How to cite: Karadan, D. & T. Birişçi, 2023. Solar power plants in terms of landscape protection and repair: Activities of local governments in Izmir. Ege Univ. Ziraat Fak. Derg., 60 (4): 595-610, https://doi.org/10.20289/zfdergi.1329412

Research Article
(Araştırma Makalesi)

Deniz KARADAN [1]

Tanay BİRİŞÇİ [2]

[1] Department of Landscape Architecture, Graduate School of Natural and Applied Sciences, Ege University, 35100, Bornova/İzmir, Türkiye

[2] Department of Landscape Architecture, Faculty of Agriculture, Ege University, 35100, Bornova/İzmir, Türkiye

* Corresponding author (Sorumlu Yazar): denizkaradann@gmail.com

Keywords: Environmental impact assessment, landscape protection and repair, solar power plants

Anahtar sözcükler: Çevresel etki değerlendirmesi, peyzaj onarım ve koruma, güneş enerji santralleri

Ege Üniv. Ziraat Fak. Derg., 2023, 60 (4):595-610
https://doi.org/10.20289/zfdergi.1329412

Solar power plants in terms of landscape protection and repair: activities of local governments in İzmir

Peyzaj koruma ve onarım açısından güneş enerji santralleri: İzmir'de yerel yönetimlerin faaliyetleri

Received (Alınış): **18.07.2023** **Accepted** (Kabul Tarihi): **05.12.2023**

ABSTRACT

Objective: The aim is to reveal depending on the location choices of solar power plantsthe landscape protection strategies and what needs to be done in terms of landscape restoration after the operations of the power plants are completed.

Material and Methods: Seven solar power plants owned by local governments in İzmir constituted the main material of this study. In this context, observations were made in the research areas, the characteristics of the installed solar power plants were determined and their environmental effects were evaluated within the scope of landscape protection and repair.

Results: The installation years, locations, installed capacity, and installation areas of the solar power plants, which are the subject of the research differ from each other. Therefore, their environmental impacts are different from each other. In order to evaluate the environmental impact, the profiles of the power plants within the scope of the research were examined by taking into account the standards of electricity generation from solar energy, and their distances to different uses and transportation axes were measured as bird flights. In addition, the areas covered by the installed power plants were revealed and the usage areas of the produced energy were specified.

Conclusion: Five of the seven solar power plants examined within the scope of the research are assembled roofs and the other two are land applications. Since more space is required in the area preparation, logistics, and installation of solar power plants, which are land applications, the negative impact on the environment is higher. In order to prevent or reduce these negative effects, appropriate and comprehensive landscape repair plans should be prepared with conservation decisions for the solar power plant areas that are actively working, whose activities have been terminated and will be newly installed.

ÖZ

Amaç: Güneş enerji santrallerinin yer seçimlerine bağlı olarak peyzaj koruma stratejilerinin ve santrallerin faaliyetleri tamamlandıktan sonra peyzaj onarımı açısından yapılması gerekenlerin ortaya konulmasıdır.

Materyal ve Yöntem: İzmir'de yerel yönetimlere ait yedi güneş enerji santrali, araştırmanın ana materyalini oluşturmaktadır. Bu kapsamda araştırma alanlarında gözlemler yapılmış, santrallerin özellikleri tanımlanmış ve çevresel etkileri, peyzaj koruma ve onarım kapsamında değerlendirilmiştir.

Araştırma Bulguları: Seçilen santrallerin kurulum yılları, konumları, kurulu güç miktarları ve kurulum yüzeyleri birbirinden farklılık göstermektedir. Bu nedenle çevresel etkileri birbirlerinden farklıdır. Çevresel etki değerlendirilmesi için güneş enerjisinden elektrik üretimi standartları dikkate alınarak araştırma kapsamındaki santrallerin profilleri incelenmiş, farklı kullanımlara ve ulaşım akslarına olan uzaklıkları kuş uçuşu olarak ölçülmüştür. Ayrıca kurulu santrallerin kapladıkları alanlar ortaya konulmuş ve üretilen enerjinin kullanım alanları belirtilmiştir.

Sonuç: Araştırma kapsamında incelenen yedi güneş enerji santralinin beşi çatı uygulaması, diğer ikisi ise arazi uygulamasıdır. Arazi uygulaması olan güneş enerji santrallerinin alan hazırlığı, lojistik ve kurulumunda daha fazla alan kullanımı gerektiğinden çevreye olumsuz etkisi daha fazladır. Bu olumsuz etkileri önlemek ya da azaltmak için aktif olarak çalışan, faaliyeti sonlandırılmış ve yeni kurulacak güneş enerji santrali alanlarına yönelik, koruma kararları ile uygun ve kapsamlı peyzaj onarım planları hazırlanmalıdır.

INTRODUCTION

Meeting the energy need in a way that does not harm nature and people, and alleviating energy-related climate change depends on the use of renewable energy, which includes water, solar, wind, biomass and other renewable types that are more environmentally friendly than traditional fuels. While electricity is produced using renewable energy sources, it can also help reduce the effects of climate change globally. In this context, solar energy is among the energy types that come to the fore due to its high potential, ease of use and environmental friendliness (Cao, 2003). Instead of using fossil, which account for more than 80% of human-caused greenhouse gas emissions, solar power plants contribute to the reduction of greenhouse gas emissions and provide clean and renewable energy (Akpan & Akpan, 2012).

Solar energy potential and solar radiation (Charabi & Gastli, 2011; Effat, 2013; Kengpol et al., 2013) are the most important criteria in site selection for solar power plants. The choice of location is very important because of the efficiency of solar energy, the geographical location of the place selected for the power plant, the structure of the land, whether it is flat or uneven, its slope, gaze, the angle of arrival of the sun during the day and depending on the season and the climate (Birişçi et al., 2012.). The slope of the region should be low and the slope should be in the south direction in terms of insolation (Effat, 2013; Noorollahi et al., 2016). Factors such as the area use status of the region (lack of structural and vegetable elements that will shade such as tree cover, etc.), and geological structure (being away from fault lines, etc.) are important geographic criteria. Location criteria such as network connection, proximity to energy consumption zones, accessibility, distance to water resources (in terms of facilitating cleaning and cooling processes), ownership status and installation cost are also of great importance in location selection (Şenlik, 2017; Aydın, 2020).

