



Multi-criteria Analysis

Using QGIS

Tutorial ID: IGET_SA_001



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Multi-Criteria Analysis

Objective: To understand Concept of Multi-criteria analysis using spatial analysis tools of QGIS.

Software: QGIS 2.0.1

Level: Advance

Time required: 3 Hour

Prerequisites and Geospatial Skills

1. QGIS should be installed on the computer
2. Basic knowledge about the QGIS interface
3. Should have completed Exercise all the exercises related to QGIS from IGET

Reading

Ronald C. Estoque, GIS based Multi-Criteria Analysis,
http://giswin.geo.tsukuba.ac.jp/sis/tutorial/GIS-based%20MCDA%20_RCEstoque.pdf

Introduction:

GIS often used as a supportive tool in decision making process. Multi-criteria Analysis is one of the common GIS operation used to assess and aggregate the many criteria for suitability mapping and resource allocation decisions. Multi-criteria Analysis (MCA) or Evaluation (MCE) is a technique used in decision making to analyze and compare how well different alternatives achieve different objectives and through this process identifying a preferred alternative (Therivel, (2004). GIS-based Multi-criteria decision analysis is a process that transforms and combines geographical data (Map Criteria) and value judgments (Decision-makers preferences) to obtain relevant information for decision making (Eastmen et al. 1995, Malczewski 1999).

GIS has capabilities to store, manage and analyze volumes of diverse information and also has the functionality to perform “what if” scenarios. A systematic use of GIS tools can allow us to test the impacts of different planning policies under varied scenarios. Site selection among number potential sites is one of the common task in GIS based multi-criteria analysis. The objective of this tutorial is to introduce the basic concepts of the multi criteria analysis in GIS. Our main objective would be selecting a suitable site for construction of wind farms in Stara district of Maharashtra state in India.

The first step in multi-criteria analysis is to identify the criterion, a criterion can be defined as a principle or standard by which something may be judged or decided. The criteria can be a constraint or a factor. Constraints limits the suitability where as a factor enhances the suitability. The identification of criterions is a crucial step in MCA, it require extensive study of literature and expert knowledge in the concerned subject. Generally criterions used in suitability analysis belong to different fields and also have different unit of measurements. Therefore, all criterions should be scaled or weighted into a common scale. In order to keep the tutorial simple a minimum criterions are used and the all criterions are scaled. The following list shows the criterions used in this tutorial.

Criteria for selecting suitable site for Wind farm:

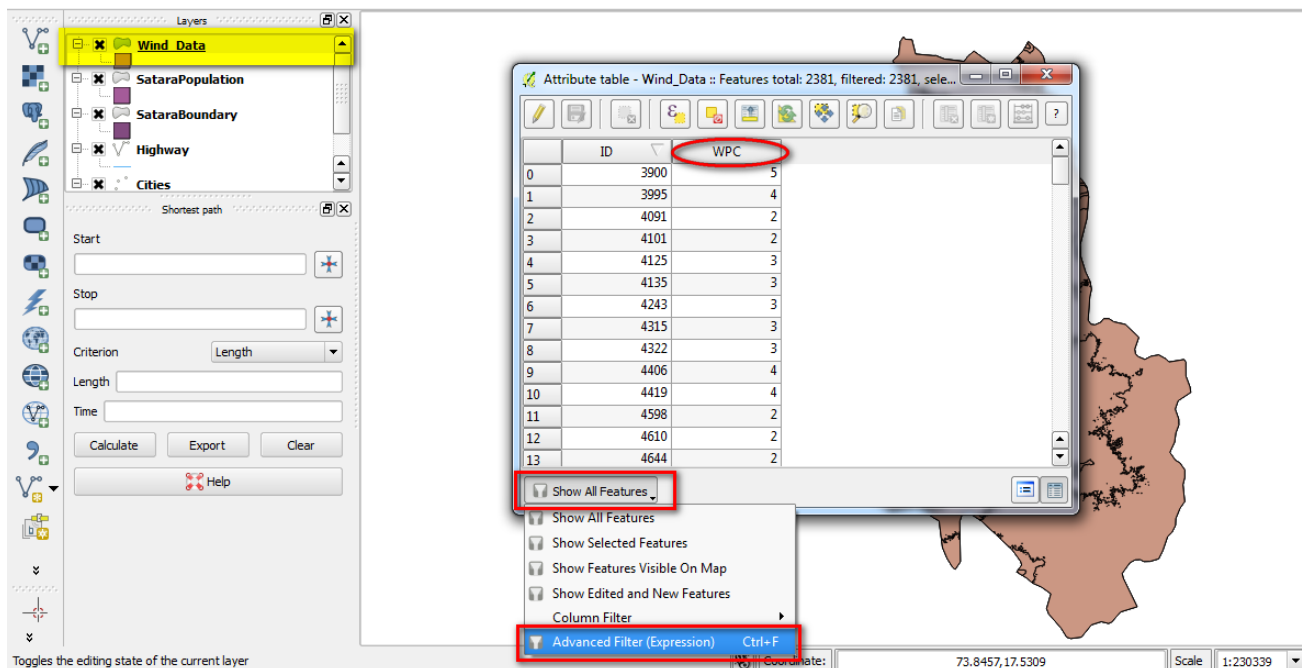
To determine the most suitable sites for planning new wind energy farms. The sites must be:

