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Investigation of the shadow effect of urbanization on green areas with shadow impact analysis

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ABSTRACT

Today, the use of information technologies has made life easier and helps people to take precautions against problems that may arise in the future. 3D GIS (Geographic Information Systems) is also used for various purposes to facilitate human life today. One of these goals is to improve the foresight ability in plans. In the studies carried out until today, the power of 3D GIS to produce solutions to various problems in the world is revealed. In this study, the effects of urban shadowing because of wrong urbanization have been investigated by using the power of 3D GIS. The data was provided via OSM (Open Street Map), which is an open-source map provider. The obtained data were analyzed and a park which is the surrounding area is not yet developed was determined. In the aim of the study, new buildings were added around the park by evaluating the direction of urban growth and possibilities, and the effect of the shadow it created on the sunbathing time of the park was investigated. The details of the work carried out are given in detail in the following stages.

1. INTRODUCTION

Unplanned and rapid urbanization is one of the major problems in developed and developing countries. Migration from rural areas to cities has caused the cities to grow in an unplanned manner. Unplanned urbanization resulting from migration causes difficulties in processing urban data and making plans. Therefore, the concept of "Smart City" has been introduced to make future city plans smooth and effective and to make them sustainable. The smart city is one of the most current concepts of the last twenty years. The smart city can also serve as a decision support tool for better planning and management of infrastructure requirements.

3D city models, which are generally used for visualization purposes, can also be used effectively for planning and development purposes (Şenol et al., 2018; Şenol ve Kaya, 2019). Today we live in a fast-developing world. For this reason, it is vital to take preventions in the planning stages. Problems that can be predicted during the planning phase can be easily observed with 3D GIS and its solutions.

However, it is still difficult to get the correct data. Although open-source data sharing is advanced, they still do not have enough skills to give accurate results. Elevation information, which is especially important for a subject such as 3D GIS, is not yet available in most of these data. For this reason, researchers have generally paid for the data access. However, although there are free data provided by local governments, it cannot be said that these data are very healthy. There is still a regular 3D GIS data shortage in the majority of our country.

While forming the basis of this research, we will first talk about 3D GIS and some of its uses. 3D GIS has been used for shadow and solar analysis for several years. 3D city models are used to estimate how much a building is exposed to the sun (Redweik et al., 2013; Eicker et al., 2014; Santos et al., 2014). 3D city models provide geometric information such as the slope, direction, and area of the roof used as input for the study of sun exposure time (Biljecki et al., 2015).

However, some researchers may use dense point clouds instead of 3D city models for solar energy studies (Gooding et al., 2015). Both forms of research (point cloud and 3D model) allow us to design an urban settlement to maximize sunbathing of a neighborhood (Vermeulen et al., 2015) and estimate the capacities of decentralized energy resources in crisis management practices (Aarsen et al., 2015). . Besides, 3D city models

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with window details can be used to estimate indoor lighting (Saran et al., 2015).

Visualization is one of the main purposes of 3D GIS and 3D city models. Thanks to model production, we can easily present features that are impossible to present in a 2D environment in 3D models (Köninger & Bartel, 1998, Ellul & Altenbuchner, 2014). In this way, the perspective of decision-makers and users on city plans has changed and the model experience has been a factor in decision making. Also, the use of 3D models based on visualization is available in various fields. Such as rainwater harvesting in development areas (Yiğit et al., 2020), solar impact analysis (Büyüksalih et al., 2017) etc.

3D city models are also indispensable for many visibility analyzes, such as determining the line of sight between two points in an urban area and predicting the volume of view (Lonergan & Hedley, 2016; Peters et al., 2015). 3D city models can also be used to predict sky visibility. An example of this can be the degree to which the surrounding buildings cover the sky from the perspective of the person.

Estimating building shadows is also frequently used in urban planning applications (Zhou et al., 2019). The analysis of building shadows is also important in positioning the buildings to be designed solar energy panels and estimating the energy potential (Strzalka et al., 2012; Eicker et al., 2015). This use case is closely related to the prediction of the sun exposure of buildings described earlier, and they are often used together.

