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GIS 6100

Suiting up for Solar in North Florida

Abstract

In the United States energy consumption is on the rise as population growth and technological advances increase the demand for power. To meet this higher demand, power companies need to produce more power by increasing the output of existing power facilities or creating new ones. Recently, power companies are increasingly choosing renewable sources such as solar, wind, geothermal or wave over traditional nonrenewable sources of power production . In Florida, the Sunshine State, Florida Power and Light has chosen to build solar farms to meet future energy demand.They call it the ‘30 for 30’ plan to increase solar energy production capacity. In this study, Geographic Information Systems (GIS) was utilized to perform a suitability analysis on North Florida to determine what areas to place these new solar installations, which produced a map depicting highly suitable areas. These results were then compared to existing solar installations to ensure the accuracy of the models predictions. Using data from local and federal institutions such as the Saint Johns Water Management District and the Florida Department of Environmental Protection it was found that areas South of Jacksonville near I-95 and Northwest of Gainesville to be highly suitable for solar energy production installations.

Introduction

Implementing new energy infrastructure is increasingly more important across America. In the United States energy consumption is projected to rise by 0.9% in 2021 (U.S. Energy Information Administration). Public power companies are looking to renewables for new efficient ‘green’ means of powering homes and industry. Solar energy production along with other renewables increased from 2019 18% to 20% in 2020 and is projected to reach 22% of all energy production in the U.S. by 2021 (U.S. Energy Information Administration). One benefit of solar is the potential for multi use facilities. Multi use facilities are energy installations that produce power and provide at least one other land use feature. In the case of solar installations, planting wildflowers in and around the solar panels can encourage pollinators to come to the area to benefit local agriculture (Solar Energy Industries Association). This is important to regions where there is agricultural industry such as North Florida.

Florida's population has been trending upward for decades. People enjoy the subtropical climate and beaches. Major population centers include Miami Dade, Tampa, Orlando, Jacksonville, Palm Beach, Tallahassee and Gainesville. In Florida, Florida Power and Light has begun to heavily invest in solar energy infrastructure. Currently Florida Power and Light is on the path to become the leading producer of solar energy in the United States by 2030 as a result of the ‘30 by 30’ plan (Florida Power and Light). The ‘30 for 30’ plan calls for the implementation of 30 million solar panels by 2030. All of the new solar panels and electric infrastructure will require a joint effort of electrical engineers, city planners and local communities to choose where new solar farms will be located. The use of GIS will play a role in determining suitable areas for new energy infrastructure.

A GIS suitability analysis can combine land use features, relevant human impact data and a user weighted overlay to determine where land should be acquired for power companies looking to build new energy installations. In this study, road, solar radiation, land use and land hazards was used to produce a map highlighting areas with the greatest suitability for solar installations.

Methods

Study Area

In an effort to examine potential solar installations, the area north of Gainesville, west of Jacksonville, and south of Lake City was selected as an ideal study area because of its central location within the state. Four solar installations are already active in the area. By superimposing the results of the analysis with existing solar installation locations, we can determine the accuracy of this study's model. If these existing sites overlap with the highly suitable areas predicted by the model, the model can be said to be accurate. The implication that solar installations can provide additional benefits such as wildflower areas that encourage pollinators was also taken into account, the study area has agriculture that would benefit from a multi use solar development.

Data Collection and Sources

Relevant data to this model included a study area layer, roads, cities, hydrology, parks, direct normal irradiance (DNI), land use, and elevation data. The study area layer was created in ESRI ArcGIS. Major roads data was collected from the open data portal of the census bureau, Tiger Roads. Roads included interstates, state and U.S. highways, and county roads. City data was acquired by making a point feature in ESRI ArcGIS with z and m data to yield a cities layer in the area of their relative elevation and location data. The hydrology and parks layers were acquired from the Saint Johns Water Management DIstrict that depicted lakes, rivers, swamps, intracoastal and ocean waters in the form of a polygon layer. Elevation data was downloaded from the Florida Department of Environmental Protection (Florida Department of Environmental Protection). The elevation data collected was in the form of polylines, 5 ft contours. Land use polygon data was sourced from the Florida Department of Environmental Protection (Florida Department of Environmental Protection).

