Title:
Assessment of solar photovoltaic potential of building rooftops based on multicriteria spatial analysis

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Level of study or work: Research

Information about you (and your team): Natasha Malijanska Andreevska is a member of the Chair of Geodesy and a PhD student at the Faculty of Civil Engineering at Ss. Cyril and Methodius University. The Chair of Geodesy has conducted various research projects focusing on the utilization of point cloud data for infrastructure recognition, building detection, and the recent assessment of photovoltaic potential on building rooftops. Natasha Malijanska Andreevska, the author of this paper, has been actively involved in these research activities, contributing significantly to achieving the research objectives.

Area of interest

The world has undergone rapid urbanization, technological advancement, and industrial growth in recent decades. While these developments have brought many benefits, they have also resulted in increased electricity consumption and atmospheric pollution due to the use of traditional energy sources such as fossil fuels for electricity production. Although cities cover only 3% of the Earth's surface, their contribution is up to 80% of global energy consumption and 75% of greenhouse gas emissions [7]. The increased demand for electricity, as well as concerns about environmental degradation, have led to increased interest in renewable energy sources which are sustainable and environmentally friendly alternatives to mitigate the negative effects of using fossil fuels.

In urban areas, where solar energy is one of the more accessible renewable energy sources, building rooftops is considered one of the most suitable locations for installing a photovoltaic system for electricity production. It is important to note that not all roof surfaces are equally suitable for installing a photovoltaic system. The identification of suitable building rooftops in terms of their solar potential and estimation of the amount of electricity that could be produced if there is a photovoltaic system installed can be performed using multicriteria spatial analysis utilizing GIS [2, 5].

By integrating data from various sources, such as LiDAR data, orthophoto and satellite imagery, cadastral data, solar radiation data, etc. three-dimensional spatial models are created as a foundation for complex spatial analyses for assessment of the solar photovoltaic potential of building rooftops [3, 4].

Approach to the problem

The purpose of the research is to establish a methodology for evaluating the solar photovoltaic potential of building rooftops based on LiDAR point cloud data utilizing GIS.

The process for assessment of solar photovoltaic potential of buildings rooftops can be divided into two main parts:

1. Extraction of building footprints,
2. Assessment of solar photovoltaic potential.

Figure 1. Methodology for assessing the solar photovoltaic potential of building rooftops

The first part represents the extraction of building footprints that are subject to the analysis in the second part. The second part is assessing of solar photovoltaic potential of building rooftops, where a variety of digital spatial models were generated. These models help identify the roofs that are suitable for installing solar photovoltaic systems and to assess their solar photovoltaic potential.

The process begins by creating a digital surface model using classified LiDAR point cloud data. Based on the digital surface model, digital models of slope and aspect were generated, which provide the value of the slope and aspect of the building's roof.

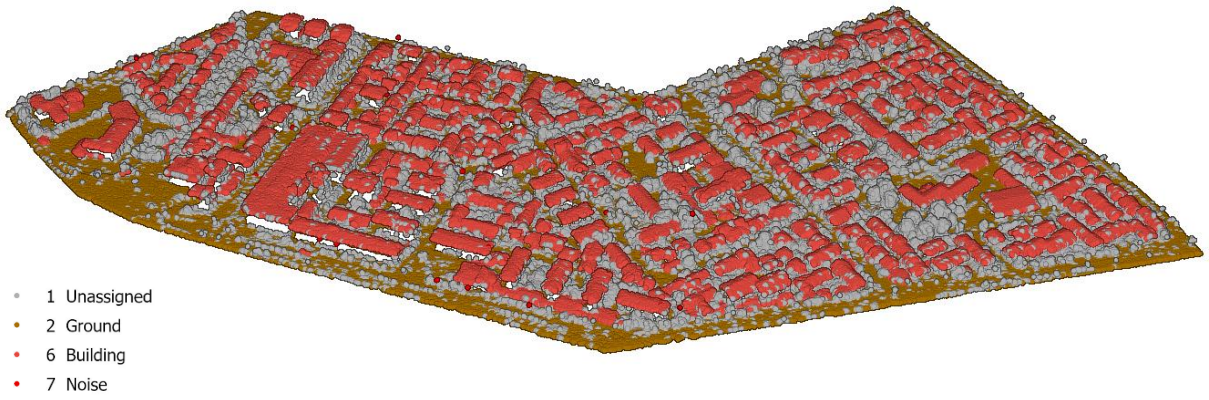

Figure 2. LiDAR point cloud from research location, points are automatically classified into four classes