Solar power plants provide clean and renewable energy, but they also affect the environment for some reasons. In a study conducted by the Ministry of Environment, Urbanization and Climate Change (2017) impacts that may occur are divided into three main stages: land preparation and construction phase, the operation phase and the phase after the operation is closed. In this context, the possible effects and reasons of solar power plants that may occur after construction, operation and operation are given in Tables 1 & 2. Human health may also be adversely affected due to pollution and deterioration that may occur in addition to the specified ones.

In parallel with the economic growth in Türkiye, energy demand is increasing by 9% per year on average. Responding to this demand has a very strong potential in terms of renewable energy sources but it is insufficient in terms of fossil resources in order to keep the energy supply-demand ratio balanced (Development Library, 2016). Türkiye is located in a geography with high potential in terms of solar energy due to its location. Sunshine duration varies throughout the year; however, it has been determined that there are approximately 2737 hours per year (7.5 hours per day) and the total annual incoming solar energy is 1.527 kWh/m^2 (4.2 kWh/m^2 per day) (TEIAŞ, 2022). Compared to other renewable energy sources, solar energy is the most potential energy source in Türkiye. Considering that the total installed power of electricity is approximately 79,000 MW as of 2016, the importance of converting the potential of solar energy into production is more clearly understood (Taktak & Ilı, 2018). In Türkiye, where the number of registered power plants was 674 as of May 2022, the power potentials of registered solar power plants are stated as 8.270 MWe. Of these power plants, which have an annual energy production of approximately 12.627 GWh, 37 are licensed and 637 are unlicensed (Energy Atlas, 2022a).

With this study, the factors that are effective in the definition and location selection of solar power plants and what needs to be done in terms of the protection and repair of natural and cultural landscapes after the applications are discussed. In addition, Türkiye's solar energy potential and suitability for the solar power plant were mentioned. In this context, solar power plants belonging to local governments in İzmir province were selected as samples. The characteristics of the power plants installed over the samples were defined and their environmental effects were evaluated within the scope of landscape protection and repair.

Table 1. Possible effects and reasons of solar power plants in construction, operation and post-operation periods (created from the Ministry of Environment, Urbanization and Climate Change, 2017)

Çizelge 1. *Güneş enerji santrallerinin inşaat, işletme ve işletme sonrası dönemlerde meydana gelebilecek olası etkileri ve nedenleri (Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, 2017'den oluşturulmuştur)*

Reasons	Effects (Results)	Process		
		Construction	Business Administration	Post-Operation
Stripping of topsoil and temporary storage of plants not carried out under appropriate conditions	Decrease in the amount of organic matter in the soil	✓		✓
Leveling, excavation-filling operations, works of construction machines and vehicle and pedestrian traffic within the site	Compaction of soil	✓	✓	✓
Acceleration of precipitation surface flow and erosion by removing vegetation	Losses from soil	✓	✓	✓
As a result of uncontrolled or accidental spillage of fuels used in chemical and fuel supply used during the use and maintenance of vehicles and equipment on the site infiltration or spread of contaminants into the soil	Soil contamination	✓	✓	✓
Traffic, construction works (installation of solar energy panel feet, power plant building, office and auxiliary construction and installation of facilities) used tools and equipment	Noise pollution	✓		✓
Soil stripping, leveling, excavation - filling etc. dust emissions from construction activities, bare ground and traffic, and exhaust emissions from vehicles, machinery and equipment	Air pollution	✓		✓
Absence of wastewater discharge, sedimentation caused by construction activities and rainwater flow and erosion reducing surface water quality and domestic wastes	Water pollution (surface and underground)	✓	✓	✓
Dismantling with construction activities such as blasting, stone or rock extraction, building foundations, pile driving, etc. machines used during	Vibration	✓		✓
Domestic wastes, packaging and packaging wastes, hazardous wastes, special wastes (waste oils, batteries and filters), excavation and construction wastes and system equipment wastes (panel, cable, electronics, etc.)	Waste generation	✓	✓	✓
The incoming angle of the sun's rays and the geographical location of the power plant	Reflection and glare		✓	
Degradation of habitats with new transportation axes, narrowing or loss of nesting and habitat of rare, threatened or endangered species, restriction of wildlife activity, visual and auditory emergence of disturbances	Ecological degradation	✓	✓	

MATERIALS and METHODS

Material

İzmir is very popular with its geographical location, cultural and historical richness and socio-cultural structure (Yanardağ, 2014; Karadan & Birişçi, 2020). Also, energy etc.suitability for investments highlights the city in terms of renewable energy and trade. When İzmir is examined in terms of solar power plants, especially in the energy sector, the presence of licensed, unlicensed and under construction power plants

emerges. As of December 2022, there are 39 licensed power plants in the city, with a total of 17 MW; while the exact number of unlicensed power plants is unknown, it is known that these power plants do not produce a total of 290 MW (Energy Atlas, 2022b).

The main materials of the research consist of a total of 7 solar power plants (SPP) located in İzmir province, under the auspices of local municipalities, especially the metropolitan municipality. The locations of the power plants subject to the research in our country and in the city of İzmir are depicted in Figure 1.