- i. In an area where the wind Power Class is at least 2, which is “good” or better in terms of wind farm resource potential.
- ii. It should be with in 5kilometers from the highways, so that the maintenance crews can more easily access the wind turbines.
- iii. It should be within 4 kilometers from a city with atleast PD (Population density) 8 to ensure a nearby target market.

- iv. It should be at least 1 sq-km in size, large enough for a wind farm.

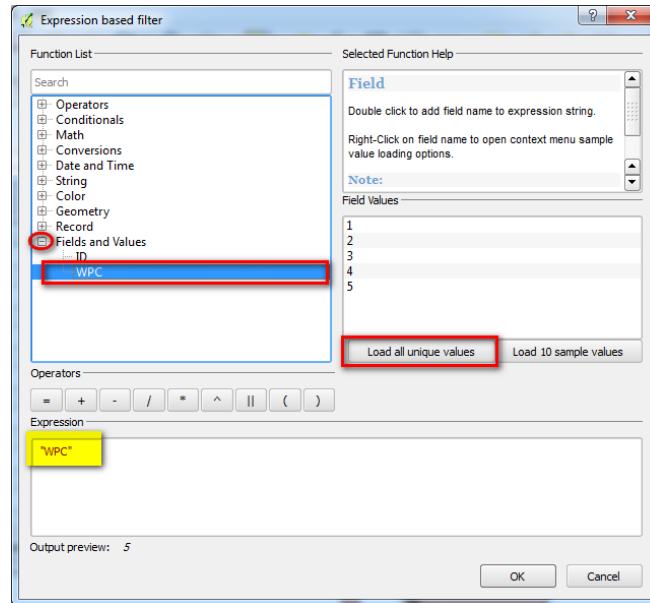
In order to select the suitable site for construction of wind farm, we will concentrate on developing each criterion individually and then combine all four to identify the best suitable site for construction of wind farms.

1. First, open Quantum GIS (QGIS) via, the Start menu. (*Start → All Programs → QGIS Dufour → QGIS Desktop 2.0.1*).
2. Add all the shapefiles supplied with tutorial data into QGIS canvas (Layers → Add Vector Layer). Explore the data to understand it. The supplied data contains shapefiles of Cities, Highways, Wind Data, and SataraBoundary.
3. Now we will look into the first criterion. Open the attribute table of Wind_Data (*Select the 'Wind_Data' layer under layers tab → right click → Open Attribute Table*). The attribute table contains the Area ID along with its scaled WPC value. In order to meet the first criterion we will to select the areas which have WPC value at least 2.



