750532(Rahul Patil)

Wind Energy Planning and Applied Geoinformatics

Exercise: 1

Objective: - To visualize wind power potential and aspects that relate to wind energy utilization in a country of your choice.

Process: -

Download data on wind speed and wind power density at 100 meters for Sri Lanka from the Global Wind Atlas website.

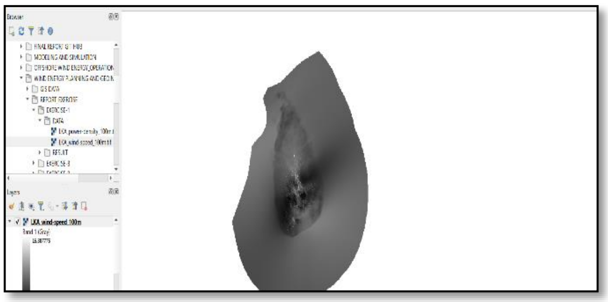

Figure:1.1:- Wind Speed map of Sri Lanka

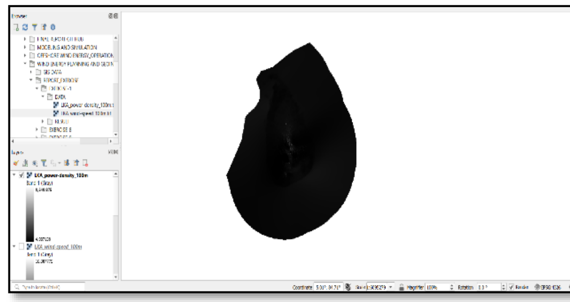

Figure:1.2:- Wind Power density map of Sri Lanka

Start a new project by selecting the New Project option (shortcut: Ctrl + N) from the toolbar. In the Browser Panel, locate and choose your data, such as LKA_wind-speed_100m. Next, go to the Layer Panel, select the required layer, right-click, and open Properties. Navigate to histogram to observe the spread of the data to focus on high values and then go to the Symbology, then under Band Rendering, select Single band pseudo color. Choose a Color Ramp and adjust the colors and divide the values to effectively visualize the layer. By this we can observe that at what location wind speed or Wind power density is high.

Output:

Now, we can identify regions with high wind speeds and wind power density.

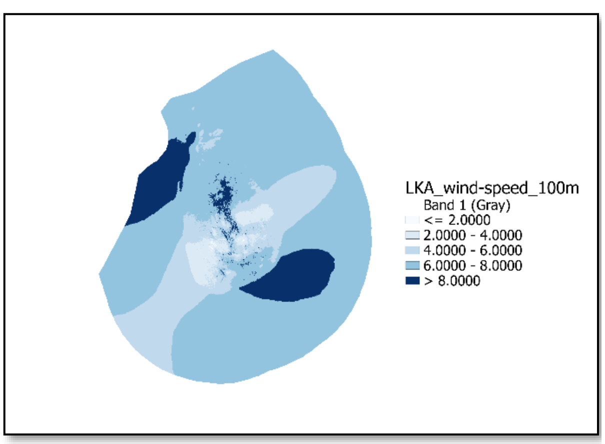

Figure:1.3:- High Wind zones of Sri Lanka

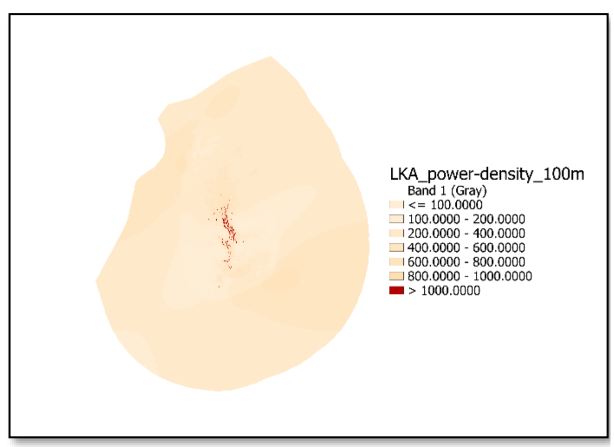

Figure:1.4:- High Wind Power Density zones of Sri Lanka

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Exercise : 2

Objective: - Download and visualize the wind speed and power density map for Denmark and add CSV file and decorations.

Process: -

To visualize the wind speed and power density for Denmark we followed same procedure as Exercise:1.

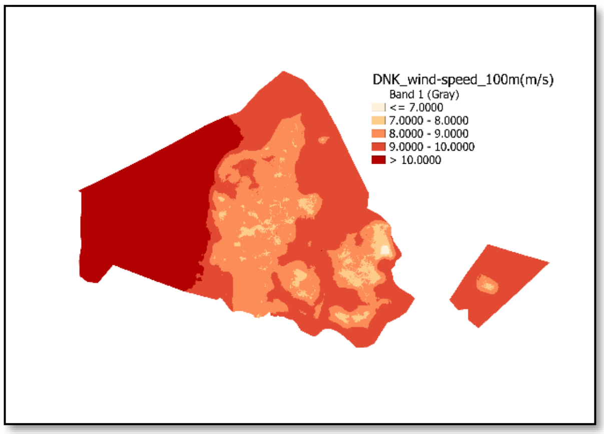

Figure:2.1:- High Wind Speed zones of Danmark

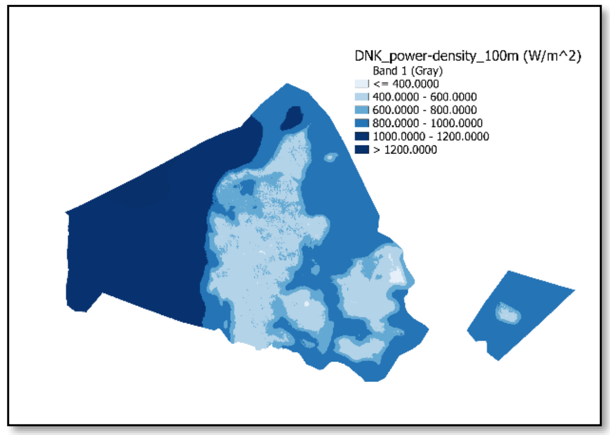

Figure:2.2:- High Wind Power Density zones of Danmark

Bring in data from a CSV file using the Delimited Text file method: In the menu, go to Layer, then select Add Layer, and choose Add Delimited Text Layer.