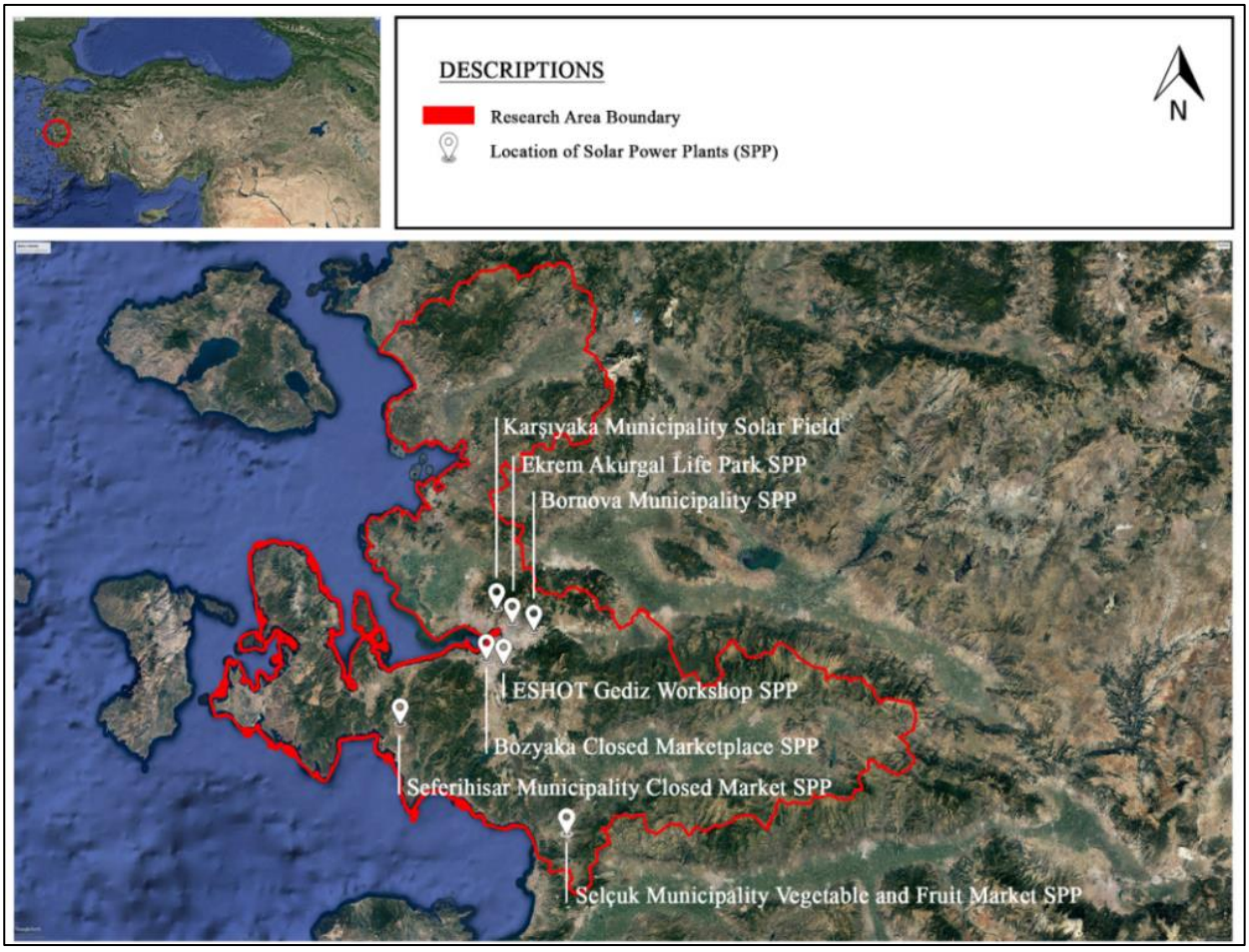

Figure 1. Locations of research areas.

Şekil 1. *Araştırma alanlarının konumları.*

Ekrem Akurgal Life Park SPP

(ESHOT, 2017)

ESHOT Gediz Workshop SPP

(ESHOT, 2020)

Figure 2. Solar power plants belonging to İzmir Metropolitan Municipality.

Şekil 2. *İzmir Büyükşehir Belediyesi'ne ait güneş enerji santralleri.*

. Two of the solar power plants in the city belong to İzmir Metropolitan Municipality and are named as ESHOT Gediz Workshop SPP and Ekrem Akurgal Life Park SPP (Figure 2). The other 5 belong to different local municipalities and are named as Karşıyaka Municipality Solar Field, Bozyaka Closed Marketplace SPP, Bornova Municipality SPP, Seferihisar Municipality SPP and Selçuk Municipality Vegetable and Fruit Market SPP (Figures 3 & 4).

Karşıyaka Municipality Solar Field

(Karşıyaka Municipality, 2022)

Bozyaka Closed Marketplace SPP

(Karabağlar Municipality, 2014)

Figure 3. In Izmir, the solar panel belonging to different local municipalities.

Şekil 3*. İzmir'deki yerel belediyelere ait güneş enerji santralleri.*

Bornova Municipality SPP
(Energy Diary, 2016)

Seferihisar Municipality Closed Marketplace SPP
(Energy Atlas, 2022c)

Selçuk Municipality Vegetable and Fruit Market SPP
(İpekler Electric, 2022)

Figure 4. In Izmir, continuous of the solar panel belonging to different local municipalities.

Şekil 4*. İzmir'deki yerel belediyelere ait güneş enerji santrallerinin devamı.*

Other materials of the research consisted of national and international literary sources on the subject, examples of solar power plants whose construction has been completed, and notes taken during the field research. Additionally, the data obtained from the internet and photographs for field research also constitute visual data. The definitions made as a result of the observations related to the research and the computer software used in the processing, analysis and evaluation of the data obtained from the research constitute the other materials of the research.

Methods

In this study, in which solar power plants owned by the municipalities in İzmir are examined, firstly, the conceptual framework is drawn and scientific studies on the subject are examined. Then, considering the condition of belonging to local governments in Izmir, the solar power plants to be examined in the research were determined. Specific observation forms were created in accordance with the objective of the research and field analyses were carried out by on-site observation method in the determined solar power plants. With these observation forms, general information about the location, installation year, installed power amount and installation surfaces of the solar power plants, and site selection features such as land ownership forms, distances to different uses and distances to transport axes were examined. While these forms were being prepared, Uyan (2017) and Güner et al. (2021) studies are

taken as reference. In addition, the environmental impacts of the solar power plants on the spatial uses in the vicinity were evaluated (Figure 5).

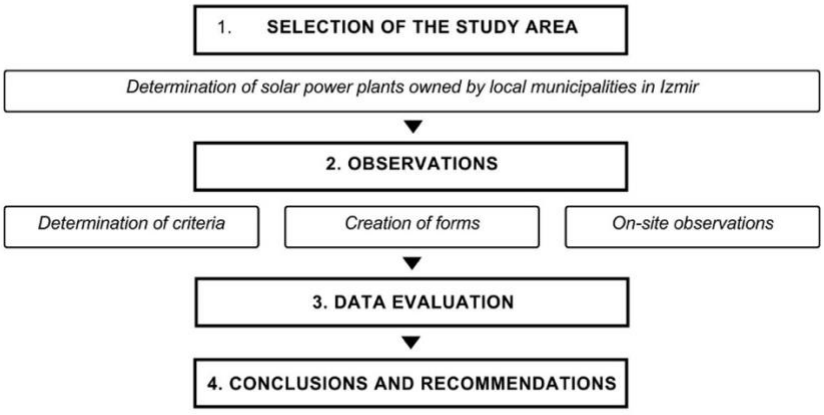

Figure 5. Methodology of the study.
Şekil 5*. Çalışmanın yöntem akışı.*

All data obtained during the observation studies, notes taken and photographs taken were transferred to the computer. Maps obtained from Google Earth software were updated in line with the intended use. Then, the data obtained from the application area were analyzed, processed into forms and the data were evaluated. In the conclusion phase, the findings determined in the light of the literature information and the data obtained through observation studies were evaluated.

