College of Engineering, Informatics, and Applied Sciences

Memorandum

To: Dianne McDonnell

CC:

From: Isaac Taylor

Date: December 12, 2018

Subject: Final Project

Final Project

The pages that follow include information regarding the process and results of the final project. Please contact Isaac Taylor at (816) 797-3648 or at zrt23@nau.edu if any questions arise.

Attached:

Final Report

Slope and Aspect map layout

Solar Radiation map layout

College of Engineering, Informatics, and Applied Sciences

Land Suitability and the Solar Radiation Potential on a Limited Plot in the Phoenix Metropolitan Region

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Prepared for: D. McDonnell

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CENE 599: GIS/RS

College of Engineering, Informatics, and Applied Sciences

Introduction

The goal of this study is to determine the annual solar radiation and perform a surface analysis on a self-identified plot of land. The locational focus is within the Phoenix Metropolitan Region, specifically near Cave Creek, AZ and Carefree, AZ. To design this project, data was gathered from several different sources and financial data was estimated based on regional information. The results and methods from this process will be used in the future to do preliminary determinations prior to purchasing a ranch property within the Phoenix Area.

Methodology

Prior to the beginning of the project, several assumptions were made to simplify the process and reduce the variables considered:

1. All potential ground will be use for solar production only
2. A 15% space margin will be allowed per individual panel
3. All produced energy will be assumed to have 100% efficiency and no regard for battery limitations

Data files for ArcMap were gathered mainly from two different sources both headed by the Unites States Department of Agriculture. Digital elevation model (DEM) data was produced in 2011 and gathered from Web Soil Survey, while TIGER street data was created in 2016 and downloaded from the Geospatial Data Gateway [1] [2]. All data was projected to a universal coordinate system, NAD 83 12N, to normalize the data and reduce potential errors. The project location was identified using TIGER street data and digitized with a custom shapefile to identify the project boundary.

Identifying the suitability of the land and determining the potential locations of the solar panels required for the spatial analyst functions of surface and map algebra [3] [4]. This was used in addition to modifying symbology to provide a binary output. Determining the area of suitable land was completed with data management tools, conversion tools, and modifications to the created attribute table [5]. The spatial analyst solar radiation toolbox was used again to produce the annual solar radiation on the specified plot of land [6].

Analysis

Using a production from the University of Arizona, it is identified that the maximum surface slope for solar panels is 30 degrees and the optimal aspect in the northern hemisphere is southward facing. Calculating slope and aspect through the spatial analyst and classifying them on a binary scale of "accepted" vs "non-acceptable" provided the following figure:

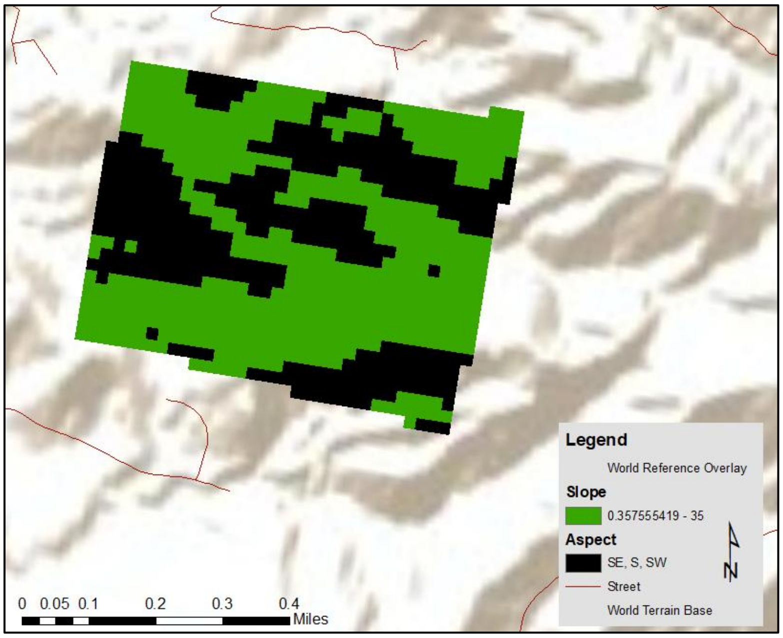

Figure 1. Slope and aspect suitability within the defined land boundary

After the identification of the locations in which the plot has both suitable aspect and slope, the panel property was defined such that it created a polygonal feature file. The polygon, in pink, was further used to alter the attribute table to calculate area for individual "squares" within the polygon.