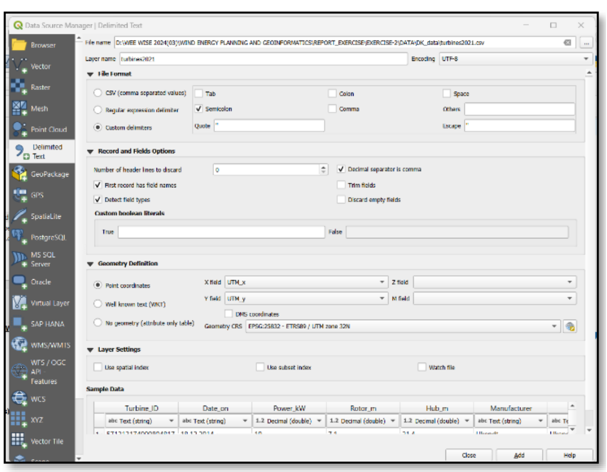

Figure2.3:- Add CSV file

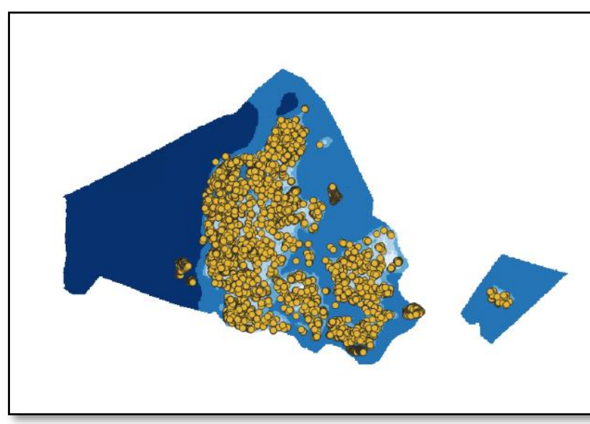

Figure:2.4:- Added Wind turbine

Right-click on the Layer and select Properties, then navigate to the Symbology tab. The objective is to represent the installed capacity of wind turbines. In the selection menu, choose the

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Graduated classification and set the value field to Power for visualization. And Similar process we have to follow for visualization based on Manufacturers.

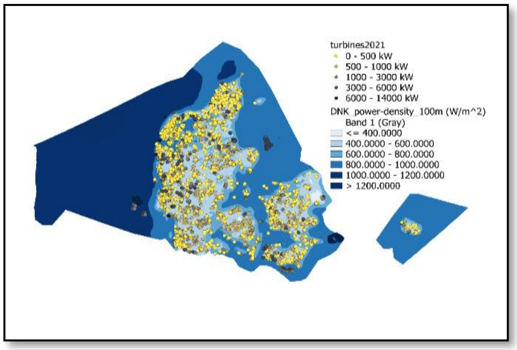

Figure:2.5:- Wind turbine based on power

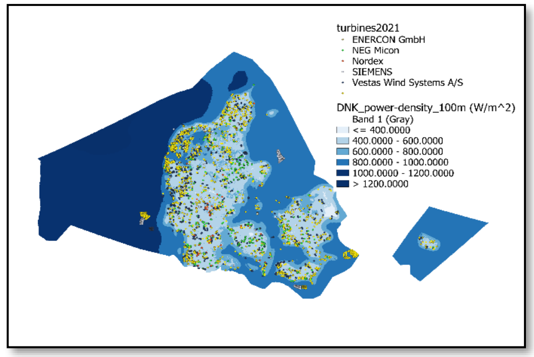

Figure:2.6:- Added Wind turbine based on Manufacturers

Output:

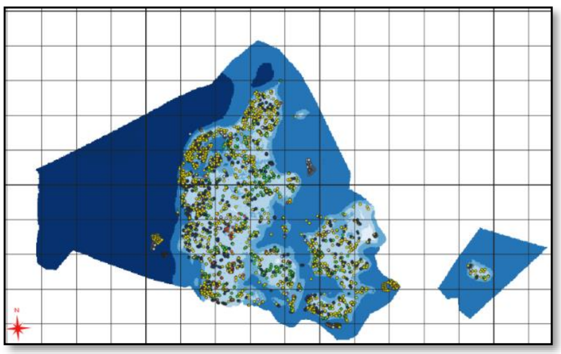

Figure:2.7:- Final Map with Decorations

Now, we have to add Grid to locate features with precise coordinates and North arrow to Indicates orientation, ensuring correct map interpretation.

Exercise: 3

Objective: Find potential wind energy locations in County Galway, Ireland

Process:

Download the Ireland shapefile along with other relevant datasets, including Turbines, OSM land use, Residential Areas, Protected Areas, Natural Areas, and Main Roads. These datasets are available in the exercise file from Stud IP.

Now from OSM land use file we have to select only forest area for further analysis, for that go to the attribute table of OSM land use, select by expression and select 'fclass' = Forest, and save it as a new layer. The same process we have to follow for extracting regions of Wind power density less than 900 W/m^2.

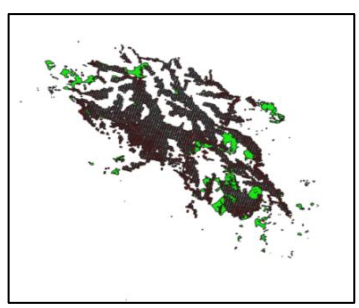

Figure:3.1:- forest and WPD less than 900 w/m^2

Now we have to find all wind turbines less than 5km away from natural heritage sites, for that, in processing toolbox select vector selection-select within distance. And then We have to produce white map, for that we have to create buffer of 1 kM from Special Areas of Conservation and Natural Heritage Sites, residential areas, 0.5 kM from Wind turbines and 0.2 kM from main roads.

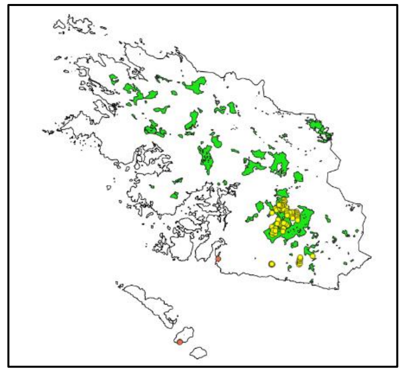

Figure:3.2:- Wind turbines 5kM away from Nat.Haritage

Next, Merge all no-go areas (buffers and other unsuitable areas) with merge vector layers tool. And after that erase all no-go areas from Co. Galway using the Difference tool, so that we can find out potential wind energy locations in County Galway, Ireland.

Output:

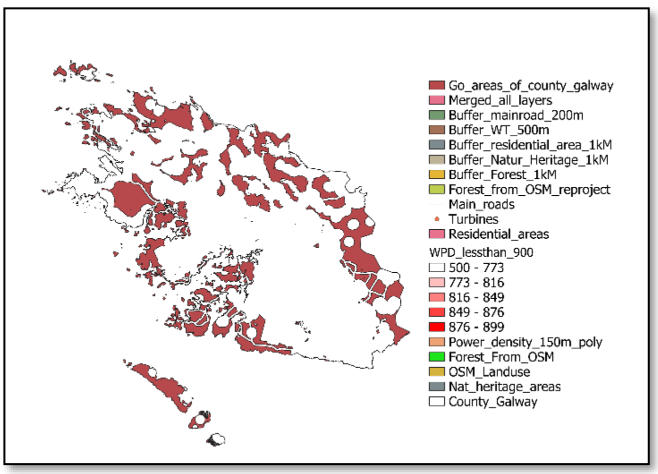

Figure:3.3:- Potential wind energy locations in County Galway, Ireland.

