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The establishment and significance of district/regional roof cadastres in the utilization of solar energy

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Abstract: After its establishment, the roof cadastre – solar cadastre I wish to introduce in this article will form a database, with the help of which we will be able to analyse solar radiation factors on the local level (street, house), and a map display will also be available. Through the implementation of the appropriate methods, we can establish roof/solar cadastres on the settlement/district/regional level and these can help to increase the rate of utilization of renewable energy sources.

Keywords: renewable energy, geoinformatics, solar energy potential, GIS, SEAP

1. Introduction

Due to the gaining ground of renewable energy sources in the 21st century and the development of the geographic information and remote sensing methods, there are several opportunities to create databases related to innovative, utilizable and alternative energy resources. These cadastres, digital databases – depending on the size of the examined area – can facilitate the calculation of the solar energy potential of the settlement or district. I would like to present the current state of the creation of such a roof cadastre and the significance/opportunities of its utilization.

2. Materials and methods

As of today, analogue cadastre maps are dominant in Hungary, and these show buildings in two dimensions. The 3D representation of buildings is possible, similarly to the floor-by-floor plan of the condominiums, but the use of codes and the display of a unique identifier are necessary on the map.
The permanent development in the geographic information system makes possible the creation of spatial maps, the visualization of buildings and 3D representation.

Digital maps must show the horizontal situation and the elevation, dimension and shape of underground and overground buildings. An important characteristic of spatial modelling is the level of detail (Level of Detail, LOD), in the case of which Europe distinguishes the following levels for city models and building models [1, 2]:

- LOD 0: regional model, 2.5D field model, with orthophoto texture;
- LOD 1: city/building model, 3D taking the model plan showing the block of building as starting point;
- LOD 2: city/building model, 3D building model including walls and roof shown with simplified texture;
- LOD 3: city/building model, 3D architecturally detailed model;
- LOD 4: interior model, which is the exterior and interior 3D model of the building with texture.

To establish the roof cadastre I wish to create, the LOD 2 level must be reached, as this level of detail makes possible the observance/calculation of the shape of the roof structure, the exposure and the extent of leaning, and further calculations can be made on the basis of the model. To establish roof surface models, we need to know the height data of the given buildings, which we can get through 3 different digital height measurement procedures: field measurement, photogrammetry/photo matching and the LiDAR measurement [5].

The basis of my research was served by the LIDAR measurement carried out with the help of the Remote Sensing and Rural Development Research Institution of Róbert Károly College of Gyöngyös in the spring of 2013. The LiDAR (Light Detection And Ranging) measurement is a laser scanning based on distance measurement with the help of laser light. When creating a roof surface model, the measurement is made by a laser distance gauge mounted on an airplane. The necessary data during the measurement are the spatial place of the instrument and the ray direction of the emitted laser; thus, we can calculate the height of a given point from which the laser ray is reflected. The point cloud created by the measurement can then be “cleared” to a set of points we are interested in: in the present case, to the set of points reflected by the roof surfaces [3]. A big advantage is that this procedure makes possible the measurement of thousands of points per second, and the height values we receive are very punctual [4]. With the help of appropriate software, it is then easier to calculate the size, exposure and leaning angle of the roof surfaces of the buildings. In order for the roof cadastre to be suitable for the estimation of the solar energy potential, we need to know the relatively exact amount of sunshine – incident sunshine in the given area, which we can get either by our own measurement (with the help of a pyranometer) or by the results measured by the measuring stations of the National Meteorology Institution (Országos Meteorológiai Szolgálat – OMSZ) (other options: values calculated by algorithms of geographic information software packages: ArcGIS, GRASS GIS, on-line databases – SOLEMI, SoDa, etc.) [6].

I am processing both the point cloud received from the LiDAR measurement and the data provided by the OMSZ with ESRI's ArcGIS 10.1 software. ArcGIS's version 10 can handle files with LAS extension coming from LiDAR measurements; so, they have been insertable and editable since 2010, plus the sunshine data can also be processed by the Solar Radiation that can be found in the SpatialAnalyst toolbar of the ArcGIS 10.1 software. The import of the own data gives an even more exact result, as if our research were based on the irradiation values automatically calculated by the programme. "Putting" the irradiation values calculated per m^2 we thus receive on the roof surfaces of the prepared 3D settlement models, the amount of irradiation falling on the given roof surfaces can be calculated in a daily, monthly or yearly breakdown.

3. Results and discussions

During the LiDAR measurement in the valley of the River Bódva in Northern Hungary, in Borsod-Abaúj-Zemplén County (see Figs. 1 and 2), approximately 618 million points got into the created point cloud on a 218 km flying route; so, the point density was 5 points/m^2. According to international specialist literature, such a point density is sufficient to exactly determine the size, exposure and leaning angle of particular surfaces (including roof surfaces).

