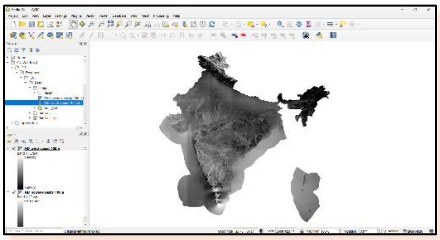
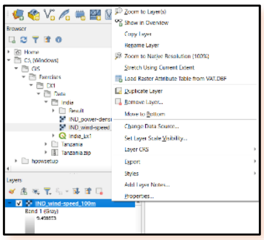
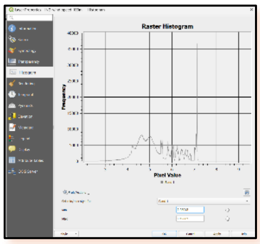
Exercise 1: To visualise wind power potential and aspects that relate to wind energy utilisation in a country of your choice.



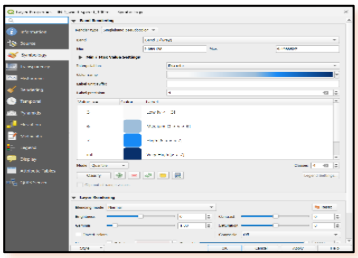
Step 1: Open QGIS→ Open .Tif file form browser



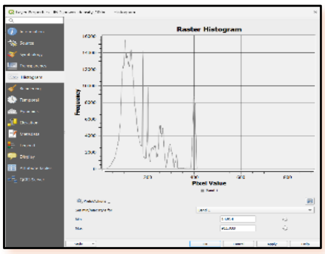
Step 2: Right Click on Layer → Properties



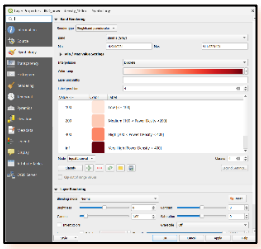
Step 3: Properties → Histogram



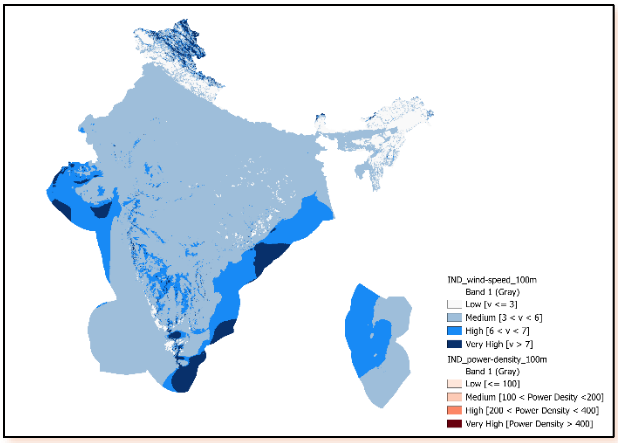
Step 4: Properties → Symbology



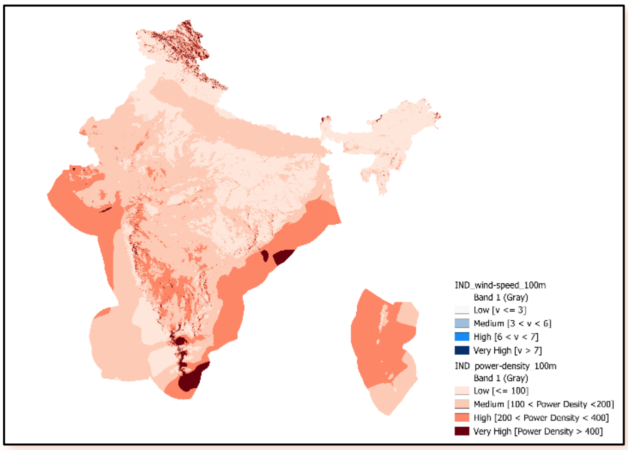
Step 5: Properties → Histrogram



Step 6: Symbology Windowmenu



(Figure 1.1: Average Wind Speed at a Hight of 100 m)



(Figure 1.2: Average Power Density at a Hight of 100 m)

Country	India
Download Wind Data	Energy data info
Content of Data	Wind Speed and Power Density

In a Figure 1.1, you can see the approach used to find the solution for average wind speed at a height of 100 meters. Specifically, in Step 3, my first approach involved analysing the data using a histogram and dividing it into four categories: Low, Medium, High, and Very High. The categories are based on wind speed values as follows:

Low: Less than 3 m/s
Medium: Between 3 and 6 m/s
High: Between 6 and 7 m/s
Very High: Greater than 7 m/s

In Step 4, I applied this classification in the Symbology menu, as you can see in the image.

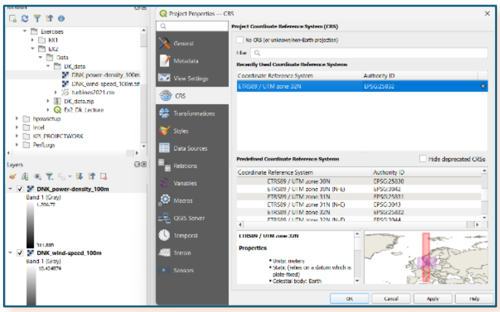
In a Figure 1.2, you can see the approach used to find the solution for average power density at a height of 100 meters. I followed same approach of Figure 1.1, see in step 5 and step 6.

Low: Less than 100 W/m^2
Medium: Between 100 and 200 W/m^2
High: Between 200 and 400 W/m^2
Very High: Greater than 400 W/m^2

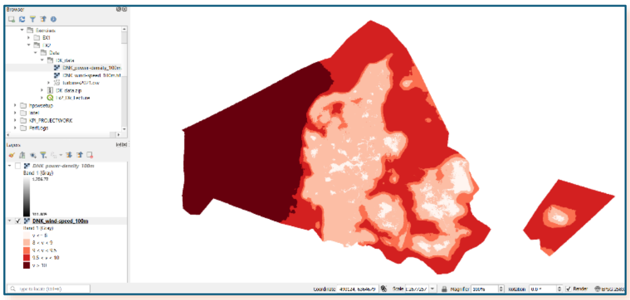
Exercise 2: Download and visualise the wind speed and power density map for Denmark.

