SUITABILITY ANALYSIS

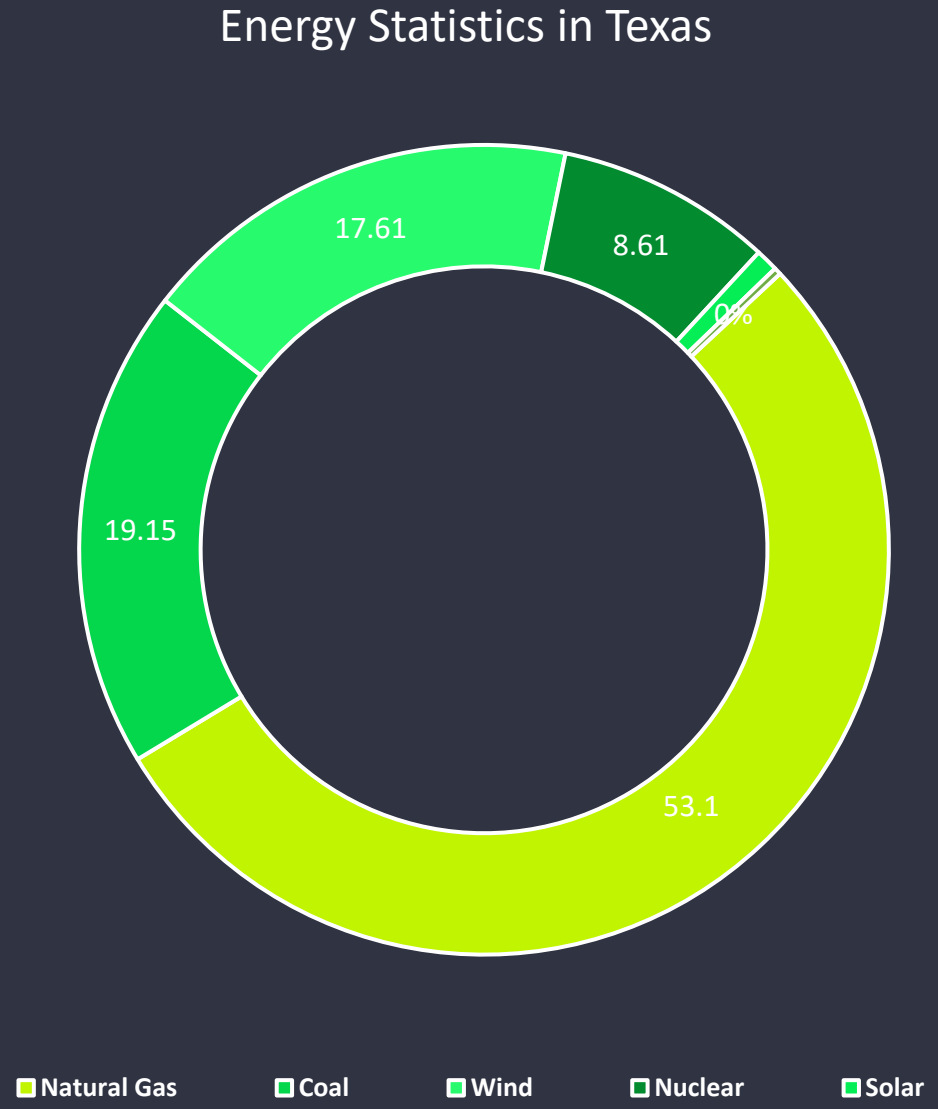
Wind Farms

ENERGY TODAY

Electric Grid Mix

- As our need for alternative energy increases, we can use the Suitability Analysis Model to select sites for offshore wind farms near Corpus Christi and around the coast regions of Texas.

