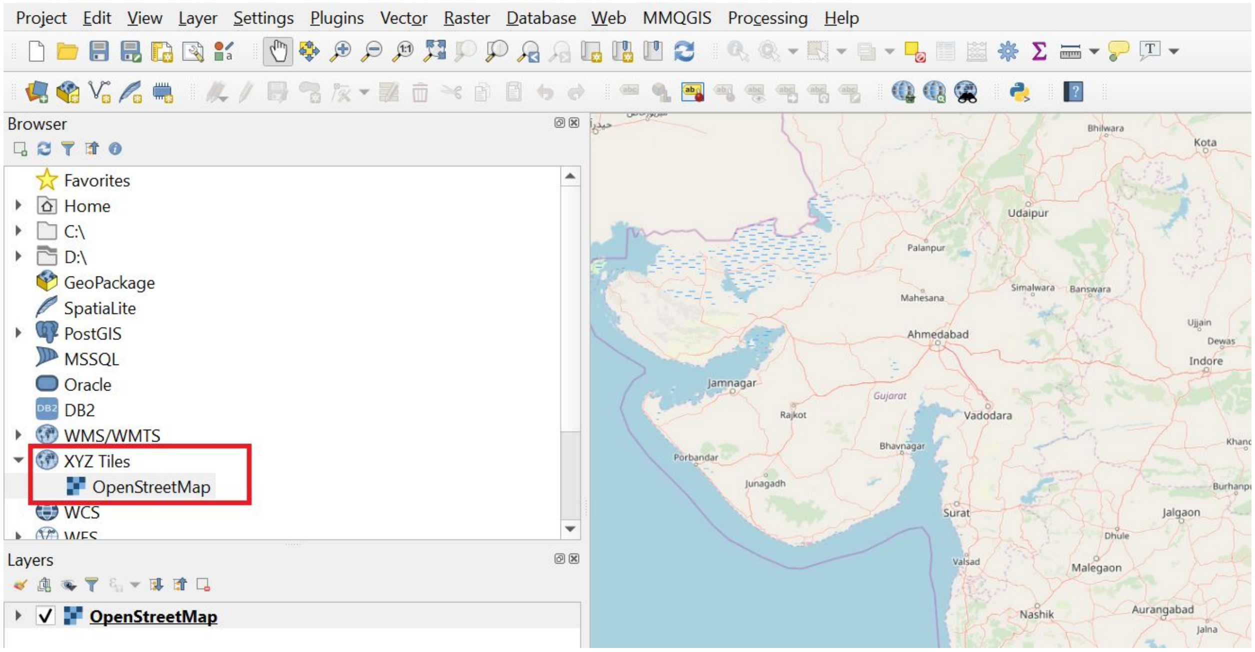


Figure 2.2. OSM World Tile layer zoomed to India

- Panning the map, Zooming in , Zooming out options are available in ”View”, also the legends are available on the panel on the top.
- The panels can be made visible by right clicking on the top of QGIS frame, and checking the boxes of panels we want to make visible.

2.3.3. Identify the feature/ properties of selected feature

- To identify the object and its features,
- Go to ‘‘View’’.
- Select ‘‘Identify Feature’’.

2.3.4. Measure angle, area, line, giving bookmark etc.

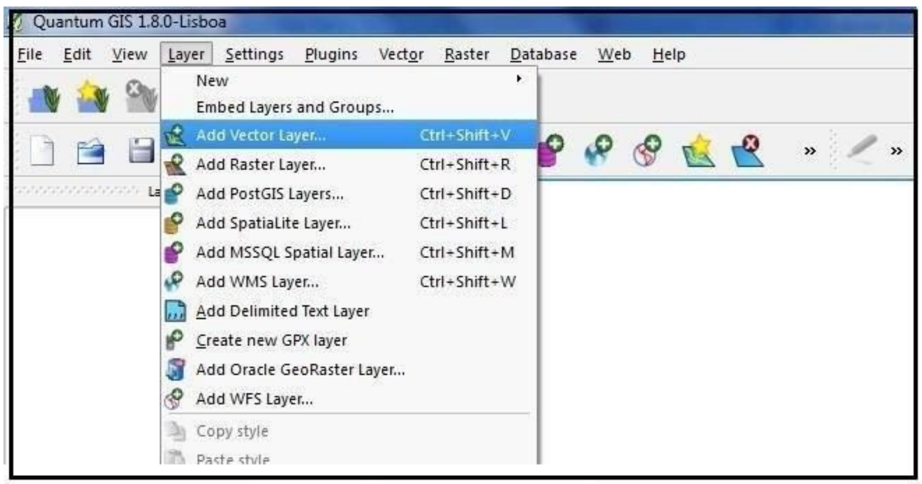
- Make the toolbar - “attributes” visible. The above operations and few more can be done using this tool.
- The length is measured in Kilometer and angle(latitude and longitude) in degrees.

3. Working with Vector data

3.1. General operations

3.1.1. Importing a Layer

- Go to ‘‘Layer’’ option on the topmost panel of the QGIS frame.
- Following options are available:
    - Add vector layer, add raster layer, add postGIS layer etc. Select add vector layer.
- Browse the location where you have saved the shape files.
- You can select one or more shape files at the same time.
- Click on ‘‘Open’’.



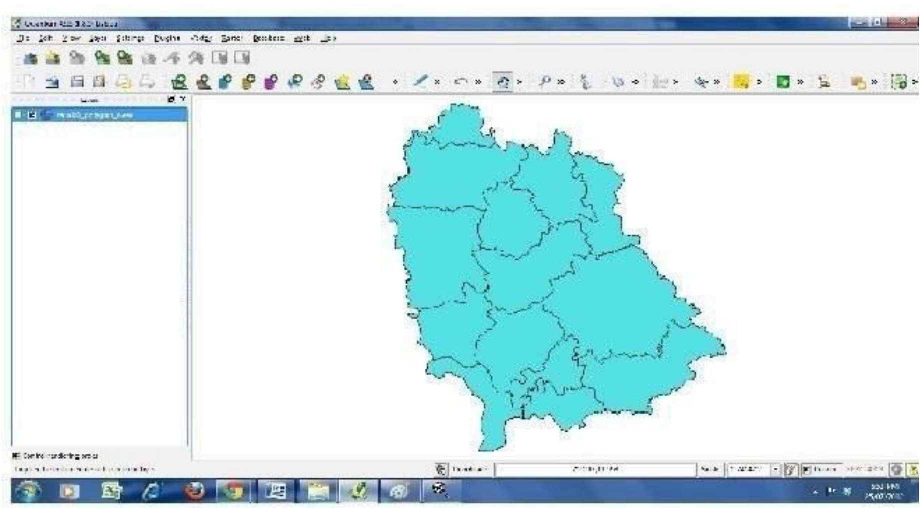


Figure 3.1. importing a layer and viewing list of layers on the view panel

3.1.2. View layer panel

- To view the layer panel: 1. Go to ''View'' on the top of the frame.
- Click on the option ‣ ''Panels''.
- Check on the option ‣ ''Layers''.
- You can drag and resize the ''Layer Panel''.

3.1.3. Adding multiple layers

Multiple layers can be added using the "Adding/Importing a Layer" procedure. Layers are overlapped on top of each other, in the order shown in the layer list panel. If a layer made up of lines or .points is overlapped by a layer of polygons, the point/line layer won't be visible. Thus, we may have to bring the layers above other layers. The following steps will change overlap sequence between layers,

- Select the layer we want to move and drag it
- Drop layer at the level we want it at

Figure 3.1 shows two views related to adding/importing a layer and the layer list panel (on the left) displaying the list of added layers. A simple example showing how an overlapping layer hides the previously added layer is shown in Figure 3.3 .

3.1.4. Remove layer

- Right click on the layer visible in view panel
- Click on ''Remove''.

3.1.5. Zoom to the layer

To see the full layer in one screen, we need to zoom to the layer extent. To do so,

- Add a vector layer
- Right click on the layer we want to zoom into.
- Click on ''Zoom to layer extent''.

3.1.6. View the coordinates and scale

The coordinates and scale can be seen on the bottom right of the programme interface.

3.1.7. Set the Projection system

Projection system defines the geographic coordinate system, units of the map etc. Usually, we set the coordinate system to “WGS 84”. The files given for the experimental purpose are already in the “WGS 84" co-ordinate reference system. The CRS can be changed as follows,

- Right click on the layer in the view panel whose CRS is to be changed or set.
- Click on Set layer CRS.
- Select the CRS we want (we use WGS 84).
- Click OK. Now check the coordinates. They should be matching as the coordinates of the location of the layer on Google earth or any other earth browser.

3.1.8. View attributes

Attributes of the layer can be viewed by following steps below:

- Right click on the layer in the layer panel.
- Click on ‘‘Open attribute table’’.
- The tabs in the bottom represent operations like copy, select, deselect rows, edit row, add new column, delete new column.
- Figure 3.2b shows the operations that QGIS offers for the layer, on right clicking the layer name and highlighting the ones which are described here.

3.2. Properties of map

This section describes how to change the properties for visualization of the map.

- Right click on the layer name. (Figure 3.3 shows the properties toolbar.)
- Click on properties.
- Following are the properties that we can change for visualization. Note: Options may change according to the software release version of QGIS.

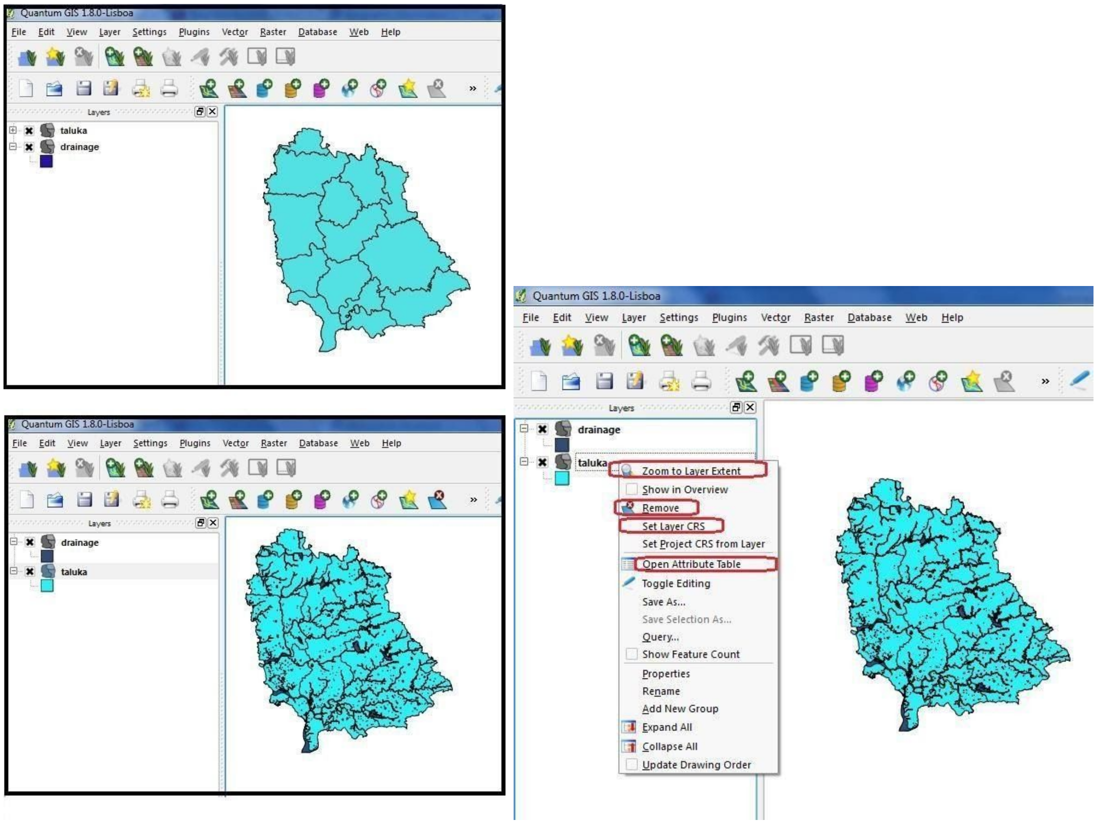


Figure 3,2. (a) Effect of adding multiple layers. *(b) Operation on layers (available on right-click).*

3.2.1. General

The "General" tab can be used to specify the coordinate system, CRS etc.

3.2.2. Style

The renderer has the following options: Single symbol, categorized, graduated. Figure 3.4 shows a taluka layer with different renderings.

- Single symbol (default):
  - The whole layer selected will be rendered with a single colour .
  - Colour change - by selecting the colour by clicking on the "change" button.
  - Transparency - can be changed by dragging the pointer from 0 transparency level to 100 percent.
  - Unit can be changed from the default millimeter to map unit.
  - Style [solid fill, horizontal lines fill, vertical lines fill etc.] can be used to fill styles with a solid colour .