Task 1: Consider type of symbology and choice of colours.

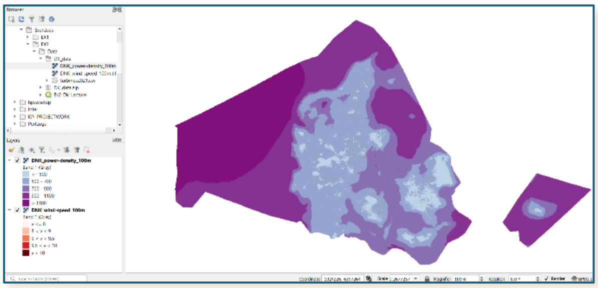
Step 1: Open QGIS → Open (.Tif) files of Wind speed and Power density map for Denmark, **Step 2**: Project → Properties [See Fig. 2.1, Change coordinates reference system, Used **ETRS89 / UTM zone 32N**], **Step 3:** Right click on Layer → Properties → Histogram [my first approach involved analysing the data using a histogram] → Symbology [dividing it into categories, names and different colours]. I didn't include photos of step 2 and 3 because it has already explained in Exercise 1. I added only final look photos, see in Fig 2.2 [Wind speed] and 2.3 [Power density].



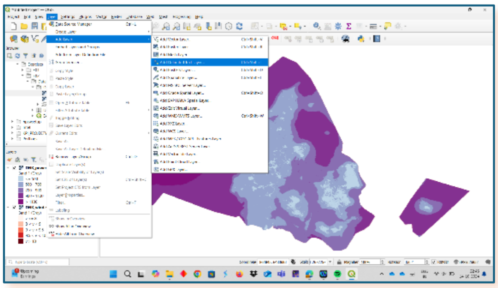
(Figure 2.1)



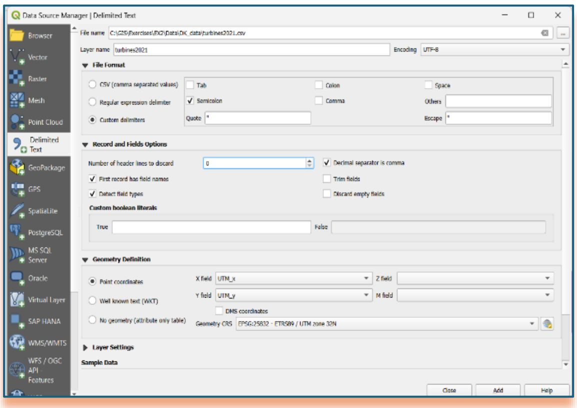
(Figure 2.2)



(Figure 2.3)



(Figure 2.4)



(Figure 2.5)

Task 2: Add the csv-file containing wind turbines.

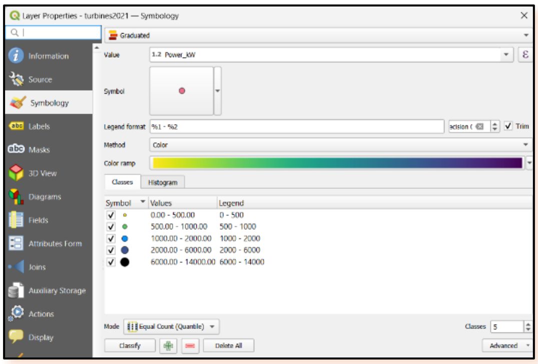
Step 4: Layer → Add Layer → Add Delimited Test Layer [See fig. 2.4 and 2.5], Here basically added (.csv) file of containing of Wind turbine. Before added in QGIS, Opened in Notepad (App) and understood given data.

Task 3 & 4: Visualise the wind turbines in Denmark by Installed Capacity and Manufacturer. Use the methods Unique Values, Graduated Symbols, Graduated Colours etc.

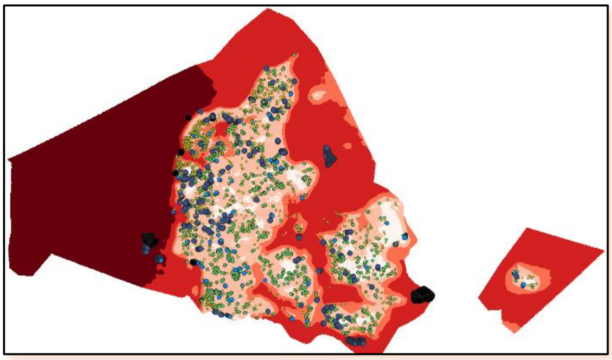
Step 5: Right click on Layer → Properties → Symbology [See Fig. 2.6], Here, the task is to visualize the installed capacity of the wind turbines. In the selection menu, choose the **Graduated** category and set the value to **Power**. The output is shown in Fig. 2.7. **Step 6:** I followed the same steps to visualize the **manufacturer** of the wind turbines, but I changed the category type. I selected specific companies and removed other companies for visualization [See Fig. 2.8]. The result is shown in Fig. 2.9.

Task 5: Add a grid, North arrow etc to your map.

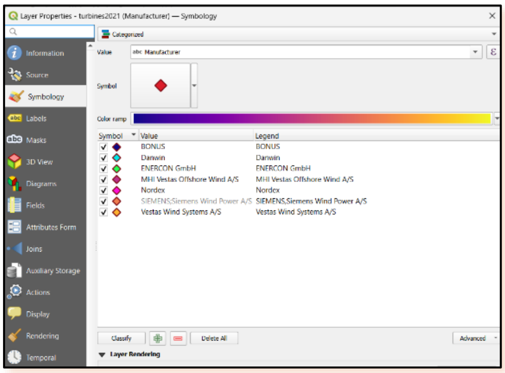
Step 7: Go to View → Decorations, I added a Grid, a North arrow using this option [See Fig. 2.10].