Natural Gas	53.1
Coal	19.15
Wind	17.61
Nuclear	8.61
Solar	0.9
Biomass	0.28

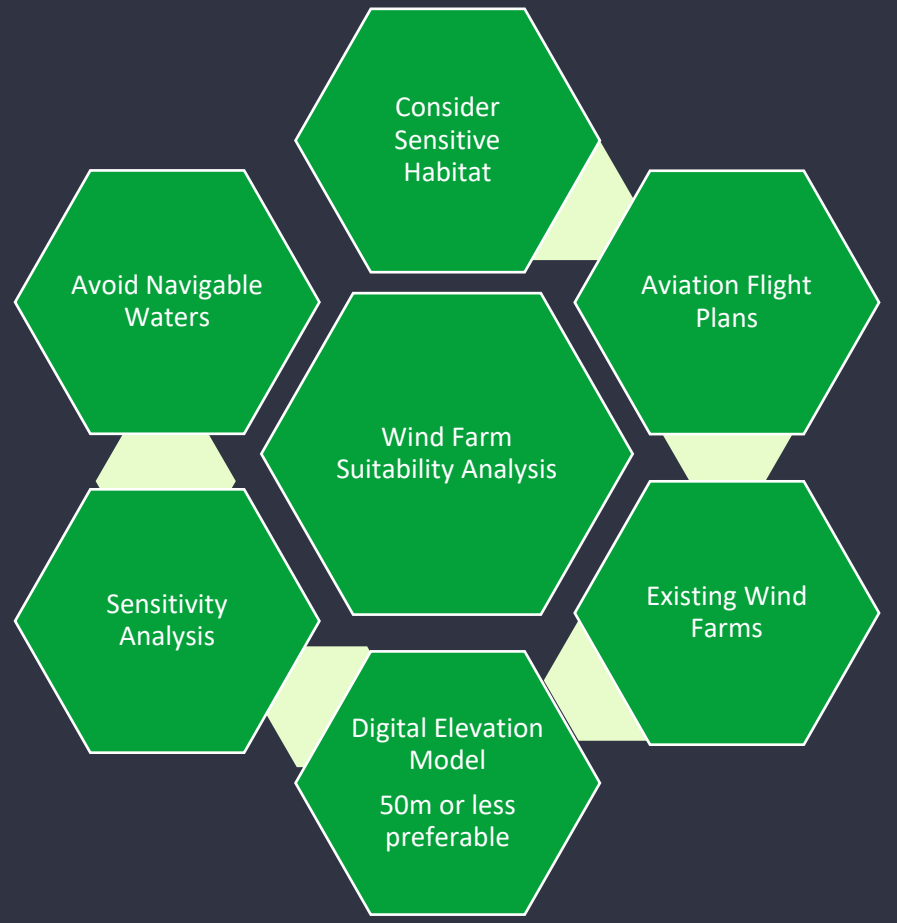


METADATA – WIND FARM SUITABILITY

Name of Layer	File	Source	Provenance
Wind	wtk_conus_100m_mean_masked.tif	https://data.nrel.gov/submissions/70	Compressed geodatabases containing statistical summaries aligned with lease blocks (aliquots) stored in a GIS format. These data are partitioned into Pacific, Atlantic, and Gulf resource regions.
Corpus Christi 1/3 arc Elevation Model	corpus_christi_13_mhw_2007.nc	https://www.ngdc.noaa.gov/mgg/coastal/grddas05/grddas05.htm	2007 Corpus Christi, Texas 1/3 arc-second MHW Coastal Digital Elevation Model
Navigation Districts	GDB_NavDist.Zip	https://www.glo.texas.gov/land/land-management/gis/index.html	Submerged lands granted with mineral reservations by the Texas legislature to Navigation Districts. - Updated 28 Feb 2017
United States Wind Turbine Database	uswtdb_v3_1_20200717.shp	https://eerscmap.usgs.gov/uswtdb/	Utility-scale turbines are ones that generate power and feed it into the grid, supplying a utility with energy. – updated Quarterly - 202007
Coastal Boundary	CoastalZoneBoundary.shp	https://www.glo.texas.gov/land/land-management/gis/index.html	The official boundary of the Texas Coastal Management Program (CMP).
Public Beaches	PublicBeachAccess	https://www.glo.texas.gov	Public Beaches around Corpus Christi, Texas

References: Offshore Wind Energy Facility Characteristics – Musial, Walt (2018) NREL

LOGIC BEHIND A WIND FARM SUITABILITY ANALYSIS



aviation flight plans would be required if an application for a windfarm permit is pursued

PYTHON

windfarm Suitability Analysis

REPROJECT VECTORS

```
def reproject (layer):

    "This is the function that reproject the vector layer
s"

    master_crs = 'EPSG:26914'

    if layer.crs != master_crs:

        #print(list_of_lables[idx], 'is not on the master
 projection, reprojecting now..')

        layer = layer.to_crs(master_crs)

        print (layer.crs, 'and', master_crs)


    return layer
```