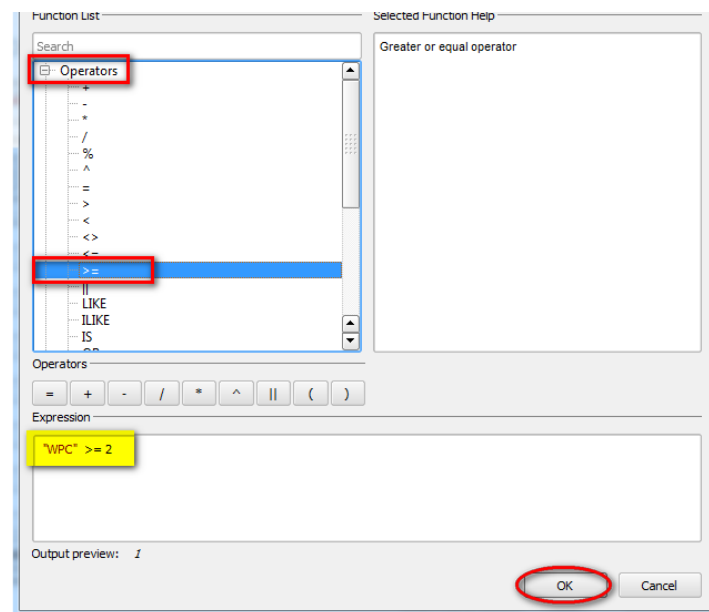
4. Click on "Show All Features" tab at the left bottom of the attribute table. Select "Advance Filter (Expression)" from the drop down menu. The 'Expression based filter window' will open.
5. In this window we have to write an expression for selecting areas having WPC at least 2. How will you mathematically express WPC at least 2? It can be expressed mathematically as $WPC \geq 2$ i.e. WPC must be greater than or equal to 2.

6. Now we will see how to form this equation in the expression window. In the “*Function List*” double click on “***Fields and Values***” (Or click on ‘+’ sign in front of it). The attributes of the Wind_Data will be listed under it. Now double click on WPC to add to the expression.

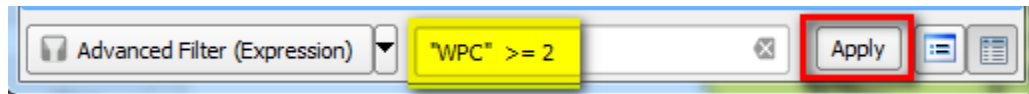


7. Now we have to add greater than equal to sign to the expression; this could be added in a similar way from “***Operators***” under function list. Then just type ‘2’ next to it. This completes equation as “***WPC >=2***” and click on ‘***OK***’.

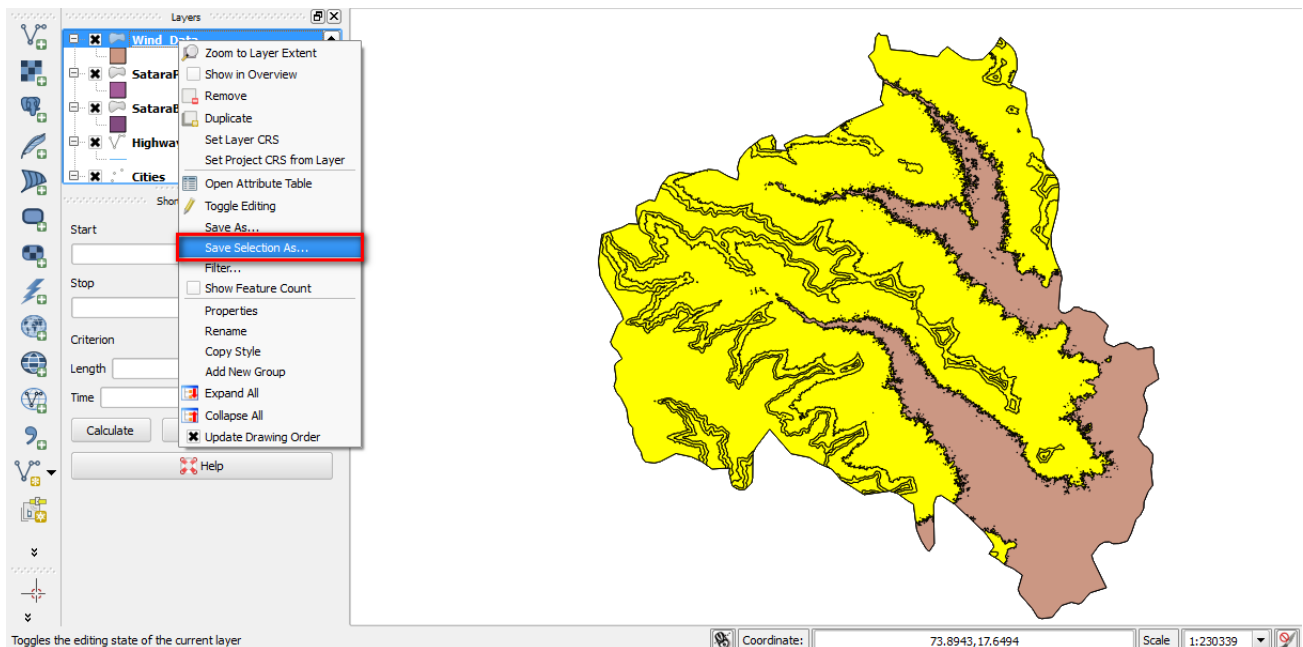
Note: We can also directly type the required equation in expression window