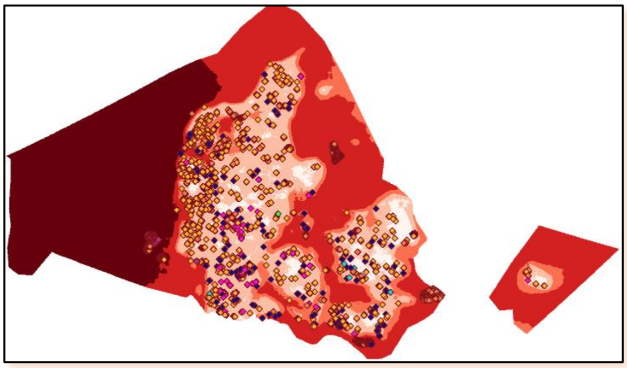
(Figure 2.6)



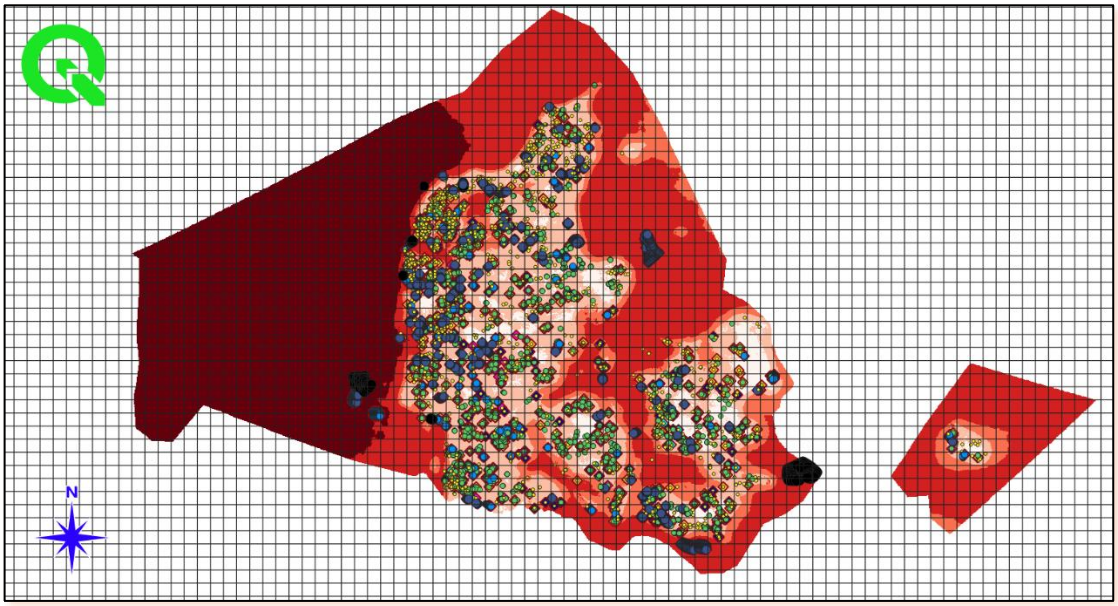
(Figure 2.7)



(Figure 2.8)



(Figure 2.9)



(Figure 2.10)

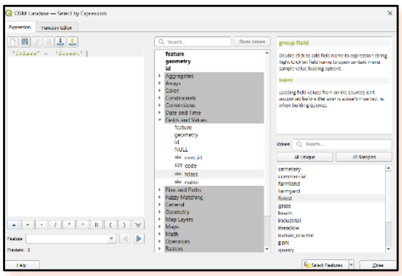
Exercise 3: Find potential wind energy locations in County Galway, Ireland

Task 1: Load the shape files into QGIS, arrange and visualise them to get an overview. Borrow the projection from County_Galway.shp!

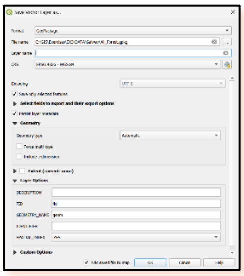
Step 1: Import “County_Galway.shp” and other “.shp” files, adjust their Colours.

Task 2: Identify by attribute query and save as new layers: All forests from the OSM land use layer, save the result as a new Shapefile– All areas with wind power densities less than 900 W/m².

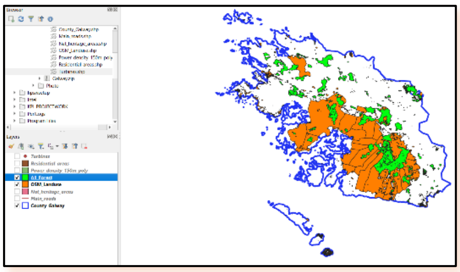
Step 2: Right click in OSM_Landuse → Open attribute table → Select by expression. For future selections, set “fclass” to the condition “fclass” = “forest” [See Fig 3.1]. **Step 3**: Right click in OSM_Landuse → Export → Save selected Features As. Save file under the new name “All_Forest”[See Fig 3.2]. The result is shown in Fig. 3.3.



(Figure 3.1)

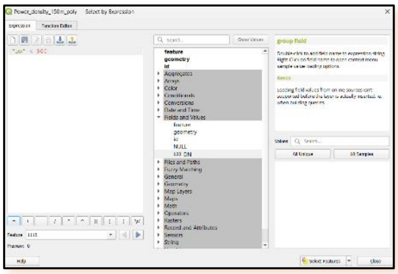


(Figure 3.2)

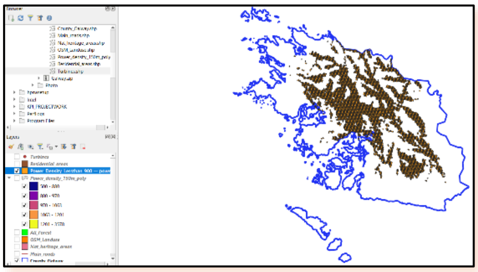


(Figure 3.3)

Step 4: I followed the same steps as above to find areas with wind power densities less than 900 $\frac{W}{m^2}$.[see Fig. 3.4 and 3.5].



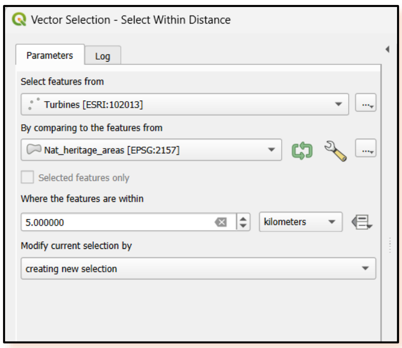
(Figure 3.4)



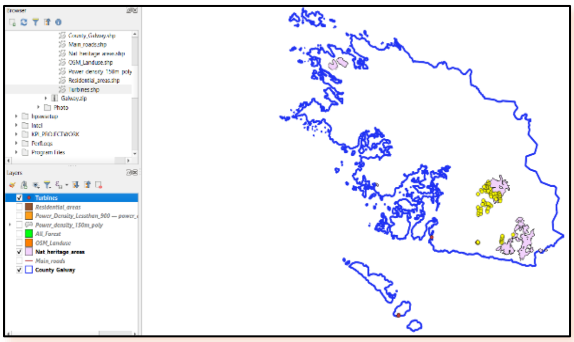
(Figure 3.5)

Task 3: Identify by attribute query All wind turbines less than 5km away from natural heritage sites.

