Boletín de la Asociación de Geógrafos Españoles, (98)
eISSN: 2605-3322

How to cite this work: Martín Ávila, A.M.ª (2023). *A geographic model development for the analysis of solar potential in urban environments from LIDAR data* (Summary of Doctoral dissertation, Complutense University of Madrid, Spain). *Boletín de la Asociación de Geógrafos Españoles,* (98). https://bage.age-geografia.es/ojs/index.php/bage/article/view/3489

SUMMARY OF DOCTORAL THESIS

Martín Ávila, Ana María. *A geographic model development for the analysis of solar potential in urban environments from LIDAR data*. Complutense University of Madrid (Spain), April 2023. Director: Dr. Javier Domínguez Bravo.

Population growth is turning cities into major energy consumers. However, they can also become producers and help adapt their supply systems to the new energy context from a more sustainable perspective. Proposals to diversify resources through the use of renewable sources such as solar energy are a clean generation alternative that is essential to achieve sustainability goals and help neutralise the effects of climate change. As it is an accessible option for on-site power generation, more and more projects are being developed for its use in urban areas (EEA, 2015; Jo et al., 2015; Masson et al., 2016). Through the implementation of smaller-scale plants, local resources can be used and energy dependence on foreign countries can be reduced.

As the consumption of renewable energy becomes more widespread, there is a need to better understand its feasibility for energy production. In this sense, it is reasonable to consider the assessment of solar potential as a tool to develop strategies for the use of these energy sources and to establish policies that improve urban planning (IRENA, 2020; Sarralde et al., 2015). When it comes to implementing plans at the urban scale, it is necessary to know how this space is organised, without neglecting the spatial relationships between and within the different sectors. In this context, models based on geographic information systems in planning (Alhamwi et al., 2017; Gassar & Cha, 2021; Shafiullah et al., 2016) and the application of detection technologies such as LIDAR sensors (Nelson & Grubesic, 2020; Szabó et al., 2016) play an important role in the deployment of solar energy supply in cities.

The research has been developed in the Geographic Information Technologies and Renewable Energies (gTIGER) group at CIEMAT, which works on the integration of renewable energies. The research lines in which this thesis is included are the gSolarRoof project (CIEMAT, 2020).

The main objective of this thesis is to evaluate the capacity of urban environments to generate their own energy by installing solar panels on roofs. The analysis is based on a three-dimensional building model generated from LIDAR data as a basis for defining the urban structure and identifying the roof area for solar installations. The research establishes the methodology on which the gSolarRoof geographic model, developed using ArcGIS software, is based to determine the solar potential of all buildings in an urban area. The model combines ArcGIS geoprocessing tools with new ones developed in Python to incorporate the necessary processes related to solar energy. Taking into account variables such as solar radiation, characteristics of the urban environment and the type of buildings, it defines the criteria for the ideal location of solar installations on rooftops in order to determine the energy produced by each building using different solar technologies. The model determines the potential for both photovoltaic electricity production and solar hot water production. It is intended to offer different exploitation solutions depending on the technology chosen and the resolution of the LIDAR data available for the identification of the roofs.

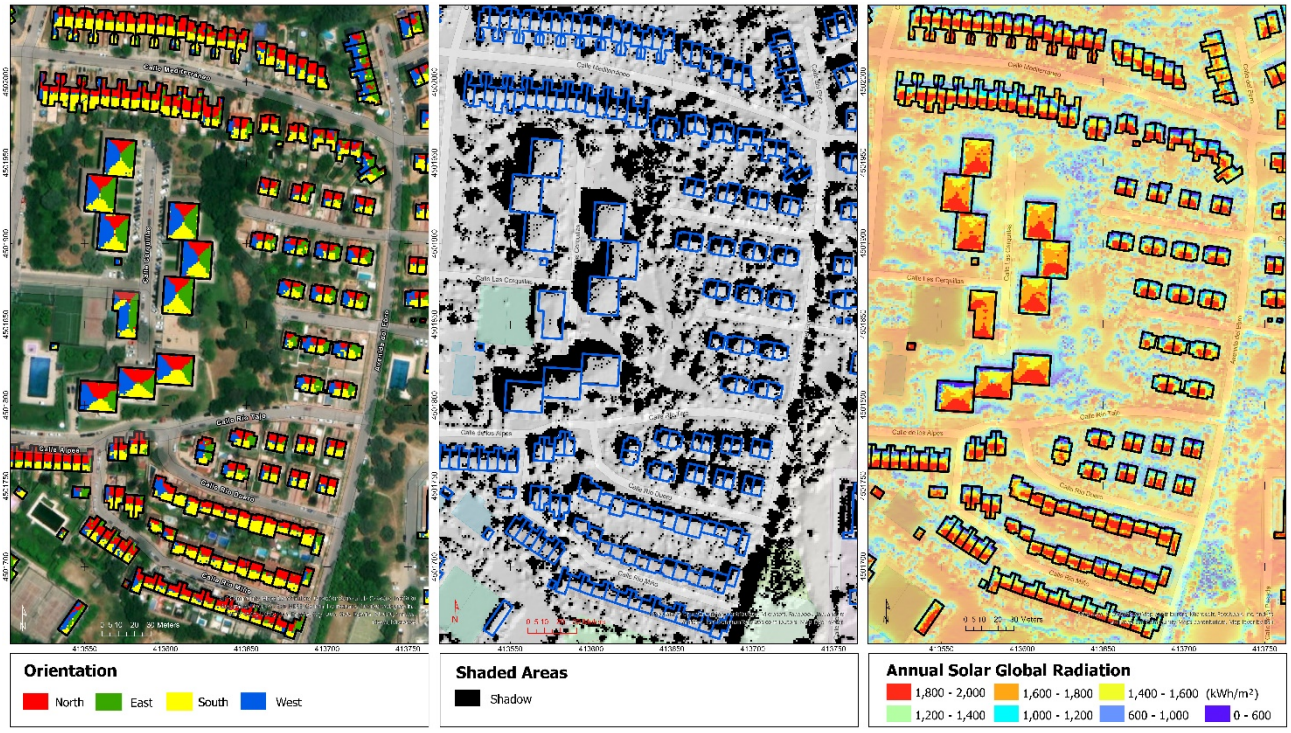
One of the features of the study is the in-depth verification of the data sources and the control of the observed errors in the processing and configuration phases of the info layers. The availability of up-to-date data with good resolution will not only determine the feasibility of the analysis and the precision of the results, but also the possibility of replicating it in other areas. The gSolarRoof model is characterised by the fact that it is based on freely available geographic data. In addition, the presentation and dissemination of information is given a prominent role. As part of the development, an internet map viewer (CIEMAT & Ayuntamiento Alpedrete, 2018) of solar potential has been created to consult the information related to each of the buildings.

The results obtained in the proposed case study of the municipality of Alpedrete, in the Community of Madrid, have made it possible to determine the high impact that solar integration could have, with more than 90% of the buildings having available roof space for solar installations. However, the results of this study are not considered sufficient for a comprehensive assessment of the application. For this reason, one research objective was to verify its functionality through a model validation process. A selection of buildings was studied to determine the accuracy of the parameters analysed and to propose methodological adjustments to improve its operation.

Finally, it should be noted that these geographical tools facilitate the visualisation of spatio-temporal factors and the programming of quantitative and qualitative analyses of renewable

generation data, as well as the investigation of scenarios in the development of strategies by those responsible for urban planning to promote initiatives aimed at stimulating their progress.

Figure 1. Some of analysed parameters for gSolarRoof model



Source: author's own elaboration

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