With this Output layer we can find out the Suitable wind energy locations without any constrain in county Galway

Exercise: 4

Objective: local wind farm planning in Lindewitt Municipality, Schleswig-Holstein

Process:

First extract all the data (Geodata regional Planning) related to the exercise from Stud IP.

Next, separate goals and Principles into two different groups, where goals are binding regulations that must be followed in regional planning. They define strict exclusion or restriction zones where wind energy development is **prohibited** or **limited**, such as near settlements, military areas, and nature reserves. And Principles are guidelines that **should be considered** but allow for some flexibility. They influence decision-making but do not strictly prohibit wind energy development. Principles include aspects like maintaining landscape aesthetics, preserving biotopes, and ensuring tourism compatibility.

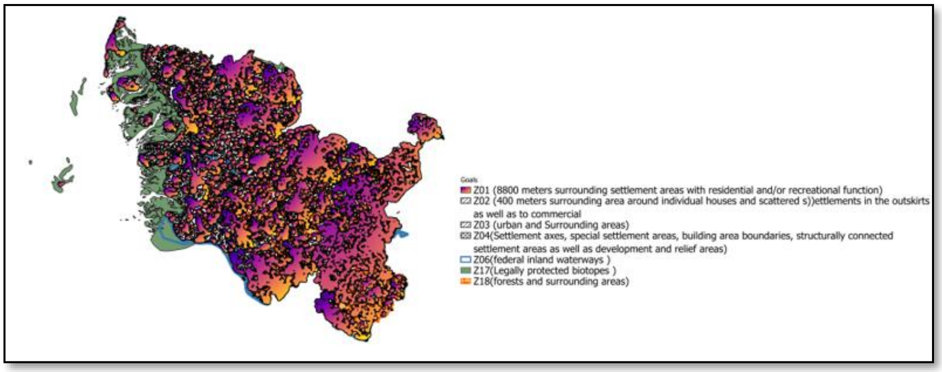

Figure:4.1:- Goals

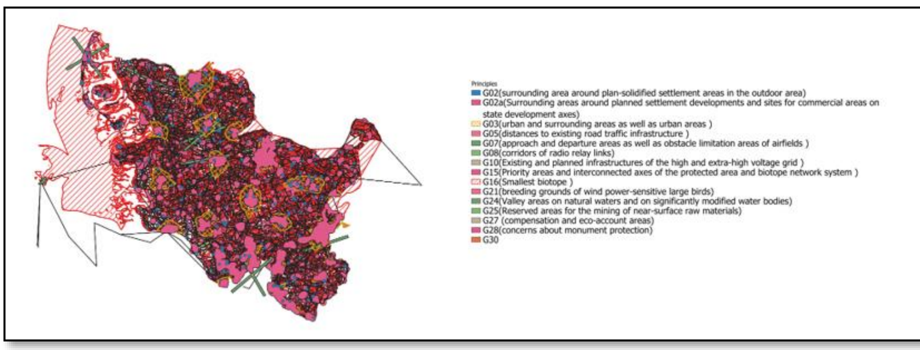

Figure:4.2:- Principles

Now, add Turbine using delimited text layer and create buffer of 1000 m around wind turbine and then use difference tool to get white map without existing wind turbines.

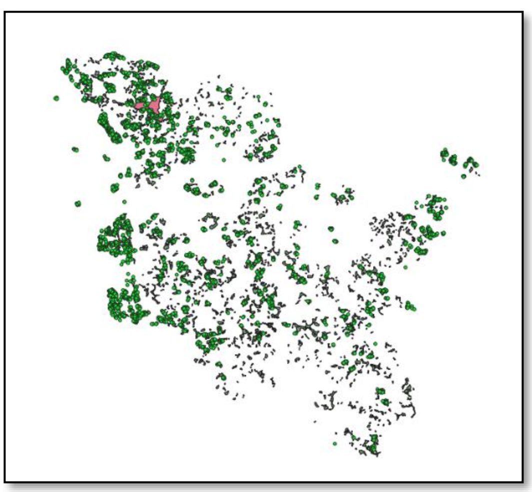

Figure:4.3:- Add WT using Delimited text layer

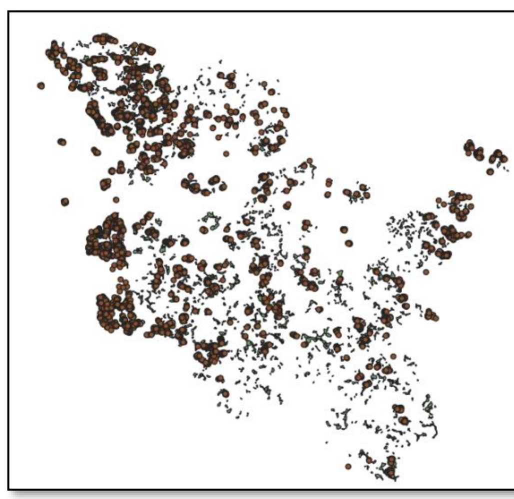

Figure:4.4:- Buffer around WT

Output:

Goals (Z) contribute by defining clear exclusion zones, ensuring wind farms do not interfere with Settlement areas (8800m buffer), Military and aviation infrastructure (e.g., airfields, radar stations, Environmental protection areas (e.g., bird sanctuaries, forests, wetlands). While Principles (G) contribute by offering flexible planning considerations such as maintaining certain buffer distances from roads and settlements encouraging placement in areas with minimal ecological disruption, prioritizing landscape conservation and tourism-friendly zones.

Figure:4.5:- Wind farm development map for an area without existing wind turbines

Exercise: 5

Objective: Editing Points, Lines and Polygons

Process:

First, add file ‘Wind_Prio_Areas_2020’ and then extract ‘PR1_NFL_036’ area from file ‘Wind_Prio_Areas_2020’ by using select by using Expression tool.

