Texas Renewable Energy Potentials: GIS-Based Analysis

Matt Kelly, Dr. Esayas Gebremichael

Department of Geological Sciences

Abstract

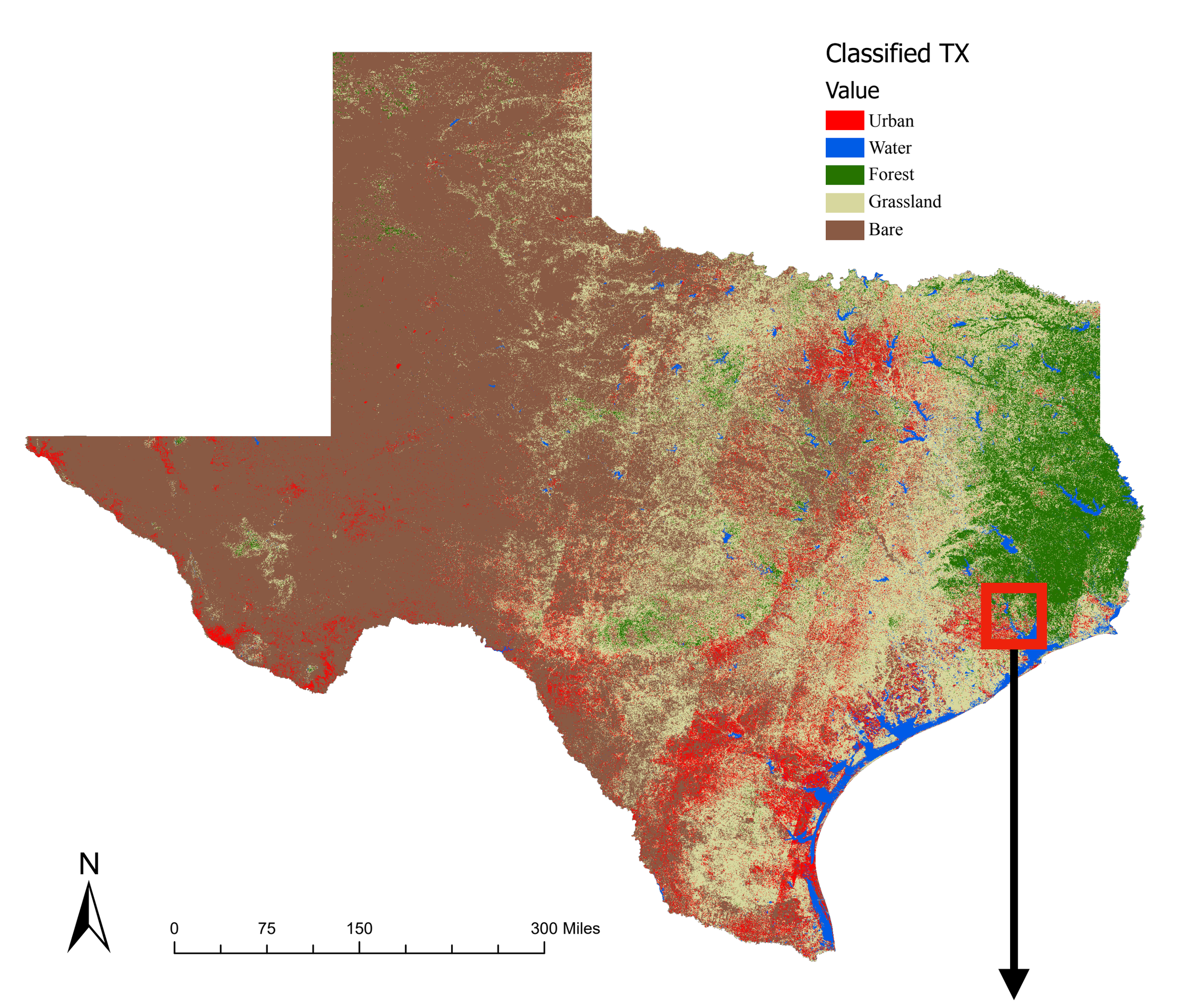
Given the drastic rise in renewable energy investment across the US and globally, along with global sustainable development goals, it is important to develop techniques for renewable resource assessment. The study aims to identify the most suitable areas for renewable energy development in Texas by analyzing various geospatial factors that influence renewable energy production, such as slope and land use. Resource-specific data such as surface direct normal irradiance (DNI), wind speed and power density were used to ensure resource availability. Proximity to infrastructure such as highways, transmission lines, and substations were also integrated. Products generated use an integration of remote sensing data, geospatial analysis, and machine learning algorithms to develop a spatially-explicit multi-criteria decision analysis (MCDA) for solar and wind resources in Texas.

