## EE Frogs Detailed Report for the Pale Blue Dot: Visualization Challenge

1. How does your visual inform a decision or action that furthers one or more of the key competition SDGs (zero hunger, clean water and sanitation, climate action)?

Our visualization shows areas of high and low suitability for the placement of solar panels in the Turks and Caicos Islands which directly furthers the Climate Action SDG. One of the most important and impactful actions that can be taken to further this SDG is to decrease the use of fossil fuels by transitioning to renewable sources of energy which directly reduces the amount of greenhouse gases being emitted into the atmosphere. According to a National Renewable Energy Lab report[1] the Turks and Caicos Islands have the highest greenhouse gas emissions in the Caribbean region due to the current reliance on imported diesel fuel for power generation and have begun exploring the process to expand domestic renewable energy generation. We believe this visualization would inform actions stakeholders in the Turks and Caicos Islands could take in the process of installing renewable sources of energy. It aids in the site selection process based on the physical criteria of surface temperature, vegetation cover, elevation, and slope which all have impact on the site suitability and efficiency of solar panels in producing energy. Clearly these are not the only criteria that should be considered but we hope this visualization serves as a starting point and can be built on top of by adding more data to narrow down potential sites even further.

[1] https://www.nrel.gov/docs/fy15osti/62698.pdf

2. How did you create your submission? Include the tools you used (e.g., Python, Excel, specific python packages), how you processed the data, and (if applicable) how you managed your codebase. If you have a public repository with code, you can share a link here.

The methodology for creating this visualization was heavily inspired by and adapted from Doorga et al. 2019[2]. This paper identifies many different criteria that are important for the placement of solar farms including environmental and social data. From their criteria, we identified several that we could gather data on for the Turks and Caicos Islands that are freely and openly available including surface temperature, elevation, and slope. We chose to add an additional criterion of our own which is vegetation cover. There are many other criteria we hoped to include but simply could not find sources of data on including sunshine duration, access to road/grid network, and many others. We do not intend our visualization to be the final say on what areas are highly suitable for solar panels or not, we only intend for it to act as a starting point based on several variables and could be built on if someone had additional data on other important variables.

Surface temperature is included as it affects the electrical generation efficiency of solar panels and work optimally at about 25 degrees Celsius and lower. Higher elevations can improve solar panel output as the atmosphere thins at higher elevations leading to less scattering and absorption of photons by the atmosphere. This criterion is not very impactful in the Turks and Caicos Islands since the islands tend to be very flat and near sea level with the highest point being at ~49m above mean sea level, but was still included. Slope is an important criterion to consider for construction of solar farms as slope introduces a complicating factor for installation and could raise costs as well as reduce overall output if the slope is great enough and panels begin casting shadows on each other. Vegetation cover was included as well since we determined that areas that are currently highly vegetated are less suitable for solar farms. This is because installation would require clearing of vegetation which could go against our SDG of Climate Action. The Turks and Caicos Islands are home to many climatically important ecosystems such as mangroves and clearing of such ecosystems could offset the potential greenhouse gas reduction benefits of installing solar panels in the first place.

Vegetation cover is included in our analysis as the normalized difference vegetation index (NDVI). Both NDVI and surface temperature are calculated using Landsat 8 and 9 imagery downloaded from the U.S. Geological Survery (USGS) EarthExplorer website. Images were filtered to include only those with less than 16% cloud cover and within the years 2022, 2023, and 2024. Elevation and slope data were derived from the ASTER Global Digital Elevation Model V003 downloaded from the NASA EarthData website. A shapefile of the Turks and Caicos Islands boundaries was downloaded from the [Humanitarian Data Exchange]().

Code was written in Python in order to derive NDVI and surface temperature from the Landsat imagery. A Github repository was used to store the various scripts written for processing the images including making a single mean composite image from the downloaded imagery, clipping the imagery to only the Turks and Caicos Islands area, computing NDVI and land surface temperature, and converting the files into GeoJSON formats. Here is the link to the full repository including detailed descriptions of the scripts written:

https://github.com/bastian6666/PBD_code

The DEM was processed in QGIS in order to derive the elevation and slope maps for the area and clipped using the boundary shapefile. Slope was calculated using the GDAL Raster Analysis Slope Function and values correspond to the percentage of vertical distance that equates to travelling the same horizontal distance.