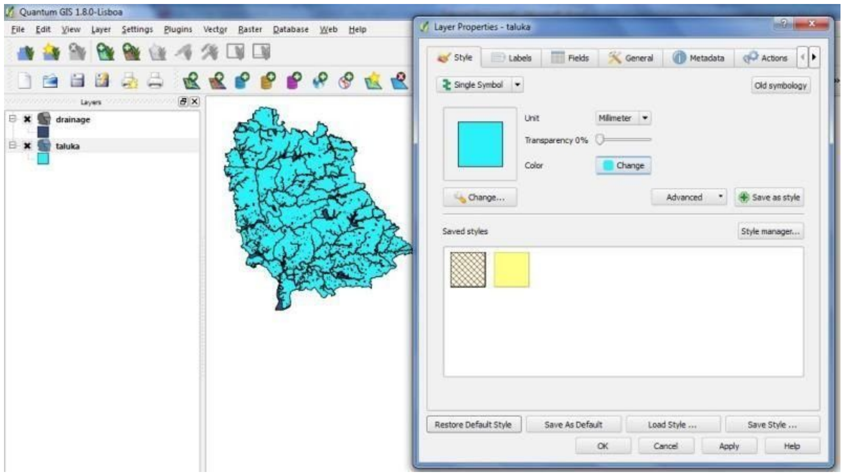


Figure 3.3: The properties panel for a layer

- Graduated
  - This option helps to colour a layer according to different attribute values of the vector polygons. For example, different talukas can be colour coded based on their area, taluka name etc.
  - Select the 'Graduated' style option.
  - Select the 'Column' that should be used for colour coding, e.g., perimeter, area etc. - Select number of classes. An automatic colour coding based on the number of classes should be displayed.
  - Select 'OK' to view graduated styling on the map

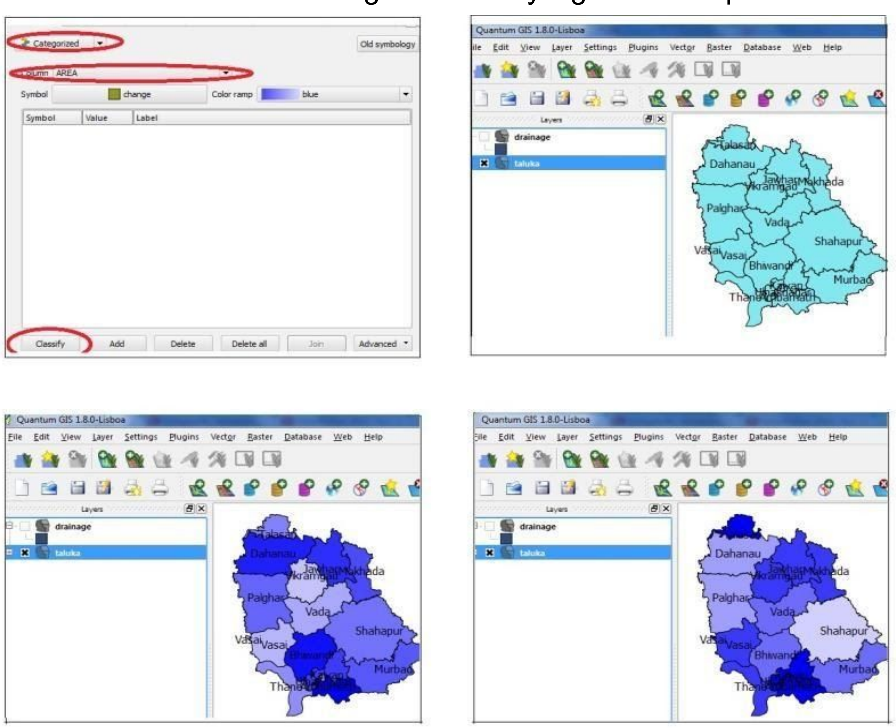


Figure 3.4. The Thane taluka layer with different renderings.

3.2.3. Labels

Labels are notations on the objects which we can visualize on the map. Labels can be chosen from one of the attributes that are associated with the object/vector polygon . For labeling the objects on a map, follow these steps:

- Check on the checkbox “Display labels”(Figure 3.5).
- Select the attribute whose value is to be given as label “Field containing label”.
- Select the font size, placement of the label.

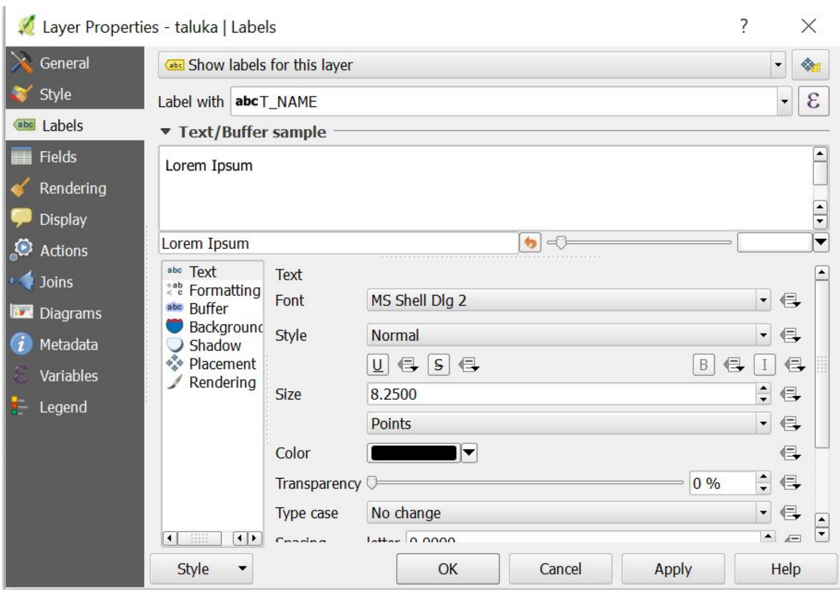


Figure 3.5 Layer Properties - Labels panel

3.2.4. Fields

- Click the “Field” tab(Figure 3.6).
- The “Field” tab displays the list of attributes associated with objects.

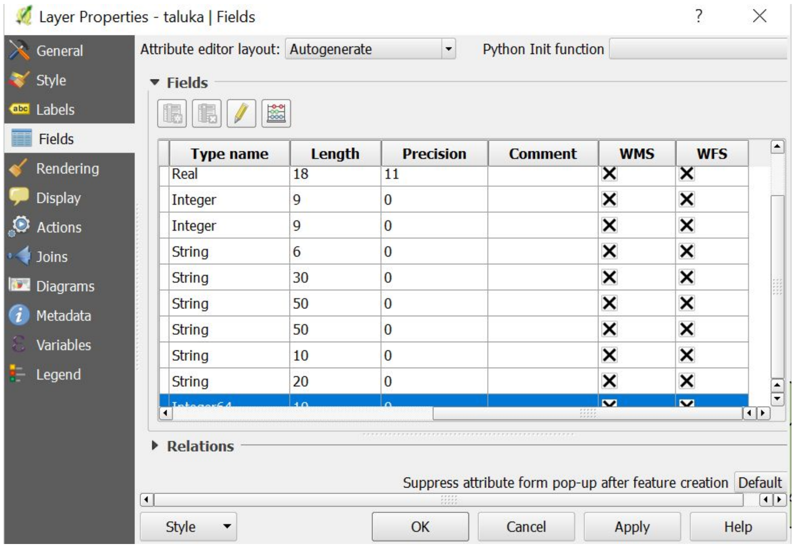


Figure 3.6 Layer Properties - Field Panel

3.3. Querying maps

A query is a question often required to be expressed in a formal way. For querying maps, SQL (sequential query language) support is required. QGIS provides querying facilities on maps, results of which are visual outputs, i.e., sub-objects on a map. The output of the query can be stored as a separate shape file to be imported as a layer. A query can be issued on attributes of the shape file/object. The geometries satisfying the conditions of attributes are returned as the map.

The general format to specify a condition is:
“FIELDNAME” “OPERATOR” “VALUE”

e.g., “Talukaname=Thane” will show all sub-object/polygons of the map/vector layer that have it Talukname attribute as Thane.

The general procedure to query a map is as follows:

- Right click on the layer.
- Click on ‘’Query.Builder.’’.
- Select the ‘’Field’’ to be used as a condition for the query. The fields displayed on the bottom tab named ‘’SQL where clause’’.
- Next, select the operator for the condition by double clicking on the ‘’Operator’’ button(Figure 3.7).
- To see what all values are associated with the select field, click ‘’ALL’’ at the bottom of the ‘’value’’ block in the Query builder Dialog box.

- Double click on the value, which gets written in the ''SQL where clause''.Now the query takes the form of expression described above.
- Click on ''OK''.The layer will show the objects satisfying condition given.
- The layer can be saved by right clicking on the layer and selecting the option ''Save''.
- The original layer can be restored choosing ''Clear'' (instead of specifying a query condition) in the query builder menu of the layer. This clears the condition and original view of the layer we restored.

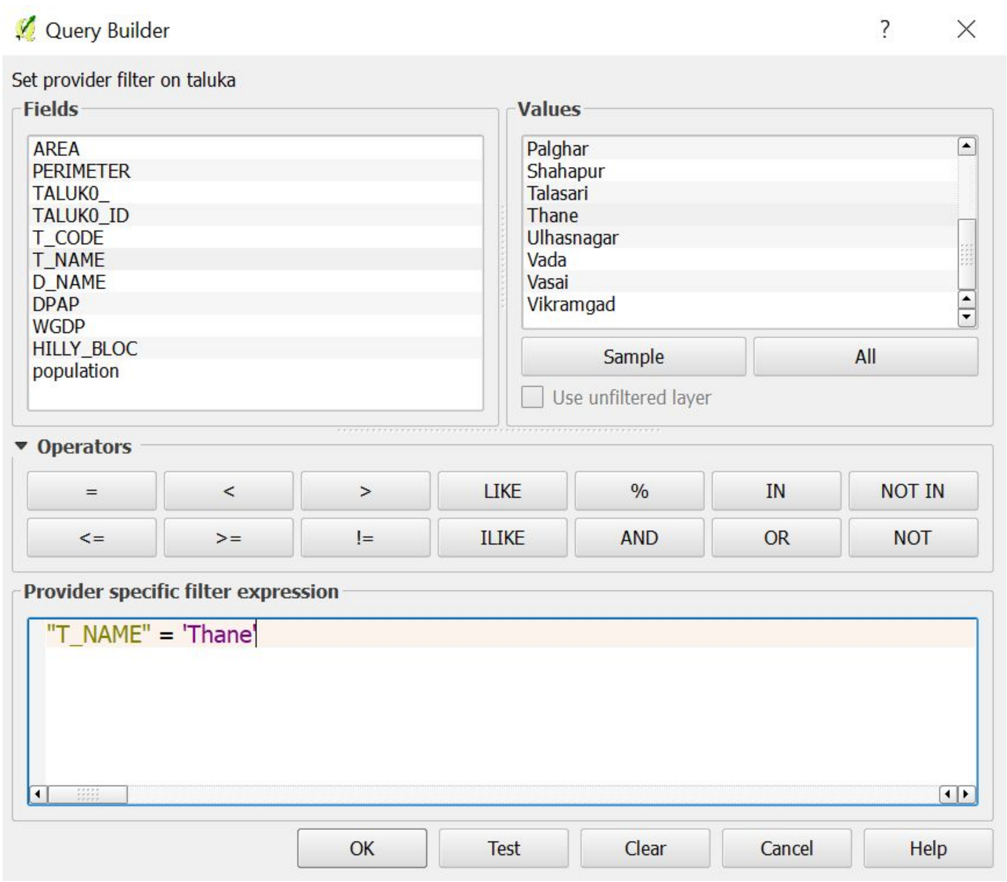


Figure 3.7. Query builder interface

Example,

Given data:

- District boundary (using the district layer).
- Tehsil Boundary - Area, perimeter, taluka ID, taluka name, District name, Hilly Block, Geom- etry (Polygon).
- Drainage - Area, perimeter, drainage polygon ID, Type (reservoir, tanks, river), area in hectors, Geometry (Polyline).

Query : Locate on map the Tehsil with name “Thane”.

- First import the above layers and arrange them such that the district layer will be the bottommost layer , the taluka layer next and and the drainage layer at the top.
- In the Query builder select the field - “T_NAME” which stands for name of tehsil.
- Select the operator “=” as the name of Tehsil is to be compared.
- Click on the “All” button in the values block to see all the values for the Tehsil field.
- Select Thane (double click).
- The “SQL where clause” should display “T_NAME = Thane”.
- Click OK.
- The Tehsil layer should display only the Thane tehsil.(Figure 3.8)
- The query result is just viewed on query execution, and not saved until the layer is saved. as a new shape file

Figure 3.8. Output of query “T_NAME”=”Thane”

- To bring back the original layer as it was, clear the query as instructed in the instructions above.

3.4. Analysis tool

- Go to ‘‘Vector’’ tab on the Menu bar and select the ‘‘Analysis Tool’’.
- Following operations can be performed,
    - Sum Line length (sums up the line length),
    - Distance Matrix (gives distance matrix between points of two different layers),
    - Points in polygon (given a polygon layer, gives number of points of another layer in it)
    - Nearer Neighbour(gives statistic of nearest neighbour)

3.5. Geo-Processing tool

Another useful tool is a geo-processing tool having operations like union, intersection, buffer.

- Go to ‘‘Vector” on the Menu bar.
- Go to ‘‘Geoprocessing tool’’.
  The functions in it do following tasks -

- Intersection (gives intersection of two layers)
    - Convex hull (creates convex hull for selected layer, for selected field)
    - Union (Gives union of two layers)
    - Buffer (buffer of specified area)
    - Dissolve (dissolve the polygons of some specified selected features)
    - Difference (Difference between two layers)
    - Clip (Clip a layer to the target layer)
    - Output is saved as a new file, for which the folder has to be browsed.

3.6. Practice Examples

3.6.1. Import and visualize the layer

- Import Layer- Drainage from the given folder.
- Import Layer- Taluka.
- View the layer panel.
- The Drainage layer is below the Taluka Layer. Thus the drainage layer is not visible as Taluka polygons are getting overlapped over it.
- Drag the drainage layer above the Taluka layer on the layer list panel. So, the layers look as shown in Figure 3.2b.