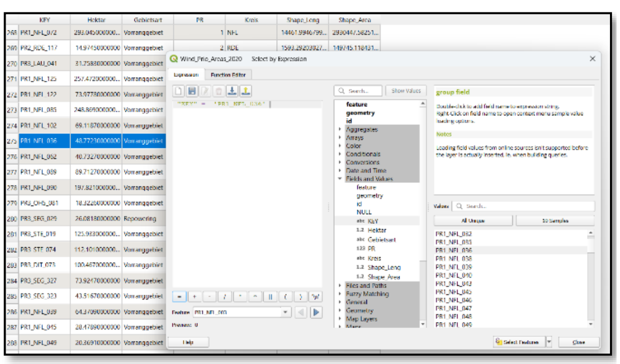

Figure:5.1:- Extract area PR1_NFL_036

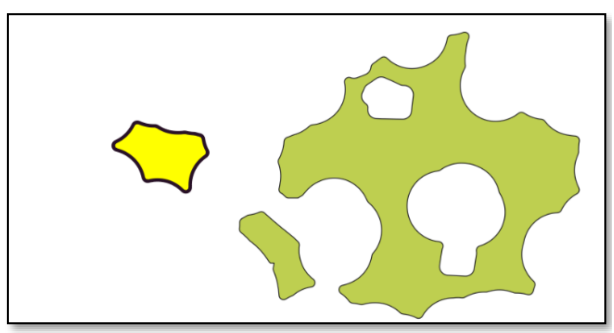

Figure:5.2:- Extracted area PR1_NFL_036 in yellow

Now, add ESRI World Imagery or any other high-resolution image as a backdrop for digitalization, go to the map and Quick map service to add ESRI imagery. And then, to add the location of wind turbines (points), Create a new shapefile layer and add attributes for the wind turbine. Click Toggle Editing, then choose Add Point Feature and place a point near the wind turbine.

Figure:5.3:- Added Wind turbine layer

The same process should be followed for creating agricultural fields, but in geometry type select polygon. And then while making fields by polygon use snapping tool to create features that connect to each other and are coincided, so edits are more accurate, with fewer errors.

Output:

This enables highly efficient and precise wind farm planning in a region. It improves data analysis, visualization, and decision-making while also aiding conflict resolution between farmers.

Figure:5.4:- output layer

Exercise: 6

Objective: Visibility Analysis in QGIS and Visualize the Result with color and transparency.

Process:

To install the Viewshed Analysis Plugin, open the menu and select Plugins. Then, go to Manage and Install, search for Visibility Analysis, and select it. Finally, proceed with the installation.

Import the data such as DSM_ETRS89_LAEA and Wind turbines for Schleswig-Holstein.

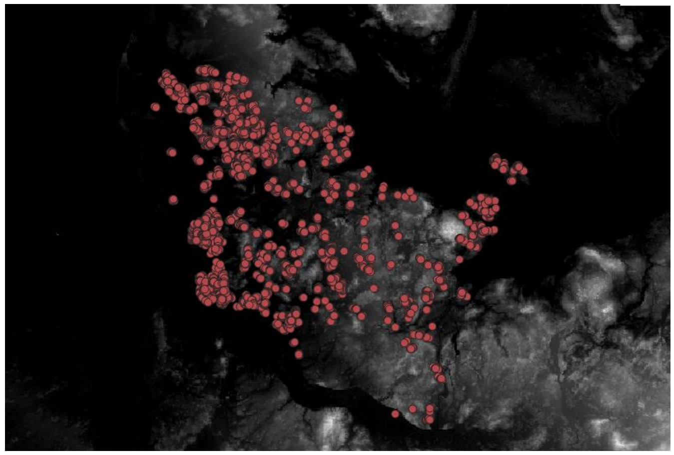

Figure:6.1:- Wind turbines in SH

Now, We have to create view point, for that we need to add two columns in to attribute table, the first is Observer height H [m] = hub height + 0.5 * rotor diameter, and second is Radius = 150 x turbine height. This can be created by selecting field calculator attribute table.

Next, we have to calculate the binary viewshed of existing wind turbines, for that go to the Viewshed tool and Choose the Observer Location, which is the Turbine Shape File. Save your settings and execute the process by clicking Run.

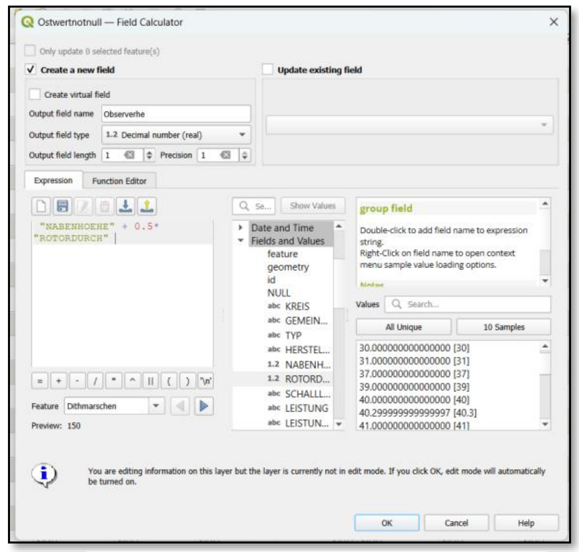

Figure:6.2:-Add viewpoints

Output:

This output is used to determine the areas that are visible from a specific point or multiple points in a landscape. It helps analyze the line of sight, considering terrain elevation, obstacles, and structures.

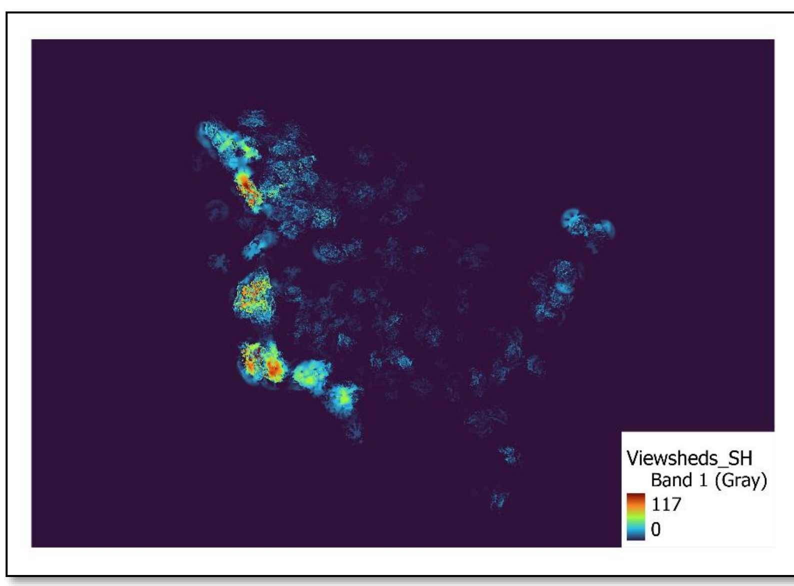

Figure:6.3:- viewshed

Exercise:7.1

Objective: Convert (Rasterize Vector to Raster) the electric grid layer to an input raster for distance mapping.

Process:

If, We want to find out the distance of grid from particular location so therefore we have to convert the Vector data in to Raster data by using Rasterize (Vector to raster) tool from processing tool box.

Then, calculate the distance from the grid in meters by using r.grow.distance tool, and select Metric = Euclidean to measure the distance in straight line.