In this study, a park which is located in Diyarbakır, Turkey and the construction around it has not been completed yet was selected. Two scenarios are presented according to the existing structures around the park and the predicted structures expected to be built in the future, and the shadow effects of these scenarios on the park have been analyzed.

2. METHOD

Although shadow impact analysis is a method that can be used for predicting future scenarios, it is still a new method and is not common. In line with this study, firstly the field of study was determined and Open Street Map, which provides open-source GIS data, was examined to obtain the data of the determined study area. Open Street Map is an open-source and external user-supported map platform. For this reason, the data provided by the system may not always provide accurate data since it is user-sourced.

For this reason, after selecting an area belonging to Diyarbakır, which is the study area, the accuracy of the data was compared via Google Street View, and also the missing building floor height data were obtained through this platform. Building heights and sun angle are of great importance in the shadow effect analysis. For this reason, the study area was chosen as a park in the east-west direction and with a small number of buildings around it (Figure 1).

In this direction, using the tools provided by ArcGIS Solutions, first the basic structures and then the proposed structures were introduced to the system. While the buildings were entered into the system, the height of the buildings was given by using the CityEngine software and simple models were produced. Thanks to these 3D models, shadow effect analysis, which is a 3D analysis, can be done easily. The models produced are colored and divided as follows;

- The green zone is the park area,
- Blue structures are existing buildings and
- Red structures are the proposed buildings (Figure 2).

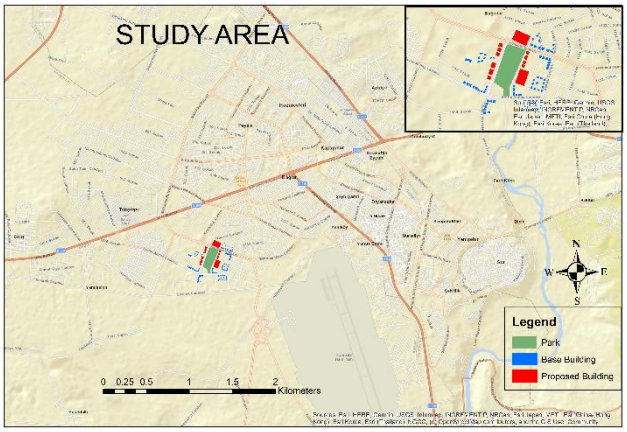

Figure 1. Study Area

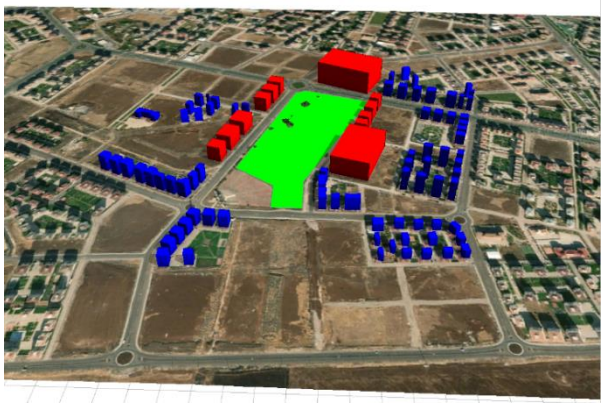

Figure 2. 3D model of the study area

2.1. Shadow Impact Analysis

ArcGIS Pro software was used for shadow impact analysis and previously created 3D models were transferred to the software. To ensure the accuracy of the analysis, attention was paid to the height of the building and the geographical accuracy of the structures.

The shadow movements of the 3D models that were included in the shadow impact analysis were observed according to two separate situations. To compare the shadows obtained in two different situations, first, the basic structures were analyzed and the shadow conditions were revealed, and then the effect of the proposed structures on the park was investigated if they were built in the area. All the sun conditions of the buildings were examined and their effect on the park was analyzed (Figure 3).

