METHODS IN SPATIAL ANALYSIS

LAB SUN-SHINE ENERGY

SÃO PAULO SOLAR ENERGY POTENTIAL

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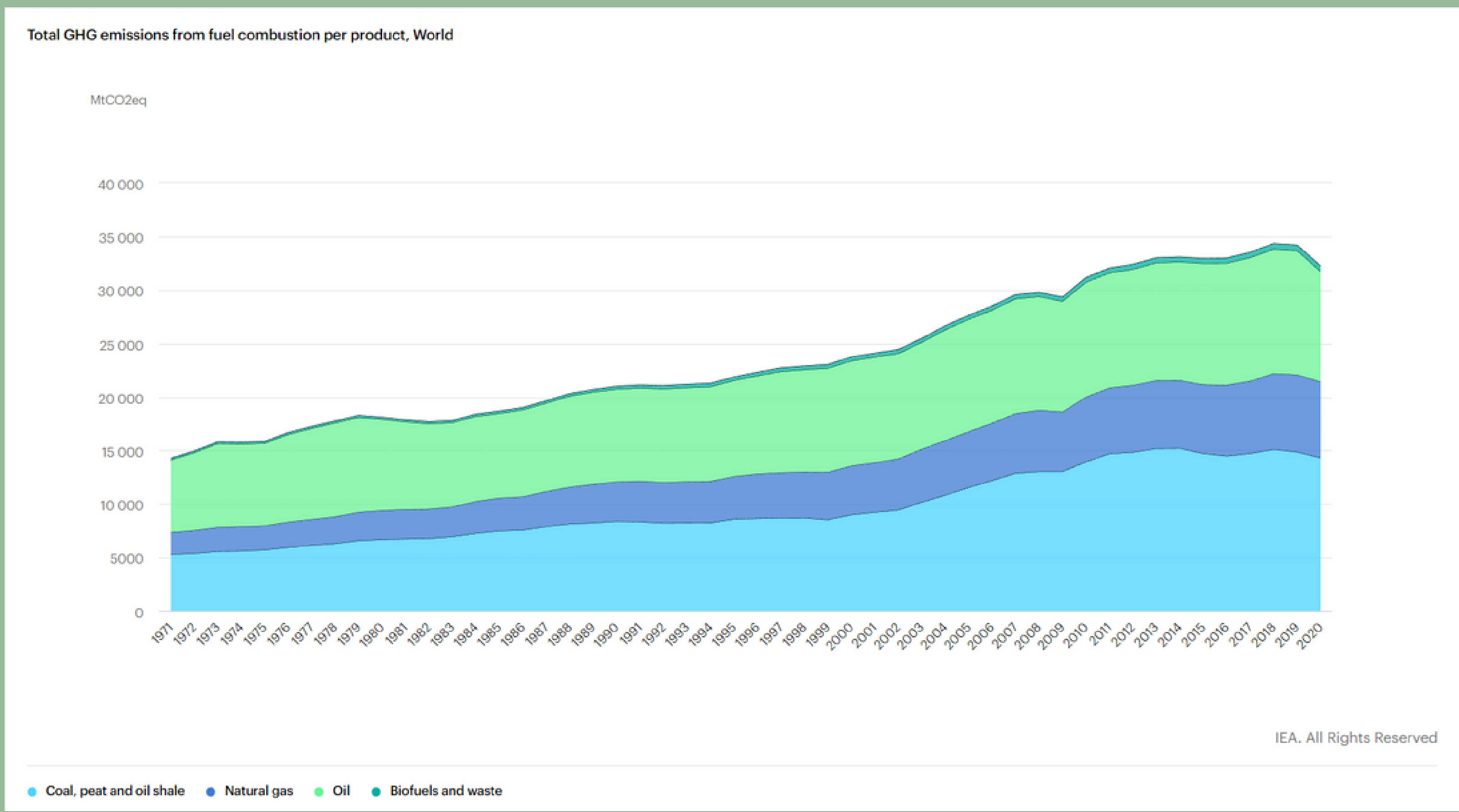
1. INTRODUCTION

Human activities are changing Earth's climate. Greenhouse gases emitted in our daily actions are increasing temperatures worldwide, besides changing natural phenomena.