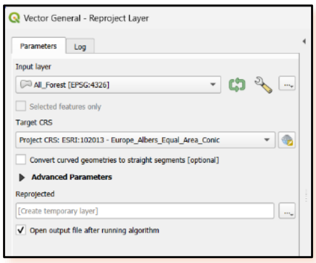
Step 5: In the Processing Toolbox → Search Vector Selection-select within distance. [See Fig 3.6]. This provides the results for all wind turbines located less than 5 km away from natural heritage sites. [See Fig. 3.7].



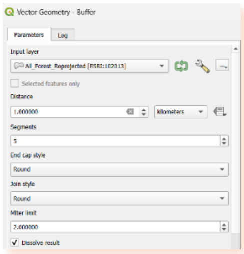
(Figure 3.6)



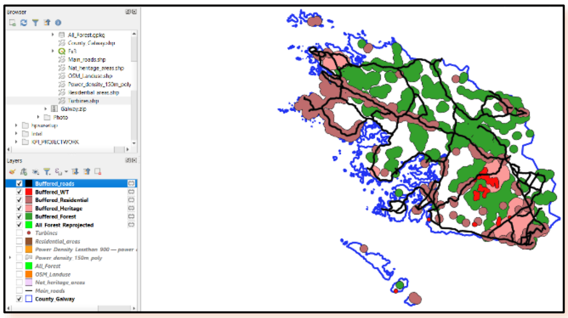
(Figure 3.7)



(Figure 3.8)



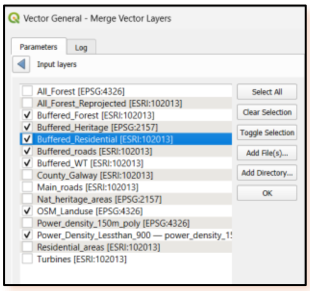
(Figure 3.9)



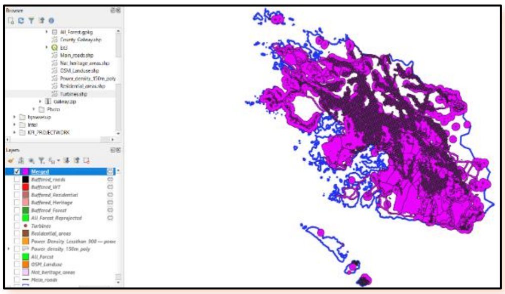
(Figure 3.10)

Task 4: Produce a "White map".

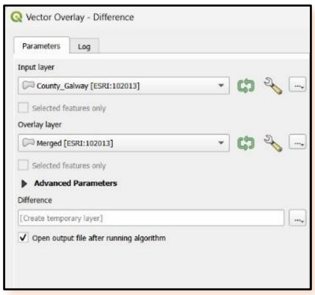
Step 6: Vector → Geoprocessing tools → Buffer. I Created buffer of 1 km for (Forest, Natural Heritage and Residential areas), 0.5 km (Wind turbine) and 0.2 km (Main roads), resulting in a total of five buffered areas. [See Fig. 3.9 and 3.10].



(Figure 3.11)



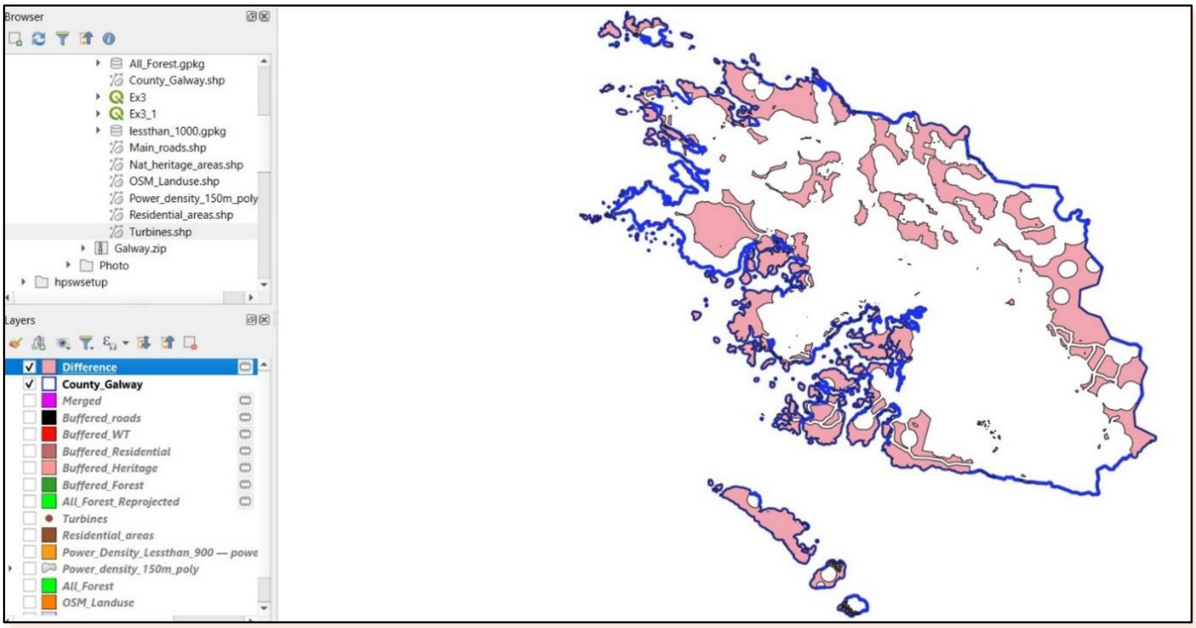
(Figure 3.12)



(Figure 3.13)

Step 7: Vector General → Merge Vector Layers. Select five buffered area, "OSM_Landuse" and "Power_Density_Lessthan_900" to merge them together [See Fig. 3.11]. The result is shown in Fig. 3.12. [No go area]

Step 8: Vector → Geoprocessing tools → Difference. Here, subtract the merged area from "County_Galway" to find the difference area [See fig. 3.13], also referred to as potential wind areas [See fig.3.14].



