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Application of the Visual Protection Surface Method (VPS) for Protection of Landscape Interiors within a City

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Abstract. The article concerns application of the Visual Protection Surface method for analysing landscape interiors and to provide objective computer simulations useful in planning. In this article, landscape interiors are understood as open areas within the city borders, chiefly composed greenery (e.g. Champ-de-Mars in Paris or Belvederegarten in Vienna). The Visual Protection Surface method (VPS) allows to analyse geometrical relationships between the scope of visual protection (selected strategic views) and the heights of new buildings (planned investments). According to a simplified approach, the VPS determines a surface above the city, which defines the maximum height of new buildings in such a way that no new facility can be seen in any of protected strategic views. The research shows how to apply the VPS method for the protection of landscape interiors. It introduces a case study prepared for the Central Cemetery in Szczecin, Poland (described in detail). Related computational aspects, such as 3D models, greenery modelling and scanning, LiDAR, application of VPS, and software solutions, are also analysed.

1. Introduction – landscape interiors

The research presented in this article concerns the application of digital urban simulation techniques aimed at the protection of valuable landscape interiors in the city. Such interiors are understood as relatively wide open areas within the city, bordered (in a significant part) by composed greenery systems. Well known examples include, inter alia, Champ-de-Mars and Jardin-du-Luxembourg in Paris or Belvederegarten in Vienna (figure 1).

New investment, in particular tall buildings, may pose a threat to the composition integrity of landscape interiors. A well-known example is the Tour de Montparnasse (built in 1970s) which disharmonises the view from Champ-de-Mars (however distance between view point and this facility is over 2.5km) (figure 1b). It shows that the methodology of protecting landscape interiors should include a wider context (up to 5km form centre of landscape interior). Moreover, in most cases landscape interiors are historically composed and completed. They have to be protected as built and visual influence of new investment is undesirable (cannot be accepted).

Landscape interiors are obviously significant for the cultural identity of a city, whereas possible threats are growing incrementally. Tall buildings have become increasingly popular in the world. The majority of contemporary tall buildings have been built in the recent two decades [1]. This trend is very explicit in Europe. In many instances, the development of new landmarks results from a rapid investment process combined with the shortage of time for any in-depth landscape analysis. This indicates the need for creating protection schemes for landscape interiors.

The expected result should be specific possibilities for establishing landscape interior protection schemes – determining the maximum height of buildings in a city. The analysis of visual relations between a landscape interior and a city can a subject of objective assessment by using the VPS method. One of difficulties to be overcome is to reflect tall green in the 3D model and provide relevant computation. The article presents an example of the Central Cemetery in Szczecin, which shows how the proposed formula of establishing a landscape interior protection scheme can be applied in practice.

Figure 1. Landscape interiors: a) Belvederegarten in Vienna, b) Champ-de-Mars in Paris with Tour de Montparnasse, c) Jasne Błona in Szczecin (Poland). Source: photos by author

2. Introduction – landscape interiors

The goal of the research is to prove the application ability of the Visual Protection Surface (VPS) method for analysing landscape interiors and to provide objective computer simulations useful in planning.

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3. Visual Protection Surface method (VPS)

The Visual Protection Surface method (VPS) allows processing of 3D models of cities to study visual relationships for wide cityscape. It allows to analyse geometrical relationships between the scope of visual protection of the city and the maximum heights of new buildings. The input data include coordinates for a number of strategic views. VPS result is a surface above the city, which defines the maximum height of new buildings in such a way that no new facility can be seen in any of the strategic views. Theoretical assumptions and geometric aspects of VPS are presented in other publications [2, 3]. The method has been prepared partly within the 2TaLL project: "Application of 3D Virtual City Models in Urban Analyses of Tall Buildings" conducted as a Polish-Norwegian grant finished in 2016 [4]. Software solutions (C++) allowing application of VPS was developed by author. All simulations presented in this article are prepared using this environment.