8. Click on **“Apply”** besides the condition window. The areas having WPC greater than 2 will be filtered, now **“ctrl+A”** and select all the filtered attributes of Wind_Data.



9. The selected areas will be highlighted in map canvas. Now Export the selected data as different shapefile and name the layer as **“Wind_Acceptable”** (Right click on ‘Wind_Data’ layer → Save Selection As). This completes the task of development of first criterion, i.e., Wind power class at least 2. Add the ‘Wind_Acceptable.shp’ file to the map canvas if it was not added.

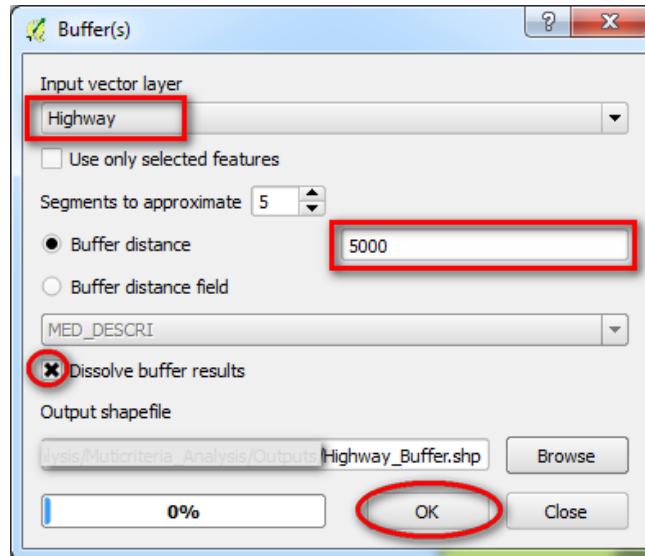


10. As per the second Criterion, the suitable area for the construction of wind farm would be within 5 kilometers from the highway, so that the maintenance crews can easily access the wind turbines.

Question 1: How can we find an area within 5km from Highways?