REPROJECT RASTERS

```
def reproject_r(in_path, out_path):
    'This is the function to reproject the raster data '
    dst_crs = 'EPSG:26914'
    with rasterio.open(in_path) as src:
        transform, width, height = calculate_default_transform(
            src.crs, dst_crs, src.width, src.height, *src.bounds)
        kwargs = src.meta.copy()
        kwargs.update({
            'crs': dst_crs,
            'transform': transform,
            'width': width,
            'height': height
        })
        with rasterio.open(out_path, 'w', **kwargs) as dst:
            for i in range(1, src.count + 1):
                reproject(
                    source=rasterio.band(src, i),
                    destination=rasterio.band(dst, i),
                    src_transform=src.transform,
                    src_crs=src.crs,
                    dst_transform=transform,
                    dst_crs=dst_crs,
                    resampling=Resampling.nearest)
    return(out_path)
```

SUITABILITY ANALYSIS

```
hab_Raster = rasterio.open(in_data_dir + './habitat_ras.tif'  , 'r')
hab_arr = hab_Raster.read(1)
hab_Raster.meta
suit_hab = np.where(hab_arr == 1, 0, 1)
show(suit_hab)
print('The number of sites ', suit_hab.sum())

dem_raster =  rasterio.open(in_data_dir + './depth_ras.tif', 'r')
dem_arr = dem_raster.read(1)
dem_raster.meta
dem_suit = np.where(dem_arr == 1, 1, 0)
show(dem_suit)
print('The number of sites ', dem_suit.sum())

speed_Wind_Raster = rasterio.open(in_data_dir + './wind_suit.tif', 'r')
Wind_arr = speed_Wind_Raster.read(1)
speed_Wind_Raster.meta
Suit_speed_wind = np.where(Wind_arr == 1, 1, 0)
show(Suit_speed_wind)
print('The number of sites ', Suit_speed_wind.sum())

beach_buff_Raster = rasterio.open(in_data_dir + './beaches_buff.tif', 'r')
beach_arr = beach_buff_Raster.read(1)
beach_buff_Raster.meta
suit_beach = np.where(beach_arr == 0, 0, 1)
show(suit_beach)
print('The number of sites ', suit_beach.sum())

meta = speed_Wind_Raster.meta
meta.update({'dtype':'int32', 'nodata' : 0})

sum_area = suit_eas + suit_no_oil + suit_leases + suit_navdist + suit_hab +
Suit_speed_wind + dem_suit + suit_beach
suit_arr = np.where(sum_area == 8, 1, 0)
show(suit_arr)
print('Total area of suitable sites is ', suit_arr .sum())

#export windfarm sites to raster
with rasterio.open(in_data_dir + './suit_windfarm.tif', 'w', **meta) as ds:
    ds.write_band(1, suit_arr)
```

ELEVATION ZONAL STATS

```
#compute elevation statistics for each of the proposed windfarm sites (sites are greater than 60ha)

def get_zonal_stats(vector, raster, stats):

    # Run zonal statistics, store result in geopandas dataframe

    result = zonal_stats(vector, raster, stats=stats)

    df = pd.DataFrame(result)

    return df


stats = get_zonal_stats(in_data_dir + './suit_sites_UID.shp' ,in_data_dir + './reproject_corpuschristi_dem.tif', stats=['mean', 'min', 'max', 'count'])

stats.to_csv(in_data_dir + './elevation_stats.csv')

stats[stats['count'] > 60]
```

ID	min (m)	max (m)	mean (m)	area (ha)
0	-16	-12	-14.31	303
1	-18	-12	-15.00	1030
2	-4	-3	-3.96	67
3	-4	-3	-3.03	74
4	-4	0	-3.26	1036
5	-10	-6	-9.35	112
6	-10	0	-2.34	1863
7	0	0	0.00	149
8	-4	-3	-3.70	67
9	-4	-2	-3.64	315
10	-5	-2	-3.97	812
11	-3	-1	-1.92	61
12	-3	-1	-2.62	89
13	-4	-3	-3.93	61
14	-4	-4	-4.00	216
15	-5	-2	-4.32	1463
16	-4	0	-3.30	1591
17	-5	-4	-4.72	61
18	-4	0	-3.46	107

PYTHON CODE

mbtamucc/windfarm_GEOG5092: geog5092 programming and automation group project (github.com)

Please click the hyperlinked button to find the github repository. There, you'll also find the rasters used as inputs for the analysis

created by: windfarm team

Repository stored on github

Group collaboration

Work in progress for efficiency, nearest neighbor, distance analysis

REFERENCES

- Sanjeev Malhotra (2011). Selection, Design and Construction of Offshore Wind Turbine Foundations, Wind Turbines, Dr. Ibrahim Al-Bahadly (Ed.), ISBN: 978-953-307-221-0, InTech, Available from: http://www.intechopen.com/books/wind-turbines/selection-design-and-construction-of-offshore-wind-turbinefoundations