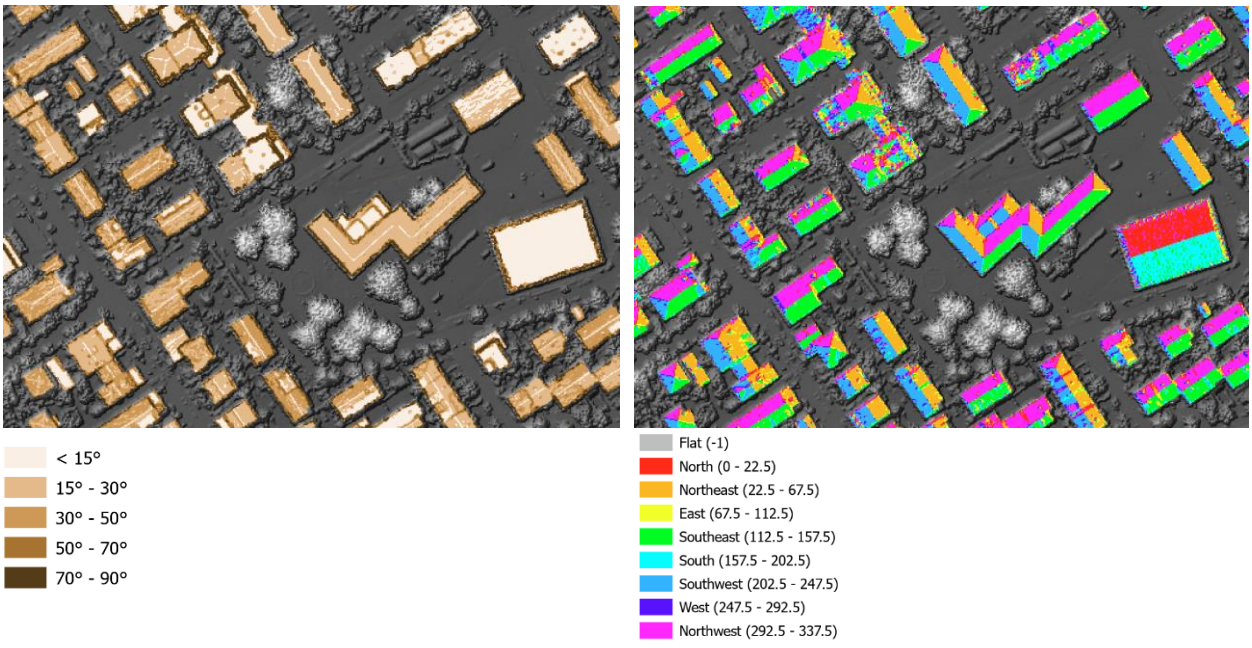

Figure 3 Digital model of rooftops slope (left), digital model of rooftops aspect (right)

In the end, a comprehensive mathematical model is used to create a digital model of solar radiation, considering the position of the sun through the year and different times of day, as well as any obstacles that may block sunlight (such as nearby trees or buildings) as well as the slope and aspect of the roof surface. The method for generating the digital solar radiation model is based on the hemispherical viewshed algorithm developed by Rich et al. (1994, 2000, 2002) [1, 6].