3.6.2. Style and categorize the map

- Import only the taluka layer. If other layers are imported, turn them off by checking on the check box.
- Change the colour of the Taluka Layer.
- Label Taluka layer with the Taluka name attribute.
- Change the transparency of the Taluka layer.
- Now try changing the colour in different ways.
    - Single symbol
    - Categorized - select categorize, select the field Taluka Name, click on classify(Figure 3.9a)
    - Graduated- select categorize, select the field Area, click on classify (Figure 3.9b)

Figure 3.9 Styling using (a). Categorized style ***(b) Graduated style***

3.6.3. Query to highlight talukas with population > 1 million

- Import the taluka layer and open the attributes table.
- To add a new column, first click on Toggle Editing mode symbol .
- Click on the add new field button
- Enter the name of a new column as "population" and type "integer".
- A new column named population has been added with all values initiated as NULL.
- Edit all the values by entering values from the given population dataset of the talukas.
- As an exercise, try rendering a map with the graduation of the population.(Figure 3.11)
- Query on the map for showing talukas with populations greater than 1 million and which are in hilly blocks.
- Check the attribute table (Figure 3.12)

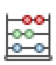
Figure 3.10. Geometry of taluka with population > 1 million

Figure 3.11. Graduated style by population

T_NAME	D_NAME	DPAP	WGDP	HILLY_BLOC	population
Jawhar	THANE		WGDP	Hilly Block	111039
Vada	THANE		WGDP	Hilly Block	142753
Shahapur	THANE		WGDP	Hilly Block	273304
Murbad	THANE		WGDP	Hilly Block	170267

Figure 3.12. Attribute table of taluka with population greater than 1 million

3.6.4. Calculate area of each taluka

- Import taluka layer
- Right click on the layer in Layer List panel and open attribute table
- Layer already contain the area field lets delete it and convert the area from m sq to km sq
- Delete the area field by clicking on toggle editing mode button 
- Click on delete field button and select area field 
- Now, open field calculator  (Figure 3.13)
- Enter Output field name
- Set Output field type to Decimal number
- Set Output field length and precision
- Go to Geometry and select $area from dropdown

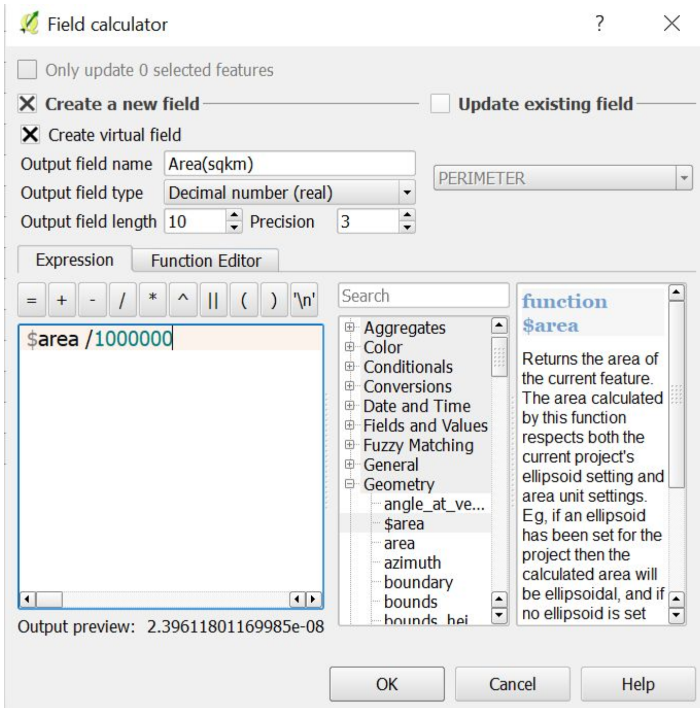


Figure 3.13. Field Calculator Interface

- Now edit the area by dividing it with 10e6 since we want the area in square kilometer since default measurement unit of area is square meter
- Now click ok, field will be added to attribute table (Figure 3.14)

	PERIMETER	TALUK0_	TALUK0_ID	T_CODE	T_NAME	D_NAME	DPAP	WGDP	HILLY_BLOC	population	Area(sqkm)
1	197099.24...	4	3	110204	Dahanau	THANE				331829	1048.333
2	193819.44...	7	5	110203	Palghar	THANE				454635	1130.216
3	16037.288...	16	13	110213	Ulhasnagar	THANE				473731	14.736
4	254027.73...	9	7	110210	Shahapur	THANE		WGDP	Hilly Block	273304	1713.636
5	133048.23...	2	1	110205	Talasari	THANE				121217	296.928
6	147300.48...	14	11	110212	Kalyan	THANE				1276614	332.366
7	123763.23...	17	15	110215	Ambarnath	THANE				366501	345.196
8	8381.6702...	12	8	110202	Vasai	THANE				273304	4.556
9	143236.82...	15	12	110201	Thane	THANE				2486941	435.137
10	169302.65...	5	2	110207	Mokhada	THANE		WGDP	Hilly Block	67319	529.521
11	122645.01...	6	4	110214	Vikramgad	THANE				114254	558.680
12	120671.49...	10	8	110202	Vasai	THANE			Hilly Sub-b...	795863	595.837
13	168195.44...	3	4	110206	Jawhar	THANE		WGDP	Hilly Block	111039	652.337
14	134991.89...	11	9	110209	Bhiwandi	THANE			Hilly Sub-b...	945582	739.712
15	172917.35...	8	6	110208	Vada	THANE		WGDP	Hilly Block	142753	831.818
16	218815.68...	13	10	110211	Murbad	THANE		WGDP	Hilly Block	170267	974.265

Figure 3.14. Area(sqkm) added as last field in attribute table

3.6.5. Find total length of road arcs(Analysis)

- Import Road Arc Layer.
- Import District Layer.
- Go to Vector in the menu bar.
- Go to the Analysis Tool from the drop down and select Sum line lengths.
- Select the district polygon layer and road arc layer in the tool, which means that the sum of lines (road arcs) in the district polygon will be stored in the output layer.
- Fill line length field name , line count field name and give a new output file name.
- Now check the attributes of the new output layer, which will give you the total length of road arcs in the district polygon(Figure 3.15).
- As an exercise, do the same with the Taluka layer and Road arc. The output will have a Taluka layer with one extra column having total length of road arc in each taluka polygon(Figure 3.16).

	AREA	PERIMETER	DISTRICT0_	DISTRICT01	D_CODE	D_NAME	DISTRICT_N	AREA_HA	length	count
1	95448173...	650774.70...	2	18	1102	Thane	Thane	954481.73...	52.86333	8301.00000

Figure 3.15. Total Road length in thane district

TALUK0_ID	T_CODE	T_NAME	D_NAME	DPAP	WGDP	HILLY_BLOC	population	Road lengt	Road count
1	110205	Talasari	THANE				121217	1.69910	225.00000
4	110206	Jawhar	THANE		WGDP	Hilly Block	111039	4.23002	540.00000
3	110204	Dahanau	THANE				331829	5.43566	803.00000
2	110207	Mokhada	THANE		WGDP	Hilly Block	67319	2.49582	336.00000
4	110214	Vikramgad	THANE				114254	3.31442	442.00000
5	110203	Palghar	THANE				454635	5.92027	916.00000
6	110208	Vada	THANE		WGDP	Hilly Block	142753	4.30910	674.00000
7	110210	Shahapur	THANE		WGDP	Hilly Block	273304	6.83849	1055.00000
8	110202	Vasai	THANE			Hilly Sub-b...	795863	3.13118	620.00000
9	110209	Bhiwandi	THANE			Hilly Sub-b...	945582	4.09737	794.00000
8	110202	Vasai	THANE				273304	0.00000	0.00000
10	110211	Murbad	THANE		WGDP	Hilly Block	170267	5.34900	886.00000
11	110212	Kalyan	THANE				1276614	2.13259	395.00000
12	110201	Thane	THANE				2486941	1.57217	313.00000
13	110213	Ulhasnagar	THANE				473731	0.06750	23.00000

Figure 3.16. Road Length of each taluka in Thane district

3.6.6. Query the taluka and find intersection with drainage

- Import drainage layer.

- Import taluka layer
- Query on taluka for Taluka name - Shahapur in taluka layer
- Consider the layer taluka consisting of only the Shahapur taluka.
- Intersect this taluka layer with drainage.
- Save the layer.

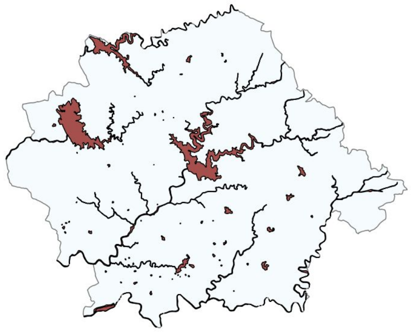


Figure 3.17. Shahapur taluka drainage

3.6.7. Create new layer by querying tanker fed villages

- Import Village layer.
- Query on the village layer and form a new layer named Tanker-fed villages. The list of tanker-fed villages is part of the data directory for this tutorial. Use tankfer-fed villages names to query the Village- layer and generate and save a new tanker-fed villages layer(Figure 3.18).
- Check attribute table of the filtered layer(Figure 3.19)

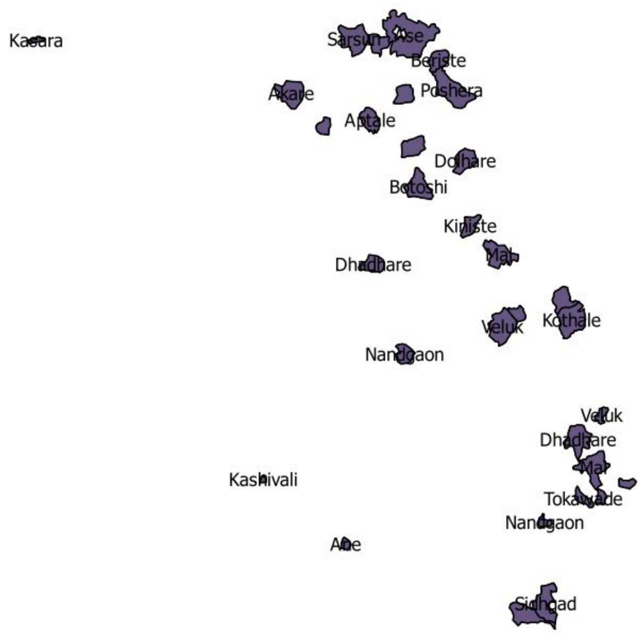


Figure 3.18. Tanker-fed villages

Tanker-fed villages :: Features total: 32, filtered: 32, selected: 0

	AREA	PERIMETER	VILLAGE_	VILLAGE_ID	SCODE	LOCATION	V_TYPE	T_NAME	D_NAME	orig_ogc_f
4	7728107.5...	13275.827...	137	177	110206040	Hateri	Village	JAWHAR	THANE	135
5	8396589.1...	12268.317...	170	18	110207037	Beriste	Village	MOKHADA	THANE	168
6	20948305....	23262.640...	199	68	110207042	Poshera	Village	MOKHADA	THANE	197
7	14442240....	16561.435...	226	145	110207018	Akare	Village	MOKHADA	THANE	224
8	7725365.7...	11788.122...	238	149	110206049	Nyahale Bk.	Village	JAWHAR	THANE	236
9	8870525.9...	13485.043...	287	153	110206060	Aptale	Village	JAWHAR	THANE	285
10	4671377.3...	8874.2805...	304	90	110206020	Kasatwadi	Village	JAWHAR	THANE	302
11	9700185.7...	12877.298...	354	157	110206067	Nandgaon	Village	JAWHAR	THANE	352
12	10129454....	13550.901...	381	88	110207055	Dolhare	Village	MOKHADA	THANE	379
13	13126254....	16331.361...	422	4	110207060	Botoshi	Village	MOKHADA	THANE	420
14	6509400.1...	11757.214...	543	102	110207074	Kiniste	Village	MOKHADA	THANE	541
15	14106356....	19821.655...	613	533	110210053	Mal	Village	SHAHAPUR	THANE	611
16	7938547.0...	11799.942...	645	324	110208133	Dhadhare	Village	VADA	THANE	643
17	9594791.8...	15478.836...	732	663	110210078	Fugale	Village	SHAHAPUR	THANE	730
18	17865349....	20252.308...	766	667	110210085	Kothale	Village	SHAHAPUR	THANE	764
19	4598065.5...	9179.7546...	772	568	110210080	Vashala Kh	Village	SHAHAPUR	THANE	770
20	17905778....	18061.557...	780	567	110210074	Veluk	Village	SHAHAPUR	THANE	778

Figure 3.19. Attribute table for filtered 32 tenker fed villages

3.6.8. Dissolve the village layer to taluka layer

- Dissolve the villages with the same taluka name in the new tanker-fed layer villages, and form a new layer from it(Figure 3.20).
  The dissolve feature combines polygon boundaries of polygons which meet a certain common cri- teria, e.g., same taluka name. In the above operation, "'dissolve" will plot all villages with the same taluka name with the same colour /style and append all taluka attributes/fields to the village attributes list(Figure 3.21).

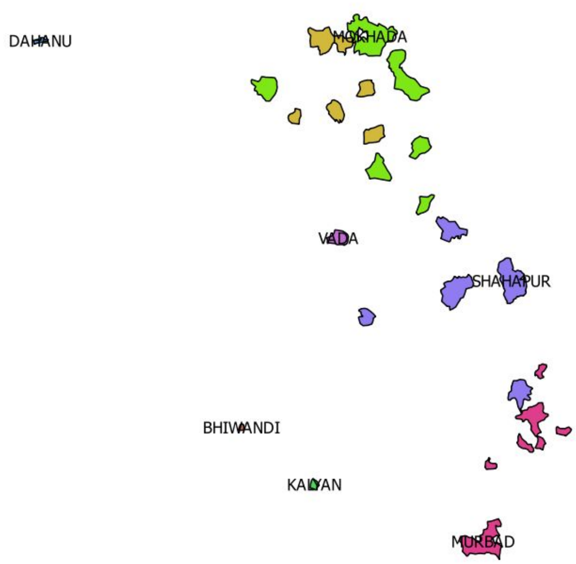
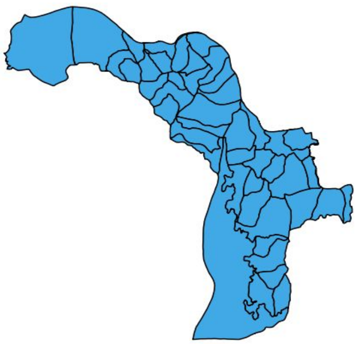


Figure 3.20. Tanker fed village dissolved by taluka name

	AREA	PERIMETER	VILLAGE_	VILLAGE_ID	SCODE	LOCATION	V_TYPE	T_NAME	D_NAME	orig_ogc_f
1	2277037.8...	6077.95119	1535	76	110212043	Ane	Village	KALYAN	THANE	1533
2	7938547.0...	11799.942...	645	324	110208133	Dhadhare	Village	VADA	THANE	643
3	16196740....	18111.514...	116	792	110206037	Sarsun	Village	JAWHAR	THANE	114
4	3256292.7...	8845.83044	1076	1053	110211103	Veluk	Village	MURBAD	THANE	1074
5	936818.18...	4015.93119	1310	459	110209124	Kashivali	Village	BHIWANDI	THANE	1308
6	39360376....	43942.493...	93	52	110207030	Ase	Village	MOKHADA	THANE	91
7	1631769.1...	7833.78754	124	1508	110204020	Kasara	Village	DAHANU	THANE	122
8	14106356....	19821.655...	613	533	110210053	Mal	Village	SHAHAPUR	THANE	611

Figure 3.21.Attribute table for dissolved 8 taluka for tanker fed villages

3.6.9. Find watershed of a Taluka



- Import the watershed layer.
- Choose any one taluka and intersect the watershed layer with that taluka.
- Output view should show watersheds of selected taluka and none for other talukas(Figure 3.22).