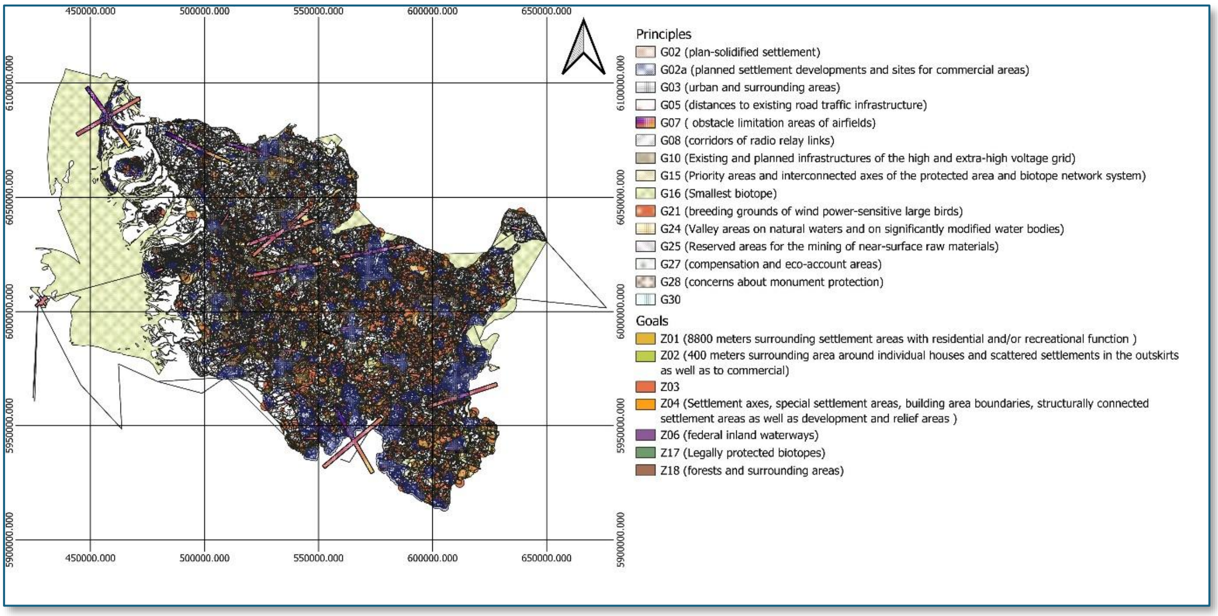
(Figure 3.14)

Exercise 4: Local Wind Farm Planning (Location: Lindewitt Municipality, Schleswig-Holstein).

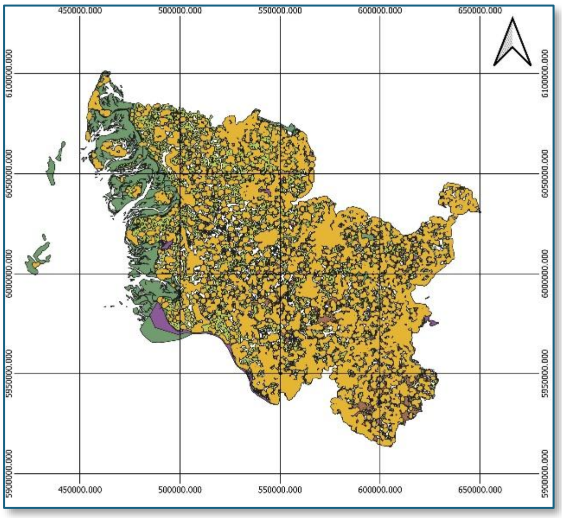
<u>Step 1</u>: Import all ".shp" files, adjust their colours and styles. **<u>Step 2:</u>** Create two group, first is Principle [See Fig. 4.1] and second is Goals [See Fig. 4.2]. **<u>Step 3:</u>** Add Wind turbine. [See Fig. 4.4] First download ".csv" file from the official Schleswig-Holstein site https://opendata.schleswig-holstein.de/dataset/windkraftanlagen-2023-07-13 . Refer to Figure 4.3 to view the *Potential Wind Areas* layer with the wind turbines.

How Goals and Principles contribute to Potential wind areas around Lindewitt? •

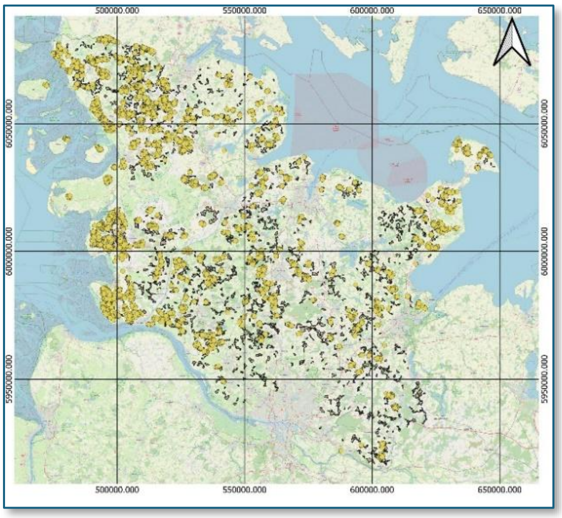
Which goals and principles cut across potential wind areas?