Producing energy is one of the most polluting activities. According to International Energy Agency (IEA, 2021), **in 2020, CO_2 emissions per total energy supply was 54.2 tCO_2/TJ**, as shown in the image below. It was the first annual reduction since 2009, due to the COVID-19 pandemic.

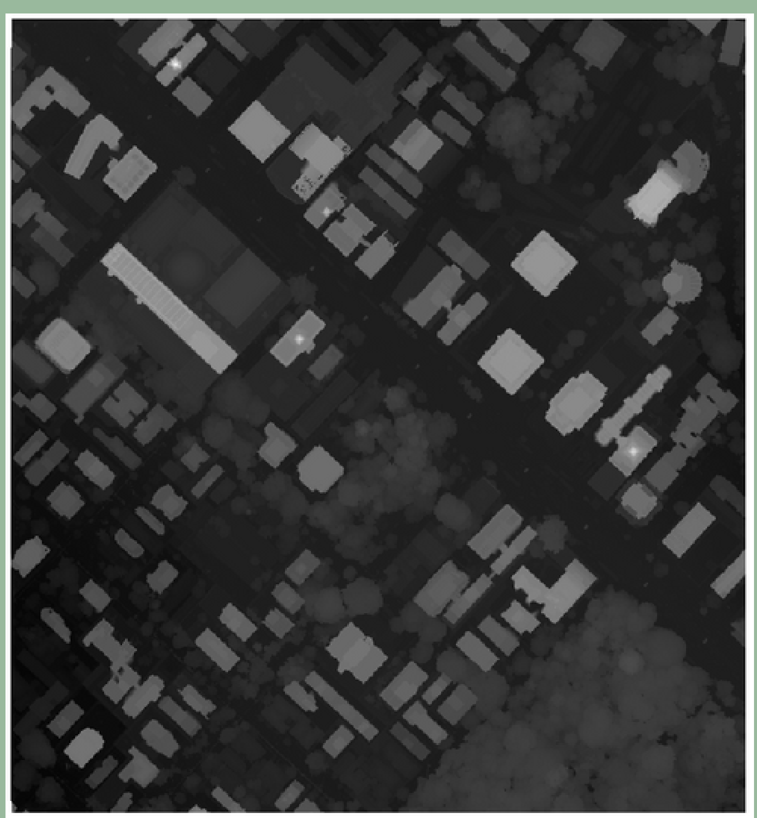


Even though this abrupt reduction, it is still necessary to look for a fewer pollutant means of producing energy. Nowadays, there are a lot of renewable energy options, and probably the most famous is solar panels.

Solar panels can be installed in houses, factories, buildings, and even in a form of "solar farms". Although the initial cost for house owners is expensive, for companies and factories it plays a major role in saving in terms of finance and energy. This energy source can be one of the solutions for reducing CO_2 and other GHG emissions.