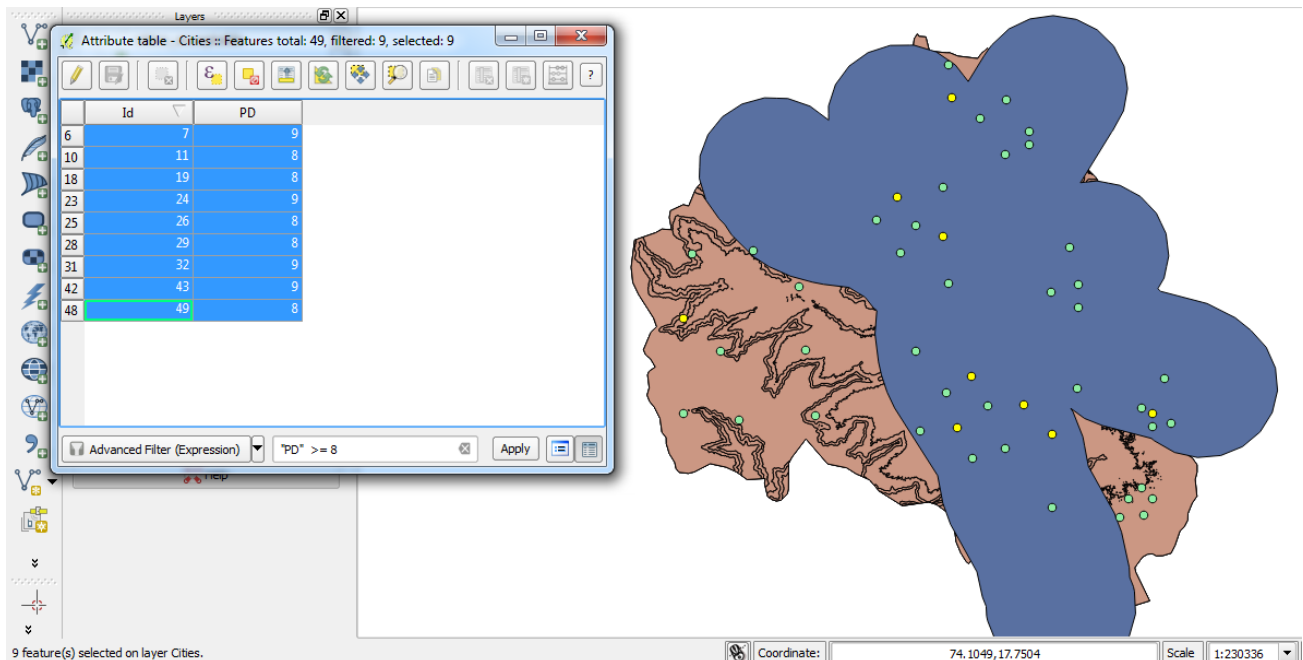
11. Buffer tool can be used to identify the areas within 5 km from the highways. Access the buffer tool via, *Vector → Geoprocessing Tools → Buffer(s)*. In the popup window of ‘Buffer(s)’ fill the details as shown in the screen shot below.

12. To dissolve the buffer results make sure to check the check-in box in front of *Dissolve buffer results*. Name the buffer file as 'Highway_Buffer' and click on "OK".