(Figure 4.1: All layers with principles)



(Figure 4.2: All layers with goals)

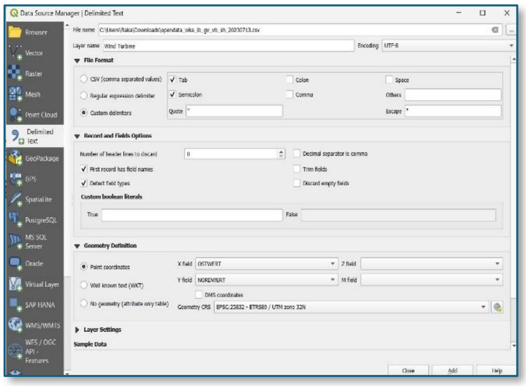


(Figure 4.3: Potential Wind areas with Wind Turbine)

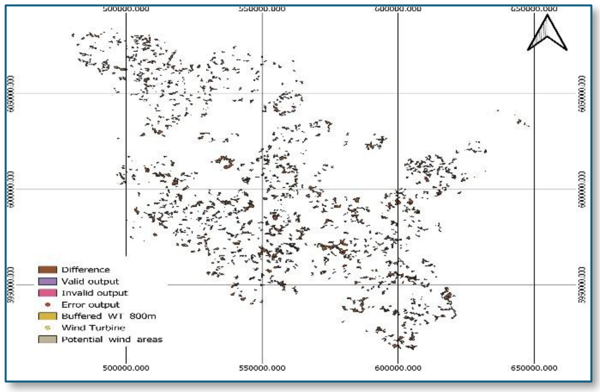
Task : Create a Wind Farm Development Map for an Area Without Existing Wind Turbines:

First, create an 800 m buffer around the wind turbine layer. Next, attempt to perform a Difference operation between the Potential Wind Areas layer and the 800 m buffered wind turbine layer. However, an error occurred:

"Feature (5) from Potential Wind Areas has invalid geometry. Please fix the geometry or change the 'Invalid features filtering' option for this input or globally in Processing settings." To address this, I checked and fixed the geometry: Go to Vector→ Geometry Tools→ Check Validity. After obtaining the valid output, I performed the Difference operation between the valid output and the 800 m buffered wind turbine layer. The result is shown in Fig. 4.5.



(Figure 4.4: Add data of Wind Turbine)



(Figure 4.5: Wind farm development map for an area without existing wind turbine)

Exercise 5: Editing Points, Lines and Polygons

Task 1: Find Wind Farm priority Area "PR1_NFL_036".

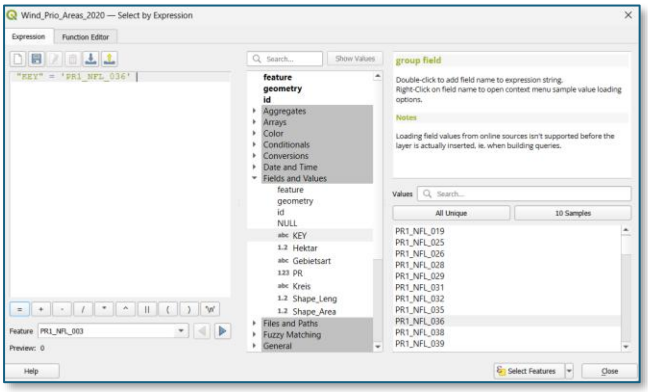
Step 1: import→ Wind Prio Area 2020 from Stud IP. **Step 2:** Right click → Open Attribute table → Select by Expression → Fields and Values → "KEY" → select "PR1_NFL_036" → Select Features → Close. [Fig. 5.1]. **Step 3:** Right click in Wind Prio Areas 2020 → Export → Save selected Features As → Save priority Area (PR1_NFL_036). [Fig 5.2].

Task 2: Add ESRI World Imagery or any other high-resolution image as a backdrop for digitalization.

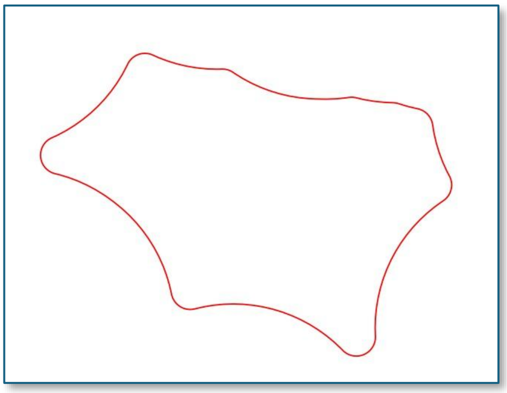
Step 4: Option 1: Web → QuickMapService → ESIR. **Option 2:** Use online site. [https://server.arcgisonline.com/arcgis/rest/services/World_Imagery/MapServer]. [See Fig 5.3]

Task 3: Map the following: The location of wind turbines (points), Access roads from the nearest road (lines), Agricultural fields that intersect with the priority area (polygons). Use snapping where appropriate. Add attributes.

Step 5: New shapefile Layer→ Add new Wind Turbine Attributes. [See Fig. 5.4]. **Step 6:** Select Toggle Editing → Select Add Point Feature → Drop point near to Wind Turbine. [See Fig 5.3: Blue point]. **Step 7:** Near Road data already available. [See Fig 5.3: Yellow Lines]. **Step 8:**

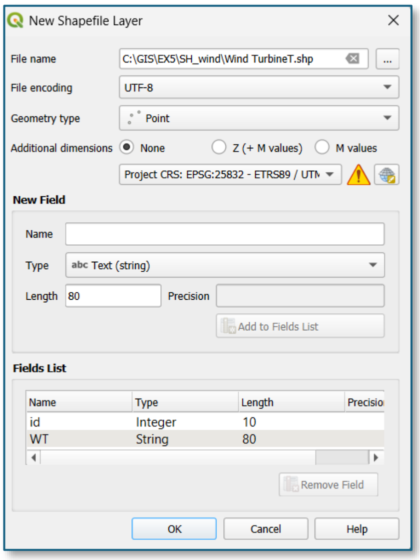


(Figure 5.1: Select Wind Farm priority Area “PR1_NFL_036”)



(Figure 5.2: Wind Priority Area “PR1_NFL_036”)

(Figure 5.3)



(Figure 5.4)

Exercise 6: Visualise the results with colours and transparency

Task 1: Install the Visibility Analysis Plug-In, if not installed yet.

Step 1: Plugins → Manage and install Plugins → Visibility Analysis

Task 2: Data (available on Stud.IP): SRTM3 elevation model (DSM!) of Schleswig-Holstein), Existing wind turbines in Schleswig-Holstein (from previous).

Step 2: import→ Data from Stud IP. [See Fig. 6.1]

Task 3: Create viewpoints: Estimate observer height from installed power: H [m] = hub height + 0.5 * rotor diameter, Set the search radius according to a rule of thumb: Radius = 150 x turbine height, Add 2 new fields “tot_height” and “radius” to the attribute table and calculate their content.