2. METHODOLOGICAL ANALYSIS

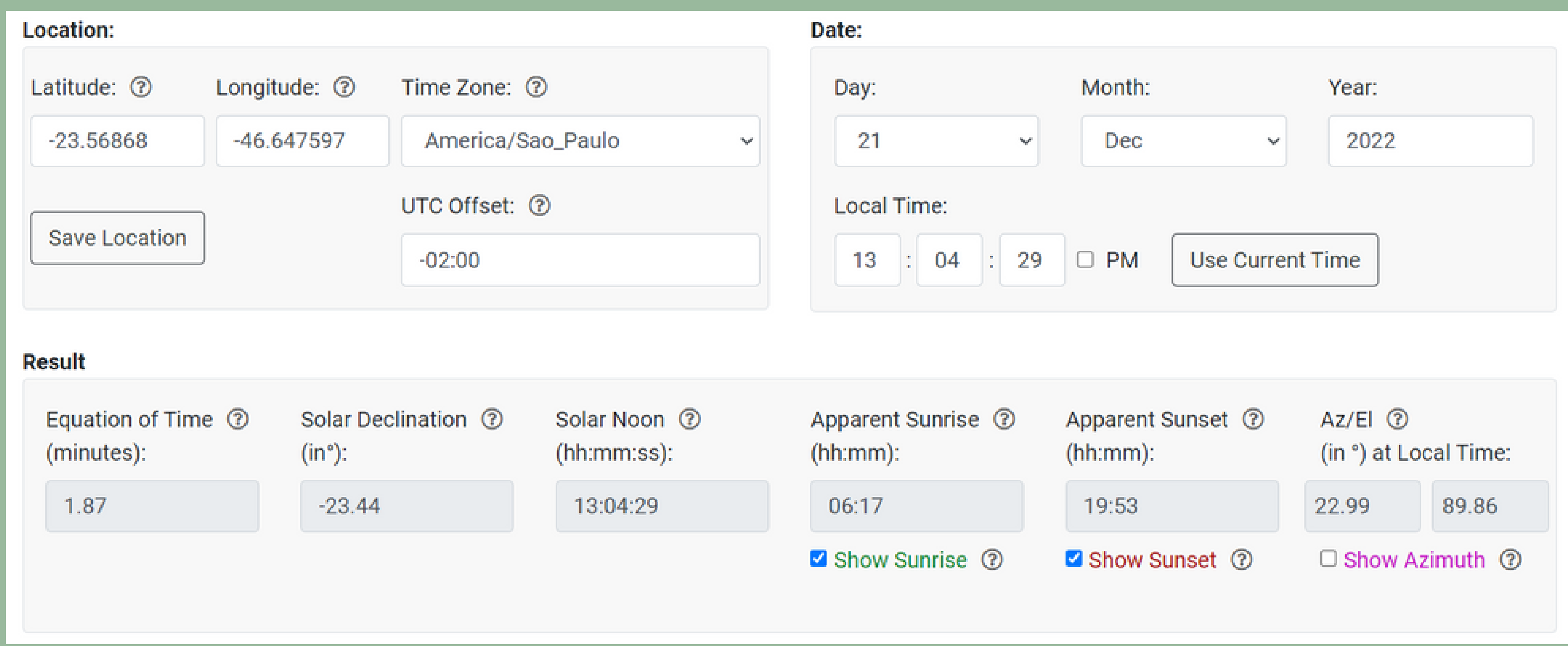
For the Lab Sun-Shine Energy, an area at the Avenida Paulista, São Paulo Downtown (Brazil) will be analyzed in order to point out the most promising areas for solar panel installation. Such analysis can be useful for companies or building administration that is interested in reducing their energy bills or want to reduce their carbon footprint as an ESG compliance. The methodological process was inspired by Rizcanofana (2021) and then simplified.
The very first step to making a sun-shine analysis is to have a Digital Surface Model (DSM). São Paulo city is mapped with LiDAR data, from which it is possible to generate the DSM.



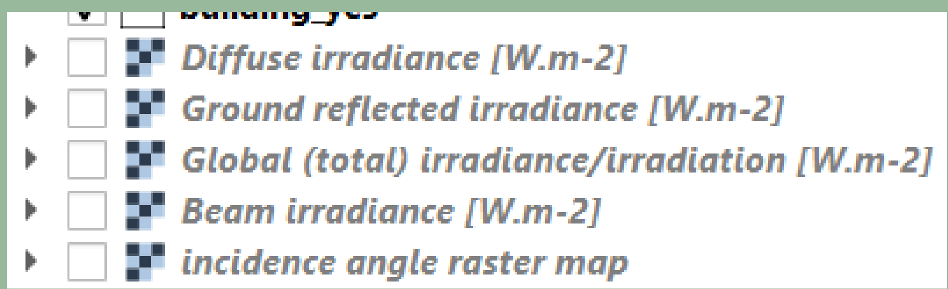
Using QGIS as an interface, GRASS, and WhiteToolbox (WTB) algorithms, all data was processed and visualized. To generate the DSM, a WTB function called *LidarDigitalSurfaceModel* was used, resulting in the following output. The pixels with a higher value were 1003m, meanwhile, the minimum value was 795m. For the whole scene, 5.3 million points were collected.