- 2018 - NREL - What-Does-an-Offshore-Wind-Energy-Facility-Look-Like.pdf PowerPoint Presentation (boem.gov)

- In addition to the labs and readings from both GEOG5090 Environmental Modeling with GIS and GEOG5092 Programming and Automation

WIND FARM SUITABILITY ANALYSIS

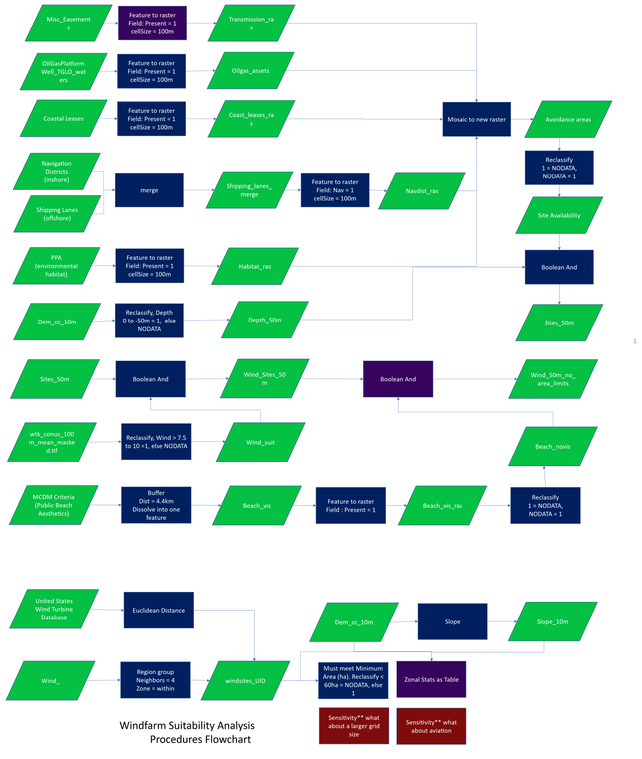
Problem

As our need for alternative energy increases, we can use the suitability analysis model to select sites for offshore wind farms near Corpus Christi, Texas.

Introduction

A Corpus Christi energy company approached the windfarm team to identify offshore areas for suitable wind farm sites to support 300MW of capacity. In 2015, the typical wind turbine produced 6MW of energy, is 100m in height and has a 150m meter rotor size. To support a capacity of 300MW proposed energy, a typical grid size 60ha will be required. To put into perspective a 30MW grid supplies electrictiy to 17k homes. Corpus Christi has 117k homes.