Figure 3.22 Watershed of taluka Thane

3.6.10. Locate talukas Thane, Murbad, Mokhada.

The SQL where clause is:

- T_NAME = Thane OR T_NAME = Murbad OR T_NAME = Mokhada

3.6.11. Locate talukas which are in District Thane and are in “Hilly Sub-Block”.

The SQL where clause is:

- DNAME = THANE AND HILLYBLOC = Hilly Sub-block

The result should display the Vasai and Bhiwandi talukas.

3.7. Importing other file formats

QGIS can import files in formats like kml, smw, image(raster), postGIS database etc. While importing a vector file, the file format option can be selected for any vector file, (from bot- tom of the import tab) before browsing the file. The following is an example importing a kml file—making a kml file in Google Earth and importing the kml file in QGIS.

Follow the steps below in Google Earth

- Search Tansa Lake,Thane, Maharashtra.
- Draw polygon with the drawing tool around the lake.
- Save the file by right clicking the kml file.

Follow the steps below in QGIS

- Go to add the vector file and select the file format kml before browsing the file.
- Import the file.
- Import the thane taluka file, which is given in the data folder as well.
- See that the kml file overlaps on the Shahapur taluka.

4. Working with Raster data

A raster is a regular grid made up of cells, or in the case of imagery, pixels. They have a fixed number of rows and columns. Each cell has a numeric value and has a certain geographic size. Multiple overlapping rasters are used to represent images using more than one colour value. Satellite imagery also represents data in multiple bands. Each band is essentially a separate, spatially overlapping raster, where each band holds values of certain wavelengths of light.
The most easily recognized form of raster data is digital satellite imagery or aerial photos. Elevation shading or digital elevation models are also typically represented as raster data.
Each pixel colour specifies the property associated with that pixel, for example, in a gray scale raster image of Digital Elevation Model (DEM), darker the pixel colour more is the elevation. Example of Shahapur DEM is displayed below.

4.1. Getting Digital Elevation Model from Bhuvan

- Go to the Bhuvan website (http://bhuvan.nrsc.gov.in/bhuvan_links.php) and register as new user to get your login details.
- Click on the open data archive https://bhuvan-app3.nrsc.gov.in/data/download/index.php
- Select the sub-category as Cartosat-1 and the product as CartoDEM Version-1.
- Select area as Mapsheet and enter Toposheet number as E43B to download the Shahapur DEM. See Figure 4.1
- Click on Download to get the DEM file.

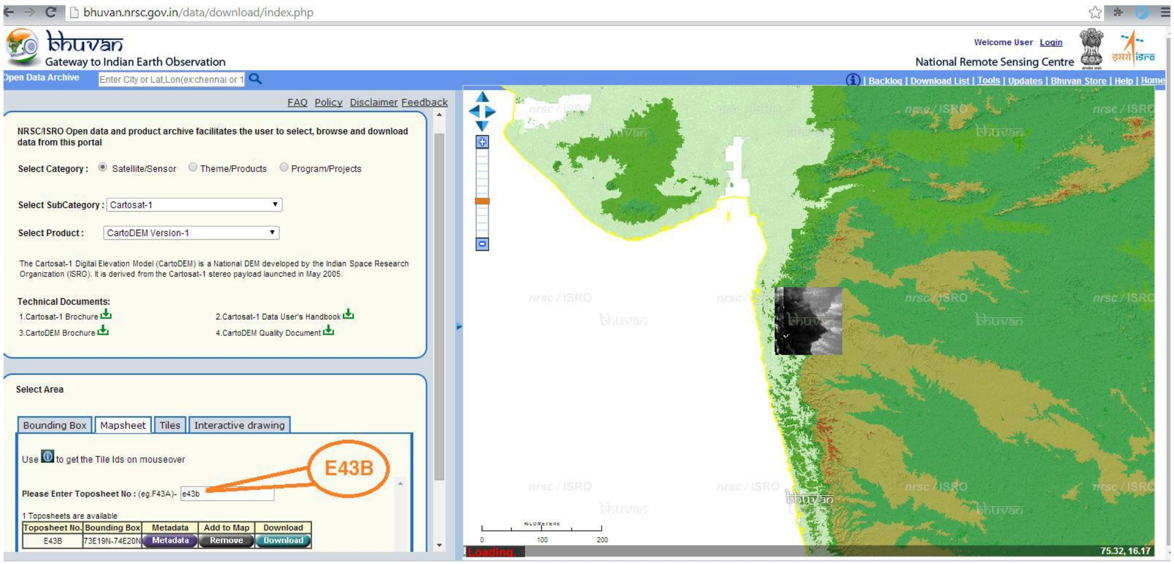


Figure 4.1. Downloading DEM from Bhuvan website[4.1]

4.2. Opening raster file in QGIS

- Create a new project in QGIS. Then open the DEM into the project by selecting ‘Add Raster Layer’ from Layer menu.See Figure 4.2

Figure 4.2. Add Raster Layer

- Browse for the downloaded DEM file (<name>.tiff) and open it. See Figure 4.3

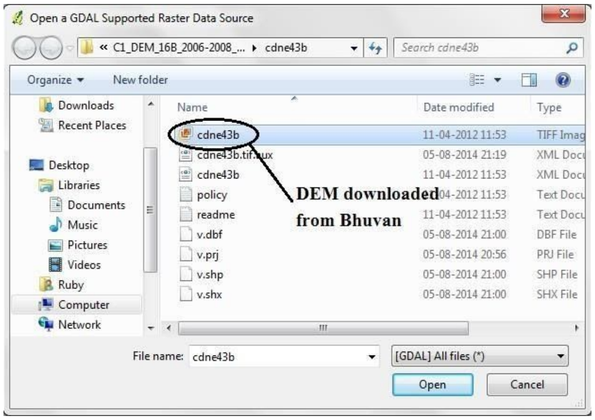


Figure 4.3. Opening Raster File

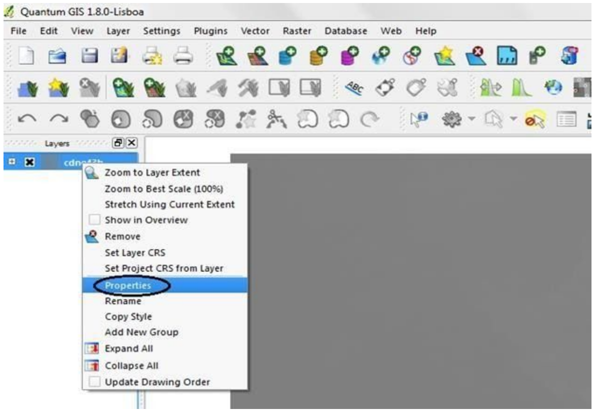
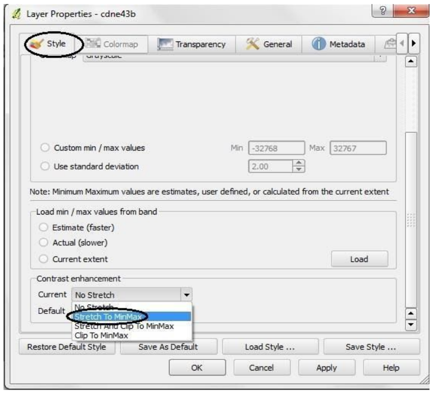


Figure 4.4. Raster properties

- Perform the following steps to display the DEM raster in proper format.
  Refer to Figure 4.4 - 4.6 for reference



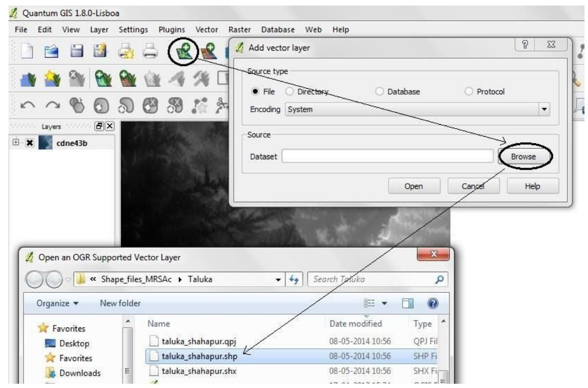


Figure 4.5. Style : Stretch to MinMax

Figure 4.6. Add vector layer

The DEM raster (E43B in this case i.e. Tile covering most of the Thane district) will be displayed as follows:

4.3. Overlaying vector on raster layer

The boundaries of DEM file are assigned as per the tile boundaries. But most of the time our study area is defined according to administrative boundaries like villages / block / state etc. In this case we can put an overlay vector layer (shapefile) over the raster layer (DEM) and concentrate only on the overlaid part of the raster.

- Click on “Add Vector Layer” menu item and browse the shape files (*.shp) – Shahapur block shape file in this case (Figure 4.7).

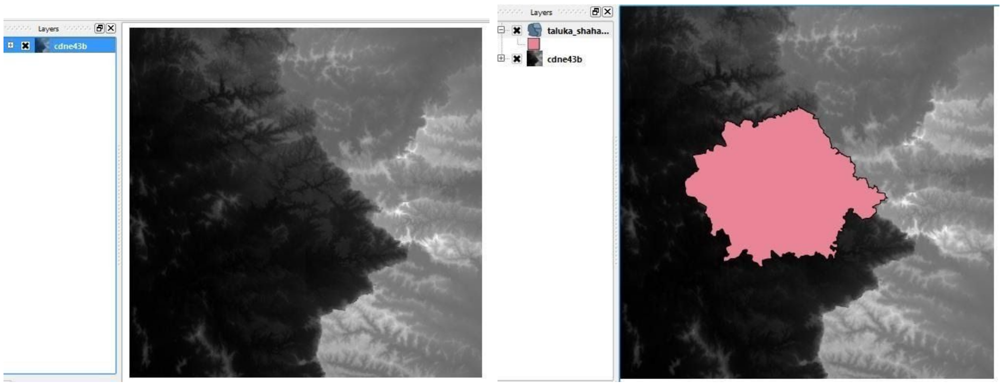


Figure 4.7. Overlaying vector layer on Raster

4.4. Extraction

4.4.1. Clipper

- Now we will use the clipper functionality to cut the DEM for Shahapur block. Click on the Raster ‣ Extraction ‣ Clipper menu item (Figure 4.8)
- In the clipper dialogue, select “Mask Layer” under “Clipping Mode” and choose the shape file around which we want to clip the DEM (Shahapur shapefile in this case)(Figure 4.9 and 4.11)

Figure 4.8. Raster Clipper

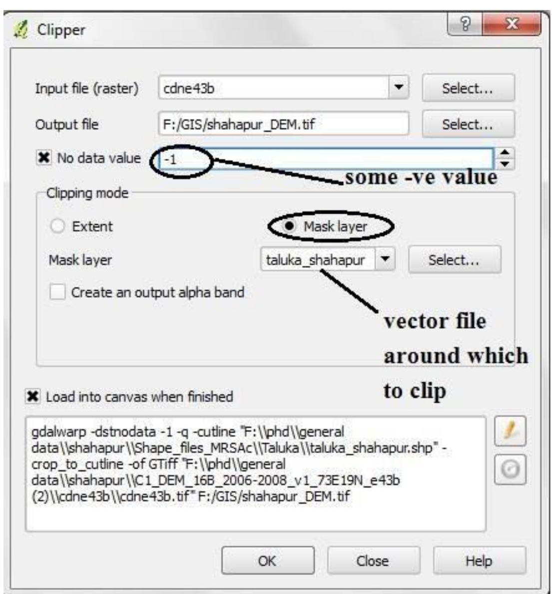


Figure 4.9. Selecting Mask Layer

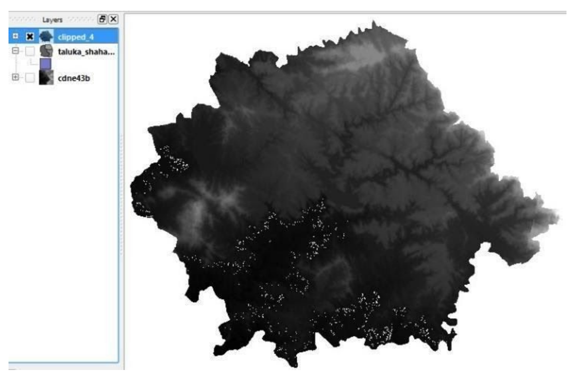


Figure 4.10. Clipped Raster Layer

- You can also clip the DEM by manually choosing a region from the original DEM. For doing so select “Extent” under “Clipping Mode” in Clipper dialogue. Drag the mouse to select the latitude- longitude range(Figure 4.11)