The VPS method was used for the first time in 2015 to protect panoramas of Dresden viewed from the bank of the river [2]. Studies available at that time did not cover tall green. The analysis input included the CityGML model encompassing solely built-up development (LoD2, LoD3). The application of the VPS method for transformation of DSM (Digital Surface Method) models was a major challenge, a challenge which was successfully met in 2017. The resulting models covered a complete picture of the spatial structure of the city including tall green. Examples of VPS analyses are presented in the figure below (figure 2).

To be able to use the VPS method for establishing landscape interior protection schemes, it crucial to deal with the following issues: 1) method for defining strategic vistas within landscape interiors, 2) quality of reflecting tall green in 3D city models, ad 3) defining of protected areas and height limits for new buildings.

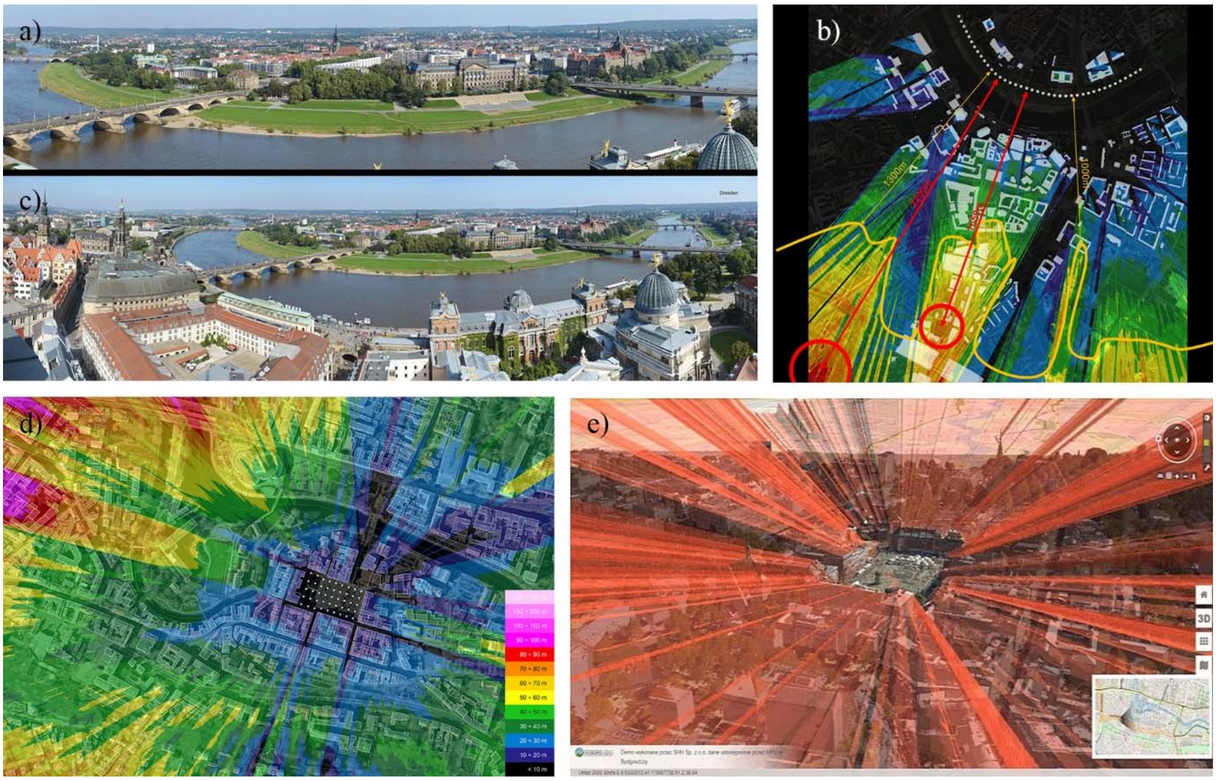

Figure 2. VPS simulations: a-c) for protection of Dresden riverside panoramas, d-e) for a main square in Bydgoszcz, Poland. Source: a-d) by author, e) in cooperation with SHH company