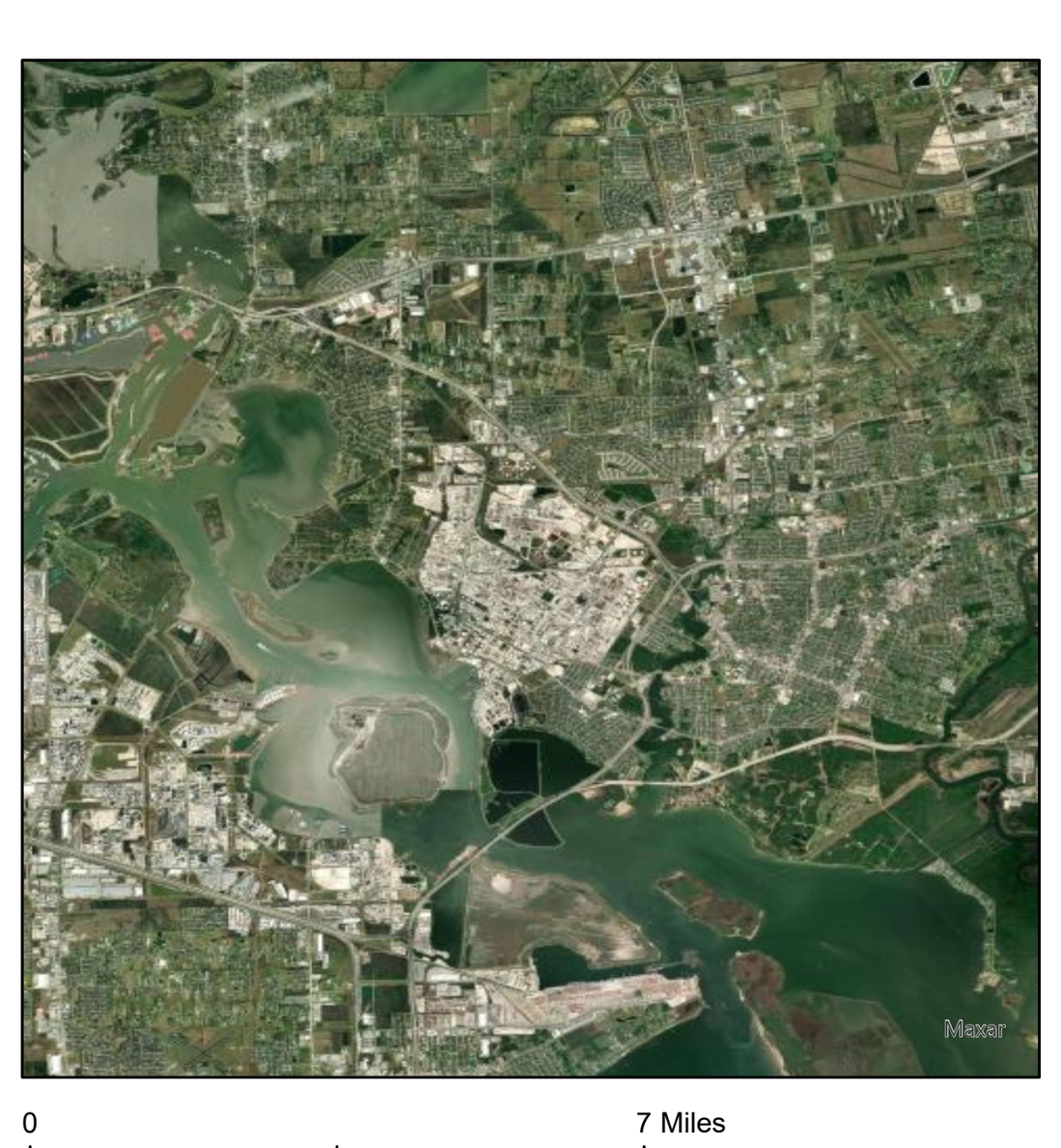
Background

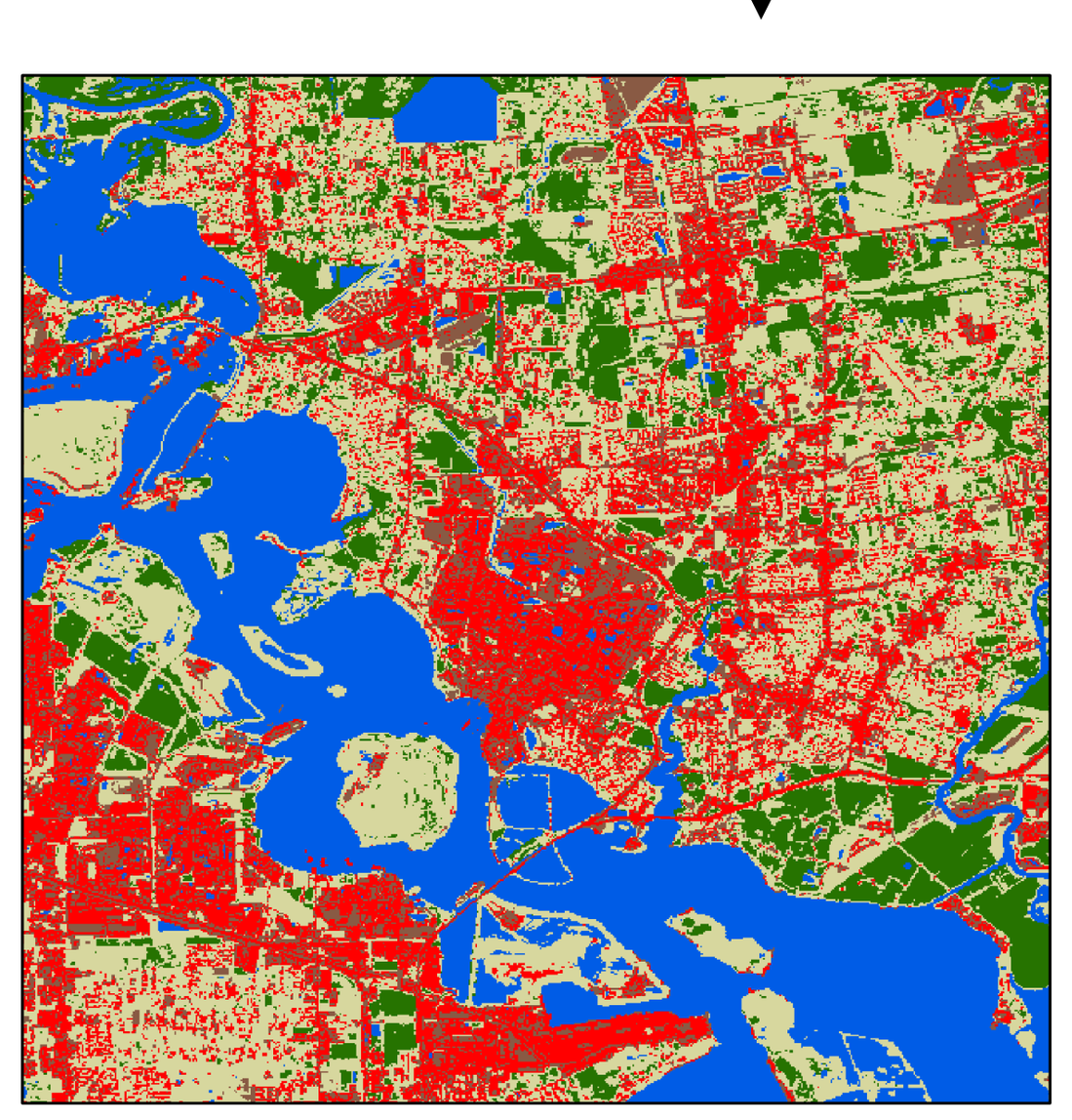
Energy is one of the most vital resources to the modern world, according to the International Energy Agency about 80% of the worlds energy source is from fossil fuels. The presence of climate change has been a key topic on a global scale, mass investment, sustainable development goals, and emissions targets have vastly increased global demand for renewable energy. Texas has already proven its capability for renewable energy generation, according to the Energy Information Administration roughly 24% and 4% of total energy use by fuel source in Texas come from wind and solar respectively.