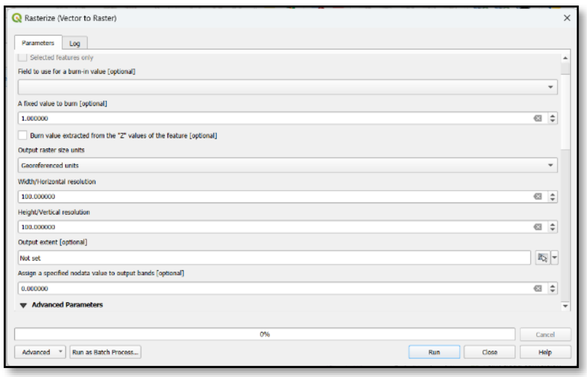

Figure:7.1.1:- vector to raster

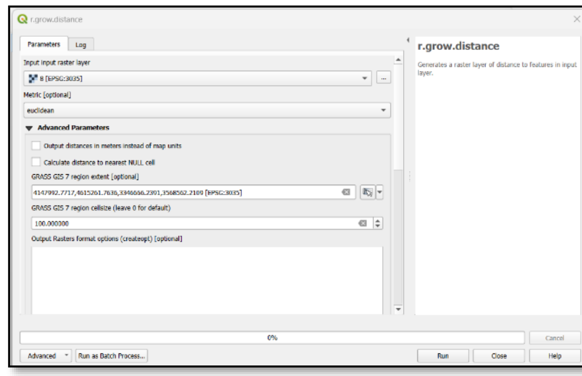

Figure:7.1.2:- Calculate Distance by r.grow.distance tool

Output:

Based on this output, we can find out the distance from the grid.

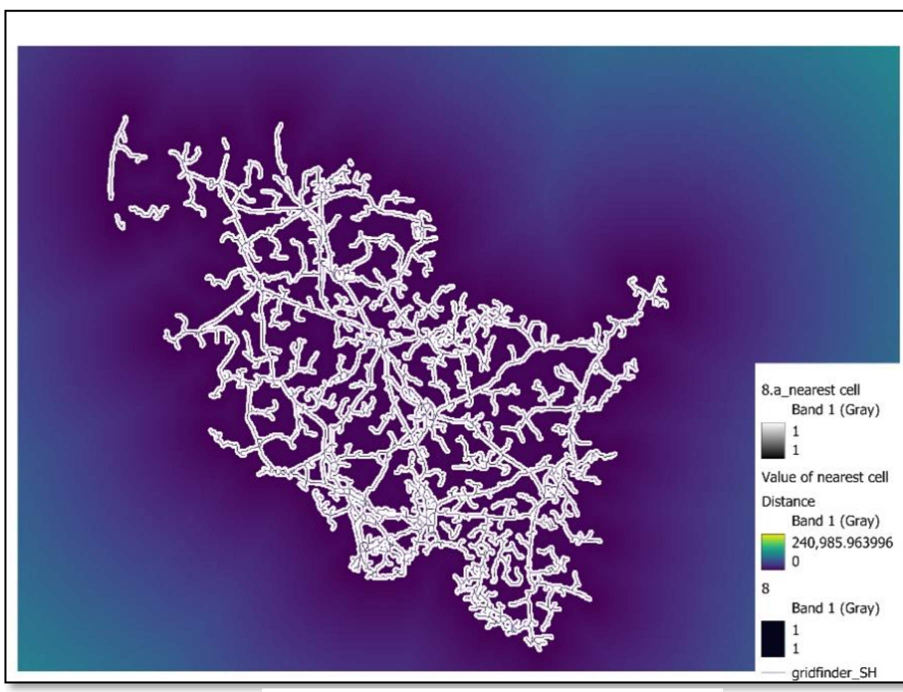

Figure:7.1.3:- Output layer with distance

Exercise : 7.2

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

Process:

We have to retrieve data such Municipalities, Wind priority area and Wind turbines from stud IP.

Then to make noise map of wind turbine we have to retrieve area ‘PR1_NFL_036’ from wind priority area by select by using expression and similarly retrieve a wind turbine for which we want to make noise map from Wind turbine file.

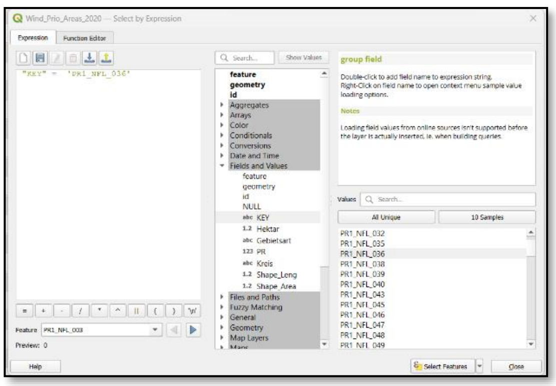

Figure:7.2.1:- Select by expression

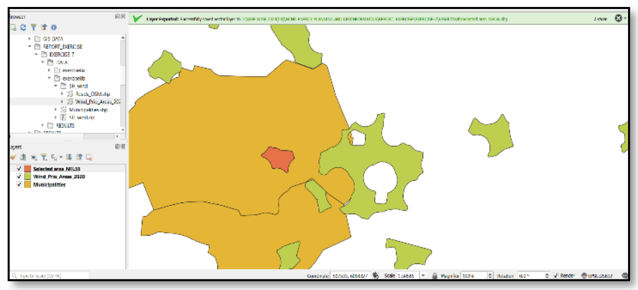

Figure:7.2.2:- Retrieved area PR1_NFL_036

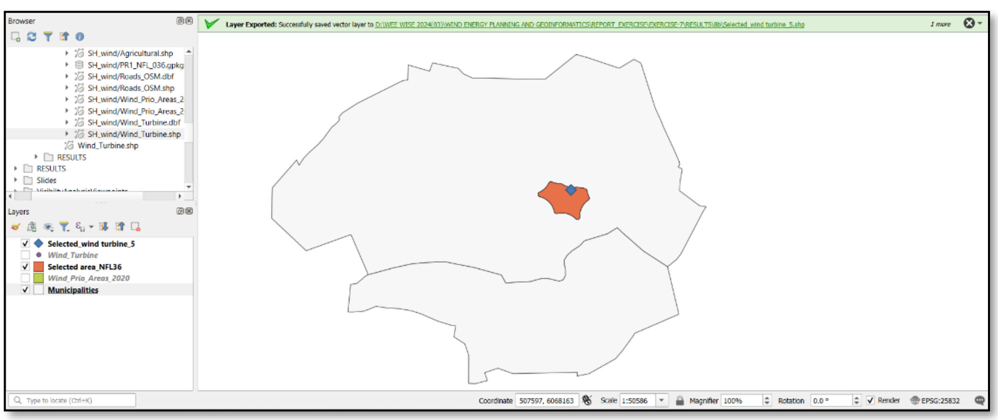

Figure:7.2.3:- Selected one Wind Turbine from area PR1_NFL_036

Now, after selecting one wind turbine we have to convert it into rasterized data to measure noise propagation. So, select vector to raster tool and select the turbine layer as input layer and after that use ‘r.grow.distance’ tool to calculate the distance.