RESULTS

İzmir is one of the prominent provinces in terms of its geographical location, ecological structure, development in the agricultural and industrial sectors and the use and development of renewable energy sources. İzmir has significant potential in the field of solar energy with an average of 300 sunny days per year, high solar radiation, sunshine time reaching 12 hours in summer, average sunshine radiation of 1500-1600 kWh/m^2, high panel utilization capacity and rapid return on investment (IZKA, 2016). In this context, solar energy investments are of great importance and interest in these investments is increasing day by day. İzmir Metropolitan Municipality and other local municipalities carry out many studies to raise awareness on issues such as the use of renewable energy sources, environmental protection, conscious energy consumption, energy efficiency and climate change in order to create healthy cities (İzmir Metropolitan Municipality, 2020). These studies are increasingly widespread in terms of awareness, quantity and efficiency, supported by various institutions.

ESHOT Gediz Workshop SPP has been operating since August 2017. The plant, which is built on the roof surface, covers an area of 10.000 m^2. Between 2018 and 2021, the power plant produced an average of 1.244.428,75 kWh of energy, which prevented an average of 619.5 tons of CO_2 equivalent emissions between the same years. The amount of energy produced is at a level that all 20 electric buses owned by ESHOT can be charged and the energy produced is used for this purpose (ESHOT, 2023). ESHOT Gediz Workshop SPP is located in the Inönü Neighborhood of Buca district. Approximately 520 meters from Buca Sanayi located in the south; it is approximately 660 meters from the 6th Industrial Site. There is no protected area around it. On the İzmir Ring Road, ESHOT Gediz Workshop Solar Power Plant is located on the distance to the 6th Industrial Site exit is approximately 550 meters. The distance of bird flight to IZBAN District Garage Station, which is the nearest railway station, is approximately 895 meters; The distance of bird flight to Konak and Göztepe Ferry Pier is almost the same and this value is approximately 7.40 km (Table 2).

Table 2. Identification of ESHOT Gediz Workshop Solar Power Plant

Çizelge 2. *ESHOT Gediz Atölyesi Güneş Eenerji Santrali'nin tanımlanması*

GENERAL INFORMATION				
Name	ESHOT Gediz Workshop Solar Power Plant			
Location	Buca			
Year of Installation	2017			
Installed Power Amount	835 kWh			
Type of Ownership of the Land	**Person (Private)**		**Treasury (State)**	**Village and Pasture**
			✓	
LOCATION SELECTION				
Installation Surface / Location Selection	**Open Land**		**Roof**	**Facing Work**
	Agriculture **Forest** **Pasture** **Other**		✓	
Distance to Different Uses	**Residential**	**Industry**		**The Protected Areas**
	0	~ 520 m		-
Distance to Transportation Axles	**Highway**		**Railway**	**Sea Route**
	~ 550 m		~ 895 m	~ 7.40 km

Ekrem Akurgal Life Park SPP was created by transforming the roofs of the gym and parking areas in Ekrem Akurgal Life Park into a power plant. In this context, there are 716 solar panels with a total area of 1.217m^2, 380 of which are on the roof of the sports hall and 336 of which are in the parking area. As of the end of October, 185 trees were saved and 19 tons of carbon dioxide (CO_2) emissions were prevented by providing 45.000 kWh of electrical energy in the first 3 months from the facility, which was commissioned in August 2017. The disabled vehicle charging station and the electric passenger vehicle station that can charge 2 vehicles at the same time in the park, which will meet all the electricity needs of Ekrem Akurgal Life Park and 40% of the energy needs in the Gas Factory, also serve the visitors (Healthy City Izmır, 2023).

Table 3. Identification of Ekrem Akurgal Life Park Solar Power Plant

Çizelge 3. *Ekrem Akurgal Yaşam Parkı Güneş Eenerji Santrali'nin tanımlanması*

GENERAL INFORMATION				
Name	Ekrem Akurgal Life Park Solar Power Plant			
Location	Bayraklı			
Year of Installation	2017			
Installed Power Amount	186 kWh			
Type of Ownership of the Land	**Person (Private)**		**Treasury (State)**	**Village and Pasture**
			✓	
LOCATION SELECTION				
Installation Surface / Location Selection	**Open Land**		**Roof**	**Facing Work**
	Agriculture **Forest** **Pasture** **Other**		✓	
Distance to Different Uses	**Residential**	**Industry**		**The Protected Areas**
	0	-		~ 10.06 km
Distance to Transportation Axles	**Highway**		**Railway**	**Sea Route**
	~ 518 m		~ 1.80 km	~ 1.50 km

Ekrem Akurgal Life Park SPP is located in the Cengizhan Neighborhood of Bayraklı district. There are residential areas in the south of the park, which does not have an industrial site in its immediate vicinity. The nearest protected area around it is the Çiçekli Nature Park, which has a bird flight distance of 10.06 km. The distance to İzmir Ring Road, which is the closest highway at bird flight distance, is approximately 518 meters, the distance to IZBAN Turan Station, which is the closest railway, is approximately 1.80 km, and the distance to Bayraklı Ferry Port, which is the closest sea route, is approximately 1.50 km (Table 3).

Karşıyaka Municipality Solar Field has been in operation since August 6, 2014 (Energy Atlas, 2023a). It was implemented to draw attention to the use of alternative energy sources (Yapı, 2014). The solar field, located on 9.000m^2 of land (Yapı, 2014), was expanded to an area of 17.000m^2 by adding 4.224 more panels to the solar power plant established with 2.013 panels in 2014 (Karşıyaka Municipality, 2023). It produces an average of 719.780 kWh energy in this power plant. This energy produced is at a level that can meet the electrical energy needed by approximately 198 people in their daily lives (housing, industry, metro transportation, official apartment, environmental lighting, etc.). When only the houses are considered, the solar field produces energy that can meet the electricity needs of approximately 241 houses (Energy Atlas, 2023a). The income provided is used in offsetting with energy companies for the electricity expenses of the buildings and facilities belonging to Karşıyaka Municipality (Karşıyaka Municipality, 2023). Karşıyaka Municipality Solar Field is located in Örnekköy Neighborhood of Karşıyaka district. However, it is 2.65 km from the residential center of Örnekköy Neighborhood. There is Karşıyaka Waste Removal Center in the north, Örnekköy Cemetery in the south, Örnekköy National Park in the west and Güler Bilgin Memorial Forest in the east. It is 1.34 km to Karşıyaka Industrial Site located in the southeast. The nearest protected area is Yamanlar Mountain Medical Park with a bird flight distance of 5.34 km. The distance to İzmir Ring Road, which is the closest highway at bird flight distance, is approximately 2.25 km, the distance to IZBAN Mavişehir Station, which is the closest railway, is approximately 3.85 km, and the distance to Karşıyaka Ferry Port, which is the closest sea route, is 5.90 km (Table 4).