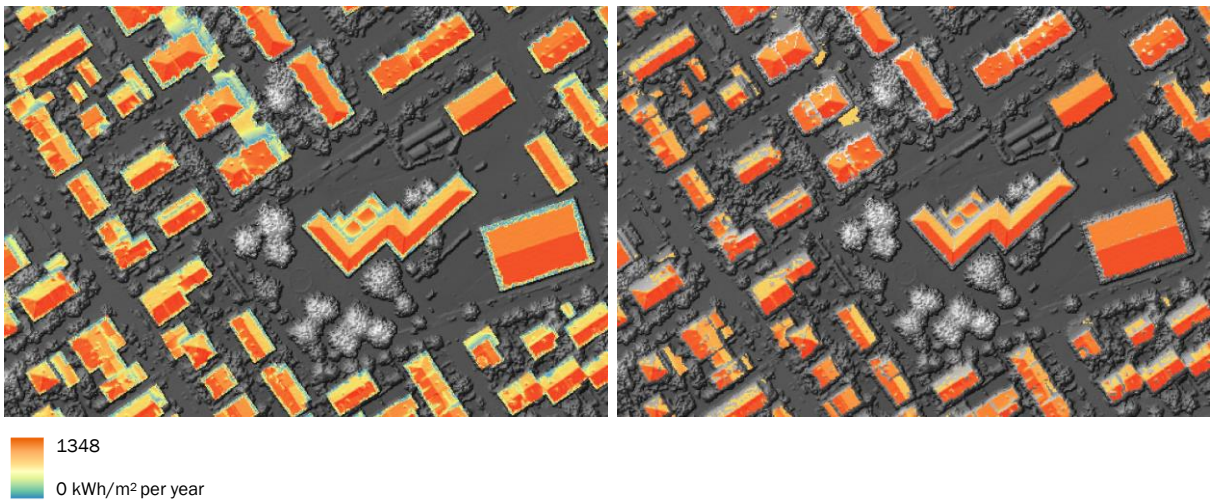

Figure 4. Digital model of solar radiation (left), rooftops or parts of rooftops identified as suitable for installing solar systems (right)

The analysis continues with identifying roof surfaces suitable for installation of solar photovoltaic systems based on criteria taking into consideration the amount of solar radiation, slope, and aspect of the roof surface. As a result of the analysis, the potential electricity that could be produced by installing a solar photovoltaic system was estimated for each suitable building.

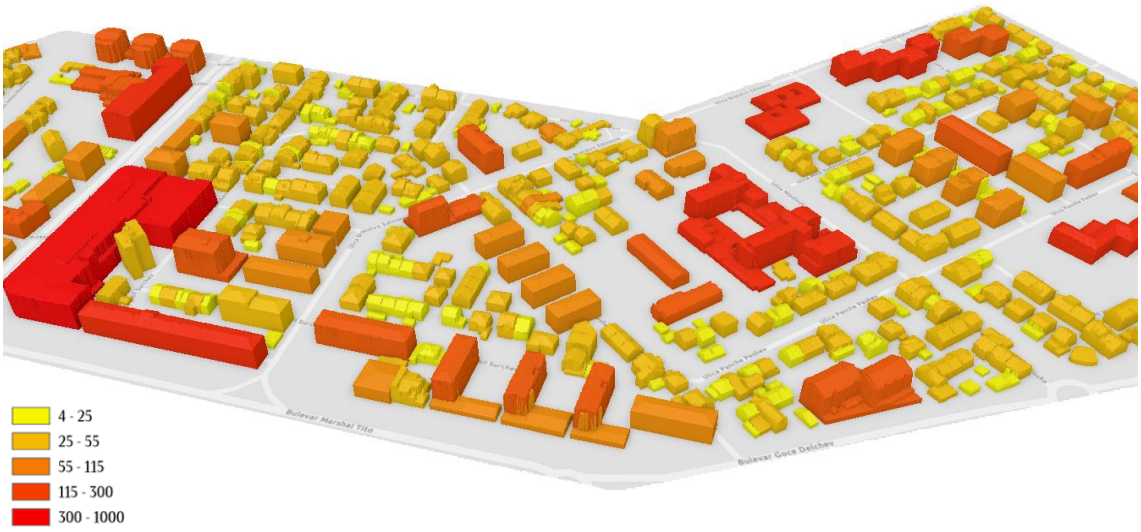

Figure 5. Potentially produced electricity (MWh) per year from each building within the case study area

Results, conclusions and next steps

The research as a case study took into consideration an urban area with a size of 38 ha, where 628 buildings have been identified with a total area of 11.9 ha. From all identified buildings, 529 suitable for the installation of photovoltaic systems with a total area of 7.3 ha have been identified, which represents 62% of the total rooftop area analysed.

The potential produced electricity per building ranges from 4 MW/h to 1000 MW/h per year and the total electricity that would be produced if solar photovoltaic systems were installed on all rooftop surfaces in the considered urban area identified as suitable, would be 11329 MW/h per year.

The combination of LiDAR data, spatial modelling and Geoinformation systems enables sophisticated analysis, and efficient identification of optimal locations for installation of solar photovoltaic systems for production of electricity from solar energy including all significant spatial factors that may affect the solar photovoltaic potential of rooftops.

In the selected case study area, the methodology has been applied to a relatively small part of an urban area. However, the same methodology could be easily applied for a much wider area, on a city, region, or country level, providing reliable sources of data for further statistical or any other types of analysis where the photovoltaic potential of building rooftops is requested.

References

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