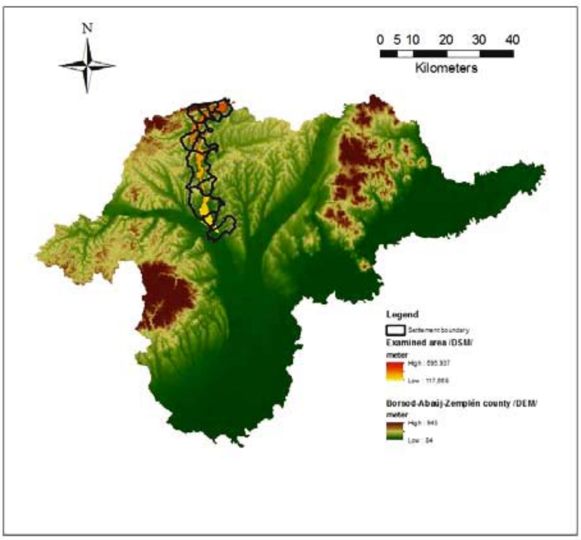

Fig. 1. The examined area in Borsod-Abaúj-Zemplén County.

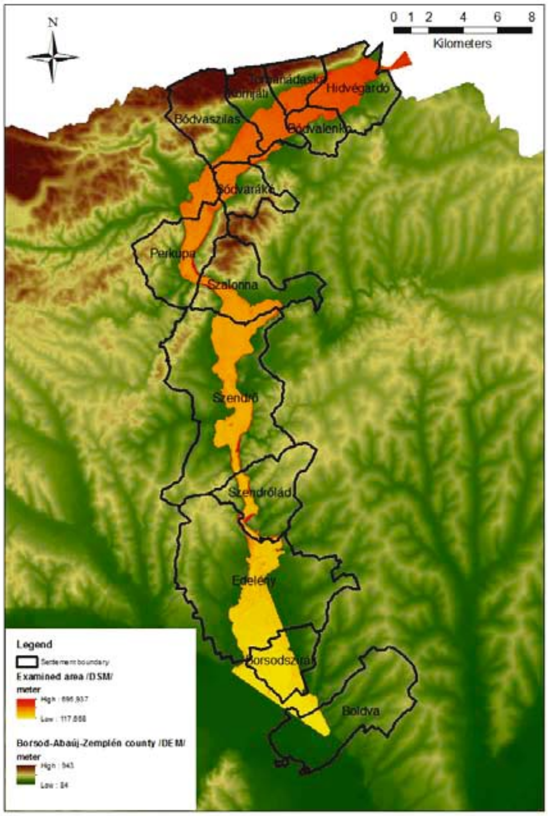

Fig. 2. Closer view of the examined area – Bódva Valley.

After clearing the received point cloud, we prepared – also with the help of Róbert Károly College of Gyöngyös – a digital surface model (DSM). An advantage of DSM is that it includes every object (tree, building, etc.) as opposed to DEM, which shows only the elevation above sea-level of the Earth's surface (see on Fig. 3). The further evaluation of the surface model we have thus received is still under way. This means selecting the buildings with the help of orthophotos and cadastre maps, thus increasing the exactness and reliability of subsequent results.

Fig. 3. Closer view of the DSM and cadastre (Edelény).

As for irradiation data, in the absence of own measurement/measuring equipment, I received exact data through acquiring the data sets recorded by the Edelény measuring station of OMSZ between 2008 and 2012. These show the amount of irradiation in J/cm^2 in a daily breakdown. By the import of these data, SolarRadiation fits on the digital surface model and shows the amount of irradiation collected on the surfaces [7].

I will continue my research by linking up the already established DSM and the irradiation values, and I will also take into account the shadiness of buildings and roof surfaces as a separate factor. This shadiness can be caused by the chimneys on the roofs, the trees and taller buildings in the surroundings of the examined buildings. I would also like to select the buildings owned by the local governments or the state, as the provision with devices utilizing solar energy of private and public buildings has to be treated separately.

4. Conclusion

As a consequence of the roof cadastres described in this study and the irradiation values linked to it, we can establish a so-called solar cadastre. Its utility lies in that on a website you can get a lot of information about the roof surface of any chosen property. Such data can be, for instance, the amount of producible

electricity and heat, the amount of CO_2 saved, the investment cost and the period of return of the planned system, etc.
Their significance, apart from the information they provide, is that individuals and state institutions alike can more easily and cheaply implement investments related to solar energy and make decisions on the planning of a system connected with solar energy. They can also act as a sort of “supporting-incentive” service for the writing of tenders related to renewable energy sources, in the hope of increasing the willingness of writing tenders in the 2014–2020 programming period, in which – in all probability – the biggest ever sums will be allocated for renewable energy sources.

For the decision-makers of settlements and regions, the existence of a solar cadastre and the database provided by it can form a significant basis to write their own (settlement-region) SEAP (Sustainable Energy Action Plan), which is an essential document for joining the Covenant of Mayors (later it can be called Climate Protection Association), which can offer a settlement further opportunities for a European collaboration and the implementation of joint projects. The SEAP documents focus on the buildings, equipment/facilities and urban transport; furthermore, they could include actions related to local electricity production. The roof cadastres could take place in the planning stage (reading of the current situation – where are we?) and could give exact numbers for the solar potential of the examined area.

In Central and Western Europe (Austria, Germany and Great Britain) and in the United States of America, there already exist roof and solar cadastres with different quality and functions, both on the settlement and the province level. It is very likely that due to the knowledge transfer, by the end of the 2010s, these information sources will appear in several Central-Eastern European countries and regions, and help further increase the proportion of utilized renewable energy sources (solar energy).

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