Table 4. Identification of Karşıyaka Municipality Solar Field

Çizelge 4*. Karşıyaka Belediyesi Güneş Tarlası'nın tanımlanması*

GENERAL INFORMATION					
Name	Karşıyaka Municipality Solar Field				
Location	Karşıyaka				
Year of Installation	2014				
Installed Power Amount	493 kWh (2014); 1000 kWh (2020)				
Type of Ownership of the Land	**Person (Private)**		**Treasury (State)**		**Village and Pasture**
			✓		
LOCATION SELECTION					
Installation Surface / Location Selection	**Open Land**			**Roof**	**Facing Work**
	Agriculture	**Forest**	**Pasture**	**Other**	
			✓		
Distance to Different Uses	**Residential**		**Industry**		**The Protected Areas**
	~ 2.65 km		~ 1.34 km		~ 5.34 km
Distance to Transportation Axles	**Highway**			**Railway**	**Sea Route**
	~ 2.25 km			~ 3.85 km	~ 5.90 km

Bozyaka Closed Market SPP generates an average of 499.320 kWh of electricity (Energy Atlas, 2023b). The plant, which is installed on the roof surface, covers an area of 5.000m^2 (Sabah Newspaper,

2014). This energy produced is at a level that can meet the electrical energy needed by approximately 198 people in their daily lives (housing, industry, metro transportation, official apartment, environmental lighting, etc.). Considering only the houses, this power plant produces energy that can meet the electricity needs of approximately 167 houses (Energy Atlas, 2023b).

Bozyaka Closed Market SPP is located in the settlement of Bozyaka Neighborhood of Karabağlar district. The distance to Karabağlar Industrial Site in the southeast is approximately 1.35 km. There is no protected area around it. Greenery, the nearest highway at bird flight distance It is approximately 1 km away from the 3rd Street, approximately 2.10 km away from IZBAN Running Station, which is the closest railway, and approximately 3.65 km away from Konak Ferry Port, which is the closest sea route (Table 5).

Table 5. Identification of Bozyaka Closed Marketplace Solar Power Plant

Çizelge 5. *Bozyaka Kapalı Pazaryeri Güneş Enerji Santrali'nin tanımlanması*

GENERAL INFORMATION					
Name	Bozyaka Closed Marketplace Solar Power Plant				
Location	Karabağlar				
Year of Installation	2014				
Installed Power Amount	342 kWh				
Type of Ownership of the Land	**Person (Private)**		**Treasury (State)**		**Village and Pasture**
			✓		
LOCATION SELECTION					
Installation Surface / Location Selection	**Open Land**			**Roof**	**Facing Work**
	Agriculture	**Forest**	**Pasture**	**Other**	✓	
Distance to Different Uses	**Residential**		**Industry**		**The Protected Areas**
	0		~ 1.35 km		-
Distance to Transportation Axles	**Highway**			**Railway**	**Sea Route**
	~ 1 km			~ 2.10 km	~ 3.65 km

1250 photovoltaic solar panels were used in Bornova Municipality SPP. This plant generates an average of 43.000 kWh of electrical energy. This energy produced is at a level that can meet the electrical energy needed by approximately 198 people in their daily lives (housing, industry, metro transportation, official apartment, environmental lighting, etc.). Considering only the houses, this power plant produces energy that can meet the electricity needs of approximately 147 houses (Energy Atlas, 2023c).

Bornova Municipality SPP, which is located on a 7000m^2 land (E-Municipality.info, 2015), is located in Erzene Neighborhood in Bornova district. Approximately 500 m bird flight to the settlements, It is located in the northeast of the Industrial Site. The distance to Ankara Street, which is the nearest highway, is approximately 784 m and the distance to Bornova Metro Station, which is the closest railway, is approximately It is 3.93 km. There is no sea transportation in the immediate vicinity (Table 6). In the service buildings of the power plant and the municipality, it is planned to meet ¼of the electrical energy needs (Energy Atlas, 2015), and also to prevent 250 tons of CO_2 emissions that cause environmental pollution every year (E-Municipality.info, 2015).

Seferihisar Municipality Closed Market SPP has been in operation since May 2014. An average of 248.200 kWh of electrical energy is produced in the power plant, which is built on the roof of the marketplace (E-Municipality.info, 2015). and photovoltaic solar panel is used. This energy produced is at a level that can meet the electrical energy needed by approximately 198 people in their daily lives (housing, industry, metro transportation, official apartments, environmental lighting, etc.). Considering only the houses, this power plant produces energy that can meet the electricity needs of approximately 83 houses (Energy Atlas, 2023d).

Table 6. Identification of Bornova Municipality Solar Power Plant

Çizelge 6. Bornova *Belediyesi Kapalı Pazaryeri Güneş Enerji Santrali'nin tanımlanması*

GENERAL INFORMATION				
Name	Bornova Municipality Solar Power Plant			
Location	Bornova			
Year of Installation	2015			
Installed Power Amount	438 kWh			
Type of Ownership of the Land	**Person (Private)**		**Treasury (State)**	**Village and Pasture**
			✓	
LOCATION SELECTION				
Installation Surface / Location Selection	**Open Land**		**Roof**	**Facing Work**
	Agriculture	**Forest**	**Pasture**	**Other**
			✓	
Distance to Different Uses	**Residential**		**Industry**	**The Protected Areas**
	~ 500 m		~ 300 m	~ 4.69 km
Distance to Transportation Axles	**Highway**		**Railway**	**Sea Route**
	~ 784 m		~ 3.93 km	-

Seferihisar Closed Market SPP is located in Camikebir Neighborhood of Seferihisar district. The bird flight distance to Seferihisar Industrial Site in the northwest is approximately 1.81 km. The closest protected area around it is the Breadless Nature Park, where bird flight is 6.25 km. The distance to İzmir Street, which is the nearest highway, is about 530 meters and the distance to Sığacık Marina, which is the closest sea route, is about 4.90 km. There is no railway around Seferihisar Closed Market SPP (Table 7). With the energy produced, the heating, cooling and lighting needs of the municipality to which it belongs are met. 180 thousand kg of CO_2 emissions are also prevented with the installed power plant (Seferihisar Municipality, 2023).