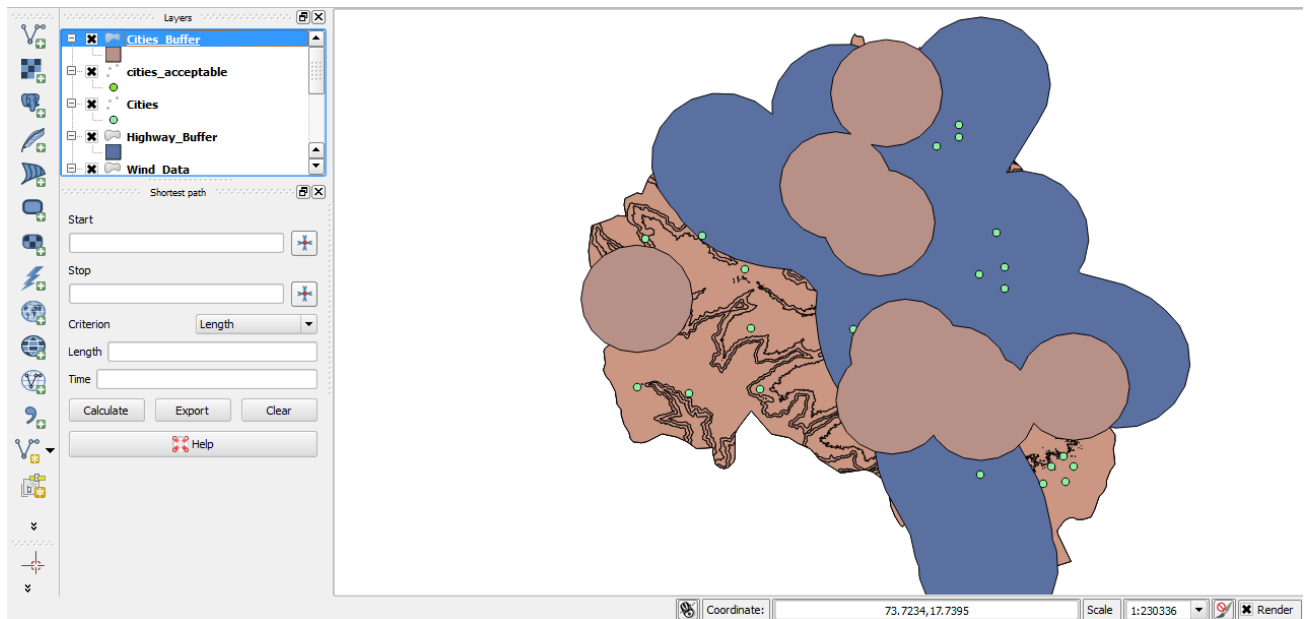
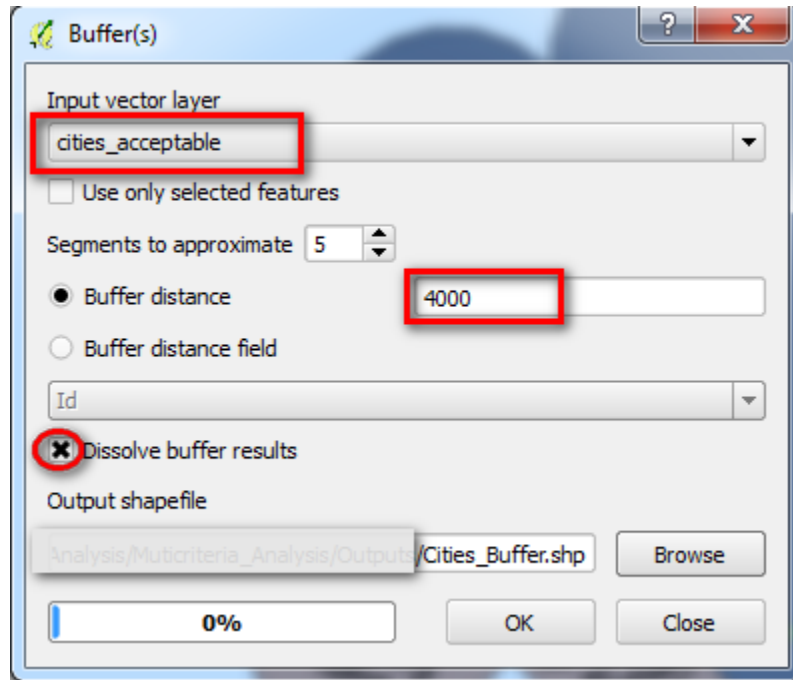


13. Now we will move on to the third criterion, which states that the area must within 4 kilometers from a city containing Population density of at least 8 to ensure a nearby target market.

14. Firstly we will work on selection of the cities having population density greater than 8. Refer steps 3 to 9 to form an expression "PD >= 8"