Data Processing and Analysis

Several steps were taken to expedite subsequent analysis and ensure that data layers were formatted correctly. All layers were clipped using the study area to remove features outside of the study area, except the cities layer because it would have been an unnecessary step. This was done to focus data and speed up processing speeds for analysis through the ESRI ArcGIS Model Builder application. Using the 5 ft contour lines a DEM layer was created. The contour to DEM tool creates a new feature that can be used to make viewshed and aspect layers. Using the DEM layer the model builder work environmental settings were configured. The Output coordinate system was set to GCS_WGS_1984. The Processing Extent was set to 'Snap Raster' input: DEM. The Raster Analysis settings were set as follows; Cell Size 'As Specified Below' .0032, this cell size was comparable to the cell size of the dem layer making all raster layers the same resolution which allows for subsequent raster calculation.

To organize a weighted suitability analysis all suitable areas were compiled into a weighted overlay as raster inputs. This called for a euclidean distance tool to be run on the cities and roads layer. The output of the cities euclidean distance tool was run through a reclassify tool, reordered from one to ten, equal intervals. Value one correlated to areas close to a city. Value ten correlated to areas far from a city. The euclidean data from roads was also reclassified one to ten, one being far from roads, ten being close to roads. The clipped DNI layer was converted from vector to raster. This raster layer was reclassified one to ten, ten being the highest DNI values one being the lowest values. An area solar radiation tool was run on the DEM layer to produce a global radiation raster for the study area. This layer was reclassified with interval one to ten, ten being the highest radiation and one being the lowest of radiation. All four layers Reclassified City, Reclassified Road, Reclassified DNI and Reclassified Radiation were input into a weighted overlay. Their relative percent influence was set as follows: 15% Recassified City, 25% Reclassified Road, Reclassified Radiation 30%, Reclassified DNI 30% totalling 100% (see figure 1 and 2). This weighted overlay valued higher DNI and radiation levels as well as proximity to roads and distance away from cities.

Areas that were not acceptable for a solar farm had to be removed from these areas to complete the final suitability analysis. An unsuitable binary layer was created by combining viewshed, water, parks and land use data, this layer is used to eliminate unsuitable areas from the weighted overlay analysis. The unsuitable layer was created by first creating buffers around parks and the hydro layer. Parks received a 100 ft buffer and water features 300 ft. Both features were then merged with their buffers. The union tool was then run individually on the hydro buffer layer, park buffer layer and the study shape file to encompass the entire study area. These layers were then run through the feature to raster tool creating two raster features. Each raster feature was reclassified '1' and '0'. An area with a '1' was deemed acceptable and an area with a '0' was deemed unacceptable for a solar installation. Combining the cities layer and DEM layer into a viewshed analysis also yielded suitable, unviewed areas and unsuitable '0' areas within the viewshed of the points representing cities. The land use layer was run through a feature to raster tool then manually reclassified by suitable '1' or unsuitable '0'. Unsuitable areas included water, swamp, parks, cemeteries, high intensity and medium intensity developed lands as well as urban undeveloped lands. All four layers were combined through a raster calculator (see figure 3 and 4). The resulting layer consisted of a raster layer with '1' areas and '0' areas that are not suitable that could be combined with the weighted overlay layer.

Combining the weighted overlay and the unsuitable areas raster layers yields a nearly completed suitability mapping analysis. Using the times tool the weighted overlay and unsuitable raster layer are multiplied by one another. This removes areas from the weighted overlay that fall within an area of '0' pixels from the unsuitable layer. It also leaves the relative weight the same of any areas outside of the '0' unsuitable areas. Using a con tool on this combined suitability layer using sql input' value > 8 ' leaves areas ranked 9 and 10 (the highest suitability). Finally a majority filter is utilized to remove isolated high suitability areas resulting in the final suitability layer used in this analysis (see figure 5).

Results

Weighted overlay suitability analysis produced a map representing areas where solar installations could be implemented and used to provide renewable energy to communities and provide for multi use benefits. The results highlighted suitable areas in the western portions of the study area as well as east along I-95. It also highlighted areas where a solar installation could not go, such as water feature areas. All four of the current Florida Power and Light solar facilities fall in areas of high suitability (see figure 6). Coral Farms 10, Trail Side Solar 9, FL Northern Preserve 9, Echo River 8.

Discussion

Suitability analysis has limitations including scope, accuracy and precision. This study's scope was limited to North Florida, and accuracy and precision determined by weighted overlay and biases inserted into the analysis. Bias in this study included avoiding cities, water and parks. It was also biased to include farm land and range land. Other studies can come up with unique results by changing biases for certain land use types and relative weight in weighted overlay analysis. The results of this suitability analysis highlighted areas north west of Gainesville and south of Jacksonville along I-95. These areas are over distance from urban centers without compromising DNI and solar irradiance values. The existing solar installations fallin in highly suitable areas is a testament to the accuracy of this model. The predicted suitable areas can be said to be accurate. Compiling and utilizing more data would yield a more accurate suitability analysis. For this analysis a layer that represents flooding could be implemented in the future to eliminate areas susceptible to flooding. Analysis could include information on land value so energy companies spend money buying land effectively. After a multi use solar installation has been adopted in an area benefits can be quantified. For instance if a solar facility was built with pollinators in mind, further study could identify the quantity and type of pollinators attracted to the area.