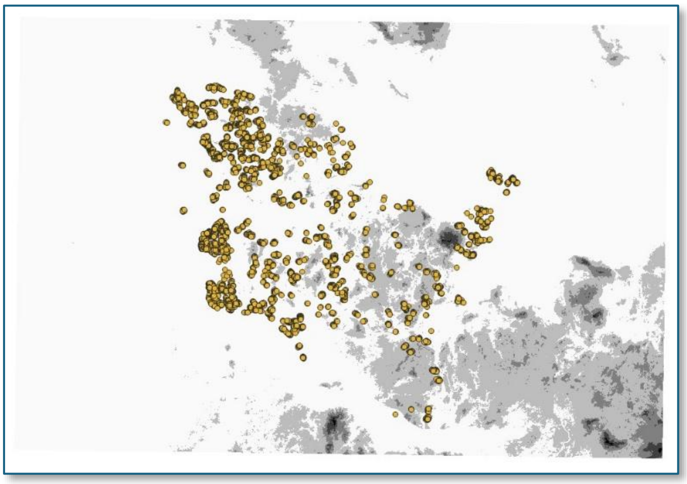
Step 3: Right click → Open Attribute table →Field Calculator → Calculate Estimate observer height from installed power. **Step 4:** Same steps follow for calculating Radius [See Fig 6.2]. Added two new fields “tot_height” and Radius to the attribute table [See Fig 6.3].

Task 4: Calculate the binary viewshed of existing wind turbines.

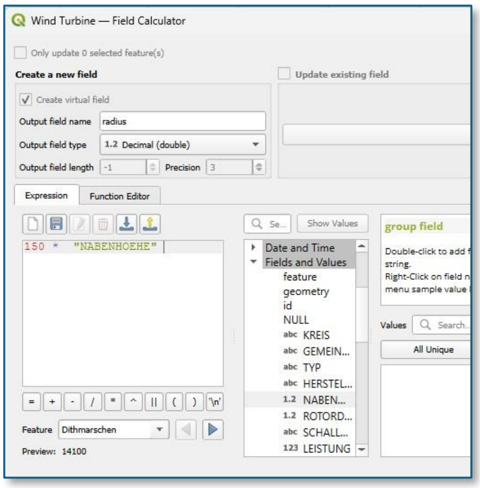
Step 5: Processing Toolbox → Search Create Viewpoints → Select Observer Locations as the Wind Turbine layer. In the Digital Elevation Model box, select **"DCM_ETRS_LAEA [EPSG:3035]"**. Set the Radius of Analysis to 5000 m and the Observer Height to 1.6 m → Save output layer → Run → Close.

Task 5: Visualise the results with colours and transparency.

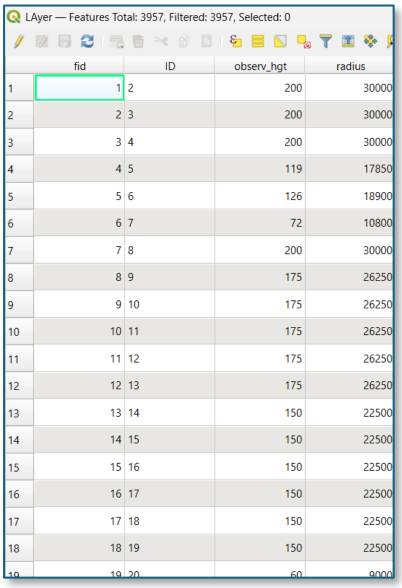
Step 6: Processing Toolbox → Viewshed → Select the Observer Location as the last layer of the binary viewshed and choose the Digital Elevation Model (DEM) as **"DCM_ETRS_LAEA [EPSG:3035]"** → Save output file → Run → close [See Fig 6.4].



[Fig. 6.1]



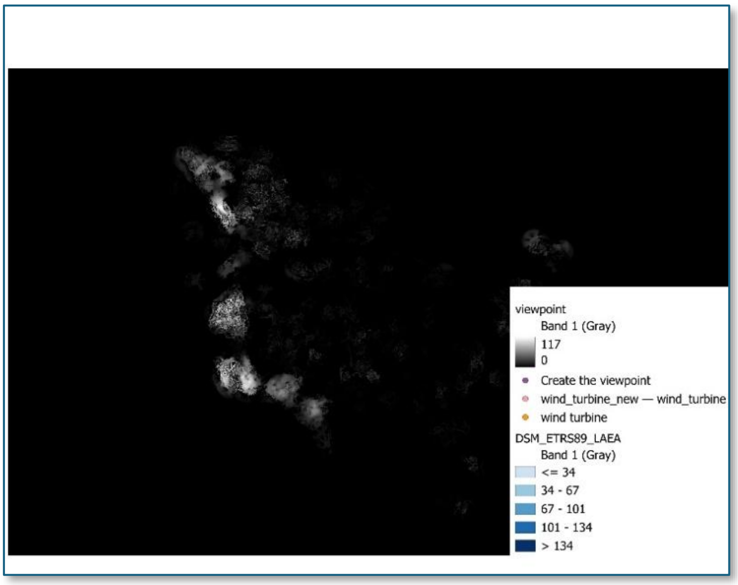
[Fig 6.2]



LAyer — Features Total: 3957, Filtered: 3957, Selected: 0

	fid	ID	observ_hgt	radius
1	1	2	200	30000
2	2	3	200	30000
3	3	4	200	30000
4	4	5	119	17850
5	5	6	126	18900
6	6	7	72	10800
7	7	8	200	30000
8	8	9	175	26250
9	9	10	175	26250
10	10	11	175	26250
11	11	12	175	26250
12	12	13	175	26250
13	13	14	150	22500
14	14	15	150	22500
15	15	16	150	22500
16	16	17	150	22500
17	17	18	150	22500
18	18	19	150	22500
19	19	20	60	9000

[Fig. 6.3]

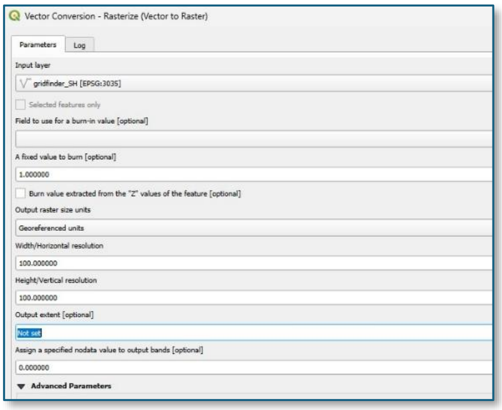


[Fig 6.4]