4. Projection of the greenery in 3D city models

While planning the protection of landscape interiors, it is important to take into account tall green with a high degree of fidelity. Tall green is a crucial component needed to define space in such interiors. Digital models frequently reflect tall green in a schematic manner or neglected (figure 3) [5]. In Western Europe, CityGML is a common standard. The classification of the precision applied in CityGML (LoD, Level of Details) is based solely on reflecting built-up development [6]: buildings excluding roofs (LoD1), buildings including roofs (LoD2), buildings with certain elements of their facades, including windows (LoD3). The LoD structure is subordinated to reflecting built-up development. Therefore, vector models available usually exclude tall green. The level of precision tall green is reflected in the 3D model is not included in the LoD scale. Nevertheless, tall green is an integral part of the city, and trees are frequently taller than buildings themselves [7, figure 5].

In the case of landscape interior analyses, a more complete picture of a city is provided by LiDAR and its derivative models, such as DSM (Digital Surface Model). DSM models present a complete structure of a city [8]. A drawback of the model is the lack of semantics. Additionally, buildings and tall green is represented at the identical degree of precision [9]. The situation is similar in the case of reality-3D-mesh models which are accessible in the Google Earth. However, the models are used solely for the visualisation of the city and are not available for scientific research or planning. Moreover, DSM data are available. In Poland all larger cities have been scanned [9] and the precision of those scans is the highest in Europe. Data can be used both for planning and for scientific research (free of charge).

Figure 3. Projection of the greenery in 3D city models – views of London: a) 3d-reality-mesh in Google Earth, b) Model by VERTEX (without greenery)

5. Application of VPS for landscape interior protection – case study

5.1. Central Cemetery in Szczecin – the research object

The research is carried out on the example of the Central Cemetery in Szczecin. An open area (landscape interior) composed within this cemetery is very representative for proposed analysis. The cemetery is one of biggest in Europe. It was designed at the beginning of 20-th century by Wilhelm Meyer-Schwartau and Georg Hannig [10]. A key element of the landscape structure is as axis with length over 1km, symmetrically clad with two lines of the greenery and is visually closed by a Neo-Romanesque chapel and a water reservoir with a fountain located on the axis before the chapel (figure 4).

The Central Cemetery in Szczecin has a unique landscape arrangement due to its sheer size (over 1.7 km2) and exceptional composition values. Although it is situated in the core city centre, one can hardly see the city n internal vistas. The terminating vista of the main axis show a chapel which is a major landmark in the cemetery. Further, at the beginning of the axis we can also see the tower of the Szczecin's cathedral. The composition has been preserved in its original form. Although none of contemporary architectural projects in the city distorted the composition, the threat remains real. In 2007, plans included the development of a tall building which, similarly to Tour de Montparnasse in Paris, could have introduced disharmony. The landscape analyses using the VIS method helped abandon the investment [11, 12].

Figure 4. Central Cemetery in Szczecin. Source: photos by author

5.2. Digital resources applied in the case study

The goal of the VPS analysis for the Central Cemetery in Szczecin is to develop a map defining maximum heights of buildings in the city, so any new project does not interfere with the composition of the landscape interior of the cemetery. A starting point for the analysis is to select a 3D model and determine the area of the city to be examined. The research in question used the DSM model (Digital Surface Model) with 50cm mesh (developed based on LiDAR data) [8]. The height measurement error is 15 cm. The visualisation of the model is presented in figure 5. The research has covered the area of 6 x 3.9 km, covering the city centre, all investment sites where buildings can pose a potential threat to the landscape interior of the Central Cemetery.