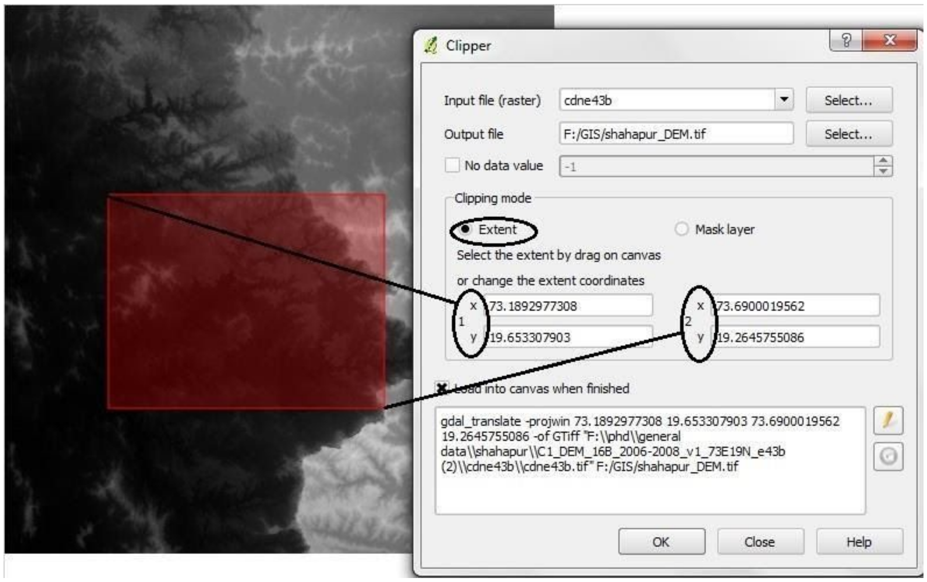
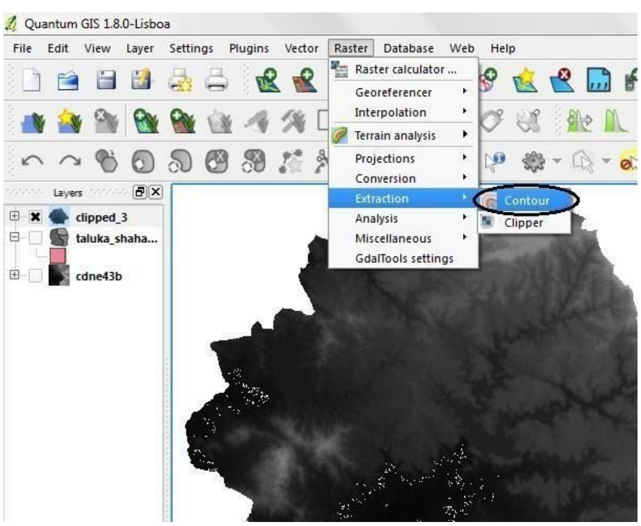


Figure 4.11. Choosing Extent

4.4.2. Contour

- Choose Raster ‣ Extraction ‣ Contour menu item(Figure 4.12)
- Select the input raster DEM, enter the name of output contour file, enter the output contour interval (in meters), enter the name of the elevation attribute in the output file in the contour dialogue(Figure 4.13)



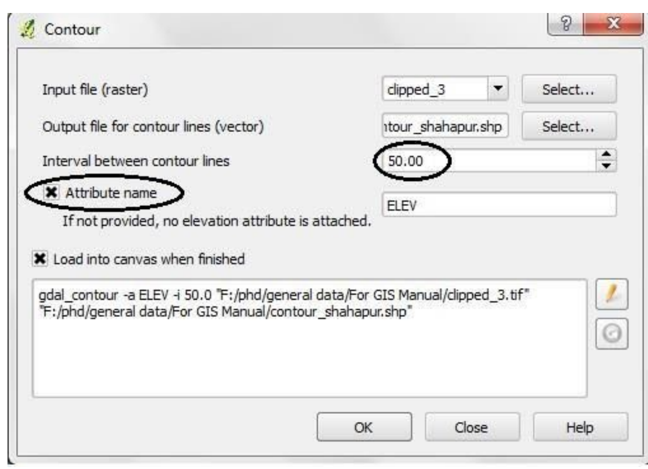


Figure 4.13. Contour interface

Figure 4.12. Raster Extraction

- As seen in the example, input raster is selected as the clipped Shahapur DEM and a 50m contour interval is chosen. The contours are displayed as in Figure 4.14:

- The generated contour file is a vector (shape) file made up of polylines(Figure 4.15). Each polyline (i.e. contour) has two attributes, ID and ELEV (the name of the elevation attribute). These details can be seen by opening the AttributeTable.(Figure 4.16)

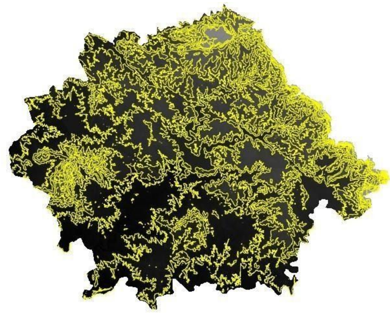


Figure 4.14. Shahapur taluka contour shapefile

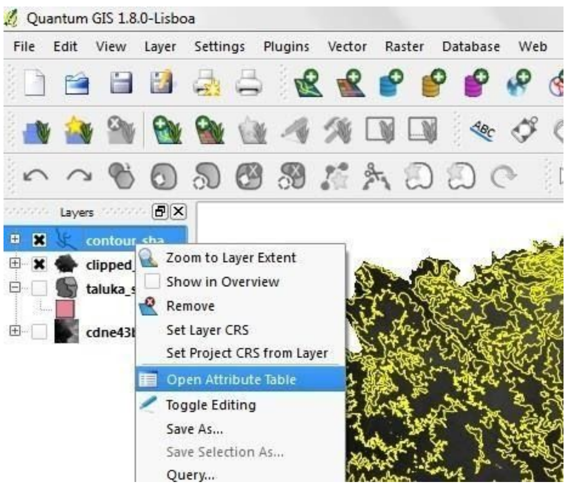


Figure 4.15. Opening Attribute table

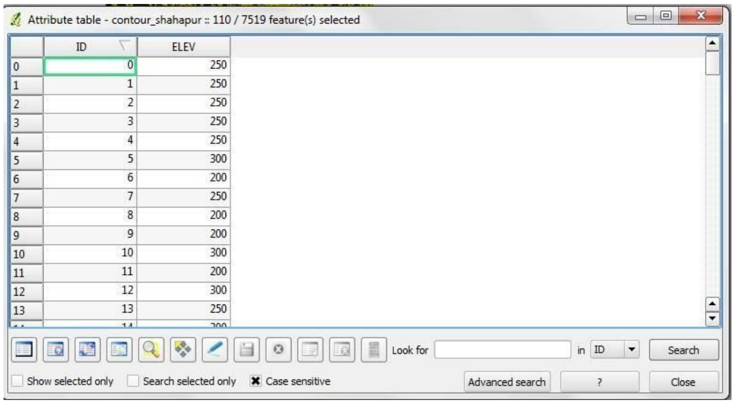


Figure 4.16. Attribute table with elevation

- We can also use “Query” tool to select and filter specific contours e.g. to see the region in the DEM where the elevation is less than 100m(Figure 4.17a). Follow the following steps and compare the output (Figure 4.17b)

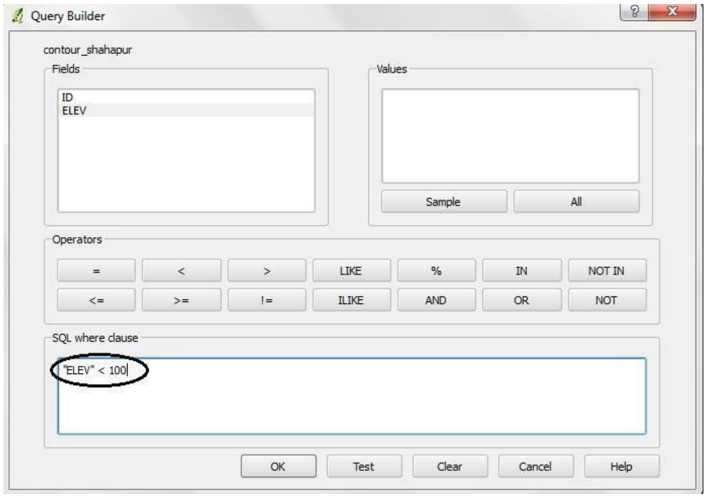
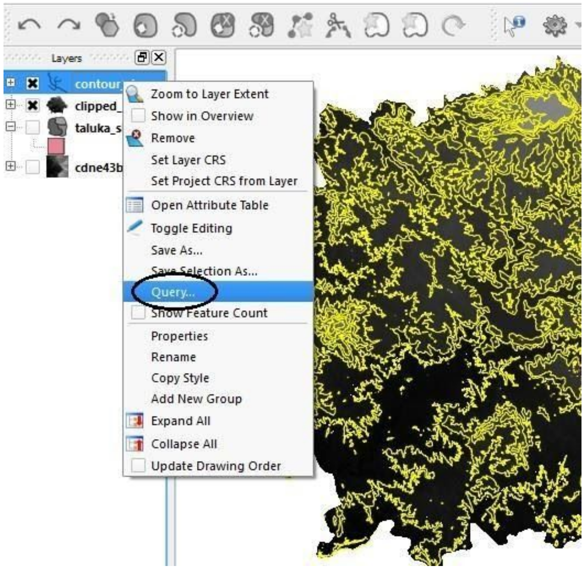


Figure 4.17. (a) Filtering contour



4.5. Analysis

4.5.1. Hillshade

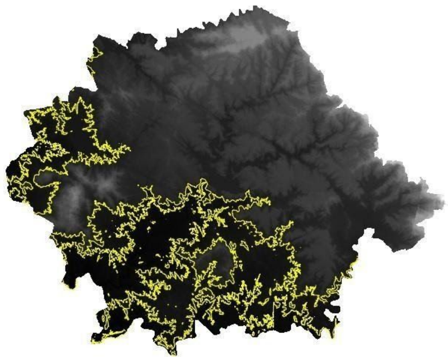


Figure 4.17. (b) Filtered contour

- To create a hillshade map from the raster. Select Raster ‣ Analysis ‣ DEM (Terrain Models).
- In the DEM (Terrain Models) dialog, choose shahapur_DEM_Clipped as the Input file. Name the Output file as Shahapur_hillshade.tif. Choose Hillshade as the Mode. Leave all other options as it is. Make sure the Load into canvas when finished option is checked, and click OK.
- Once the process finishes, you will see yet another raster loaded into QGIS canvas.
- Since you may be zoomed-in near the Shahapur contour, right click on the Shahapur_hillshade layer and choose Zoom to Layer Extent. Now you will see the full extent of the hillshade raster.(Figure 4.18)

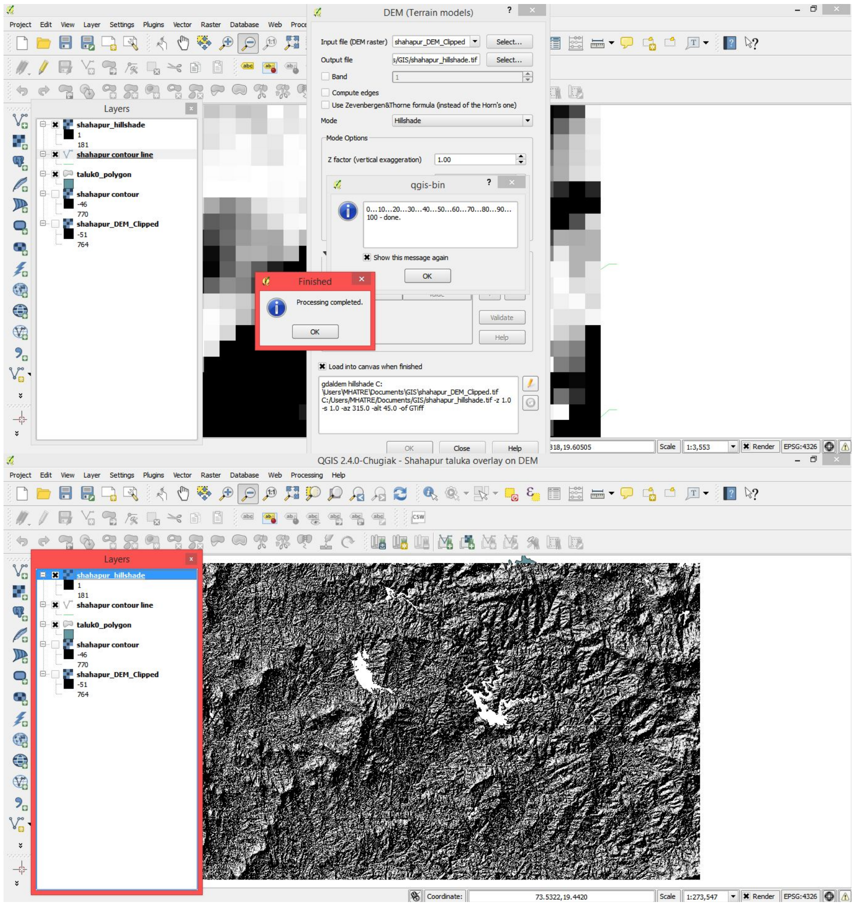


Figure 4.18. Hillshade Map

4.6. Practice Examples

4.6.1. Import the DEM and Style according to Single Band pseudocolor

- Download the DEM.tif file from given dataset
- Import the raster DEM
- Open the Layer Properties dialog for the DEM layer by right-clicking on the layer in the Layer tree and selecting Properties option.
- Switch to the Style tab.
- Change the Render type to Single Band pseudocolor , and use the default options presented.
- Click the Classify button to generate a new colour classification, and click OK to apply this classification to the DEM (Figure 4.19).

4.6.2. Clip the Mokhada DEM

- Load the Mokhada vector shapefile
- Click on Raster ‣ extraction ‣ clipper in the menu bar.
- Select the DEM raster Image and enable No data value to -1
- Change clipping mode to Raster and select “Mokhada village boundary” as mask Layer, and click OK (Figure 4.20)

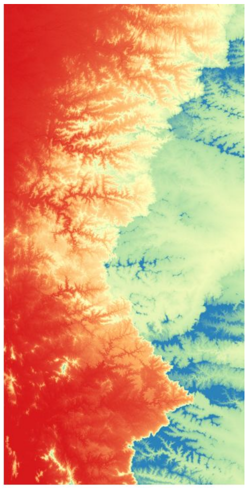


Figure 4.19. DEM rendered in single band pseudocolor

Figure 4.20.Clipped Mokhada DEM

Figure 4.21. Mokhada Hillshade

4.6.3. Calculate Hillshade

- Click on the menu item Raster ‣ Analysis ‣ DEM (Terrain models).
- In the dialog that appears, ensure that the Input file is the Mokhada_DEM layer.
- Set the Output file to Mokhada_hillshade.tif
- Also make sure that the Mode option has Hillshade selected.
- Check the box next to Load into canvas when finished.
- You may leave all the other options unchanged.
- Click OK to generate the hillshade(Figure 4.21).
- When it tells you that processing is completed, click OK on the message to get rid of it.
- Click Close on the main DEM (Terrain models) dialog.

