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Road-Parcel Situations and Property Analysis of Neighborhoods in Çukurova Regional Airport Project after Land Consolidation Projects

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Keywords
Land Consolidation,
Expropriation,
Airport Construction,
Property Analysis.

ABSTRACT

The construction of Çukurova Regional Airport, which is being built in Tarsus district of Mersin province and will be the second largest airport in Turkey with a capacity of 30 million passengers when completed, continues to work on the lower and upper structure. It is planned that the project will be completed and put into service within 2 years. It is aimed that the fragmented, scattered, distorted shaped parcels in Çiçekli, Karsavuran, Ballıca, Kargılı and Çağbaşı neighborhoods within the scope of this project will be brought together and turned into more regular and suitable parcels for use. In addition, in relation to these parcels, it is aimed to combine and reorganize in accordance with the principles of modern agricultural management and the development of irrigation services together with in-field development services. In this study, the project region and the studies were introduced, economic analysis of the old and new situation with maps and screenshots supporting the new Land Use situation and ownership structure to be formed, and it is aimed to create an academic base for similar projects to be carried out after that.

1. INTRODUCTION

Airports are an important part of the air transport system; operate as an infrastructure provider in the system. In addition to these important roles, airports also have strategic importance in terms of the regions they serve. In terms of its geographical location, Turkey is positioned as an important crossroads between the transition points between Europe, Asia and the Middle East regions. Especially in recent years, Turkey's policies have transformed this geographical location into an important center for passenger transportation. Airport passenger traffic in Turkey has increased significantly in the last decade. It is important to understand the development dynamics of the industry in terms of both the air transport industry and the Turkish economy (Ustaömer and Şengür; 2018).

Population structure and population growth rate, developments in the tourism sector, the increase in national income per capita also causes an increase in the number of passengers using the airports, thus affecting the airline transportation sector. Due to the fact that Adana Şakirpaşa Airport, which is currently in use in the region, exceeds its current capacity, remains in the city settlement and does not have the opportunity to develop, a new regional airport is needed to serve the region. For this reason, Çukurova Regional Airport, which is within the borders of Tarsus district of Mersin province, gains great importance (MGS, 2009). Transportation to the project area is provided by the D-400 Highway from Mersin and Adana provinces. Figure 1 shows the location of the Çukurova Regional Airport Project and the 8 km connection road to Mersin-Adana highway, which is required for transportation to the airport.

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Figure 1. Map showing the transportation network of the region (Çukurova Regional Airport EIA Application File 2009).

2. METHOD

After the neighborhoods within the airport project were taken into the public area, there was a change in the boundaries of the new neighborhoods to be formed, and consolidation was carried out in line with the region by informing the owners. While consolidation was carried out, the expropriation limits were preserved exactly. As a result of land consolidation in the region, it was aimed to increase productivity in agriculture and living standards in rural areas by combining the fragmented lands. In addition, increasing the economic value of the land, establishing common facilities for neighborhood roads and drainage channels, determining pre-investment barriers, producing solutions and determining the possible effects of the project on the value of agricultural enterprises are among the objectives of the project (Figure 2a, 2b). The consolidation process of the Çukurova Regional Airport Project, which is under construction, has been made by the State Hydraulic Works (DSI), and the registration process is carried out by the Mersin Tarsus Cadastre Unit.