Conclusion

As society progresses and expands there is a need for more power. Power producers are increasingly looked to renewables including solar energy installations. In Florida there are ample areas to exploit for solar energy production to the benefit of energy consumers. This analysis identified areas of high solar suitability South of Jacksonville around I-95 and Northwest of Gainesville. The results of this analysis are reinforced by the data outputs successfully ranking areas where current Florida Power and Light solar installations are located as highly suitable. Moving forward, additional analysis can include resilience data to achieve higher real world accuracy results.

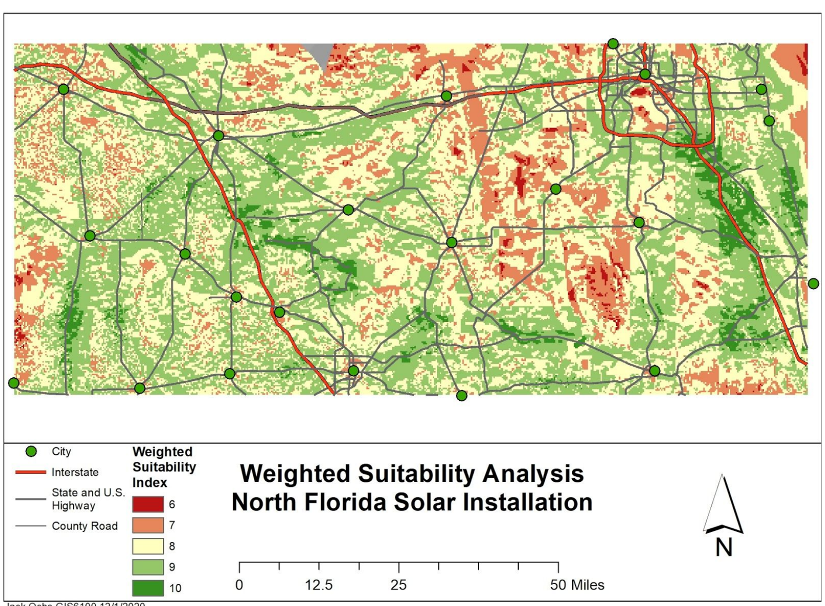

Figure 1. Weighted overlay output. Depicts areas that are suitable based on their DNI, solar irradiance, proximity to roads and cities.

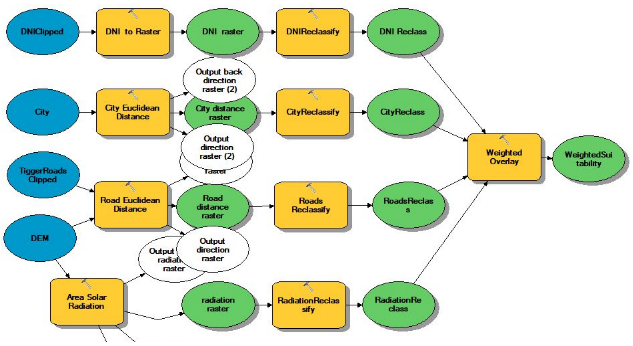

Figure 2. Weighted suitability model used to identify initial suitable areas.