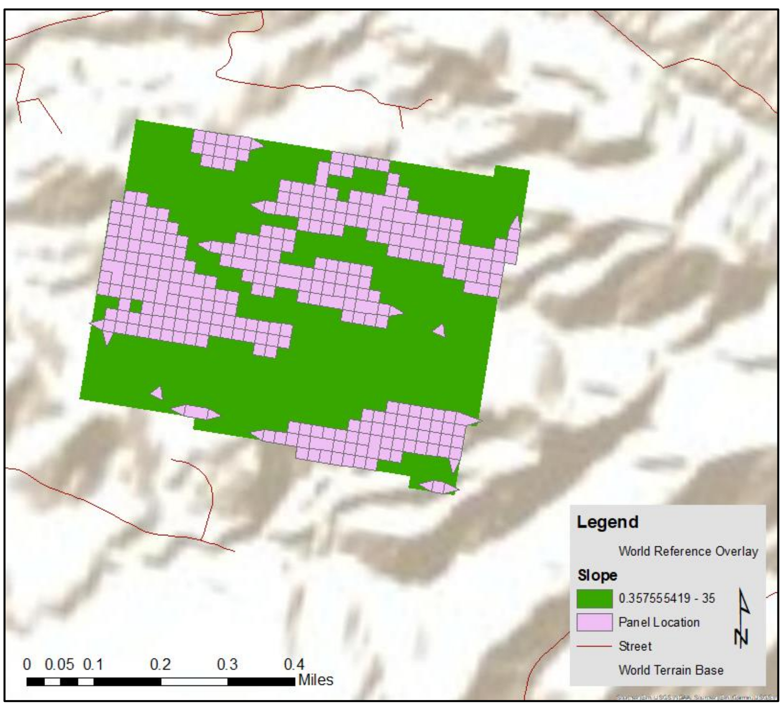

Figure 2. Polygon feature file of all panel locations within the property

The customized attribute table for the feature was exported to Excel using the provided conversion tools with ArcMAP. The converted Excel file was used to sum the ArcMap-calculated areas and compute the total usable land area based on the limitations identified. With these values and the inputted financial data, the number of panels, energy production, and net cost were calculated.

Table 1. Net financial calculations based on cost and energy production buyback

Panels	$26,070,407					
Refund	$7,821,122					
Property:	$800,000					
Year	Production days	Production hours	Buy back	Net production	Net buy back	Net financial
2021	**211**	**8**	**0.094**	**24653214.29**	**$2,317,402**	**($15,931,883)**
2022	211	8	0.085	24653214.29	$2,085,662	($13,846,221)
2023	211	8	0.085	24653214.29	$2,085,662	($11,760,559)
2024	211	8	0.085	24653214.29	$2,085,662	($9,674,897)
2025	211	8	0.085	24653214.29	$2,085,662	($7,589,235)
2026	211	8	0.085	24653214.29	$2,085,662	($5,503,573)
2027	211	8	0.085	24653214.29	$2,085,662	($3,417,911)
2028	211	8	0.085	24653214.29	$2,085,662	($1,332,249)
2029	211	8	0.085	24653214.29	$2,085,662	$753,413
2030	211	8	0.085	24653214.29	$2,085,662	$2,839,075
2031	211	8	0.085	24653214.29	$2,085,662	$4,924,736

The full project location was used to perform the solar radiation analysis rather than only the useable locations. This used more processing time, however, provided a basis of comparison for the accuracy of the surface analysis versus the solar radiation analysis.