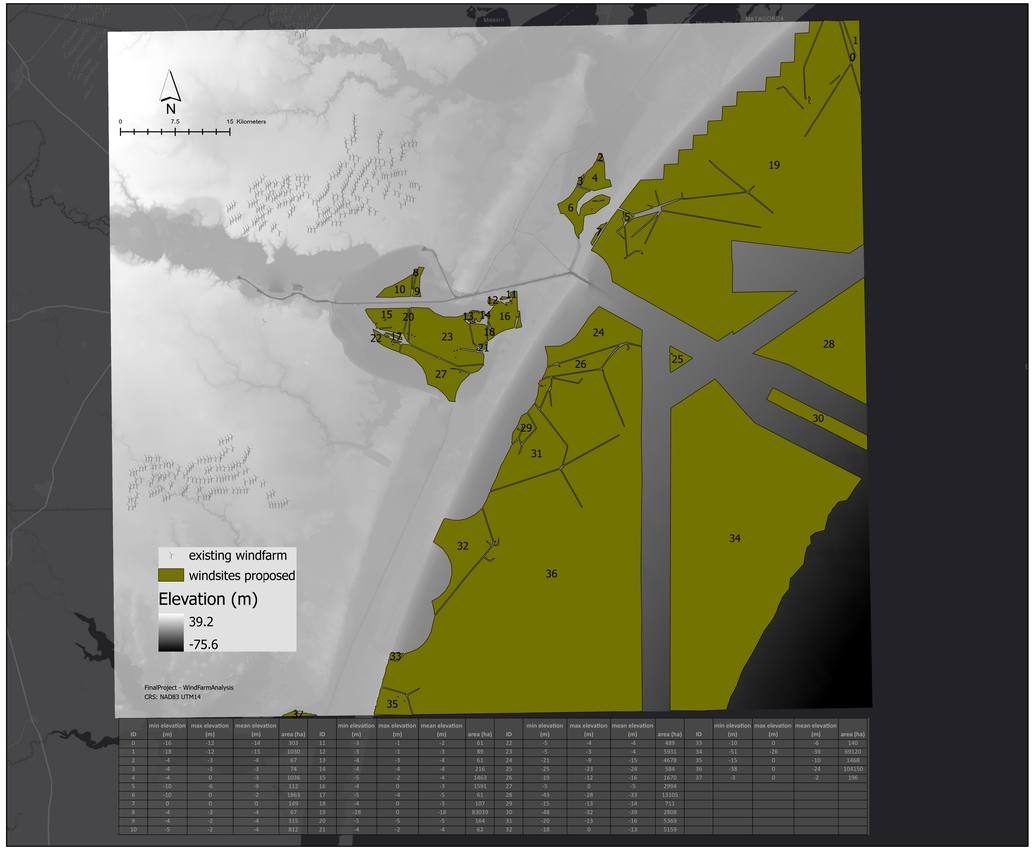
Sensitivity Analysis Model



Windfarm Suitability Analysis Procedures Flowchart

Methodology

We integrated seven different variables in our python environment to find suitable windfarm sites . Vector data is clipped, reprojected and rasterized using a function, and compiled into a single new raster. Raster data is reprojected and clipped to the target area. Unique values are assigned identifiers on all rasters and avoided areas are left with nodata. The final map indicates suitable areas which meet all the criteria presented.



ID	min elevation (m)	max elevation (m)	mean elevation (m)	area (ha)	ID	min elevation (m)	max elevation (m)	mean elevation (m)	area (ha)	ID	min elevation (m)	max elevation (m)	mean elevation (m)	area (ha)	ID	min elevation (m)	max elevation (m)	mean elevation (m)	area (ha)
0	-16	-12	-14	303	11	-3	-1	-2	81	22	-5	-3	-4	489	33	-10	0	-6	140
1	-18	-12	-15	1030	12	-3	-1	-3	89	23	-5	-3	-4	5931	34	-51	-26	-39	69120
2	-4	-3	-4	67	13	-4	-3	-4	61	24	-21	-9	-15	4678	35	-15	0	-10	1448
3	-4	-3	-3	74	14	-4	-4	-4	216	25	-25	-23	-24	584	36	-38	0	-24	104150
4	-4	0	-3	1036	15	-5	-2	-4	1463	26	-19	-12	-16	1670	37	-3	0	-2	196
5	-10	-6	-8	112	16	-4	0	-3	1591	27	-5	0	-5	2994					
6	-10	0	-2	1863	17	-5	-4	-5	61	28	-43	-28	-33	13105					
7	0	0	0	149	18	-4	0	-3	107	29	-15	-13	-14	711					
8	-4	-3	-4	67	19	-28	0	-18	83039	30	-48	-32	-39	2808					
9	-4	-2	-4	315	20	-5	-5	-5	164	31	-20	-13	-16	5369					
10	-5	-2	-4	813	21	-4	-2	-4	62	32	-18	0	-13	5159					

Results

Based on the results from the study, Corpus Christi, Texas is a great place for wind farms. In the study we found 38 sites over 60ha that meet seven given criteria, but there still needs to be more anaylsis to narrow down the number of sites such as aviation paths, etc. Overall, wind energy is an efficient and a useful source of energy. It requires more planning to determine where a new farm would best be located. There are many factors that play into one's decsions from the needs and wants of the public to the habitats in the region to the needs of the turbines used in the farm. Overall the anaylsis show the overall value of bulding a new wind farm in Corpus Christi, Texas region

Conclusion

Higher quality wind resources, proximity to coastal population centers, potential for reducing land use, aesthetic concerns, and ease of transportation and installation are a few of the compelling reasons why power companies are turning their attention to offshore development. Offshore turbines are being made larger to economize in the foundation and power collection costs.

References

2018 - NREL - What-Does-an-Offshore-Wind-Energy-Facility-Look-Like.pdf

Sanjeev Malhotra (2011). Selection, Design and Construction of Offshore Wind Turbine Foundations, Wind Turbines, Dr. Ibrahim Al-Bahadly (Ed.), ISBN: 978-953-307-221-0, InTech, Available from: http://www.intechopen.com/books/wind-turbines/selection-design-and-construction-of-offshore-wind-turbinefoundations

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GEOG5092 - Programming and Automation
Fall 2020

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