- Develop a method for optimal location selection of utility-scale renewable energy development
- Combine key economic, practical, and functional factors to create a suitability model for Texas.
- LULC and other necessary datasets made in Google Earth Engine bypassing expensive software or powerful computing which may be prohibitive factors for alternate applications of this method.

Google Earth Engine Products

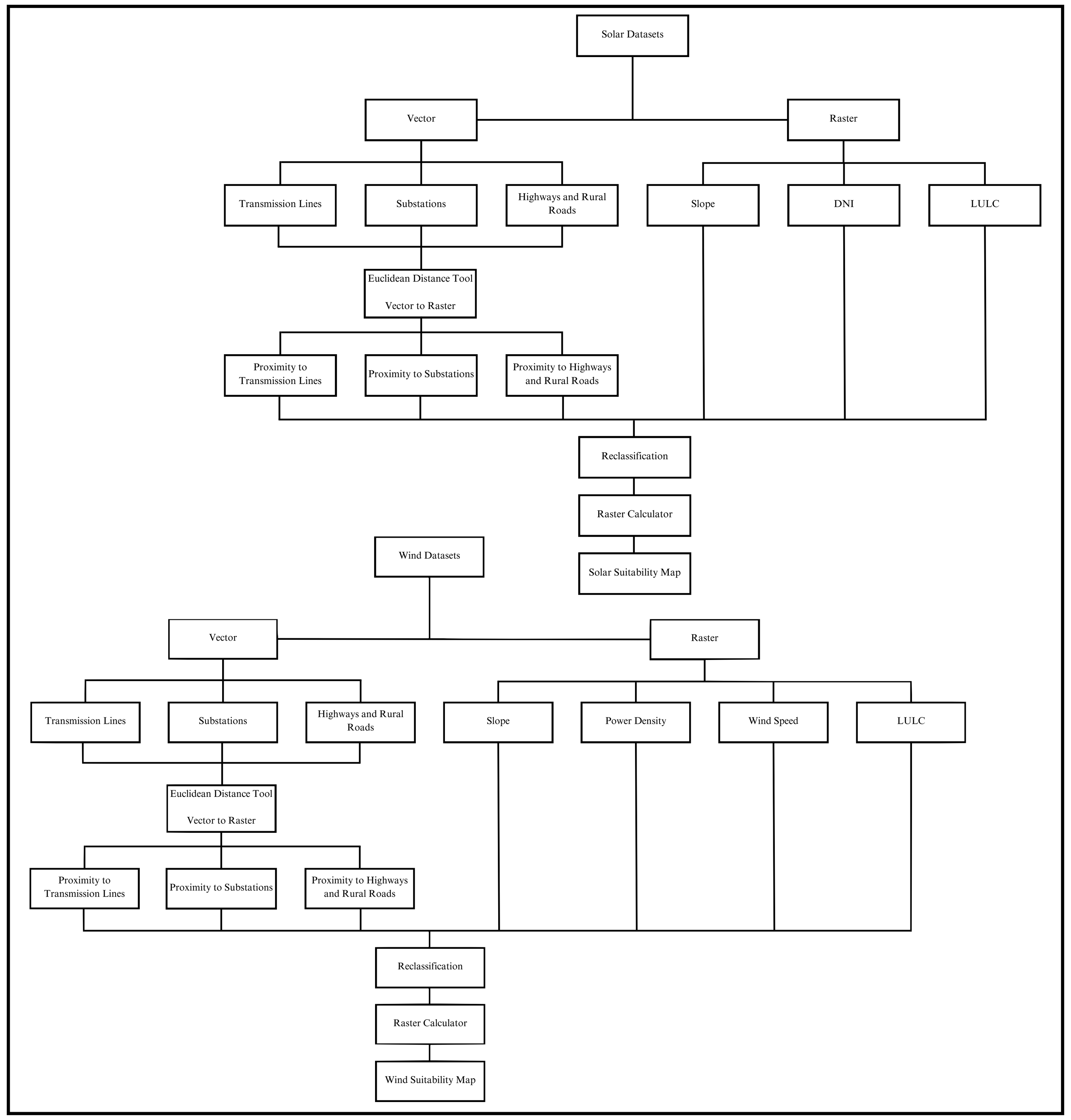






Try it yourself!
(account required)

Methods



Solar Datasets
Vector
Raster
Transmission Lines
Substations
Highways and Rural Roads
Slope
DNI
LULC
Euclidean Distance Tool
Vector to Raster
Proximity to Transmission Lines
Proximity to Substations
Proximity to Highways and Rural Roads
Reclassification
Raster Calculator
Solar Suitability Map
Wind Datasets
Vector
Raster
Transmission Lines
Substations
Highways and Rural Roads
Slope
Power Density
Wind Speed
LULC
Euclidean Distance Tool
Vector to Raster
Proximity to Transmission Lines
Proximity to Substations
Proximity to Highways and Rural Roads
Reclassification
Raster Calculator
Wind Suitability Map

Discussion

Terrain

- Relatively flat landscape, and entirely barren regions offer vast area for development
- Optimal LULC areas, which include grassland and bare land correspond spatially to areas where resources are optimal

Infrastructure

- Well developed infrastructure, especially electrical, allows for a high degree of site availability
- Proximity to infrastructure is incredibly important for site selection due to high cost of transmission lines, substations, and transport at large scale

Solar

- Favorable in western regions due to high direct normal irradiance, in this instance areas exceeding 5.5 kWh/m² per day are considered most suitable, certain areas can exceed 7.5 kWh/m²
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- Expansive area of suitable DNI provides high probability of infrastructure in close proximity
- Average suitability score of 2.42 demonstrates high suitability in this model

Wind

- Favorable in north central region, the central US from North Dakota to northern Texas is among the most power dense continental regions of wind energy on the planet
- Average suitability score of 2.07 demonstrates reasonable suitability in this model