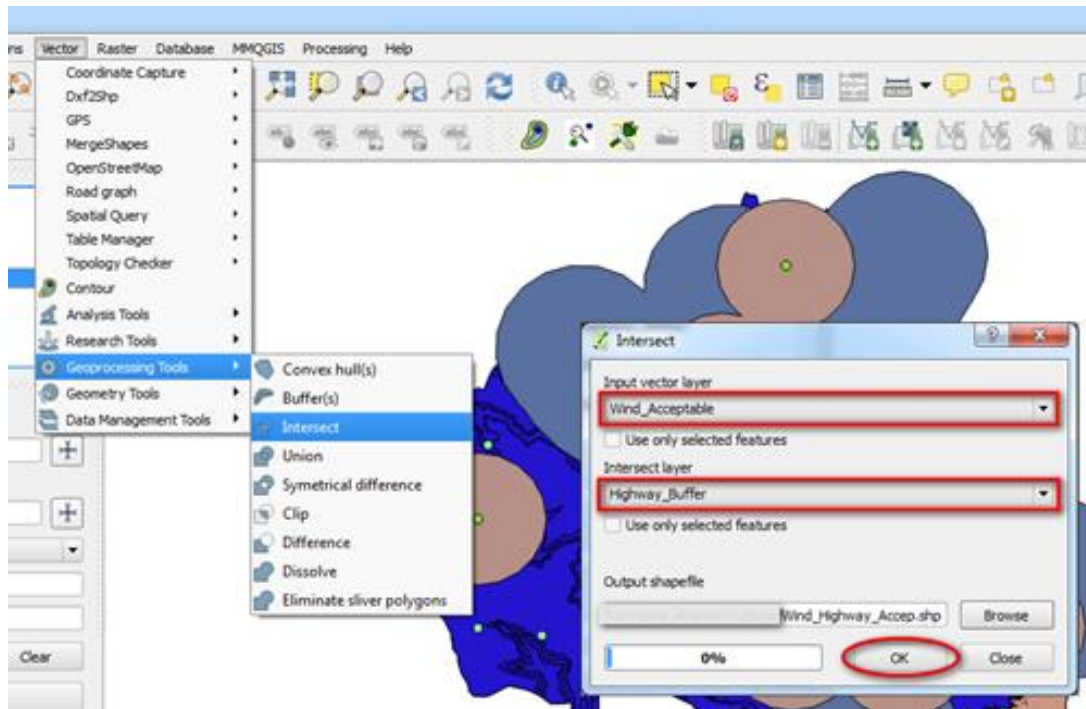
15. Once the required area is selected export it as separate shapefile and save it on your hard drive as 'Cites_acceptable'. Add that layer to the map.
16. Now we have to find out the area within 4km from the selected cities. So buffer the 'cities_acceptable' layer by keeping 4km (4000) as buffering distance with 'Dissolve buffer results' on and name the output as 'Cities_Buffer' and click 'OK'.



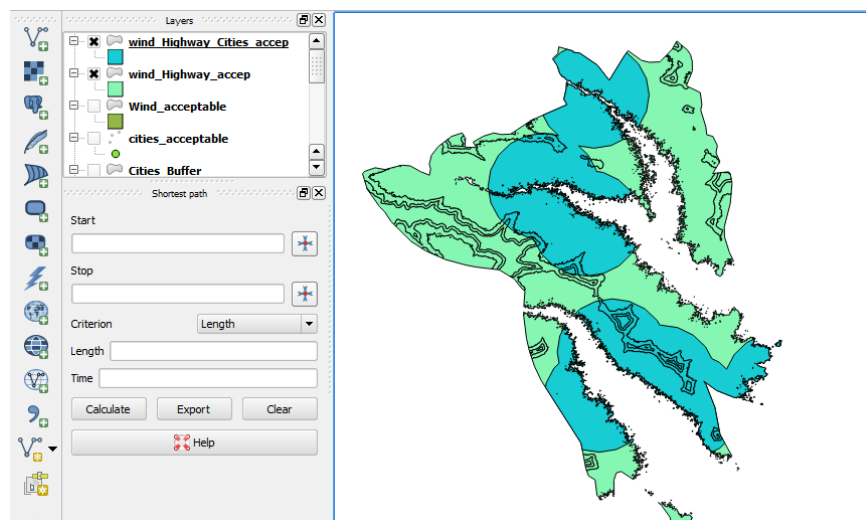
17. Now we have areas satisfying all the three criteria individually, but we need an area that satisfies the entire three criterions simultaneously.

Question 2: How can you find the common area of the three criterion layers?

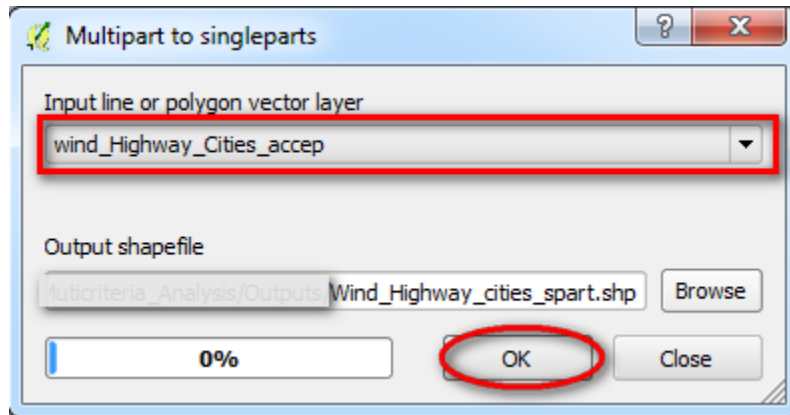
18. We will use 'Intersect' tool, it accept two layers only at a time. Therefore, we will find intersection of 'Wind_Acceptable' layer with 'Highway_Buffer' at first and will save this layer as 'Wind_Highway_Accep'. Access the Intersect tool via, *Vector* → *Geoprocessing Tool* → *Intersect*. Now provide the input and output as specified above and click on 'OK'.