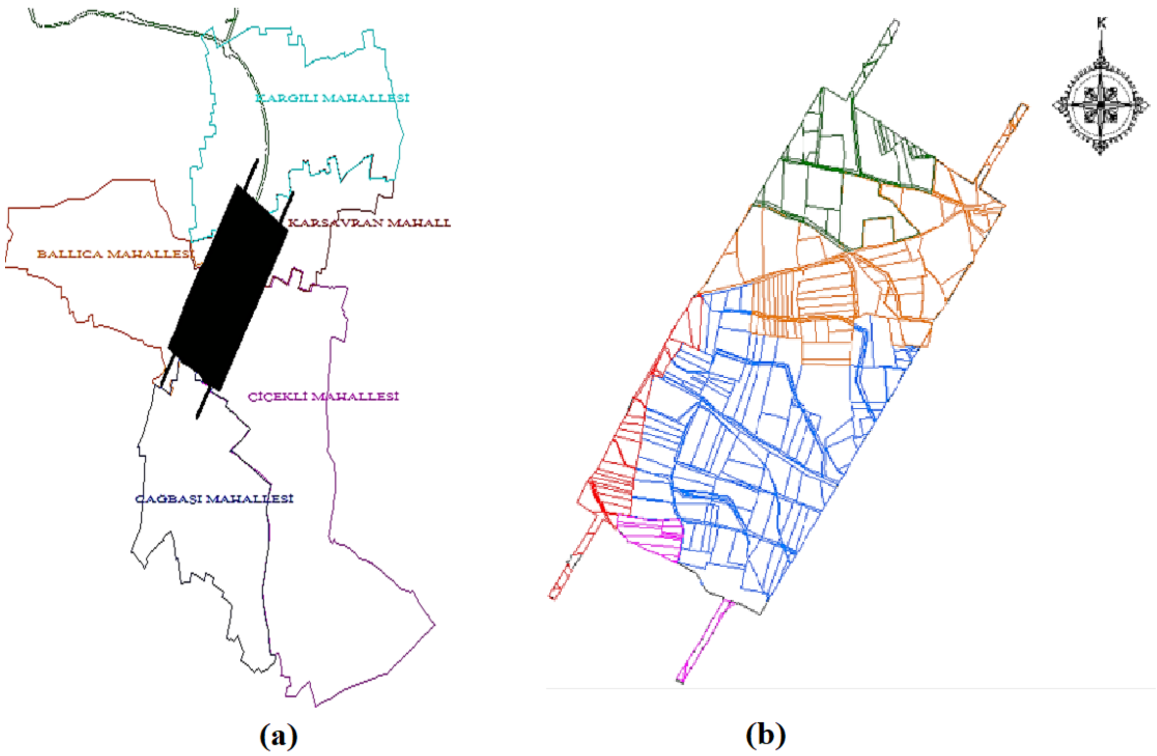

Figure 2. General view from the project site and expropriated parcels

The airport area in general has a slightly salty structure with insufficient drainage and consists of alluvial soils that can be used for irrigated agriculture. Project area III. Class is irrigated agricultural land (MGS 2009). It is a moderately fertile land for field crops that bring good income with suitable agricultural methods on it. The general features of this class of land are that the slope is moderate, the sensitivity to erosion, intense wetness, superficial soil, presence of base stone, too much sand or gravel, low water holding capacity and low productivity status (URL_1).

Land grading in the project area At the same time, it is one of the important factors in finding the share of the beneficiaries in the areas to be used for public facilities, paying the land prices to be expropriated, and giving land of equal value to the former landowners to their previous lands (Boyraz, Z and Üstündağ; 2008). The values of individual parcels before consolidation are found by overlapping the rating and old property maps (Arıcı et al. 2017). By using these data, the land values of agricultural enterprises are obtained. New parcel distributions are also made on these values (URL_2).

Tarsus River flows 5 km west of the study area and Seyhan River 10 km south. Its distance to the Mediterranean Sea is 20 km. A wastewater treatment plant will be established to clean the wastewater from the operation of the project. In order to minimize dust emissions that may occur during the construction phase, the project area will be irrigated at certain intervals. Necessary measures are taken to ensure that the water resources are not adversely affected during the construction and operation phases of the airport (Çukurova Regional Airport EIA Application File 2009). According to the net calculation made on the Netcad map drawing program, the project area is 7896223.041 m^2 in total.

3. RESULTS

3.1. Topographical Situation of Ballica District and New Property Analysis

The topographic structure of the Ballıca District is slightly inclined and covers a total of 550.35 hectares (Figure 3). Transportation is provided from Adana-Mersin Highway. The typical Mediterranean climate prevails in the project area. Ballıca Neighborhood is located within the boundaries of Mersin Tarsus Plain land consolidation and T.İ.GH project. There are not many fixed facilities affecting the project in the Ballıca District, the existing ones have been preserved. The same amount of deductions was made from all of the newly formed roads and canal shares in the project area. The roads were preserved in such a way that the existing roads used on the ground were used, and new roads were planned in case of need. Some of the lands have been detached, and some of them have been left as shares at the request of the owners, and the parcellation plan of the neighborhood has been completed.