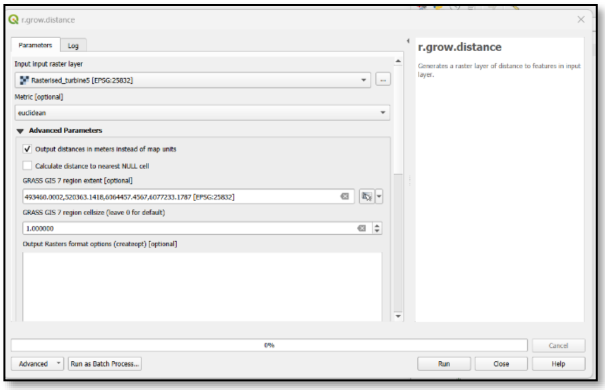

Figure:7.2.4:- r.grow.distance to measure the distance

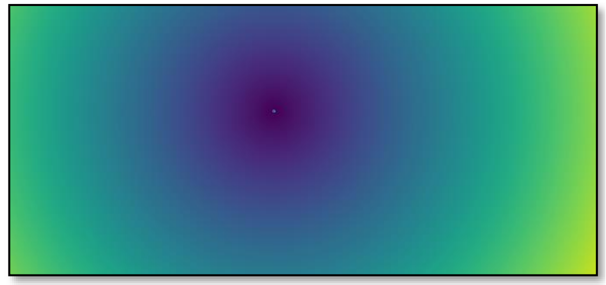

Figure:7.2.5:- Output of calculated distance

Next, Use Raster Calculator to calculate how noise decreases with distance from the turbine, from Raster Menu and use $L_p = (L_W - 10\, log_{10}(2 * 3.14 * r^2) - (a * r))$ Where, L_W is Noise at turbine, r is distance and a is atmospheric absorption (0.005 dB/m).

Output:

This noise map helps to identify the propagation of sound around the surrounding.

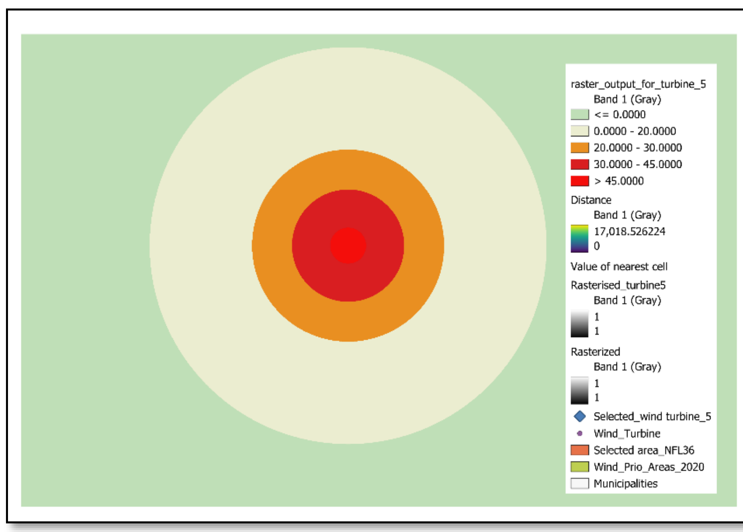

Figure:7.2.6:- Noise Map

Exercise: 8

Objective: Offshore Wind Energy Planning in Sweden

Process:

Download the data of bathymetry and Wind power Density of Sweden from the global wind atlas, and navigate to histogram to observe the spread of the data to focus on high values and then go to the Symbology, then under Band Rendering, select Single band pseudo color. Choose a Color Ramp and adjust the colors and divide the values to effectively visualize the layer. By this we can observe that at what location depth or Wind power density is high.

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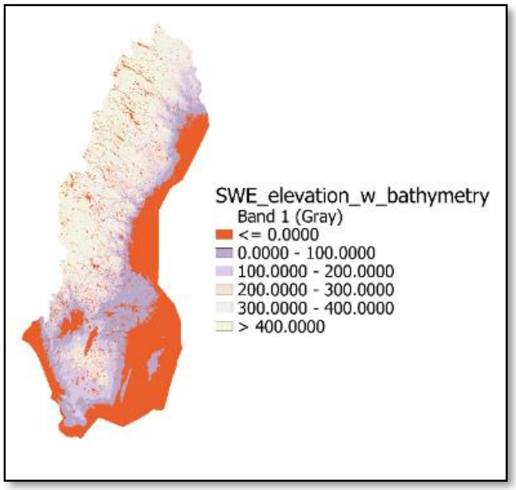

Figure:8.1:- Bathymetry of Sweden

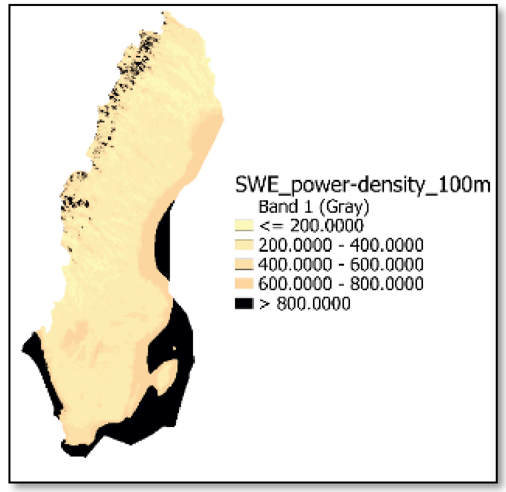

Figure:8.2:- Wind Power Density of Sweden

Now, all buffers are available except for the Power Transmission Line. First, generate a 600 m buffer for the Power Transmission Line using the Buffer Tool. Next, merge all buffers, including Commercial Fishing, Cultural Heritage, Powerlines, Protected Areas, Recreational Use, and Shipping, to create a No-Go Areas layer.