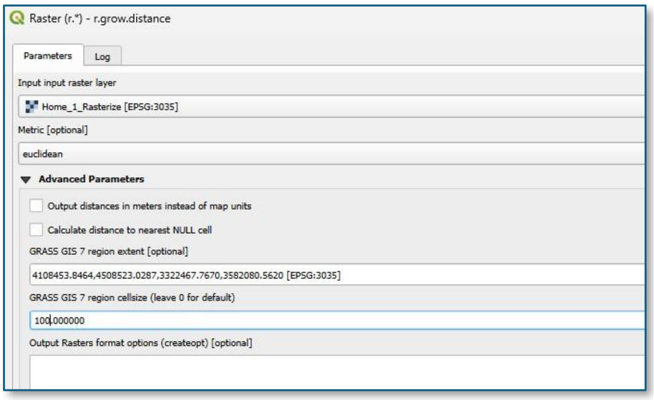
Exercise 7.1: Convert (Rasterize Vector to Raster) the electric grid layer to an input raster for distance mapping. Calculate the distance from the grid in metres (r.grow.distance).

Task 1: Convert (Rasterize Vector to Raster) the electric grid layer to an input raster for distance mapping. Burn value = 1, Cell size = 100m, Projection like grid line vector layer.

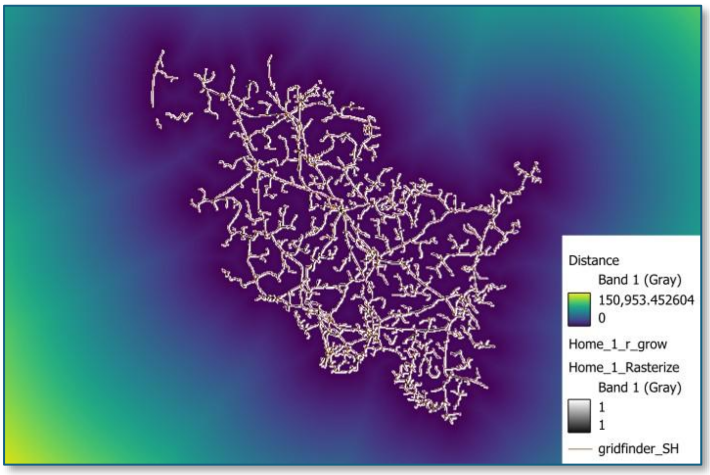
Step 1: Processing Toolbox → Vector to Raster → Select layers and filled out values [See Fig 7.1.1].



[Fig. 7.1.1]



[Fig 7.1.2]



[Fig 7.1.3]

Task 2: Convert (Rasterize Vector to Raster) the electric grid layer to an input raster for distance mapping. Burn value = 1, Cell size = 100m, Projection like grid line vector layer.

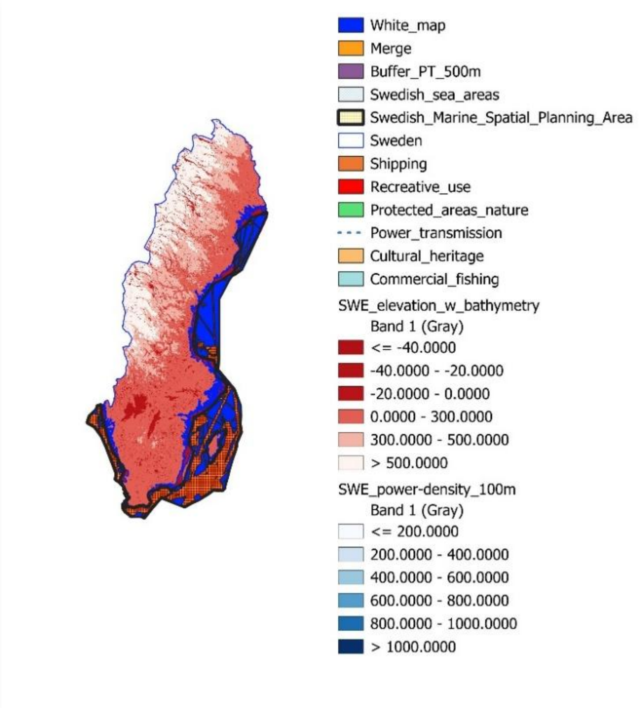
Step 2: Processing Toolbox → r.grow.distance → Select layers and filled out values [See Fig 7.1.2]. See Final Result of Exercise Fig 7.1.3.

Exercise 7.2: Make a simple noise map for a planned wind farm in priority area „PR1_NFL_036“

Exercise 8: Offshore Wind Energy Planning in Sweden

Task 1 & 2: Get the Data for Sweden from StudIP and visualise: bathymetry, wind power density, area constraints. Download bathymetry and wind power density for Sweden from the Global Wind Atlas.

Refer to Fig. 8.1. Download the bathymetry and wind power density data from the Global Wind Atlas and analyse them using a histogram. Divide the data into six distinct categories, each represented by a different colour. The files should be named **'SWE_elevation_w_bathymetry'** and **'SWE_power_density_100m'**. For the same figure, I have adjusted the colours and styles to enhance the visual representation of the presented area, such as, Swedish Sea area, Swedish marine spatial planning area, shipping, Sweden, recreative use, Protected area nature, Power transmission, cultural heritage and commercial fishing.



[Figure 8.1]

Task 3 & 4: Prepare a „white map" of sea areas without constraints or Only areas within the Swedish Marine Spatial Planning Area are to be considered.

Step 1: Vector → Geoprocessing tools → Buffer. I Created buffer of 500 m for Power Transmission and other buffer already created, resulting in a total of six buffered areas (Buffer_PT_500, Shipping, Recreative use, Protected area nature, cultural heritage and commercial fishing). [See Fig. 8.1]. **Step 2:** Vector General → Merge Vector Layers. Select six buffered area and merge them together. The result is No go Area [See Fig 8.1: Merge]. **Step 3:** Vector → Geoprocessing tools → Difference. Here, subtract the merged area from **"Swedish_sea_areas"** to find the difference area, which is "White map" of sea areas without constraints [See fig. 8.1: White map].