5.3. Selection of strategic views

In order to determine VPS surfaces, we need to select strategic vistas be protected. In the case of the Central Cemetery in Szczecin, the entire space of the main landscape interior needs to be protected. This means that in every location with the area the visibility of new architectural facilities is undesired. The number of views analysed has, however, an important impact on the computation time. Therefore, it is crucial to reach an approximation at which we can be certain that the increase in the number of views examined does not have much influence on VPS results. The study presented assumed two options: a) 15 visibility points situated in the most important locations of the landscape interior of the Central Cemetery, b) 202 visibility points spread over a regular mesh of 10 m of over the area (figure 6).

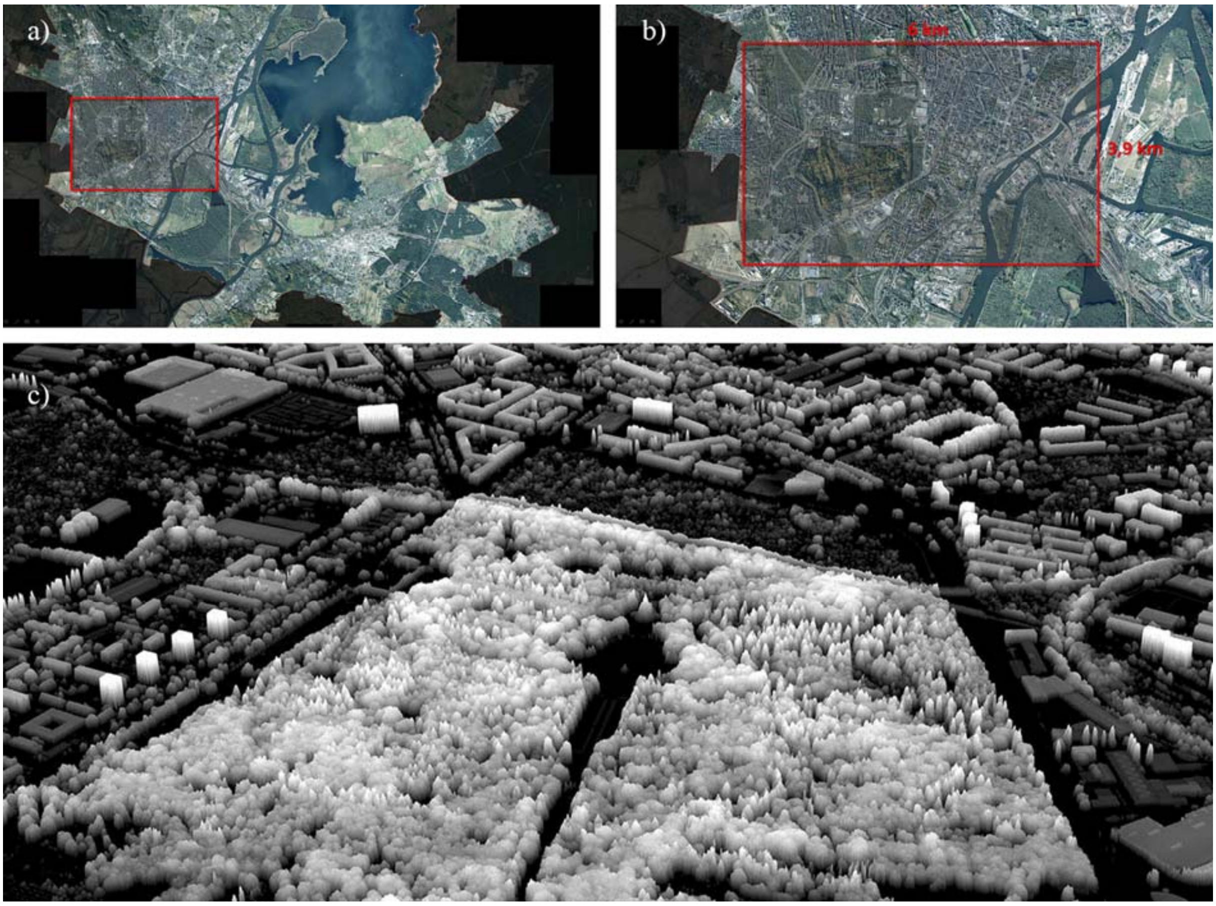

Figure 5. The area of VPS analysis of Central Cemetery in Szczecin (a, b) and visualisation of Digital Surface Model (DSM) applied in the case study