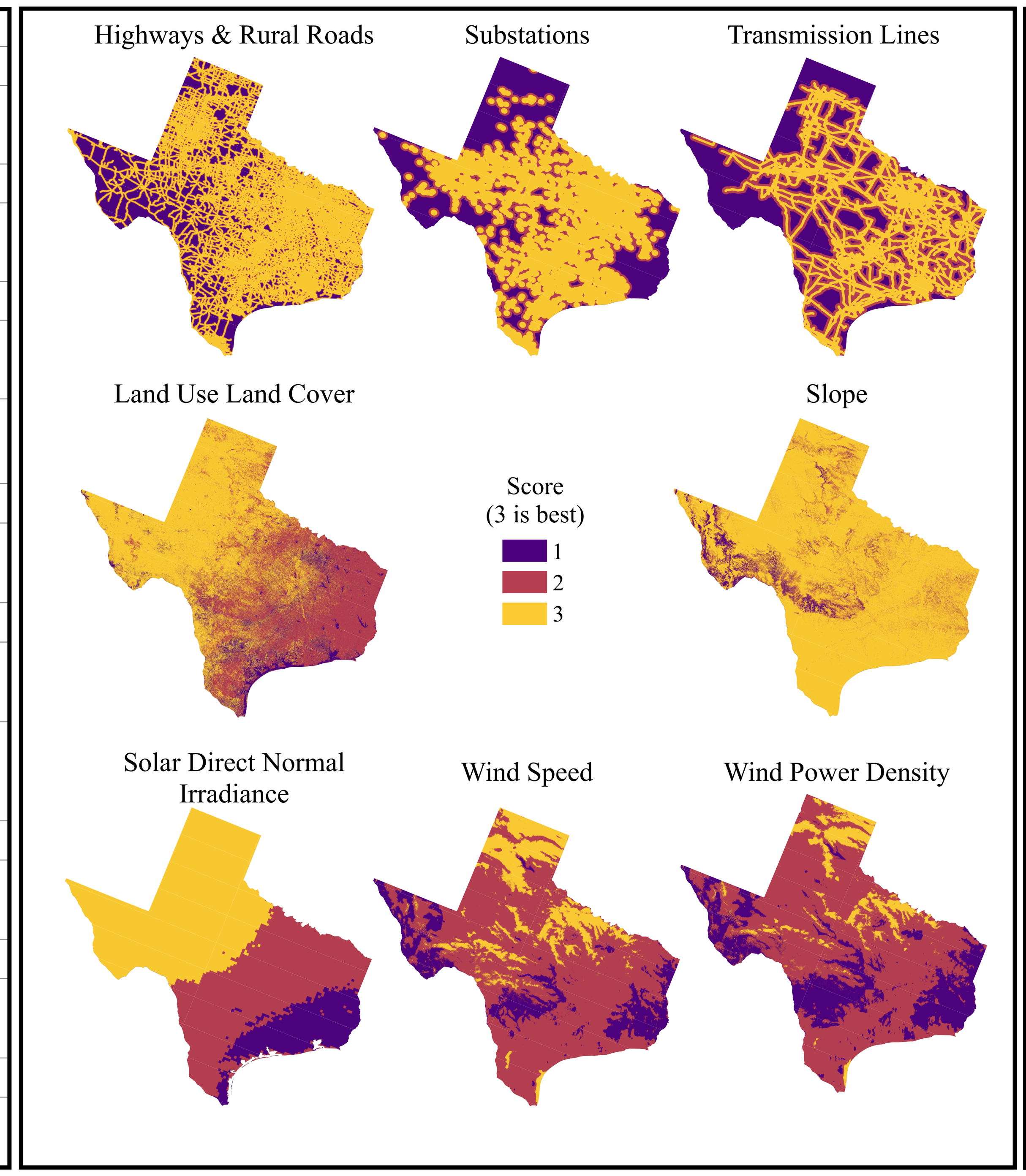
Reclassification

Infrastructure	
Roads (km)	**Score**
<3	3
3-5	2
>5	1
ERCOT Substations (km)	**Score**
<5	3
5-15	2
>15	1
Transmission Lines (km)	**Score**
<5	3
5-15	2
>15	1

Terrain	
Land Use Land Cover	**Score**
Urban and Lakes	1
Forest	2
Bare and Grassland	3
Slope (%)	**Score**
<3	3
3-7	2
>7	1

Functional Factors	
DNI (kWH/m^2)	**Score**
<4.5	1
4.5-5.5	2
>5.5	3
Wind Speed (m/s)	**Score**
<6	1
6-7	2
>7	3
Power Density (W/m^2)	**Score**
<250	1
250-500	2
>500	3

