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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 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 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 Geographic Information Systems. The data was provided via 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. It is obvious that social areas such as park areas are important for people to reach the sun they need. As a result, it is necessary to investigate the shadow effects of newly constructed buildings in order to increase the sunshine duration in the park areas.

Keywords: 3D GIS, Shadow Impact Analysis, Smart Cities, Urban Development

ŞEHİRLEŞMENİN YEŞİL ALANLAR ÜZERİNDEKİ ETKİSİNİN GÖLGE ETKİ ANALİZİ İLE ARAŞTIRILMASI

Özet

Günümüzde bilgi teknolojilerinin kullanımı hayatı kolaylaştırmış ve gelecekte karşımıza çıkabilecek sorunlara karşı önlem almakla beraber insanlara yardımcı olmaktadır. Üç boyutlu Coğrafi Bilgi Sistemleri de günümüzde insan hayatını kolaylaştırmaya yönelik çeşitli amaçlarda kullanılmaktadır. Bu amaçların başında geleceğe yönelik yapılan planlamalarda öngörü kabiliyetini geliştirmesi gelmektedir. Günümüze kadar yapılan çalışmalarda 3B Coğrafi Bilgi Sistemleri'nin dünyadaki çeşitli problemlere çözüm üretebilme gücü ortaya çıkmaktadır. Bu çalışmada ise 3B Coğrafi Bilgi Sistemleri'nin gücünden yararlanarak kent gölgelenmesinin etkileri araştırılmıştır. Bu doğrultuda açık kaynak kodlu bir harita sağlayıcısı olan Open Street Map üzerinden veri sağlanmıştır. Elde edilen veri analiz edilmiş ve etrafı henüz gelişmemi bir park tespit edilmiştir. Yapılan çalışma doğrultusunda kentsel büyüme yönü ve ihtimaller değerlendirilerek parkın etrafına yeni yapılar eklenmiş ve oluşturduğu gölgenin parkın güneşlenme süresine etkisi araştırılmıştır. Park alanları gibi sosyal alanların insanların ihtiyacı olan güneşe ulaşımı açısından önemli olduğu ortadadır. Sonuç olarak, park alanlarındaki güneşlenme süresini arttırmak için yeni yapılan yapıların gölge etkilerinin araştırılmaları gereklidir.

Anahtar Kelimeler: 3B CBS, Gölge Etki Analizi, Akıllı Şehirler, Kentsel Gelişim

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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 [1,2, 20, 21, 22]. Today we live in a fast-developing world. For this reason, it is vital to take prevention 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 [23]. Although open-source data sharing is advanced (Open Street Map etc.), they still do not have enough skills to give accurate results [19]. 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 most countries.

While forming the basis of this research, we will first talk about 3D GIS and some of its uses. Shadow Impact Analysis is a new method in development. Shadow effect reveals the effects of shadow on structures. It is an important problem today that social areas such as park structures are affected by the shade and exposed to the sun. In addition, the shadow effect affects the sunbathing of buildings. This situation may cause the buildings not to receive enough sunlight and this may affect the property value. In addition, it is necessary to examine the shadow effect for new solar energy technologies such as building surface solar panels, which are developing today, to work efficiently [7]. 3D GIS has been used for shadow and solar analysis for several years [6]. 3D city models are used to estimate how much a building is exposed to the sun [3-5]. 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 [6]. However, some researchers may use dense point clouds instead of 3D city models for solar energy studies [7]. Both forms of research (point cloud and 3D model) allow us to design an urban settlement to maximize sunbathing of a neighborhood [8] and estimate the capacities of decentralized energy resources in crisis management practices [9]. Besides, 3D city models with window details can be used to estimate indoor lighting [10].

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 [11,12]. 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 [13], solar impact analysis [14] etc. 3D city models are also indispensable for many visibility analysis, such as determining the line of sight between two points in an urban area and predicting the volume of view [15,16]. 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 [17]. The analysis of building shadows is also important in positioning the buildings to be designed solar energy panels and estimating the energy potential [18,4]. 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. Material and 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 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, can be seen in Figure 1, the study area was chosen as a park in the east-west direction and with a small number of buildings around it.