19. Now again use the intersect tool with 'Wind_Highway_Accep' and 'Cities_Buffer' layers as input and output as 'Wind_Highway_Cities_Accep' and click on 'OK'. The output layer represents the areas suitable for construction of the wind energy farms. Uncheck the rest of the layers to see the output of both intersects.

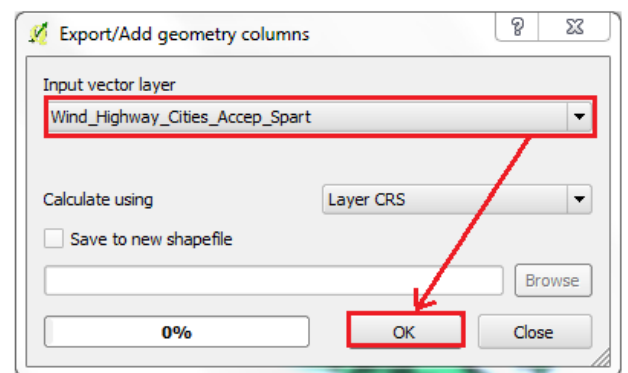
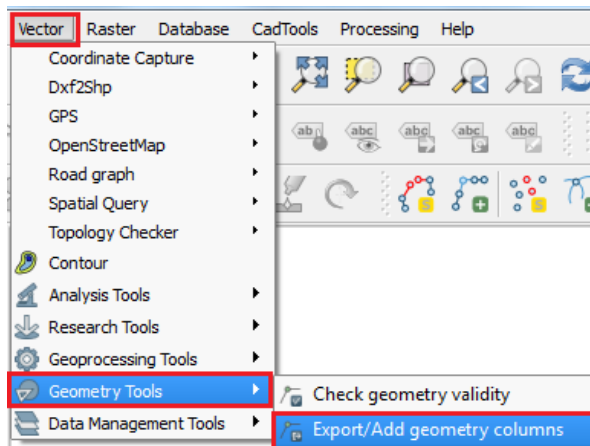


20. The fourth criterion states that the wind farm area must be greater than 1 sq.km. The overlay operations create a multipart polygon. In order to accomplish the task one should convert the multipart polygon into single part polygon.
21. First run 'Multipart to Singleparts' tool via, 'Vector → Geometry tools → Multipart to Singleparts'. Save the output in appropriate folder and name it as 'Wind_Highways_Cities_spart'.



Question 1: Examine the attribute tables and maps for 'Wind_Highways_Cities_spart' and 'Wind_Highway_Cities_Accep' layers. What did the Multipart to singlepart tool do? How many rows do the both layers have in attribute table?

22. Calculate the Area of Individual polygons via, 'Vector → Geometry Tools → Export/Add geometry Columns'. Select 'Wind_Highways_Cities_spart' as input file and click 'OK'. This operation adds two columns/fields named 'AREA' and 'PERIMETER' to the attribute table of the 'Wind_Highways_Cities_spart'.



23. Open the attribute table of 'Wind_Highways_Cities_spart' layer. By using the 'Advance Filter' (Refer steps 3 -10) write an expression "**AREA**" >= **1000000**' to select the areas with at least 1sq-km (1000000sq-m) in size.

24. Select these areas and export it to new shapefile. Create a presentable map of Final suitable sites for wind farm setup.

Question 3: How many sites suitability for construction Wind energy farms? What is the area of largest patch available for construction of wind farm?