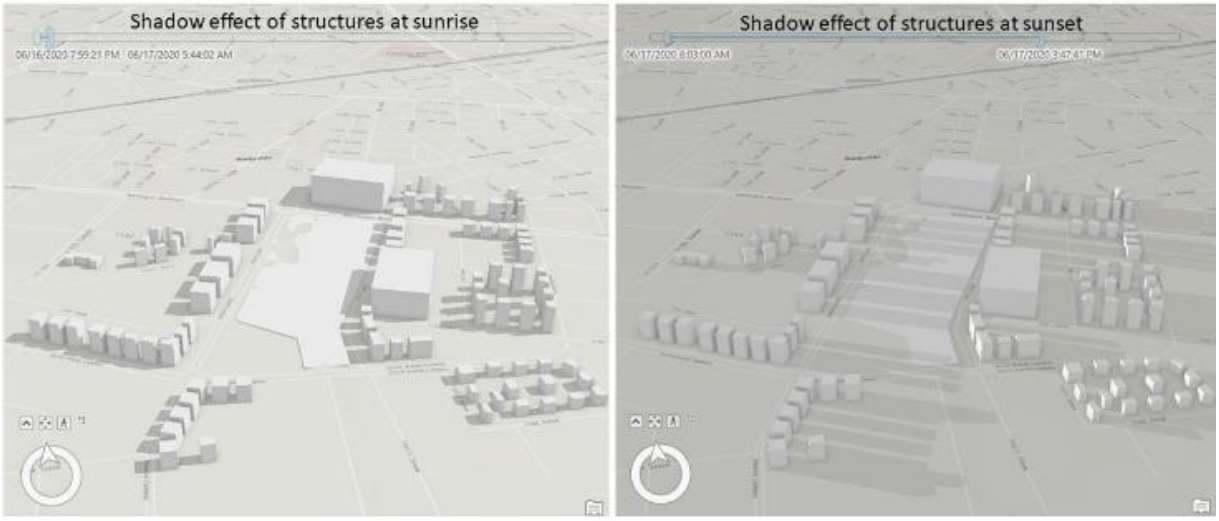

Figure 3. Shadow effect at different times of the day

As seen in Figure 3, the effect of the proposed buildings on the park is serious. This can limit the possibility of providing sunlight to people, which is one of the biggest features of green space. In the analysis results, the sunshine duration was analyzed and the shadow boundaries formed on the park were revealed. First, the shadow areas created by the existing buildings were analyzed (Figure 4), then the shadows created by the proposed buildings were analyzed too (Figure 5).

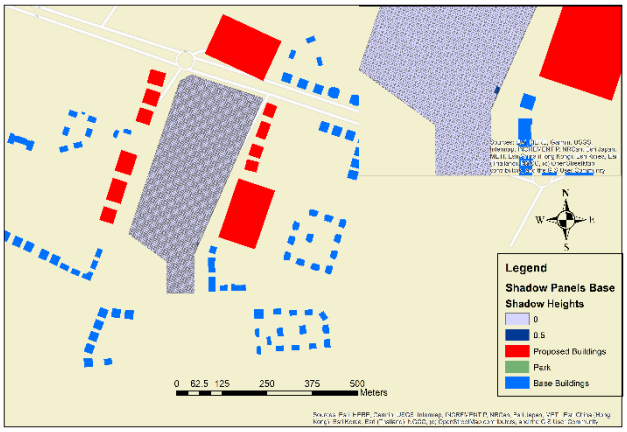

Figure 4. Shadow effect of base buildings on the park

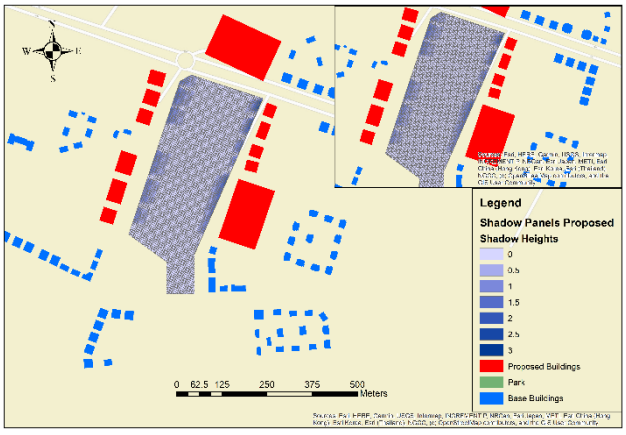

Figure 5. Shadow effect of proposed buildings on the park

When the shadow situations affected by two different building types are analyzed, it is obvious that the new buildings that can be built around the park will cause serious shadowing effects. Also, considering the shadow durations, it can be considered that building heights can be a factor in this shading. For this reason, the two shadow conditions were compared with a separate analysis, and the amount of shading was revealed (Figure 6).