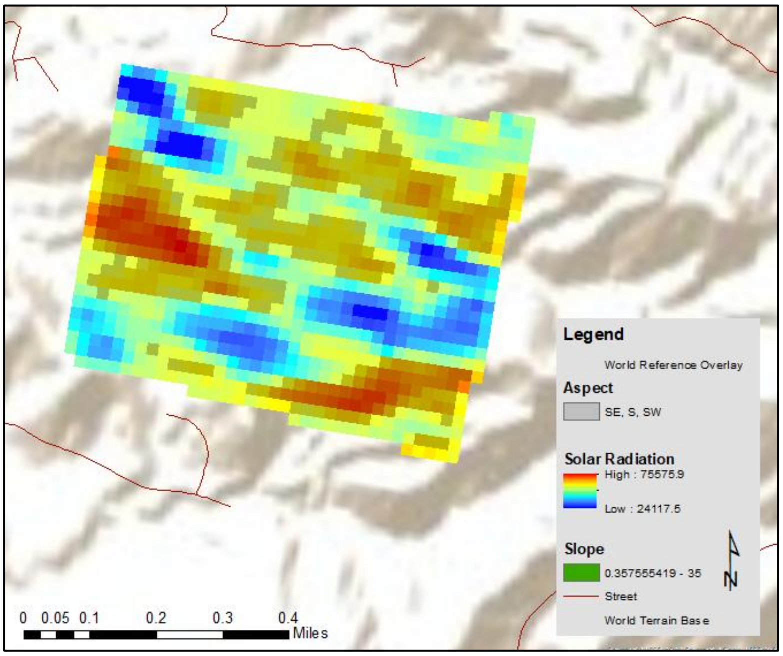

Figure 3. Annual solar radiation analysis based on the full project location. Semi-transparent aspect location overlay to show panel locations.

The solar radiation analysis is a composite raster derived from a set of monthly radiation maps for 2018. The values presented on the map are used in W-h/m^2. The map is show for the entire project region, however, there is a 75% transparent overlay of the aspect raster to identify the panel locations within the project boundaries.

Discussion

Results

Figure 3 shows a positive correlation between the calculated solar radiation and the surface analysis (aspect specifically). This is a positive indicator on the ability to provide an initial estimate for suitable panel locations based off the surface analysis alone. This analysis isolated locations within the boundary of a slope under 35 degrees and surfaces facing in the southward directions [3]. The production was favorable, as expected due to the geographical location, and proves to be profitable under initial calculations. To simplify the calculation process, a base value of 1GW-hr energy production per 2.8 acres was used [7]. An assumed climate of 211 days of sun per year with 8 hours of sun per day, on average, was identified as the production hours for this project location [8].

Arizona Public Service Electric Company (APS) currently provides a 10-year locked in buyback rate for solar energy at $0.129/kW-hr [7]. This rate is decreasing yearly at a factor of 10% resulting in a lower rate at the assumed installation date of 2021 than current [7]. Currently, the US Federal Government is offering a 30% tax refund for the installation and purchase on solar panel, this would be a beneficial reduction in cost during the first year of production [8]. The Mission Solar 360W panel was selected to perform preliminary calculations. This panel has a maximum energy output of 332.3 W, provided by the company themselves within the product specifications [9]. The known land space and panel size allows for a total of 106,410 panels on the property. Table 1 shows the net cost calculations based on these selected values, showing a net profit in the ninth year of production.

Errors

The initial identified boundary was intended to provide a total project area of 20 acres, however, due to an unidentified error, the total project location totaled 200 acres. This error caused issues with results, however, didn’t affect the overall process in any way. Another issue present within this project was the lack of hard figures for the financial calculations. Many of the figures used were estimations or speculations as the true cost of the property and its subsidiaries is unknown as this boundary was custom digitized. Using a standardized base production of energy did not account for the actual solar radiation values present for the selected location, however, with more time it would have been possible to calculate these specific values.

Further Research

Due to the initial cost of startup and the period before a profit is returned, it is advisable to consider dual land use of agriculture and solar. Special considerations must be taken on the placement of panels to ensure the pass-ability of farming equipment over the land as needed. Mounted panels provide natural shelter, shade and protection, for livestock and reduce the needs for lean-tos spread out amongst the property to combat the high summer temperatures. The number of panels required to fill the available area was higher than expected and a consideration between residential and commercial panels should be further researched.

In order to gain a better understanding of the true solar output of the land requires the potential expansion of acceptable aspects and calculations for concentration solar as opposed to photovoltaic panels. The financial and energy production computations must be recalculated using accurate, or near-accurate, efficiency and transportation loss data. Additionally, the storage capacity of the necessary batteries for energy storage must be considered in terms of quantity and land space.

Conclusion

Solar production, through this ArcMap analysis, is highly favorable and profitable within the assumed property boundary. With a steep initial investment, it may be ideal to investigate loans or other financial assistance to assist in start-up costs. This investment will neutralize and provide return in 9 years at the currently identified rates. Using ArcGIS to analyze solar production and land suitability is a reliable and visually appealing method for personal use and to provide to clients.

References

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