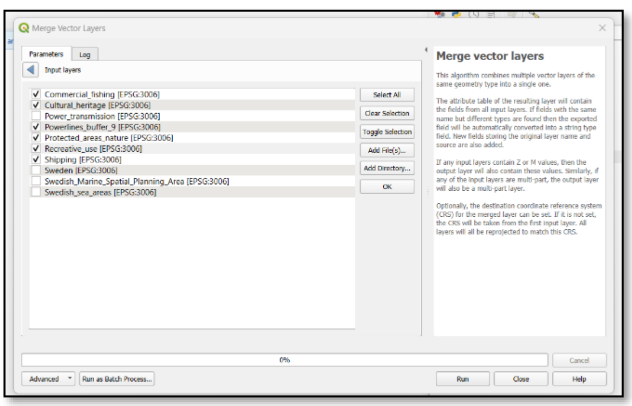

Figure:8.3:- Merge tool

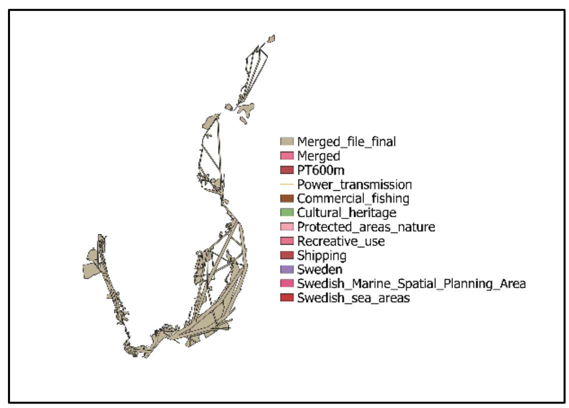

Figure:8.4:- Merged layer for No go Areas

Now, utilize the Difference tool in Geoprocessing Tools to subtract the merged buffer area from "Swedish_sea_areas." This will generate the remaining area, representing a "White Map" of sea regions without constraints.

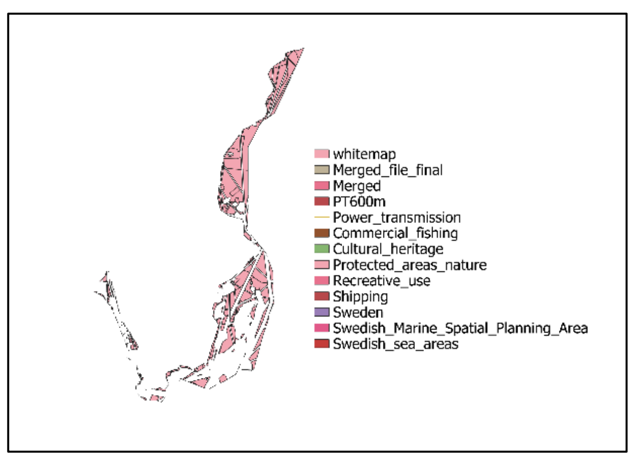

Figure:8.5:- White Map

Output:

Given maps identify the suitable locations for wind farm planning in Sweden.

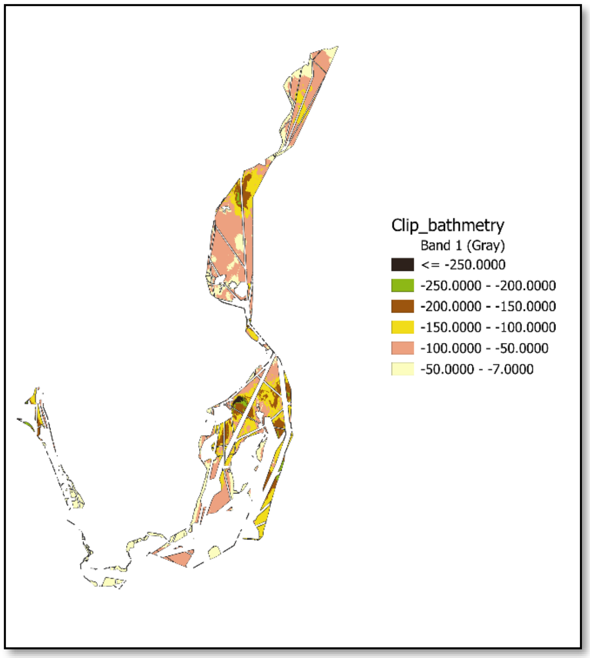

Figure:8.6:- Clip bathymetry

Figure:8.7:- Clip power density

Exercise: 9

Objective: Find good locations for wind turbine development in Sri Lanka.

Process :

We have to find a location in Sri Lanka with Good wind resource, Absence of population / distance to population, Proximity to roads and the grid, Suitable land use and Low slope.

We have data for Grid, Population, Wind power density, Landcover, and slop from the stud IP. The first step we have to take is to convert the Grid vector data to raster data, for that use the tool vector to raster.

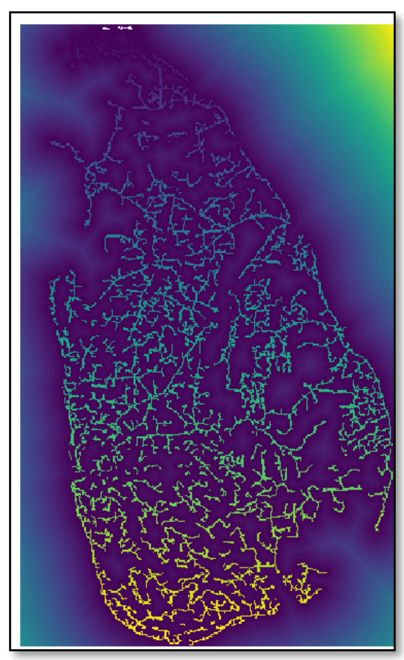

Figure:9.1:- Rasterized Grid data

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Now we have all the data, and we need to classify the data from 0 to 9, Let 9 be the best location, while 0 is a location to be excluded. So, starting with Wind power density data which was from 4.48 to 4210 W/m^2, reclassify that data from 0 to 9, where high wind density regions are 9 and lesser is 0. Same procedure of reclassification followed for Slop, landcover, Grid and Population data and results are given in figures.