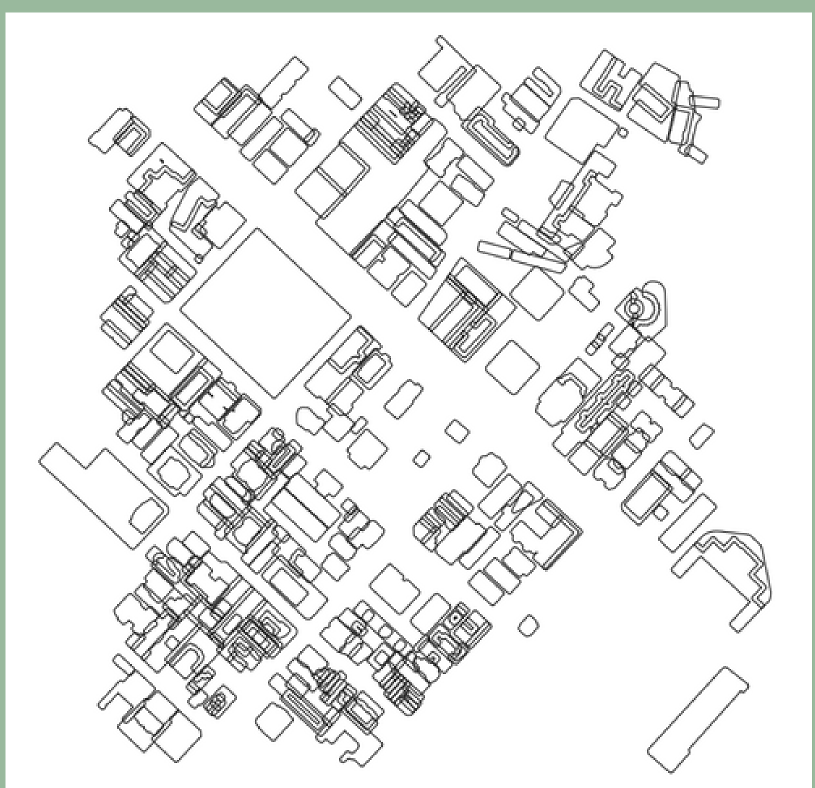
Following that, another WTB algorithm was used: *Aspect-Slope.* This algorithm's output is important because it will be input into the GRASS solar incidence function.

To have better information about Av. Paulista regarding the position and light time, it was considered December 21st since it is the solstice - the longest day in the year. Using NOAA Solar Calculator, the solar declination, azimuth, and elevation were discovered, being -23.44, 22.9, and 89.86 respectively.