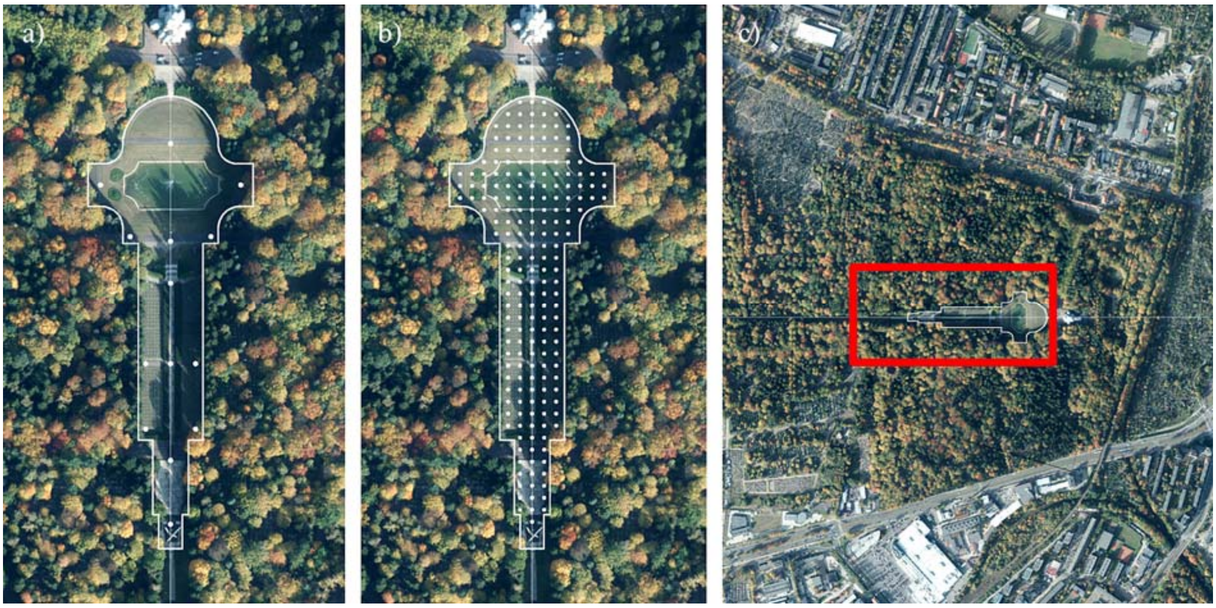

Figure 6. Selection of strategic views (view points) for VPS analysis: a) 15 visibility points situated in the most important locations, b) 202 visibility points, c) location of the landscape interior

5.4. VPS results and they implications for the city

The result of the VPS simulation aimed at protecting the landscape interior of the Central Cemetery in Szczecin is presented in figures below (figure 7, 8). For each point within the area concerned (1.0 m mesh), the maximum height of buildings has been determined in such a way that buildings cannot be seen from virtually any location of the landscape interior. The height is determined at the precision level of 15 cm. It is geometrically equivocal and its precision depends on the model used and the arrangement of strategic vistas. The difference between the two options of 15 points (figure 7a) and 202 points (figure 7b) is considerably small, which means that the result of the second option (202 points) is reliable for the analysis of the entire space of the landscape interior. The increase in the number of strategic vistas will not have any significant influence on the result. The VPS simulation time for 202 points is about 25 hours (using standard PC).

The VPS simulation shows locations where new architectural facilities could influence the landscape of the Central Cemetery in Szczecin. In this particular case, the area has an oval shape of approx. 0.6 x 3.0 km. Areas marked blue and green are the most sensitive – each building higher than 40 m can be seen from the cemetery. Areas marked magenta, are locations where tall buildings have little influence on the cemetery's landscape. In the location of the planned tall building mentioned above (2007), the height limit near the cemetery is 42 to 68 m (figure 8).