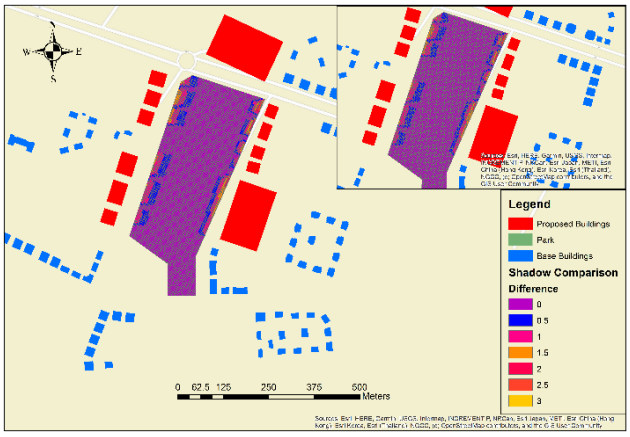

Figure 6. Comparison of shadow effects of different scenarios

3. RESULTS and DISCUSSION

When the shadowing times and amounts on the park are examined, although it is seen that there is a serious accumulation of shadows, the amount of shading remained at a certain level since the building heights in the region have a certain limit. However, the shadowing effect is serious in areas that are constantly under the shadow. When the shadow areas are examined in the generated raster file, the shadow areas are revealed and the number of shadows produced are compared in Figure 7. Shade areas are divided into areas that are mostly shaded, have equal shade and sun duration, and are not shaded.

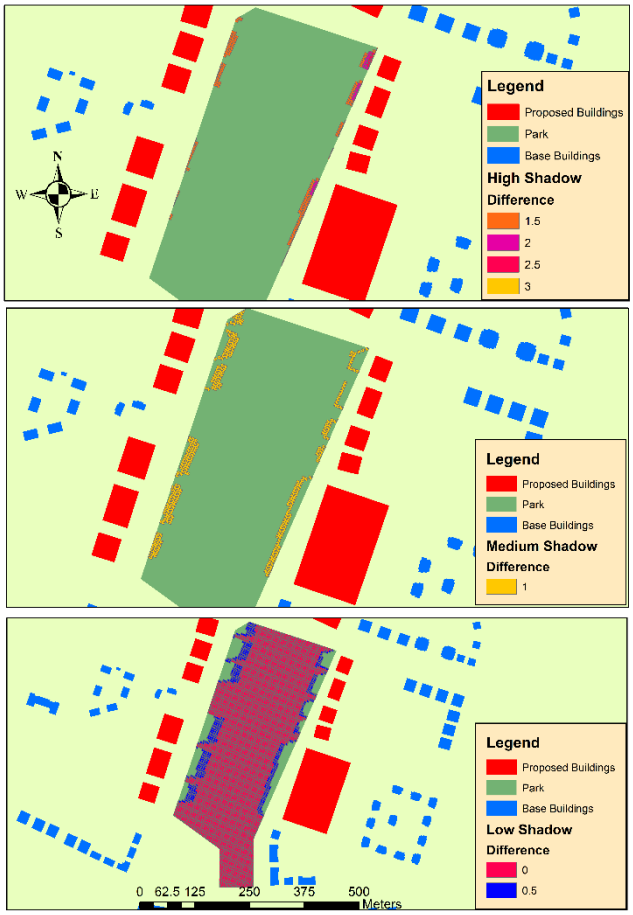

Figure 7. Amounts of shadows were obtained as a result of the analysis.

4. CONCLUSION

Nowadays, the increasing amount of degradation in green areas and the green area needs of people have led people to take various measures in the protection of these areas. Shade is an important factor in the benefit of green spaces and decreases the sunbathing effect. It is not correct to limit sunbathing periods due to construction, especially in this period, during which many studies have been conducted on the beneficial use of solar energy. For this reason, the shading periods of places open to human use such as parks should also be taken into consideration while making city plans. In future studies, sunbathing effect and solar energy utilization times can be investigated by comparing shadow and sun effects.