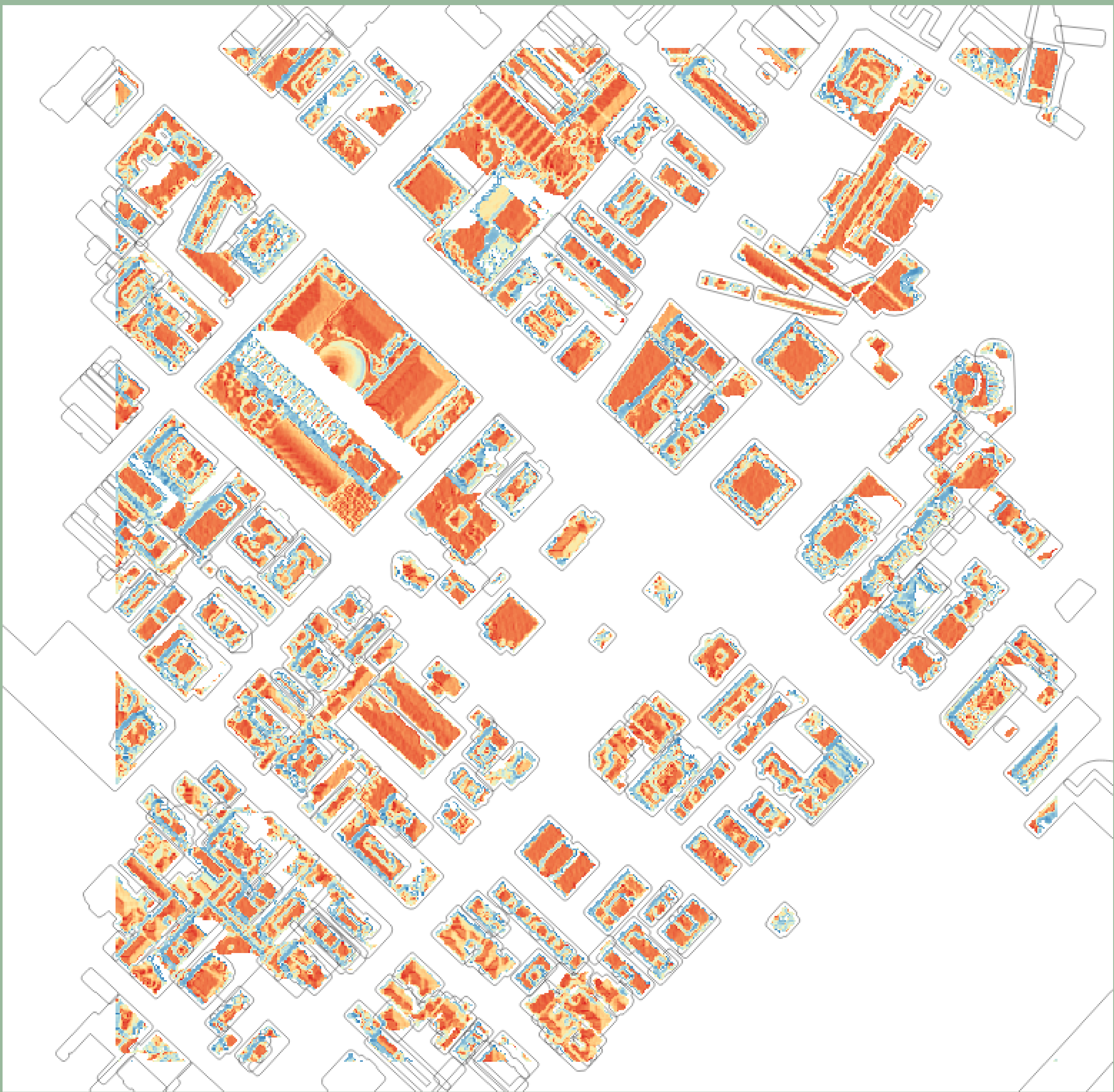
After the last step, all required information was acquired to input in the *r.sun.incidout*, from GRASS. In total, 5 layers were generated and their measurement of energy is in Watts per square meter.