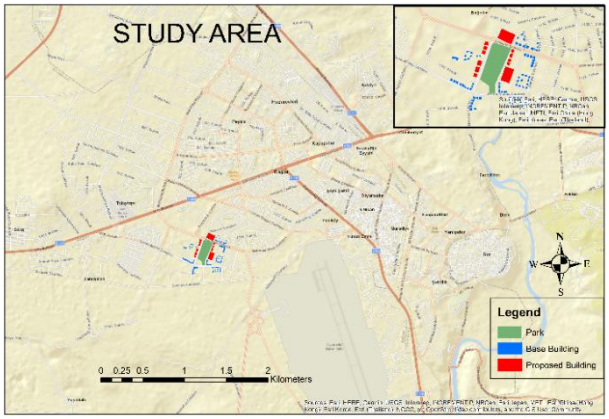

Figure 1. Study area.

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 and they are shown in Figure 2;

-The green zone is the park area,

-Blue structures are existing buildings and

-Red structures are the proposed buildings.

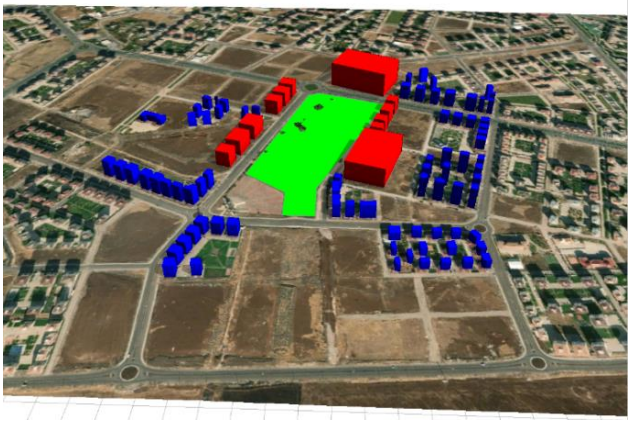

Figure 2. 3D model of the study area.

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.

In this method, planners can investigate the shadow effect on existing and proposed structures. To achieve this, the software first detects shadows due to their temporal changes and then analyzes these shadows.

Shadows belonging to different times of the day are examined on existing and planned structures for the check shadows process. In this direction, the sun positions and the position according to the selected date are determined according to the geographical location of the region and the sun movement is monitored in 3D. The shadows caused by the sun movement are detected over the existing and planned structures. This is just a process for visualizing shadow positions.

The Analyze shadows process calculates the cumulative shadow times on the structures and determines the shadow effect in the specified time period. The movement of the sun and shadows for the existing time period and structures are analyzed with the analyze shadows tool. The analysis divides the shaded region into panels and calculates the amount of shadow cast on the panel in different time periods. Using the Analyze shadow tool, the shaded panels are calculated and a detailed prediction based on the amount of shadows is revealed.

3. Results and Discussion

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 and shown in 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, then the shadows created by the proposed buildings were analyzed too and shown in Figure 4.

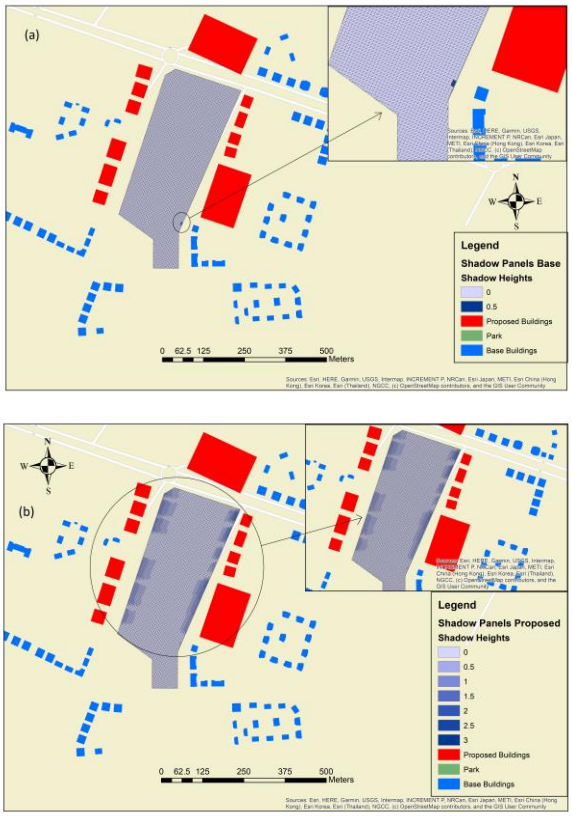

Figure 4. Shadow effect of base buildings on the park (a), shadow effect of proposed buildings on the park (b).