Table 7. Identification of Seferihisar Municipality Closed Marketplace Solar Power Plant

Çizelge 7. *Seferihisar Belediyesi Kapalı Pazaryeri Güneş Enerji Santrali'nin tanımlanması*

GENERAL INFORMATION				
Name	Seferihisar Municipality Closed Marketplace Solar Power Plant			
Location	Seferihisar			
Year of Installation	2014			
Installed Power Amount	248 kWh			
Type of Ownership of the Land	**Person (Private)**		**Treasury (State)**	**Village and Pasture**
			✓	
LOCATION SELECTION				
Installation Surface / Location Selection	**Open Land**		**Roof**	**Facing Work**
	Agriculture	**Forest**	**Pasture**	**Other**
			✓	
Distance to Different Uses	**Residential**		**Industry**	**The Protected Areas**
	0		~ 1.81 km	~ 6.25 km
Distance to Transportation Axles	**Highway**		**Railway**	**Sea Route**
	~ 530 m		-	~ 4.90 km

Selcuk Municipality Vegetable and Fruit Market SPP (Table 8) is located approximately 2.38 km from the settlement of İsa Bey Neighborhood in Selcuk district. The bird flight distance to Selçuk Efes Industrial Site, which is located in the south of the power plant located on the roof of Selçuk Municipality Vegetable and Fruit Market, is approximately 3.50 km. The Meryemana Nature Park and Selçuk Gebekirse Lake in its immediate vicinity are approximately 6.25 km away from the Wildlife Development Area. The distance to Selcuk-İzmir Road, which is the closest highway at bird flight distance, is approximately 160 m, and the distance to IZBAN Selcuk Station, which is the closest railway station, is approximately 2.40 km.

Table 8. Identification of Selçuk Municipality Vegetable and Fruit Market Solar Power Plant

Çizelge 8. *Selçuk Belediyesi Sebze ve Meyve Hali Güneş Enerji Santrali'nin tanımlanması*

GENERAL INFORMATION							
Name	Selçuk Municipality Vegetable and Fruit Market Solar Power Plant						
Location	Selçuk						
Year of Installation	-						
Installed Power Amount	-						
Type of Ownership of the Land	**Person (Private)**				**Treasury (State)**		**Village and Pasture**
					✓		
LOCATION SELECTION							
Installation Surface / Location Selection	**Open Land**				**Roof**		**Facing Work**
	Agriculture	**Forest**	**Pasture**	**Other**	✓		
Distance to Different Uses	**Residential**				**Industry**		**The Protected Areas**
	~ 2.38 km				~ 3.50 km		~ 6.25 km
Distance to Transportation Axles	**Highway**				**Railway**		**Sea Route**
	~ 160 m				~ 2.40 km		-

Selcuk Municipality Vegetable and Fruit Market SPP is located approximately 10 km away from the Aegean Sea as a bird flight, but there is no sea transportation from this region. The distance to Kuşadası Port, which is the nearest port, is 15 km by bird flight.

In addition, the fact that solar power plants are installed on bird migration routes is also considered within the scope of environmental impacts. At this point, it would be more accurate to make a general evaluation of the subject since there is no mapping of bird migration routes in Izmir. According to Ö. Döndüren (2023, oral interview), bird migrations vary depending on many variables, especially migration character and migrating species. Immigration in Türkiye is generally concentrated in the Western Anatolia region. It is from north to south in autumn and from south to north in spring. When we look at the Aegean, it is possible to say that there are not many migration routes. In general terms, migration routes follow the Aegean coasts, concentrate on the Gediz Delta and wetlands are preferred especially by water birds; there is no intense migration movement within the city. Only swallows, bee birds, ebb birds, etc. make frontal migrations and when passing through Europe, the city uses the interior. In this context, especially the bee hawk passes over the Karaburun peninsula. The migration route of this species starts from Mytilene and continues southwards through Karaburun, west of İzmir High Technology Institute and Seferihisar, respectively. Species are affected by power plants. Especially when they encounter solar power plants, they start to land by thinking that the surfaces of these structures are water. According to Sabah Newspaper (2021), Selçuk is not only a region on the migration routes of storks but also an

important feeding and shelter point for storks due to its availability in terms of wetlands and swamps and the absence of noise pollution throughout the city.

CONCLUSIONS

In this study, which focuses on the protection and repair activities carried out in natural and cultural landscapes where solar power plants are installed, eight solar power plants located in the city of İzmir and established by local governments were examined. According to the data obtained from these examinations, the installation locations, years and installed power amounts of solar power plants differ from each other. In this context, the degrees of effect are also different from each other. Among the plants examined, it is seen that six of them are roof applications and two of them are land applications. In general terms, it has been observed that solar power plants, which are land applications, have more negative environmental effects than solar power plants, which are roof applications. Because land applications require more space use in terms of area preparation, logistics and installation.

ESHOT Gediz Workshop, Ekrem Akurgal Life Park, Bozyaka Closed Marketplace, Seferihisar Closed Marketplace, Selçuk Municipality Vegetable and Fruit Market and solar power plants are located in an existing settlement. For this reason, the creation of a transportation route during its installation, the establishment of a storage area, etc. did not cause actions that required the reshaping of the land. Existing highways have been used to deliver the necessary materials to the area and no negativity has been detected in the use of the area. Since these solar power plants are roof applications as installation surfaces, they do not constitute a negative situation in terms of land cover. In addition, for the same reason, vehicle users on the route are not adversely affected by the reflection and glare effect. However, it may cause people residing in the houses in their immediate vicinity to be adversely affected by glare and reflection at certain times of the day depending on the angle of sunlight. Solar power plants, which have industrial sites in their immediate vicinity, require more frequent irrigation and washing activities due to pollutants such as dust, etc. brought by the industry. This is a factor that increases the amount of water that needs to be used for cleaning and maintenance.