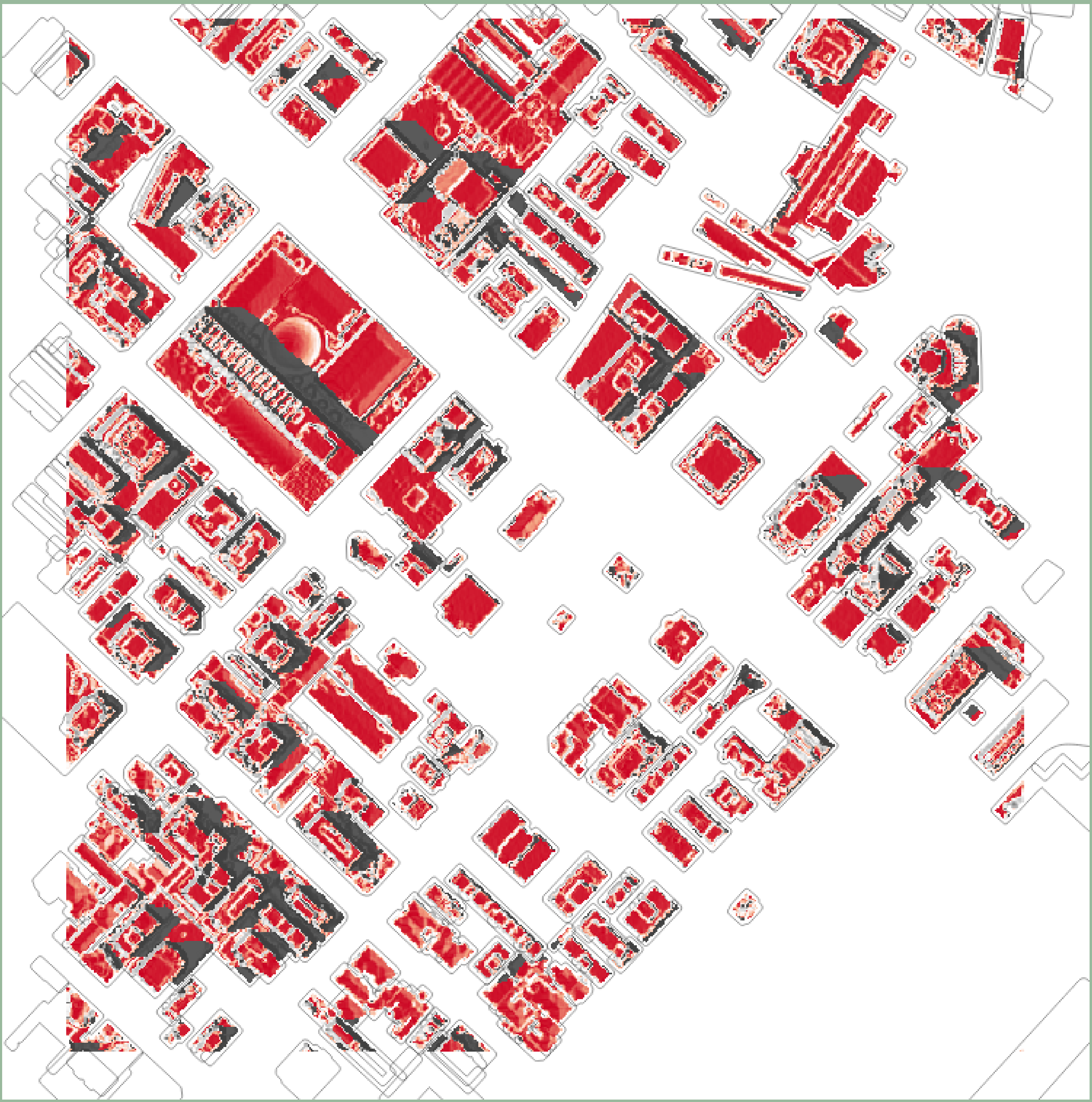


In order to filter only the areas of interest, which are buildings' rooftops, OpenStreetMap (OSM) data was downloaded for the whole study area, utilizing QGIS Plug-in named QuickOSM.

One of the outputs, which is called the "*incidence angle raster map",* shows the angle sunlight hit the surface. In most cases of our study area, it is near 90°, represented by red color, meanwhile, the blue represents angles closer to 0°.



For the purpose of this analysis, the most important output is the *"Global Total Irradiance/Irradiation W/m²".* It shows the potential for energy generation in this area, considering the solstice day. Solar panels in these rooftops can generate from 52 W/m², shown in gray color, to 1169 W/m², in red color. The whole map with more information can be seen at the end of this document.



3. CONCLUSION

The analysis presented here is not as complex as that found in other studies. It does, however, demonstrate how to work with open-data and open-source software and toolboxes to expand know-how and technical knowledge.