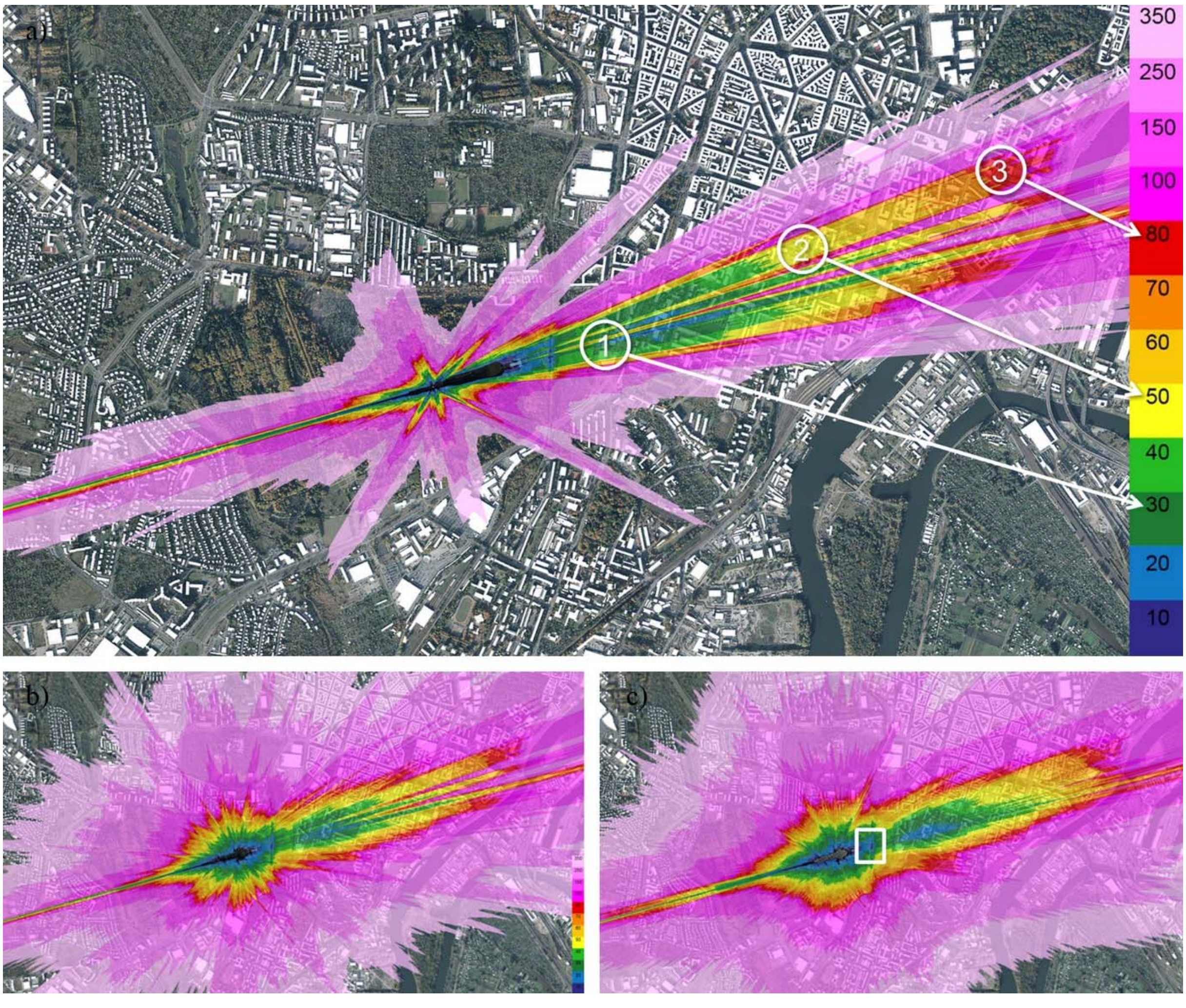

Figure 7. VPS analysis for Central Cemetery in Szczecin – for: a) a single visibility point, b) 15 visibility points, c) visibility points. Simulation made using software developed by author