Ekrem Akurgal Life Park Solar Power Plant, there is no industrial site in the immediate vicinity of the Solar Power Plant, but due to its location, it may be exposed to pollutants such as dust, etc., especially since there are open lands in the north, which may increase the amount of water required during cleaning and maintenance.

Since Karşıyaka Municipality Solar Field and Bornova Municipality Solar Power Plant is an application based on land, changes are observed in terms of land use and land cover. Vegetable topsoil on the land has been removed, leveling, and excavation-filling processes have been carried out and thus the area has been made suitable for solar power plant installation. This situation causes a decrease in the amount of organic matter in the soil, compaction n of the soil, air pollution, etc. Since new transportation axes are created in order to provide vehicle traffic with pedestrians and to carry out logistics activities, intense vibration, noise pollution and fragmentation between habitats lead to ecological deterioration.

Since Karşıyaka Municipality Solar Field and Bornova Municipality Solar Power Plant are located relatively outside the residential and transportation areas, no negativity was observed in terms of glare and reflection effect. However, since it is exposed to intensive sunlight, it is possible to state that the amount of water needed for cleaning and maintenance is high due to its proximity to the cooling and industrial site. There is also a risk of erosion in these areas. For this reason, it should be monitored at regular intervals and observations should be made.

Selçuk Municipality Vegetable and Fruit Market Solar Power Plant located in Selçuk, especially due to its proximity to Selçuk Gebekirse Lake Wildlife Development Area, its important wetlands and marshes,

which offer a favorable habitat for many species, can create negativity for these species. In addition, Seferihisar Municipality Closed Marketplace Solar Energy, which is located in the Seferihisar district on the bee hawk migration route, the power plant can also create negativity in terms of bird species. It can mislead species into landing or cause them to be negatively affected by glare.

Although the orientation of local municipalities towards solar energy for renewable energy is not limited to these plants, it is developing and expanding day by day. The applications aim to reduce greenhouse gas emissions and contribute to nature and the economy (İzmir Metropolitan Municipality, 2021). When the applications made and planned to be made are examined, it is seen that the majority of them are roof applications. This situation is considered positive in terms of realizing renewable energy applications without causing land shaping and habitat fragmentation.

Solar power plants, which reduce foreign dependence on energy (Energy Atlas, 2023d), create added value on local and economic activities when the amount of energy produced and the areas that use this energy are evaluated. However, what needs to be done to protect natural and cultural landscapes and to carry out landscape repair in degraded areas is summarized below.

- When used for logistic purposes, existing transportation corridors should be preferred as much as possible and habitat fragmentation should be prevented,
- The scraped topsoil should be stored under appropriate conditions for repair,
- Regular control and maintenance of the exhaust systems of the vehicles should be ensured, and the formation of pollutants and compaction of the soil should be prevented by controlling the speed limits,
- Frequent and sufficient irrigation should be done,
- In order to reduce the use of water, structural or plant applications that will reduce the dust retention of the panels should be included (for example, creating plant curtains in the direction of the prevailing wind, harvesting and storing rainwater, etc.),
- Erosion control has to be performed,
- Domestic wastes should be properly stored and disposed of in regular storage areas,
- Solid and liquid hazardous wastes should be stored in accordance with the regulations and on-site waste management and hazardous material management plans should be prepared,
- The transfer of pollutants to the surrounding areas and water sources has to be prevented by creating a drainage system.

In this context, appropriate and comprehensive landscape protection plans should be prepared first. During the application, the effects that may occur in certain periods in the short and long term should be monitored and changes should be made as a result of observations. In ongoing or new applications, protection decisions and repair decisions for terminated solar power plant areas should be made accordingly.

REFERENCES

Akpan, U.F. & G.E. Akpan, 2012. The contribution of energy consumption to climate change: A feasible policy direction. International Journal of Energy Economics and Policy 2 (1): 21-33. https://dergipark.org.tr/en/pub/ijeeep/issue/31899/350661?publisher=http-www-cag-edu-tr-ilhan-ozturk

Aydın, E., 2020. Küresel İklim Değişikliğinin Güneş Enerjisi Özelinde Yenilenebilir Enerji Potansiyeline Etkisi ve Arazi Örtüsü ile İlişkisi: Van örneği. Van Yüzüncü Yıl Üniversitesi (Unpublished) Master's Thesis, Van, 68s.

Birişçi, T., M.A. Güney, H.S. Türel, & Ç. Kılıçaslan, 2012. Bitkisel Tasarım. Ege Üniversitesi Yayınları, İzmir, 73s.

Cao, X. 2003 energy development: Implications for developing countries, Resources Policy, 29: 61-67s. doi:10.1016/j.resourpol.2004.05.001

Energy Atlas, 2015. Bornova Belediyesi GES haberleri. (Web page: https://www.enerjiatlasi.com/video/bornova-belediyesi-ges-haberi.html) (Date accessed: March 2023).

Energy Atlas, 2022a. Güneş enerji santralleri. (Web page: https://www.enerjiatlasi.com/gunes/) (Date accessed: October 2022).

Energy Atlas, 2022b. İzmir güneş enerjisi potansiyeli haritası. (Web page: https://www.enerjiatlasi.com/gunes-enerjisi-haritasi/izmir) (Date accessed: October 2022).

Energy Atlas, 2022c. Seferihisar Belediyesi güneş enerjisi santrali – GES. (Web page: https://www.enerjiatlasi.com/gunes/seferihisar-belediyesi-gunes-enerjisi-santrali.html) (Date accessed: November 2022).

Energy Atlas, 2023a. Karşıyaka Belediyesi güneş tarlası. (Web page: https://www.enerjiatlasi.com/gunes/karsiyaka-belediyesi-gunes-tarlasi.html) (Date accessed: March 2023).

Energy Atlas, 2023b. Bozyaka Pazaryeri güneş enerji santrali. (Web page: https://www.enerjiatlasi.com/gunes/bozyaka-pazaryeri-gunes-enerji-santrali.html) (Date accessed: March 2023).

Energy Atlas, 2023c. Bornova Belediyesi güneş enerjisi santrali. (Web page: https://www.enerjiatlasi.com/gunes/bornova-belediyesi-gunes-enerjisi-santrali.html) (Date accessed: March 2023).

Energy Atlas, 2023d. Seferihisar Belediyesi güneş enerjisi santrali. (Web page: https://www.enerjiatlasi.com/gunes/seferihisar-belediyesi-gunes-enerjisi-santrali.html) (Date accessed: March 2023).