After calculating all the necessary data, the maps were then converted to “suitability” maps for each criterion using a 1-9 ranking scale adapted from the Doorga et al. paper. 1 represents the least suitable areas and 9 represent the most suitable. Once suitability maps were made for each criterion, they were then combined into a single suitability map by multiplying each map by a factor weight provided in the Doorga et al. paper. The weights are LST: 0.033, NDVI: 0.033, elevation: 0.021, and slope: 0.194. Higher weight indicates that criteria has a higher impact on the final suitability map.

[2] Jay R.S. Doorga, Soonil D.D.V. Rughooputh, Ravindra Boojhawon, Multi-criteria GIS-based modelling technique for identifying potential solar farm sites: A case study in Mauritius, Renewable

Energy, Volume 133, 2019, Pages 1201-1219, ISSN 0960-1481, https://doi.org/10.1016/j.renene.2018.08.105

3. What motivated you to choose this topic?

We believe that climate change is the most important issue facing humanity in our time, and as such we were drawn to creating a visualization that hopefully pushes forward the Climate Action Sustainable Development Goal. One of the most meaningful actions that can be taken for supporting the climate is transitioning from fossil fuels to renewable sources of energy and we determined that creating a visual that somehow helps that transition occur faster would be one of the most valuable visualizations possible. There are many barriers in the process of transitioning to renewable energy, but one of the barriers that can be addressed using openly available earth observation data is determining what areas would be most suitable to place solar panels. Additionally, we wanted to perform this analysis on an area that may typically be overlooked in these types of assessments. Highly developed countries such as the United States or European countries likely already have many versions of this visualization, and a lot of progress has been made towards identifying sites for renewable energy projects. We believe that creating this visualization for an area of the world often overlooked or not considered would be more impactful and useful.

4. How did you learn about the broader context of your chosen issue (e.g., historical, social, political)? This could include drawing on the lived experiences of team members, reading articles and literature, conducting interviews with community members, etc. Did what you learned change your approach?

Two of our team members lived in the Turks and Caicos Islands while studying marine science with the School for Field Studies. One of the most striking things we learned while being there, especially when compared to our lived experience thus far having grown up in the United States, was how scarce and expensive various resources were that we simply took for granted in the U.S. We learned to live with having to ration water, food, and energy due to how scarce and expensive those resources were on the island of South Caicos. We engaged with the local community while there and learned how different their lives were from our own, especially when it came to accessing those basic necessities of life. We also saw how much pollution came from the current sources of energy which are diesel power plants that run on expensive imported fuel. They produce high amounts of pollution and are a relatively expensive source of energy for the local people. Transitioning to a renewable source of energy could greatly reduce the amount of pollution and possibly cost of energy, and we were curious to map the suitability of solar panel farms in the area based on experience of the area and research on it.

5. What are the ethics and/or equity issues you considered? What are some possible strategies or approaches for addressing them?

One of the primary ethical considerations for placing solar panels or any other kind of infrastructure project is how it impacts the current population and environment of the area. Many of the areas identified as suitable in the visualization already have people living on them or using the land in some way, and therefore would likely be unsuitable areas based on that criteria unless those who would be potentially impacted by such a project agreed. We chose to not exclude these areas for several reasons. One is simply that we did not have the data to exclude those areas and chose to assess the areas based on the physical characteristics we that we could collect data for alone. We intend this visualization to serve as a starting point for a process of identifying potential areas to install solar panels that could be built on top of with other types of data to narrow down potential sites even further. It may even be of interest to current stakeholders to understand whether or not land they own or live on is suitable for solar panels based on these physical criteria.

Another equity dimension to consider is the responsibility for climate change based on historical emissions. We do not intend that making this visualization implies that we believe the Turks and Caicos Islands should transition to solar energy or that they are somehow responsible for the current state of climate change. Responsibility based on historical emissions clearly indicate that developed countries such as the United States, China, and European countries are most responsible for the current state of the climate and sound arguments on ethics and equity suggest that they should lead the world in transitioning towards renewables. One of the ways equity can be addressed is equity in data made openly available to other nations who may not have the capacity or ability to collect the types of environmental data we use here to pursue their own renewable energy projects. We hope that providing this visualization and analysis based on openly available data may somewhat increase equity in climate action and inspire others to build on or adapt this work.

6. Would your team like to share the URL of an interactive visualization?

https://pbd-demo-afdddfbb9a2c.herokuapp.com/