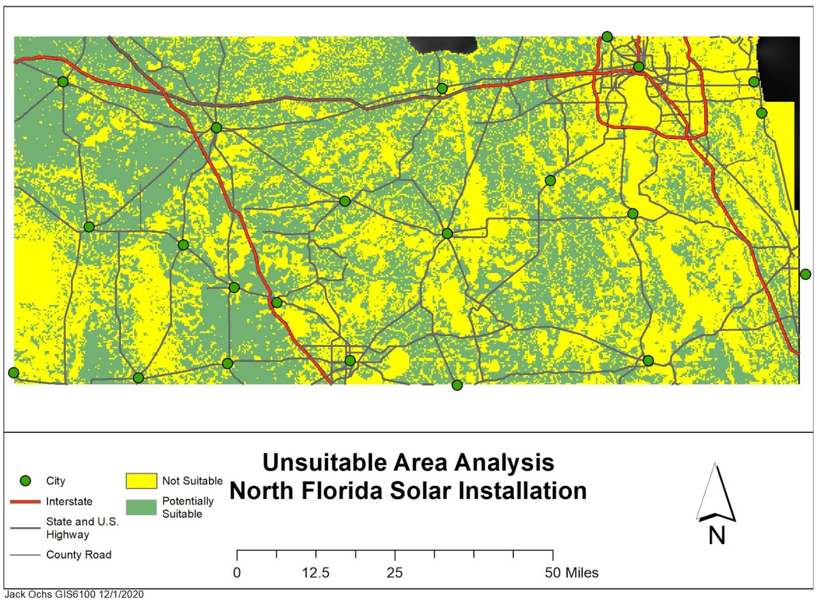

Figure 3. Unsuitable areas map highlighting areas that are not able to be developed such as water ways, highly developed lands and parks.

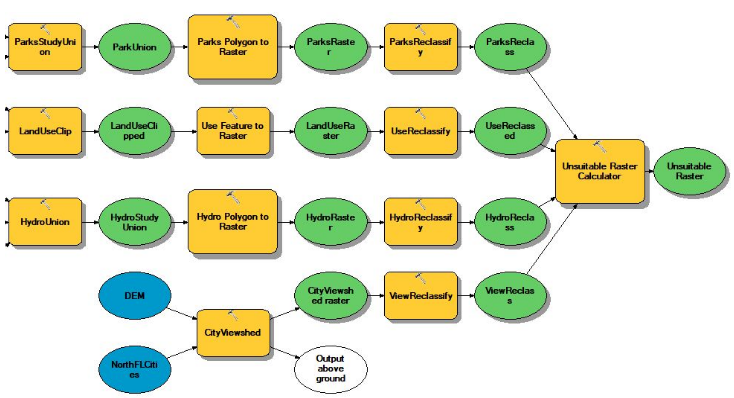

Figure 4. Model used to create unsuitable areas by combining unfavorable layers into an unsuitable layer.

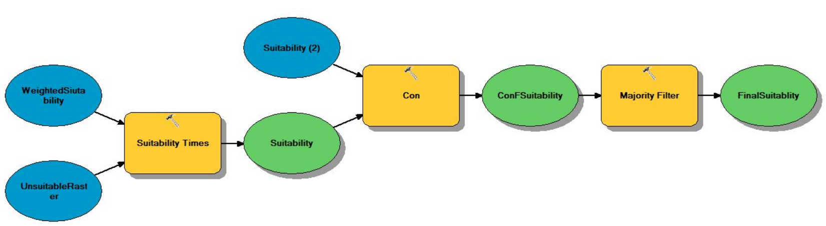

Figure 5. Final model that combined unsuitable data and the weighted overlay that could be refined concluding the suitability analysis.

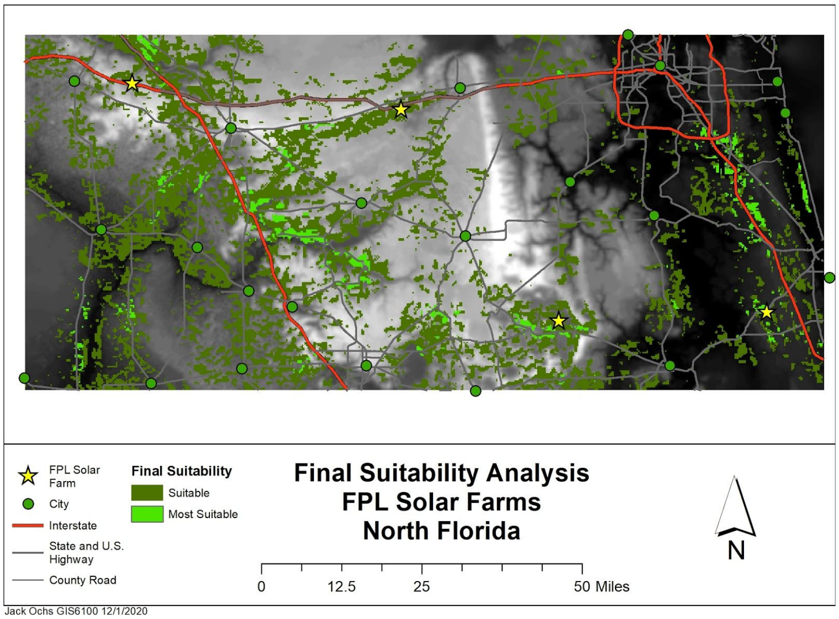

Figure 6. Finally suitability analysis with FPL solar installations superimposed. Highlights availability of lands in Northwest Central Florida highly suitable for solar energy development.

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