4.6.4. Calculate the Slope

To do this, you need to use the Slope mode of the DEM (Terrain models) tool.

- Click on the menu item Raster ‣ Analysis ‣ DEM (Terrain models).
- Select the Mode option Slope
- Set the save location to exercise_data/residential_development/slope.tif
- Enable the Load into canvas... checkbox.
- Click OK and close the dialogs when processing is complete, and click Close to close the dialog. You'll see a new raster loaded into your map.
- Enable the Raster tool you'll need by enabling View ‣ Toolbars ‣ Raster in the menu bar.
- With the new raster selected in the Layers list, click the Stretch Histogram to Full Dataset button on the Raster tool. Now you'll see the slope of the terrain, with black pixels being flat terrain and white pixels, steep terrain(Figure 4.22)

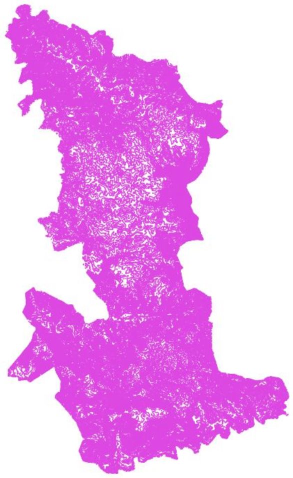
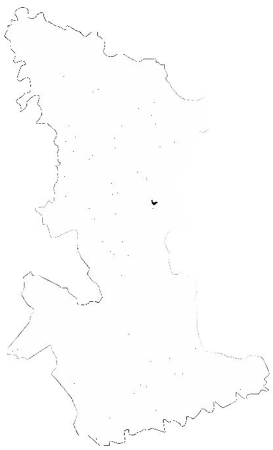


Figure 4.22. Mokhada Slope Figure



4.23. Mokhada Contours

4.6.5. Generate contours

- Click on Raster ‣ extraction ‣ contour
- Select the Mokhada_DEM as input raster Image
- Set the output file to mokhada_output
- Enable the Attribute Name checkbox to add elevations in attribute table
- Enable the Load into canvas... checkbox.
- Click OK and close the dialogs when processing is complete, and click Close to close the dialog. You'll see a new vector contour loaded into your map(Figure 4.23).
- Apply the graduated style on elevation attribute(Figure 4.24)

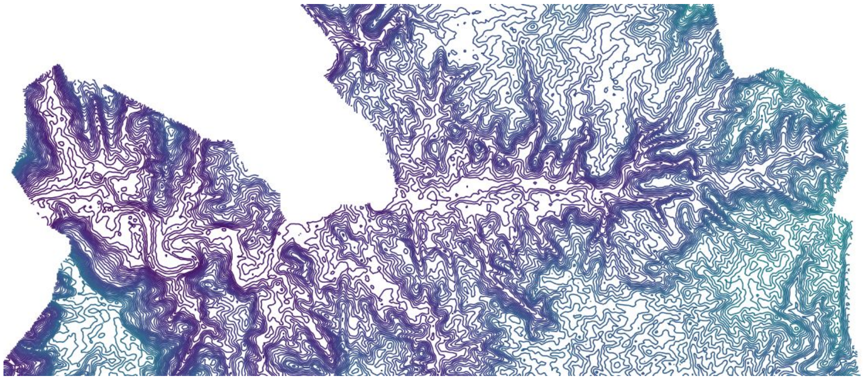


Figure 4.24. Styled and zoomed Mokhada Contours

5. Make QGIS More powerful

5.1. Plugins

Plugins allow you to extend the functionality QGIS offers

5.1.1. Enabling/installing plugin

- Click on the menu item Plugins ‣ Manage and Install Plugins.
- You can check the installed or not installed plugins in opened dialog box
- Now search for QuickMapService plugin and find information about the plugin by selecting it in the list
- Install the one(s) you are interested in by clicking the Install Plugin button below the plugin information panel.
- Installing External Plugin
- Once plugin is installed it will be available in menu bar

5.1.2. Enabling Custom Plugin

- If you don't find any plugin matching your requirement you can create it using python language.Making the plugin is out of scope of this text thus we will see how we can enable the plugin that is available.
- Kharif Model Multicrop plugin is created by IIT for generating kharif season vulnerability maps under the POCRA project. Plugin is provided along with the tutorial
- Download and unzip the “kharif_model_multicrop” plugin
- Copy and paste the plugin in QGIS directory e.g,
    - C:\Program Files\QGIS 2.18\apps\qgis-ltr\python\plugins
- Now Open Qgis,click on the menu item Plugins ‣ Manage and Install Plugins.
- Click on installed and select “kharif_model_multicrop” from the list(Figure 5.1)

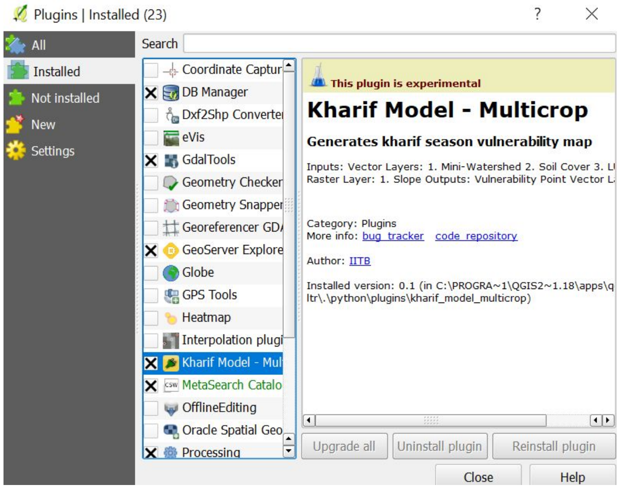


Figure 5.1. Kharif Model - Multicrop

5.2. GRASS Modules

5.2.1. What is GRASS?

QGIS can also be used as a graphical interface to GRASS GIS, which is a powerful but not a user friendly GIS application. As a free software application under the GNU GPL, the source code of QGIS can be freely modified to perform different or more specialized tasks. QGIS uses python modules/plugins to perform the GRASS operations in its interface.

The GRASS plugin provides access to GRASS GIS databases and functionalities. This includes visualization of GRASS raster and vector layers, digitizing vector layers, editing vector attributes, creating new vector layers and analyzing GRASS 2D and 3D data with more than 300 GRASS modules. Few of the grass modules and their functionalities are listed in table as below:

S. No	Module	Functionality
1	r.in.gdal.qgis	Import the raster from WGIS.
2	r.watershed	Converts DEM into stream and catchment raster.
3	r.contour	Creates contour from elevation raster.
4	r.to.vect.area	Converts raster into area vector.
5	v.voronai.area	Creates Theissen polygons from precipitation raster.
6	v.drape	Creates 3D vector from 2D vector by sampling raster.
7	r.mask	Creates a mask for limiting raster operation.
8	r.out.gdal.tiff	Export GRASS raster into Geotiff format

Table 5.1. GRASS Module Functionality

5.2.2. Setting up Interface

- Enable the GRASS plugin from plugins (main tool bar) ‣ Manage plugins.
- Click on ‘New mapset’  icon from the GRASS toolbar.
- Give the database folder name and click next.
- Give ‘Create new location’ name and click next.
- Give a projection as WGS1984 or the projection of raster file you are going to process.
- Give Default GRASS region as India or your study region.
- Give the name of the mapset and click next.(Figure 5.2)

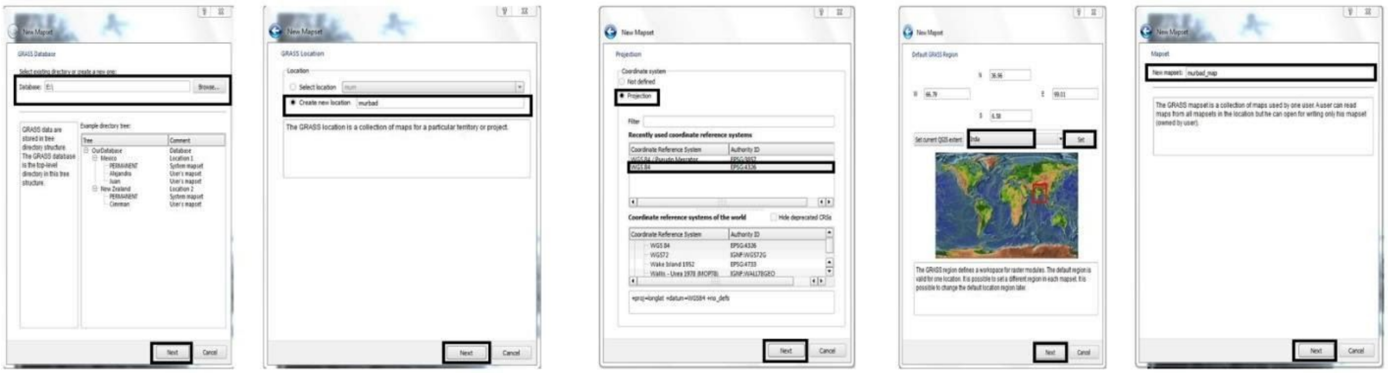


Figure 5.2. Setting up interface

5.2.3. Importing DEM raster

- Click on ‘Open Grass Tools’  icon and Go to Module Tree ‣ File Management ‣ Import into GRASS ‣ Import Raster in GRASS ‣ Import raster in GRASS from QGIS view ‣ r.in.gdal.qgis.
- Module r.in.gdal.qgis opens and go to options ‣ Select a layer(Usually the DEM file is listed in the list) ‣ Give file name for output map ‣ Click ’Run’ ‣ Click ’View output’ The DEM file will be loaded in canvas(Figure 5.3)

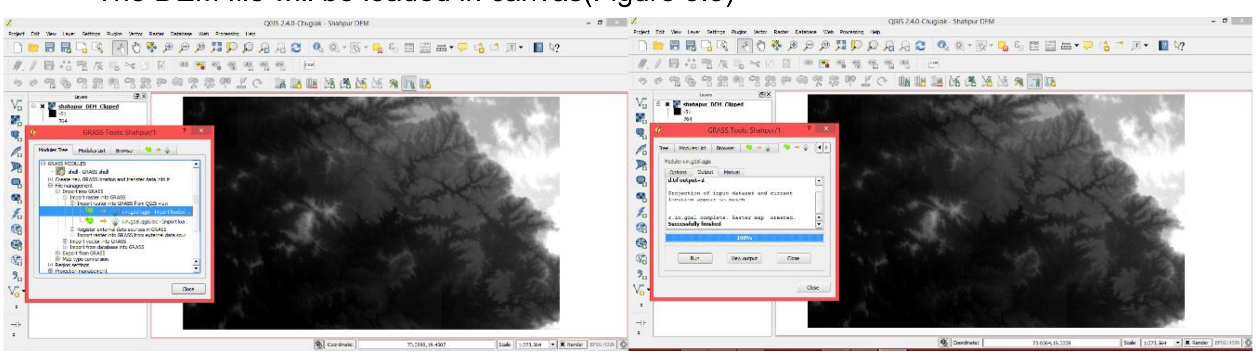


Figure 5.3. Importing DEM Raster

5.2.4. Generate contour map through GRASS

- Obtain a contour map by using the GRASS module ‘create vector contour from raster at specified steps’ (‘r.contour’).
- Click on the raster toolbar and choose the extraction menu and pick contour
- Specify the steps interval to be 15.
- Save the loaded map as shapefile with CRS WGS-84.

Thus, a contour map for the DEM will be obtained as in Figure 5.4

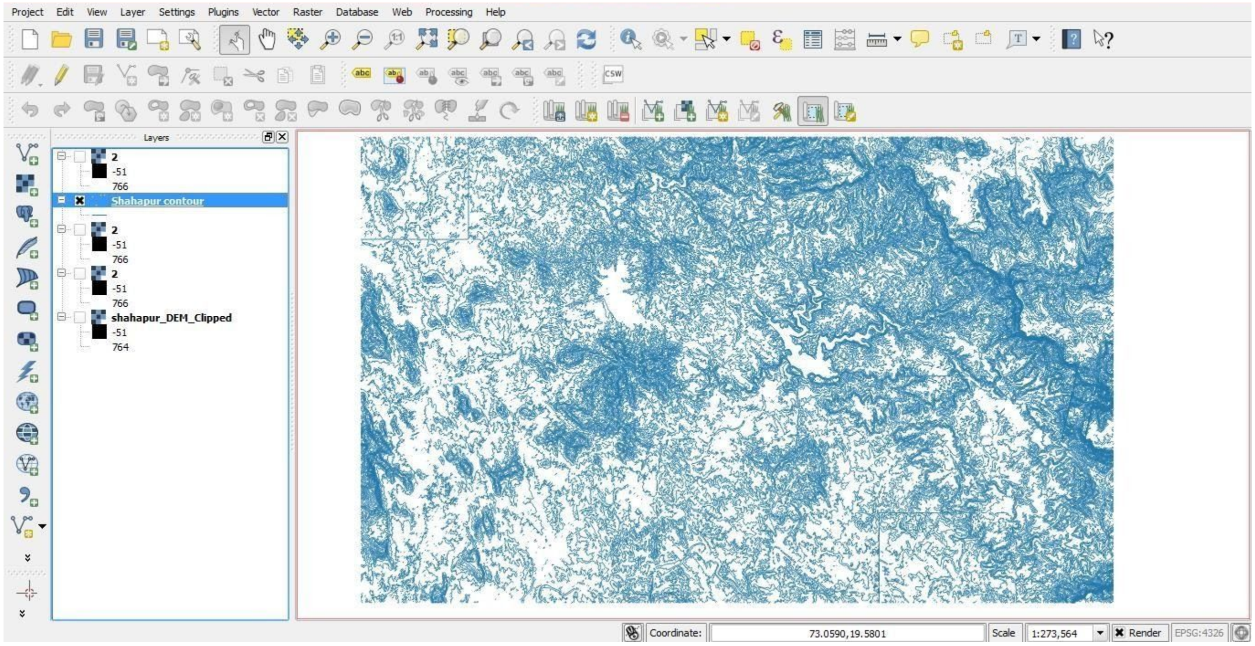


Figure 5.4. Contour Map

5.2.5. Extracting region setting from DEM

- Go to ‘Open GRASS tools’ ‣ Module Tree ‣ Shell which will open a terminal.
- Give command g.region rast=file name of DEM in GRASS
- If nothing happens the file is processed and then closes the terminal.