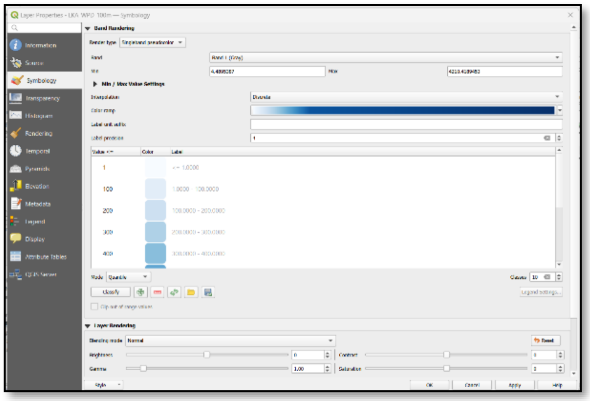

Figure:9.2:- WPD data Spread

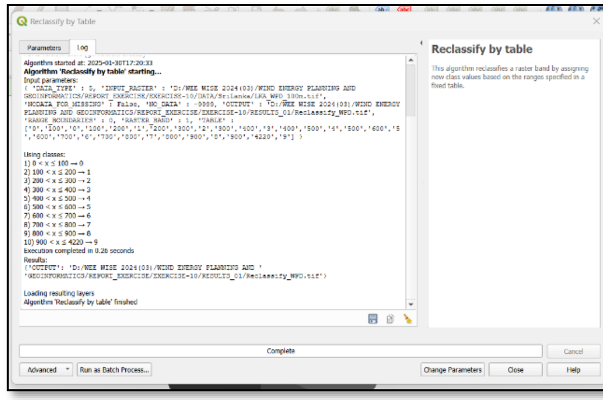

Figure:9.3:- Reclassification of Wind

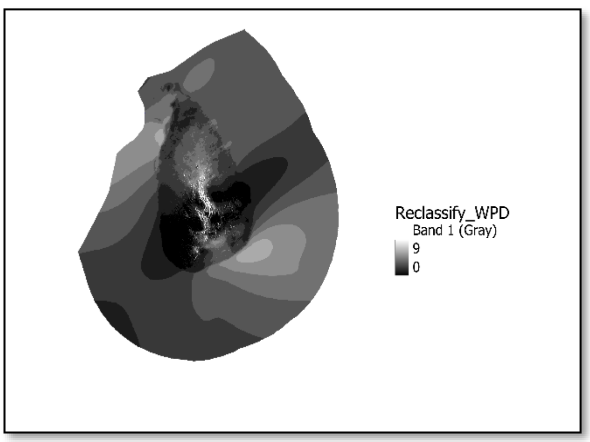

Figure:9.4:- Reclassified WPD data

Figure:9.5:- Reclassified SRTM data

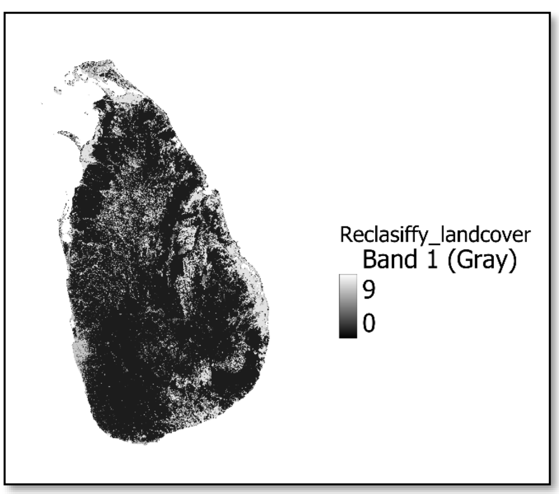

Figure:9.6:- Reclassified Land cover data

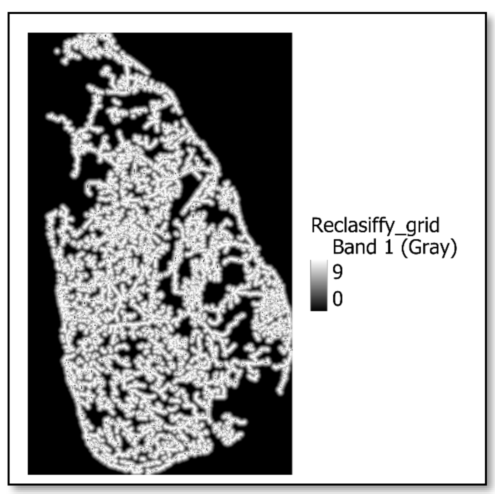

Figure:9.7:- Reclassified Grid data

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Now, after reclassification Consider weights w for each parameter P and Add the weighted parameters with individual weights in the Raster Calculator, which is available in Raster menu:

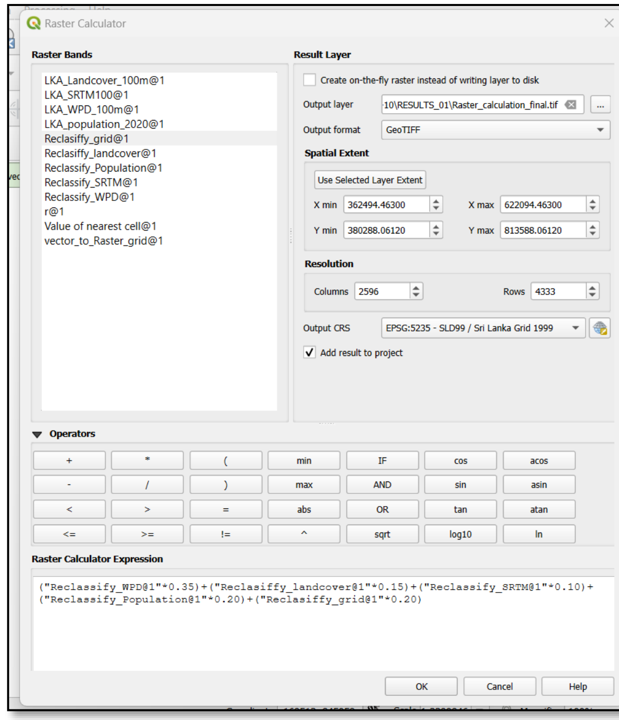

Figure:9.8:- Raster Calculator

Output:

This final map identifies suitable locations for Wind-turbine development in Sri Lanka with good Wind resource, low height, without forest and availability of electric grid in nearby areas.

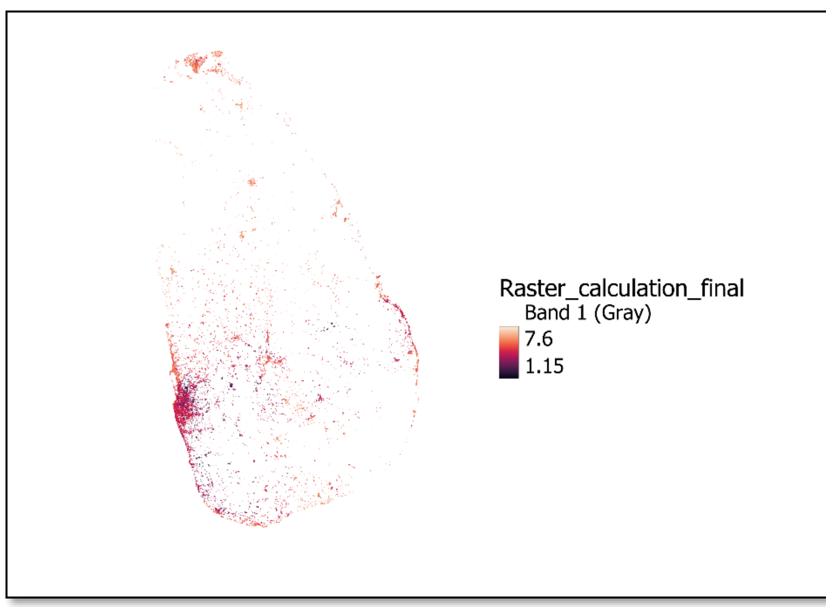

Figure:9.9:- Final Map of good location for Wind turbine Development