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, can be seen in Figure 5, the two shadow conditions were compared with a separate analysis, and the amount of shading was revealed.

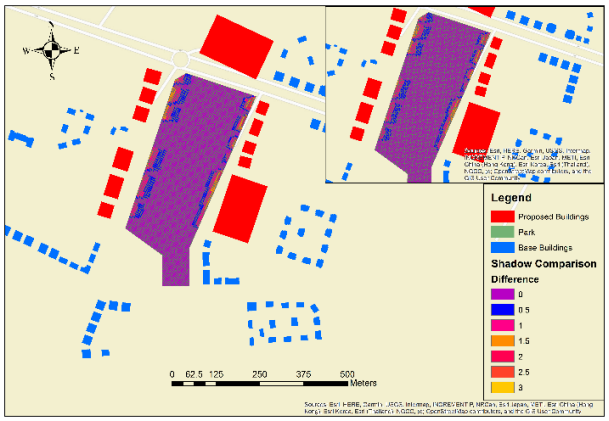

Figure 5. Comparison of shadow effects of different scenarios.

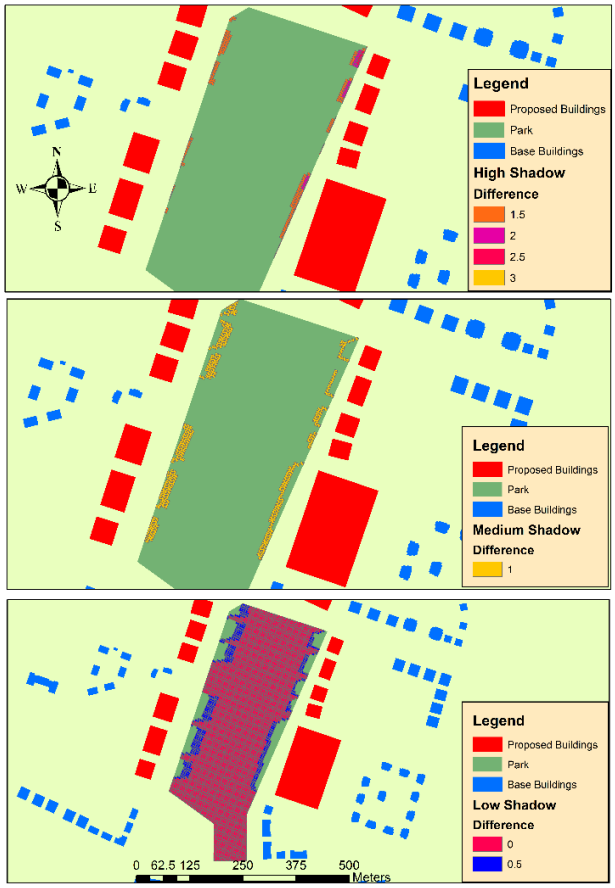

Figure 6. Amounts of shadows were obtained as a result of the analysis.

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 is compared in Figure 6. Shade areas are divided into areas that are mostly shaded, have equal shade and sun duration, and are not shaded.

However, studies on shadow analysis should be diversified. Although a park is under the spotlight in this area, examples can be multiplied with areas such as campus areas and hospital areas. In future studies, not only shadow analysis, but also solar benefit analysis will be carried out and the amount of sun benefit will be calculated with the area covered by the shade. In general, although the shadow effect in a park area was calculated in this study, its effect on quality of life could not be questioned due to insufficient data. For this reason, the effect of shadow on human life will be examined in future studies.

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.

All the structures used in this study are based on prediction and do not contain any reality. Although the buildings were built on estimation, other building dimensions in the region were considered and a scenario was created in this direction. The aim is not to present a real situation, but to highlight a future scenario. In this direction, with the shadow analysis studies being in an important position in terms of urban development, much more work should be done in this area. In addition, the use of the analyzes made on this subject by the decision makers of the municipalities is very important in the construction of cities suitable for the future smart city concept.

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