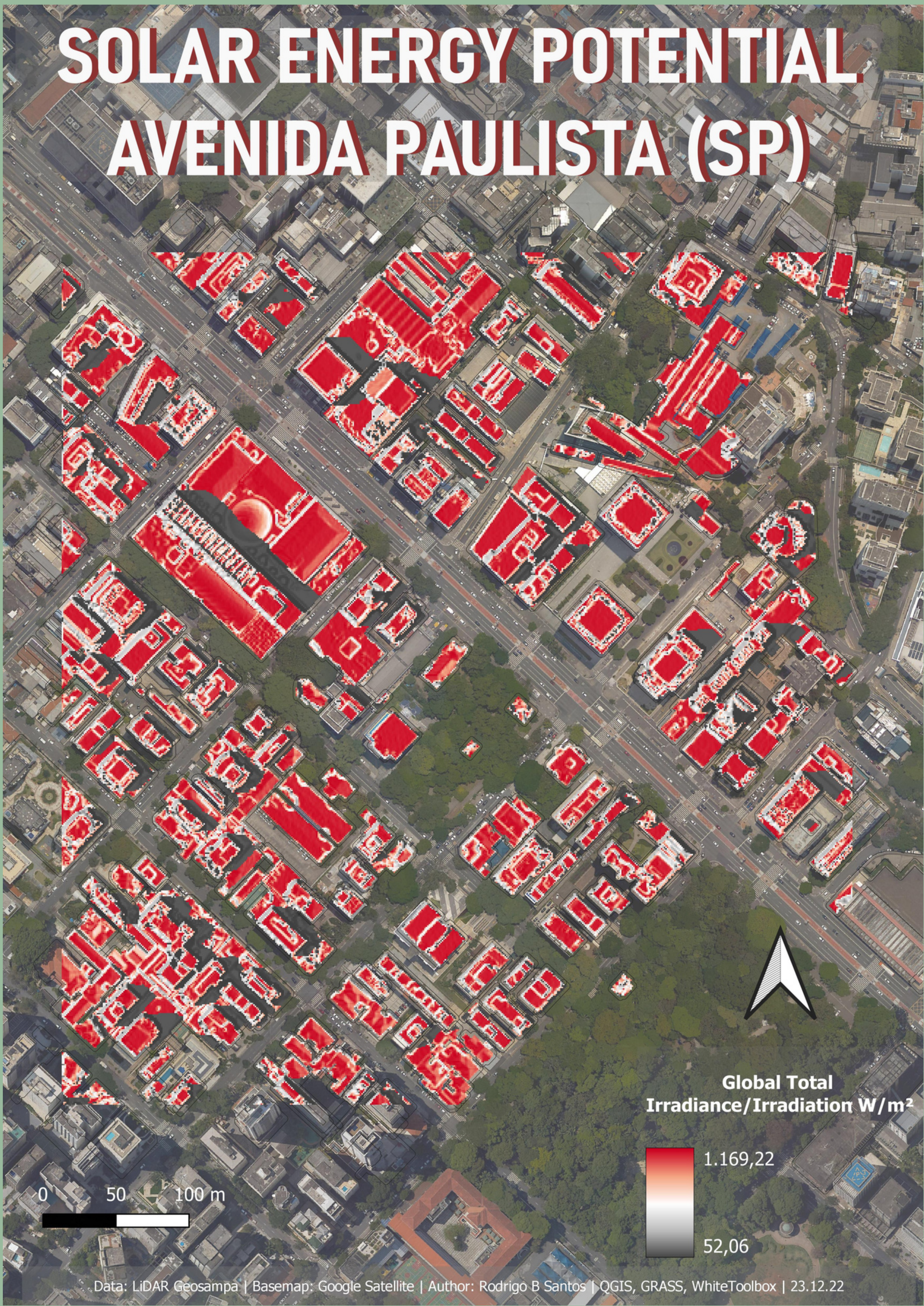
The entire workflow was completed straightforwardly, yielding satisfactory results. Even though it is essential to check the output for energy generation.

The fact that the area is not unknown confirms that the results regarding the direction, azimuth, and sunlight on the rooftops are not misleading.

4. REFERENCES

IEA (2021), **Greenhouse Gas Emissions from Energy Data Explorer**, IEA, Paris https://www.iea.org/data-and-statistics/data-tools/greenhouse-gas-emissions-from-energy-data-explorer

Rizacanofa, R. (2021), **GIS-Based Solar Photovoltaic Potential Modelling**, Palacký University Olomouc, Omoluc https://www.geoinformatics.upol.cz/dprace/magisterske/rizcanofana21/assets/file/MastersThesis_Rizcanofana.pdf


SOLAR ENERGY POTENTIAL
AVENIDA PAULISTA (SP)
Global Total
Irradiance/Irradiation W/m²
1.169,22
52,06
0
50
100 m
Data: LiDAR Geosampa | Basemap: Google Satellite | Author: Rodrigo B Santos | QGIS, GRASS, WhiteToolbox | 23.12.22