Input Data



Data Sources

Roads
TxDOT

Substations
ERCOT

Transmission Lines
ERCOT

LULC
Supervised Classification

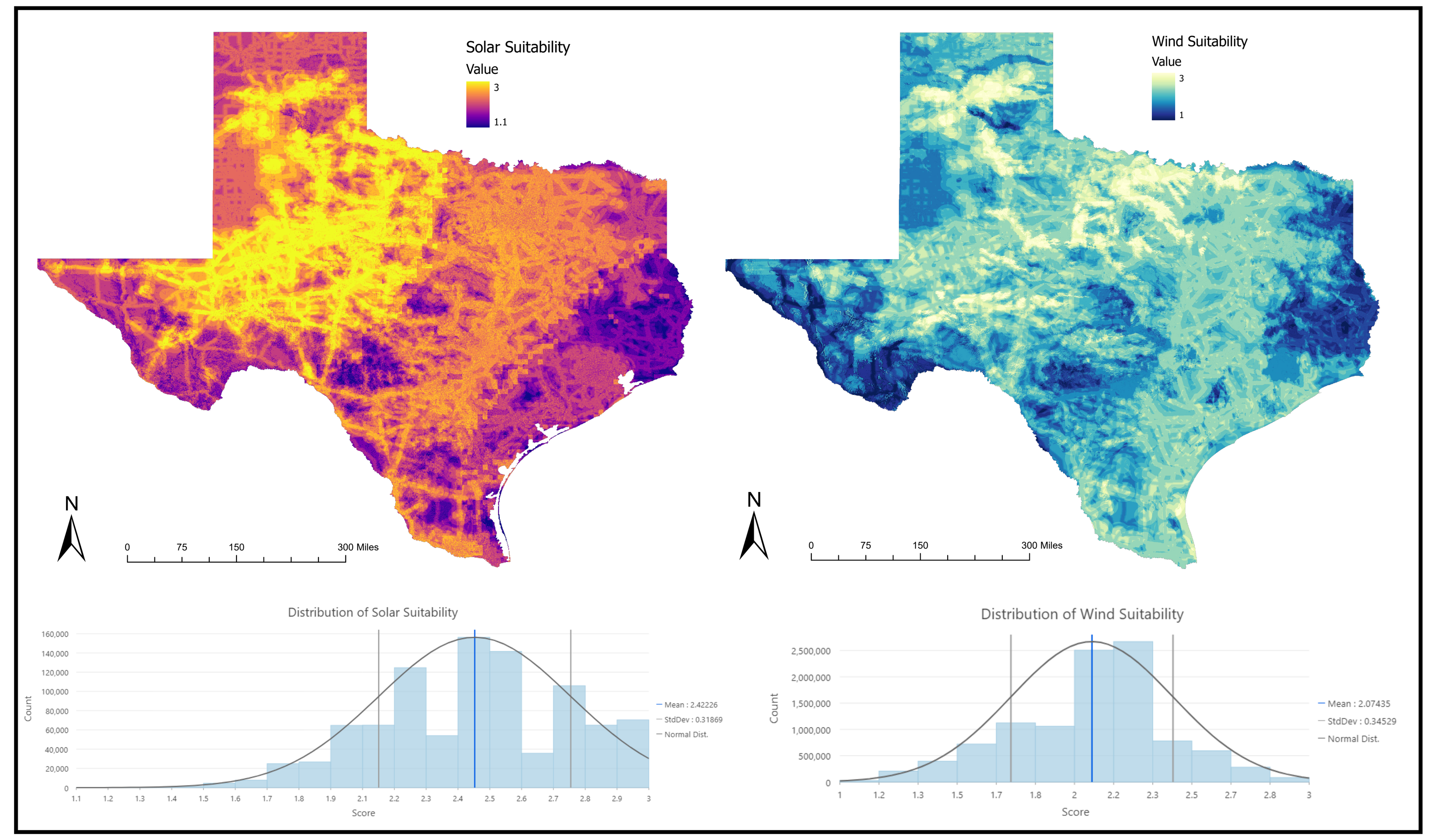
Slope
NASA SRTM

DNI
NREL

Wind Speed
Global Wind Atlas

Wind Power Density
Global Wind Atlas

Results



Conclusion

- Parameters considered relevant factors such as infrastructure, terrain, and functional energy generation
- Final maps reflect areas where solar and wind development has already occurred in Texas, providing validation for effectiveness of methods used
- Solar and Wind had mean suitability scores of 2.42 and 2.07 respectively
- Band data can be selected by score value to locate exact locations of suitable land