  Note: You will see a red border to the GRASS raster image. It represents the GRASS region for processing

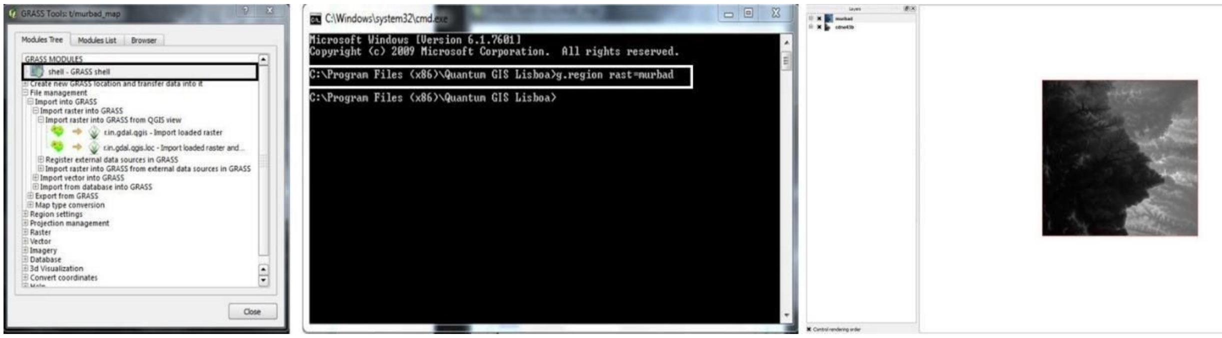


Figure 5.5. Extracting region

5.2.6. Creating watershed and stream into raster

- Go to 'GRASS tools' ‣ Module tree ‣ Raster ‣ Spatial Models ‣ Hydrologic Modelling ‣ r.watershed. The r.watershed module opens.
- Select the DEM from the list and give the file names.:
- Give size of 1000000 for boundary creation in the option 'Minimum size for each basin'.
- Give file names for raster maps. Preferred names are fdrain for the first map that gives the drainage flow. Use for second map which gives the drainage direction. Use stream for the third map which gives the stream segments. Use catch for the fourth map which gives the raster map.
- Click 'Run' and then give 'View Output'(Figure 5.6).

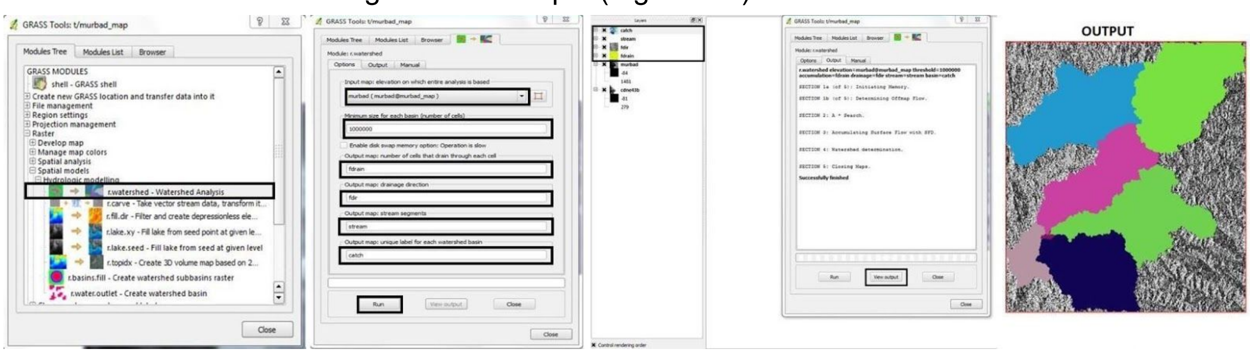


Figure 5.6. Creating watershed

5.2.7. Raster to vector conversion

- Go to 'Open Grass tools' ‣ Module list ‣ Type raster to vector ‣ r.to.vect.area.
- The module r.to.vect.area opens. Go to Options ‣ Select catch raster ‣ Run ‣ View output.
- For stream vector, follow steps 1 for conversion of raster to vector. Use r.to.vect.line module and stream raster.
  Hint: Once view output is given the vector gets loaded, change colour s appropriately.

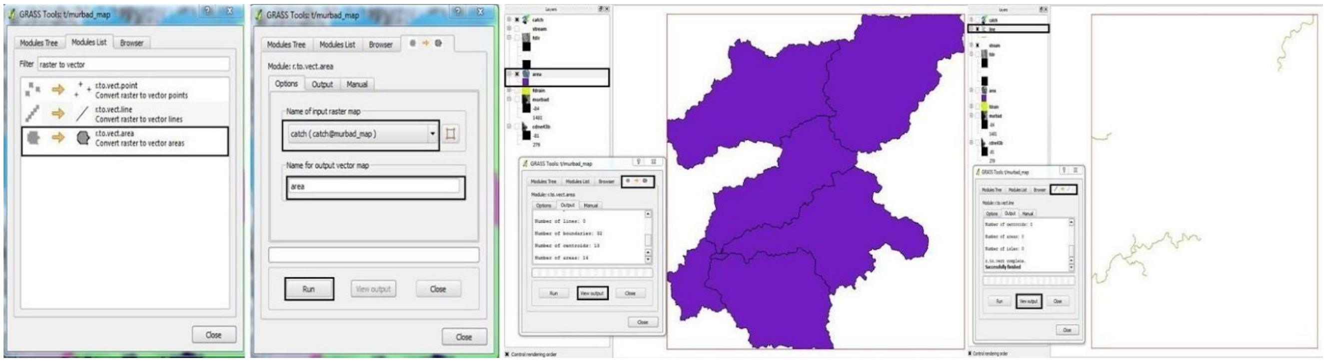


Figure 5.7. Raster to vector conversion

5.2.8. Saving watershed and stream vectors

- In layers toolbar ‣ Right click catchment vector ‣ Click ‘Save as’ (give filename and Folder and save in the folder of work).
- Follow the above step for the stream vector.

The output will be similar to Figure 5.8

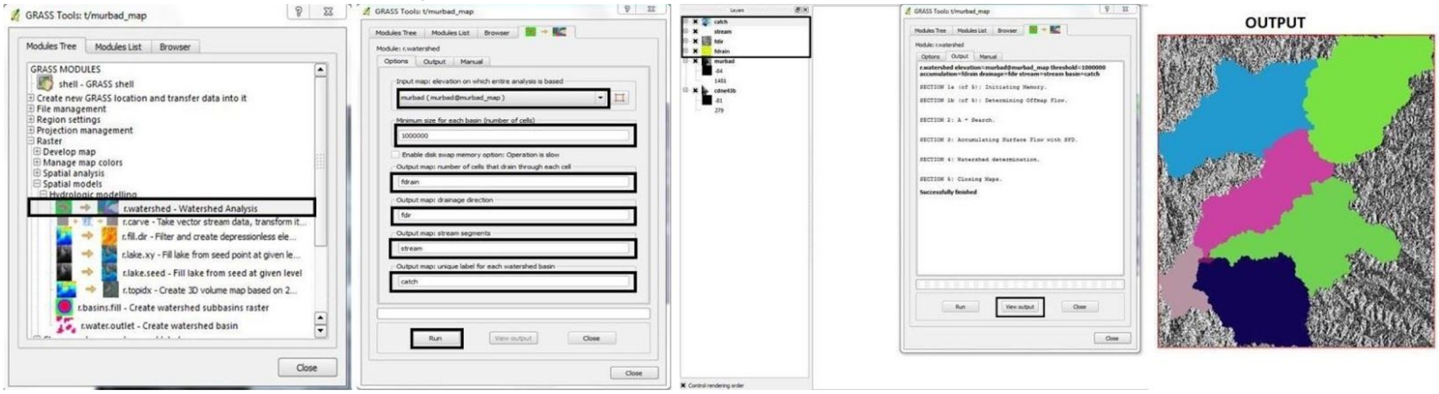


Figure 5.8. Saving watershed

6. Exercises

6.1. Vector Exercises

6.1.1. Analysis of the village level census data

Download the village level census shapefile of Nashik district from the given dataset and check the section 10.5 of appendix for description of fields in the attribute table.

Perform the following operation to analyse the demographic data.

- Add labels containing taluka names with total population.
- Calculate and add following fields
    - Sex ratio for total population
    - Sex ratio for population between 0-6 years
    - Literacy rate of total population
    - Literacy rate of men and women

Sex ratio = Number of male/number of female * 100
Literacy rate = total literate population/ total population * 100

- Style the layer using for categories with graduated style and compare
    - Sex ratio
    - SC/ST population for male and female
    - Male and female literacy
- Average sex ratio of india is **108.176** and literacy rate is **74.04%**. Query the villages that are above the national average.

Analyse the source of drinking water (e.g., Tap; Hand pump; Tube well; Well; Tank; Pond River; canal; Spring; Other) and its location.

- Use graduated style to differentiate the percent of
    - tap water from treated source or untreated source.
    - Drinking water from covered or uncovered well
- Find the villages above 70% using natural sources for drinking water like water spring, river pond lake
- Find the villages with sufficient drinking water availability by applying following conditions
    - Drinking water within premise > 70%
    - Drinking water near premise > 80%

    - Drinking water source away < 40%

Analyse the source of lighting (e.g., Electricity; kerosene; Solar energy; Other oil, Any other; No lighting)

- Style the layer to differentiate villages having electricity.
- Find the village having main source of lighting as electricity > 70%
- Find the villages where at least 30% of households are using solar energy for lighting.
- Find the average percentage of households in a village using kerosene as the main source of lighting using the field calculator and style the layer to show villages above the average value.

Analyse the access to sanitation facilities like availability of bathroom, type of latrine and type of drainage for waste water

- Find village having toilet within premise greater that 40% with pipe connected to sewer system > 20%
- Find the condition of pit latrines by applying graduated style on ventilated and open pit
- Find the villages with no latrine within premise using following conditions
    - Public latrine > 50%
    - In open > 30%
- Find the villages having bathroom facilities at least 30% within premise and not connected to closed drainage less than 40%

Analyse the availability of separate kitchen and type of fuel used for cooking (e.g., Firewood; Crop residue; Cow dung cake; Coal, Lignite, Charcoal; kerosene; LPG; Electricity; Biogas; Other)

- Visualize the type of fuel used for cooking in different villages over map using graduated style and find the most used fuel among the following.
    - Wood
    - Crop residue
    - Dung Cake
    - Coal Ignite Charcoal
    - Kerosene
    - LPG
    - Electricity
    - Biogas
- Find the village having Kitchen facility at least 50% and inside house

Analyse the availability of banking services and the specified assets (e.g., Radio, Transistor; Television; Bicycle; Motorcycle, Moped; Car, Jeep, Van; None of these)

- Find the average percentage of household in Nashik village availing banking services using field calculator
- Find the villages with household having internet facility at least 10%
- Style and compare the village with households having banking facilities against households with tv, computer/laptop, telephone/mobile phone and scooter/ car.

6.1.2. Analysis on taluka level data

- Import layer ‘taluka’ from downloaded dataset. Add columns for ‘population density’ using ‘field calculator’ and save the layer as taluka_pop_density(Figure 7.1).
  Population density = Number of people / Land area(in square kilometer)

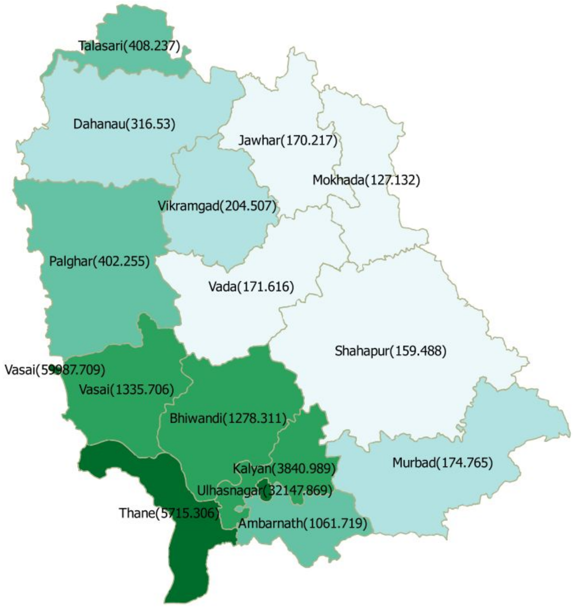
taluka :: Features total: 16, filtered: 16, selected: 0

	PERIMETER	TALUK0_	TALUK0_ID	T_CODE	T_NAME	D_NAME	DPAP	WGDP	HILLY_BLOC	population	Area(sqkm)	p_density
1	197099.24...	4	3	110204	Dahanau	THANE				331829	1048.333	316.530
2	193819.44...	7	5	110203	Palghar	THANE				454635	1130.216	402.255
3	16037.288...	16	13	110213	Ulhasnagar	THANE				473731	14.736	32147.869
4	254027.73...	9	7	110210	Shahapur	THANE		WGDP	Hilly Block	273304	1713.636	159.488
5	133048.23...	2	1	110205	Talasari	THANE				121217	296.928	408.237
6	147300.48...	14	11	110212	Kalyan	THANE				1276614	332.366	3840.989
7	123763.23...	17	15	110215	Ambarnath	THANE				366501	345.196	1061.719
8	8381.6702...	12	8	110202	Vasai	THANE				273304	4.556	59987.709
9	143236.82...	15	12	110201	Thane	THANE				2486941	435.137	5715.306
10	169302.65...	5	2	110207	Mokhada	THANE		WGDP	Hilly Block	67319	529.521	127.132
11	122645.01...	6	4	110214	Vikramgad	THANE				114254	558.680	204.507
12	120671.49...	10	8	110202	Vasai	THANE			Hilly Sub-b...	795863	595.837	1335.706
13	168195.44...	3	4	110206	Jawhar	THANE		WGDP	Hilly Block	111039	652.337	170.217
14	134991.89...	11	9	110209	Bhiwandi	THANE			Hilly Sub-b...	945582	739.712	1278.311
15	172917.35...	8	6	110208	Vada	THANE		WGDP	Hilly Block	142753	831.818	171.616
16	218815.68...	13	10	110211	Murbad	THANE		WGDP	Hilly Block	170267	974.265	174.765