REFERENCES

Aarsen, R., Janssen, M., Ramkisoen, M., Biljecki, F., Quak, W., & Verbree, E. (2015). Installed base registration of decentralised solar panels with applications in crisis management. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 40(3), 219.

Biljecki, F., Stoter, J., Ledoux, H., Zlatanova, S., & Çöltekin, A. (2015). Applications of 3D city models: State of the art review. ISPRS International Journal of Geo-Information, 4(4), 2842–2889.

Buyuksalih, G., Bayburt, S., Baskaraca, A. P., Karim, H., & Rahman, A. A. (2017). Calculating solar energy potential of buildings and visualization within unity 3d game engine. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 42(4/W5).

Eicker, U., Monien, D., Duminil, É., & Nouvel, R. (2015). Energy performance assessment in urban planning competitions. Applied Energy, 155, 323–333.Eicker, U., Nouvel, R., Duminil, E., & Coors, V. (2014). Assessing passive and active solar energy resources in cities using 3D city models. Energy Procedia, 57(896), e905.

Ellul, C., & Altenbuchner, J. (2014). Investigating approaches to improving rendering performance of 3D city models on mobile devices. Geo-Spatial Information Science, 17(2), 73–84.

Gooding, J., Crook, R., & Tomlin, A. S. (2015). Modelling of roof geometries from low-resolution LiDAR data for city-scale solar energy applications using a neighbouring buildings method. Applied Energy, 148, 93–104.

Köninger, A., & Bartel, S. (1998). 3D-GIS for urban purposes. Geoinformatica, 2(1), 79–103.

Lonergan, C., & Hedley, N. (2016). Unpacking isovists: a framework for 3D spatial visibility analysis. Cartography and Geographic Information Science, 43(2), 87–102.

Peters, R., Ledoux, H., & Biljecki, F. (2015). Visibility Analysis in a Point Cloud Based on the Medial Axis Transform. UDMV, 7–12.

Redweik, P., Catita, C., & Brito, M. (2013). Solar energy potential on roofs and facades in an urban landscape. Solar Energy, 97, 332–341.

Santos, T., Gomes, N., Freire, S., Brito, M. C., Santos, L., & Tenedório, J. A. (2014). Applications of solar mapping in the urban environment. Applied Geography, 51, 48–57.

Saran, S., Wate, P., Srivastav, S. K., & Krishna Murthy, Y. V. N. (2015). CityGML at semantic level for urban energy conservation strategies. Annals of GIS, 21(1), 27–41.

Şenol, H. İ., & Kaya, Y. (2019). İnternet Tabanlı Veri Kullanımıyla Yerleşim Alanlarının Modellenmesi: Çiftlikköy Kampüsü Örneği. Türkiye Fotogrametri Dergisi, 1(1), 11-16.

Şenol, H. İ., Ernst, F. B., & Akdağ, S. (2018). Kentsel Dönüşüm Alanlarının Geotasarım Yöntemi ile Planlanması: Eyyübiye Örneği. Harran Üniversitesi Mühendislik Dergisi, 3(3), 63-69.

Strzalka, A., Alam, N., Duminil, E., Coors, V., & Eicker, U. (2012). Large scale integration of photovoltaics in cities. Applied Energy, 93, 413–421.

Vermeulen, T., Knopf-Lenoir, C., Villon, P., & Beckers, B. (2015). Urban layout optimization framework to maximize direct solar irradiation. Computers, Environment and Urban Systems, 51, 1–12.

Yiğit, A. Y., Orhan, O., & Ulvi, A. (2020). Investigation of The Rainwater Harvesting Potential at the Mersin University, Turkey. Mersin Photogrammetry Journal, 2(2), 64-75.

Zhou, K., Lindenbergh, R., & Gorte, B. (2019). Automatic shadow detection in urban very-high-resolution images using existing 3D models for free training. Remote Sensing, 11(1), 72.