Energy Diary, 2016. Bornova Belediyesi'nin güneş enerji santrali kara geçti. (Web page: https://www.enerjigunlugu.net/bornova-belediyesinin-gunes-santrali-kara-gecti-19641h.htm) (Date accessed: November 2022).

E-Municipality.info, 2015. Belediyelerden "GES" atağı. (Web page: https://www.ebelediye.info/dosya/belediyelerden-ges-atagi) (Date accessed: November 2022).

ESHOT, 2017. Temiz enerji için İzmir örneği. (Web page: https://www.eshot.gov.tr/tr/Haberler/3571/91) (Date accessed: November 2022).

ESHOT, 2020. (Web page: https://www.eshot.gov.tr/tr/ Haberler/3734/91?AspxAutoDetectCookieSupport=1) (Date accessed: November 2022).

ESHOT, 2023. (Web page: https://www.eshot.gov.tr/tr/ GunesEnerjisiSantrali?AspxAutoDetectCookieSupport=1) (Date accessed: January 2023).

Güner, E. D., S. Tekin, A. Çilek, M. Ünal Çiçek, 2021. Güneş enerji santrali için uygun alanların CBS tabanlı AHP yöntemi ile belirlenmesi: Mersin ili örneği. Çukurova Üniversitesi Mühendislik Fakültesi Dergisi 36 (1): 11-24. doi.org/10.21605/cukurovaumfd.933209

Healthy City Izmir, 2023. Ekrem Akurgal yaşam parkı, temiz enerji için İzmir örneği. (Web page: https://skpo.izmir.bel.tr/DuyuruDetay.aspx?id=113) (Date accessed: February 2023)

İzmir Metropolitan Municipality, 2020. İzmir sustainable energy and climate action plan, (Web page: https://skpo.izmir.bel.tr/Upload_Files/FckFiles/file/2020/WEB_SAYFASI_SECAP-ingilizce.pdf) (Date accessed: March 2023).

İzmir Metropolitan Municipality, 2021. İzmir'de 5 tesisin daha çatısına güneş enerji santrali kuruluyor. (Web page: https://www.izmir.bel.tr/tr/Haberler/izmir-de-5-tesisin-daha-catisina-gunes-enerji-santrali-kuruluyor/ 45452/ 156) (Date accessed: March 2023).

İpekler Electric, 2022. Selçuk Belediyesi hal binası, İzmir (150 kWp). (Web page: https://www.ipekler.com.tr/arama?q=SEL%C3%87UK) (Date accessed: November 2022).

IZKA, 2016. İzmir güneş enerjisi sektörü. (Web page: https://www.kalkinmakutuphanesi.gov.tr/assets/upload/dosyalar/zmirde-gunes-enerjisi-sektorunde-yatirim.pdf) (Date accessed: January 2023).

Karabağlar Municipality, 2014. 2014 yılı faaliyet raporu. (Web page: https://docplayer.biz.tr/822927-2014-yili-faaliyet-raporu.html) (Date accessed: November 2022).

Karadan, D. & T. Birişçi, 2020. Investigation Of Water Facilities And Their Use In Landscape Desing In The Case Of Shopping Centers In Izmır. Ege Üniv. Ziraat Fak. Derg., 57 (4): 579-589. doi.org/10.20289/zfdergi.690231

Karşıyaka Municipality, 2022. (Web page: https://www.karsiyaka.bel.tr/karsiyakanin-ikinci-gunes-tarlasi-tamamlandi) (Date accessed: October 2022).

Karşıyaka Municipality, 2023. Karşıyaka güneş tarlasından 5 milyon kazandı. (Web page: https://www.karsiyaka.bel.tr/karsiyaka-gunes-tarlasindan-5-milyon-kazandi) (Date accessed: March 2023).

Kengpol, A., P. Rontlaong & M. Tuominen, 2013. A decision support system for selection of solar power plant locations by applying fuzzy AHP and TOPSIS: An empirical study. Journal of Software Engineering Application, 6 (9):470– 481.

Ministry of Environment, Urbanization and Climate Change, 2017. Güneş enerjisi santralleri, Çevre ve Şehircilik Bakanlığının ÇED Alanında Kapasitesinin Güçlendirilmesi için Teknik Yardım Projesi. (Web page: https://webdosya.csb.gov.tr/db/ced/editordosya/CEDbrosur9.pdf) (Date accessed: November 2022).

Noorollahi, E., D. Fadai, S. M. Akbarpour, & S. Ghodsipour, 2016. Land suitability analysis for solar farms exploitation using GIS and fuzzy analytic hierarchy process (FAHP)—a case study of Iran. Energies, 9 (8): 643.

Sabah Newspaper, 2014. Güneş enejisiyle kazanacak. (Web page: https://www.sabah.com.tr/egeli/2014/05/25/gunes-enerjisiyle-kazanacak) (Date accessed: March 2023)

Sabah Newspaper, 2021. Baharın müjdecisi leylekler Selçuk semalarında. (Web page: https://www.sabah.com.tr/izmir/2021/03/01/baharin-mujdecisi-leylekler-selcuk-semalarinda) (Date accessed: March 2023).

Seferihisar Municipality, 2023. Seferihisar Belediyesi kapalı Pazar yerinde fotovoltaik güç santrali kurulumu. (Web page: http://seferihisar.bel.tr/seferihisar-belediyesi-kapali-pazar-yerinde-fotovoltaik-guc-santrali-kurulumu/) (Date accessed: March 2023).

Taktak, F. & M. Ilı, 2018. Güneş Enerji Santrali (GES) geliştirme: Uşak örneği. *Geomatik Dergisi, 3* (1): 1-21. https://doi.org/10.29128/geomatik.329561

TEIAŞ, 2022. Yük tevzi başkanlığı – Kurulu güç raporu – Kasım 2022. (Web page: https://webim.teias.gov.tr/file/3d02c82f-83a2-46dd-bc18-7c89b27c1a13) (Date accessed: Kasım 2022).

Uyan, M. 2017. GIS-Supported mapping of solar power plants sites using AHP method. Pamukkale University Journal of Engineering Sciences 23 (4): 343-351. doi: 10.5505/pajes.2016.59489

Yapı, 2014. (Web page: http://www.yapi.com.tr/haberler/karsiyakaya-gunes-tarlasi_ 123747. html) (Date accessed: March 2023).