Figure 7.1. Taluka layer attribute table with added population density field

- Import layer taluka_pop_density and add labels containing taluka name and population density (Figure 7.2).
- Import layer taluka_pop_density and style the layer using the population density field with graduated style and find the best mode to classify density(Figure 7.3).
- Query the taluka having population density > 200 people per sq km and < 1000 people per sq km and use graduated style to differentiate(Figure 7.4)

Figure 7.2. Thane district with label



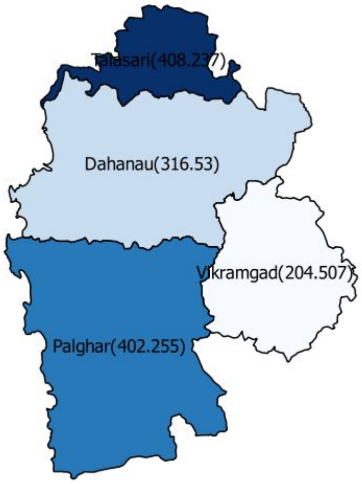


Figure 7.3. Population density variation population

Figure 7.4. Filtered taluka layer with density b/w 200-1000 people/sq km

- Find total length of road arcs in Palghar taluka(Figure 7.5)

T_NAME	D_NAME	DPAP	WGDP	HILLY_BLOC	population	Area(sqkm)	p_density	orig_ogc_fid	Road Lengt
Palghar	THANE				454635	1130.21600	402.25500	5	5.92027

- Import drainage layer form given dataset and find the drainage of Palghar taluka(Figure 7.5)

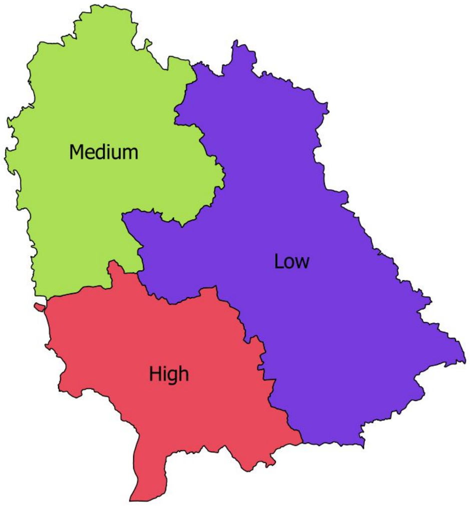


Figure 7.5. Thane district Drainage

Figure 7.6. Dissolved layer according to population density

● Dissolve the village layer to taluka layer according to following categories(Figure 7.6)

Category	Population density(people per sq km)
High	> 1000
Medium	1000 > AND < 200
Low	< 200

● Remove talukas without any values in the Hill_Block field(Figure 7.7).

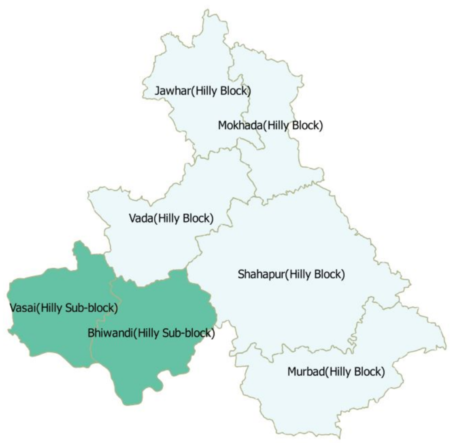


Figure 7.7.Taluka without hill block

6.2. Raster Exercises

6.2.1. Analysis on digital elevation model

● Download Toposheet number E43C and ER3B from bhuvan and merge these DEM using algorithm available in Raster -> Miscellaneous -> Merge(Figure 7.8 - 7.9)

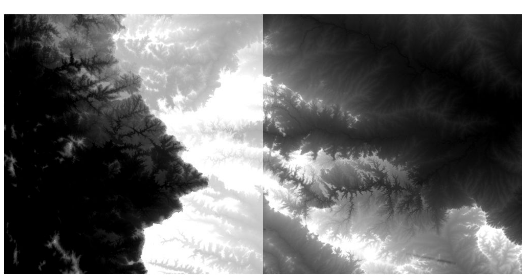


Figure 7.8. Separate toposheet E43C and ER3B

Figure 7.9.Merged DEM layer

- Style the layer using Single Band pseudocolor(Figure 7.10)

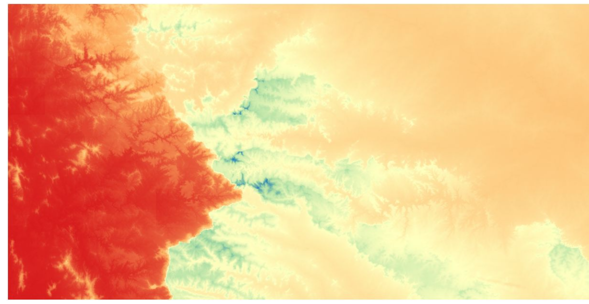
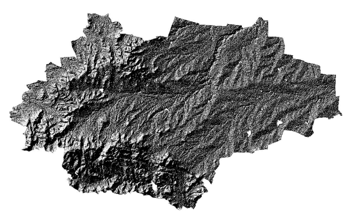
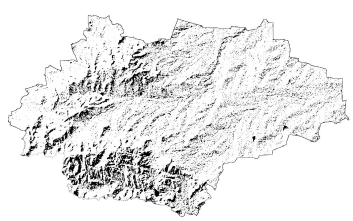


Figure 7.10. Single Band pseudocolor style

- Perform following operation on sinnar taluka and compare output

Operation	Output	Style parameters
Clip sinnar taluka provided in dataset from the merged DEM	 *Figure 7.11*	sinner_dem 440 1115
Calculate Hillshade	 *Figure 7.12*	Hillshade 1 181
Calculate the Slope	 *Figure 7.13*	Slope 0 89.9998

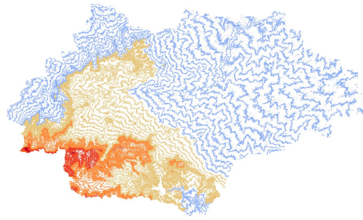
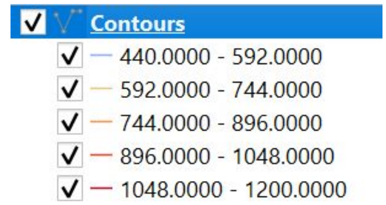
Generate contours	 *Figure 7.14*	

Table 6.1. Raster exercise output : Sinnar taluka raster layer with style parameters

7. Appendix

7.1. Download Dataset

Download data from one of the following links
https://drive.google.com/drive/folders/1BCHwPQ5yNJjL2E5iQ2iPGFyFiuAdtp5r
https://github.com/AnimeshN/tdsc_exercise_data

7.2. POCRA plugin

Download the plugin from the following link
https://drive.google.com/drive/folders/14c4i50awF5D7zQZxjLHV5jfoe3I7V8Pg?usp=sharing

For more information about the POCRA project visit following link
https://www.cse.iitb.ac.in/~pocra/

7.3. Additional References

http://qgis.spatialthoughts.com/
http://qgis.org/en/documentation.html
https://en.wikipedia.org/wiki/List_of_map_projections
https://www.nationalgeographic.org/media/selecting-map-projection/
https://2012books.lardbucket.org/books/geographic-information-system-basics
https://brilliantmaps.com/xkcd/

7.4. Census Data Fields description

You can check out the list of all the 631 fields descriptions from the following link.
https://www.cse.iitb.ac.in/~pocra/MahaCensus_shapefile_data1.2/Attribute.html

Description	Field Name
district name	district_n
taluka name	taluk_ nam
village name	area_name

Table 7.1. Name Fields

7.4.1. Demographic data.

total population	tot_p
total male population	tot_m
total female population	tot_f
total population of children in age group 0-6 years	p_06
total population of male children in age group 0-6 years	m_06
total population of female children in age group 0-6 years	f_06
total schedule caste population	p_sc
total schedule caste male population	m_sc
total schedule caste female population	f_sc
total schedule tribe population	p_st
total schedule tribe male population	m_st
total schedule tribe female population	f_st
total literate population	p_lit
total literate male population	m_lit
total literate female population	f_lit
total illiterate population	p_ill
total illiterate male population	m_ill
total illiterate female population	f_ill

Table 7.2.Demographic data.

7.4.2. Source of drinking water and its location

main source of drinking water tap water from treated source	msdw_tapt
main source of drinking water tap water from untreated source	msdw_taput
main source of drinking water covered well	msdw_cwel
main source of drinking water uncovered well	msdw_ucwel
main source of drinking water hand pump	msdw_hpump
main source of drinking water tube well/borehole	msdw_bore
main source of drinking water spring	msdw_sprin

main source of drinking water river/canal	msdw_river
main source of drinking water tank/pond/lake	msdw_lake
main source of drinking water other sources	msdw_else
location of drinking water source within premises	locdw_in
location of drinking water source near premises	locdw_near
location of drinking water source away	locdw_away

Table 7.3.Source of drinking water and its location

7.4.3. Source of lighting

main source of lighting electricity	mslit_elec
main source of lighting kerosene	mslit_kero
main source of lighting solar energy	mslit_sol
main source of lighting other oil	mslit_oil
main source of lighting any other	mslit_else
main source of lighting no lighting	mslit_no

Table 7.4. Source of lighting

7.4.4. Access to sanitation facilities

number of households having latrine facility within the premises	hh_hav_lat
flush/pour flush latrine connected to piped sewer system	flat_pipe
flush/pour flush latrine connected to septic tank	flat_sept
flush/pour flush latrine connected to other system	flat_else
pit latrine with slab/ventilated improved pit	plat_vent
pit latrine without slab/ open pit	plat_open
"night soil disposed into open drain	niso_open
service latrine night soil removed by human	serlat_hum
service latrine night soil serviced by animal	serlat_ani
number of households not having latrine facility within the premises	hh_no_lat
alternative source public latrine	alt_publat
alternative source open	alt_open

number of households having bathing facility within the premises yes bathroom	bath
number of households having bathing facility within the premises enclosure without roof	bathnoroof
number of households having bathing facility within the premises no	nobathroom
waste water outlet connected to closed drainage	ww_closed
waste water outlet connected to open drainage	ww_open
waste water outlet connected to no drainage	ww_no

Table 7.4.Access to sanitation facilities

7.4.5. Availability of separate kitchen and type of fuel used for cooking

type of fuel used for cooking fire-wood	food_wood
type of fuel used for cooking crop residue	food_crop
type of fuel used for cooking cow dung cake	food_dung
type of fuel used for cooking coal,lignite,charcoal	food_coal
type of fuel used for cooking kerosene	food_kero
type of fuel used for cooking lpg/png	food_lpg
type of fuel used for cooking electricity	food_elec
type of fuel used for cooking biogas	food_bio
type of fuel used for cooking any other	food_else
type of fuel used for cooking no cooking	food_no
kitchen facility total	kitch_tot
kitchen facility cooking inside house:	kitch_in
kitchen facility has kitchen	kitch_yesi
kitchen facility does not have kitchen	kitch_noi
kitchen facility cooking outside house:	kitch_out
kitchen facility has kitchen	kitch_yeso
kitchen facility does not have kitchen	kitch_noo
kitchen facility no cooking	kitch_noco

Table 7.5.Availability of separate kitchen and type of fuel used for cooking

7.4.6. Availability of banking services and the specified assets

total number of households availing banking services Number use bank	hh_bank
availability of assets radio/transistor	ass_radio
availability of assets television	ass_tele
availability of assets computer/laptop with internet	ass_pc_net
availability of assets without internet	ass_pc_nnt
availability of assets telephone/mobile phone landline only	ass_mob_la
availability of assets mobile only	ass_mob_mo
availability of assets both	ass_mob_bo
availability of assets bicycle	ass_cycle
availability of assets scooter/ motorcycle/moped	ass_scoot
availability of assets car/ jeep/van	ass_car
availability of assets households with tv, computer/laptop, telephone/mobile phone and scooter/ car	ass_tv_pc
availability of assets none of the assets specified in col. 10 to 19	ass_no_ass

Table 7.6.Availability of banking services and the specified assets

7.5. Image sources

[1.1] NASA and the German Aerospace Center, Gravimetry map from the Gravity Recovery and Climate Experiment—GRACE. https://en.wikipedia.org/wiki/Gravity_of_Earth#/media/File:Gravity_anomalies_on_Earth.jpg

[1.2] http://wiki.gis.com/wiki/index.php/File:OblateSpheroid.PNG

[1.3] Spatial Reference EPSG: 32643. https://spatialreference.org/ref/epsg/?search=32643&srtext=Search.Screenshot by author.

[1.4] Campbell J E, Shin M (2012) Geographic Information System Basics v. 1.0 [Online]. Available:https://2012books.lardbucket.org/books/geographic-information-system-basics

[1.5] Bostock M,https://github.com/d3/d3-geo

[1.6] *QGIS.ORG* https://docs.qgis.org/2.8/en/_images/gui_numbered.png

[1.7] Fig. 6.5 : The Vector Data Model is based around Coordinate Pairs ,Chapter 6 ,NCERT Practical Work in Geography Part II

[2.1] *QGIS.ORG* https://docs.qgis.org/2.8/en/_images/gui_numbered.png

[4.1] https://bhuvan-app3.nrsc.gov.in/data/download/index.php. Screenshot by author.