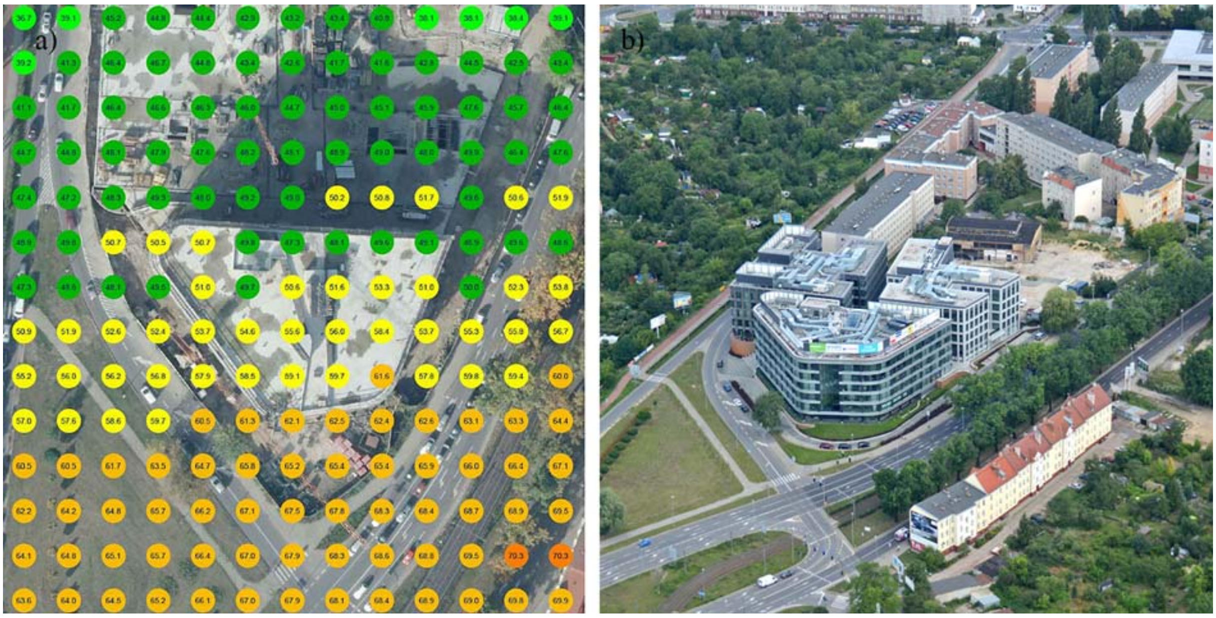

Figure 8. Visual Protection Surface analysis for Szczecin Central Cemetery in Szczecin – in the location of the tall building planned in 2007. Source: simulation and aerial photo by author

6. Conclusions

Landscape interiors are a valuable component of urban structures which is important for the city cultural identity. Thus, the necessity to protects such structures is obvious. Tall buildings, popularity of which has been growing in Europe and in the world, pose a threat to the integrity of the composition. The investment in tall buildings has been rapidly progressing and there is no time to carry out a landscape analysis. Therefore, it is crucial to create schemes for protecting landscape interiors before investment is launched.

The research discussed in the article shows that it is possible to use the Visual Protection Surface method as a tool for creating landscape interior protection plans. The possibility of using the VPS while implementing such measures has been proven, e.g. analysis of the Central Cemetery in Szczecin. Since computer simulations produce objective results, it is possible to determine 'sensitive' areas in the city where the development of new tall buildings can pose a potential threat to landscape interiors. The analysis enables to define precisely permissible height of buildings in a given point of the city. Moreover, simulations can include LiDAR data which are available and reliable in taking into account tall green as well.

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