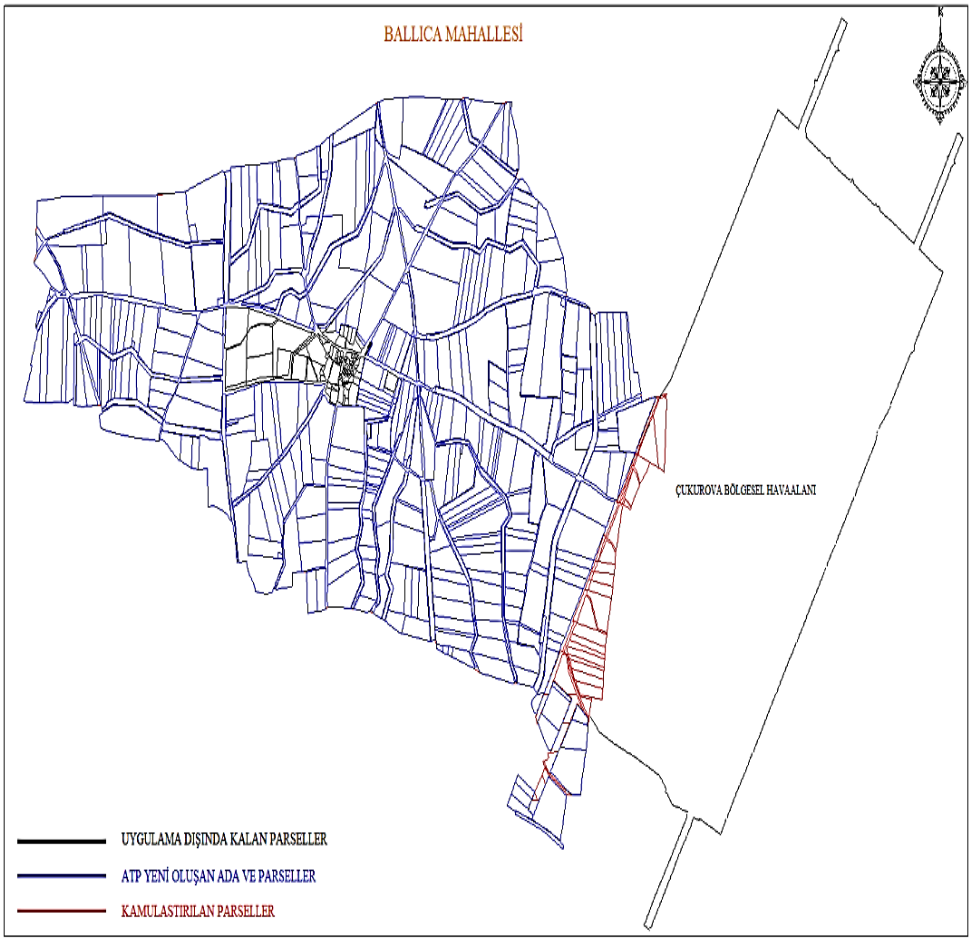

Figure 3. Ballıca neighborhood newly formed island-parcel and expropriated parcels

After creating the rating map, the parcel index value found in productivity, soil structure and location and the number of parcel values are found by multiplying the area of the parcel. As a result of the number of parcel values included in the consolidation and the redistribution and determination of the parcels, the total expropriated area in Ballıca District is 12796737.56 m². Grading is done according to the Land Consolidation Regulation. The total number of cadastral parcels in Ballıca District was 813, the number of owners was 1457, the number of islands was 119, the number of parcels was 447, and the average index value was 0.7700.

3.2. Çağbaşı District Topographical Situation and New Property Analysis

Mersin Tarsus weather is generally seen as a warm climate. Annual precipitation is around 700 mm on average (URL_3). Çağbaşı Neighborhood is located within the boundaries of Mersin Tarsus Plain land consolidation and T.İ.GH project. The height of the project site above sea level is 10-40 m. between. The general slope is north-south. The surface of the land is flat and it is a plain area and Adana-Mersin Highway passes through the project site. The total area of Çağbaşı District is 1492.39 hectares (Figure 4).

Figure 4. The newly formed island-parcel and expropriated parcels in Çağbaşı district.

The aim of the works carried out within the scope of the project is to reduce the small and scattered parcel sizes to an appropriate level, to prevent fragmentation and to ensure that there are no corrupt parcels for farmer welfare. In addition, minimizing the shareholding situation and ensuring territorial integrity is one of the important studies. In the project area, some of the lands have been detached, and the shares have been left at the request of the owners. There is a pasture area and there is no registered or unregistered protected area in the neighborhood. The roads were preserved in such a way that the existing roads were used, and new roads were planned in case of need.

The same amount of deductions was made for the new roads and canal shares to be created from the parcels in the project area. It was created from the road and used in channel blocks. The deduction calculation was calculated by dividing the total number of values of the parcels entering the project area (multiplication of the indices of the old parcel areas) by the total number of values of the parcels after subtracting the value numbers of the newly created blocks. The areas created from the road are deducted from this cut. After total consolidation, the net area is **14924989.95** m². The total number of cadastral parcels in Çağbaşı District was 586, the number of owners 905, the number of islands 117, the number of parcels 371, and the average index value was 0.7700.

The size of the consolidation rate is an indicator of the success of the consolidation. As this ratio grows, agricultural enterprises become more suitable and accordingly, the efficiency of land consolidation increases (Arslan and Tunca, 2013). It is envisaged that this consolidation and Çukurova Regional Airport Project in the Tarsus district of Mersin will enable tourism, cargo transportation, financial development and developments to be provided to Mersin and Tarsus regions.

3.3. Çiçekli District Topographic Situation and New Property Analysis

Çiçekli (Frengülüs) Neighborhood Mersin Tarsus plain is located within the boundaries of the land consolidation and T.İ.GH project. The land surface is flat and plain land. The average altitude of Çiçekli District is 30-40 meters above sea level. The same amount of deductions was made for the new roads and canal shares to be created from the parcels in the project area. There is no pasture area in Çiçekli District and there is no registered/unregistered protected area that will affect the consolidation. In the consolidation process, some of the lands were detached and some of them were left as shares. Its topography is slightly inclined and the total area is 1778.34 hectares. As seen in the new situation map formed after the consolidation, the red areas are the expropriated parcels, the blue areas are the newly formed island and parcels of the ATP, the black area is the residential area, which is out of the application, and the pink areas are the agricultural reform implementation areas (Figure 5).

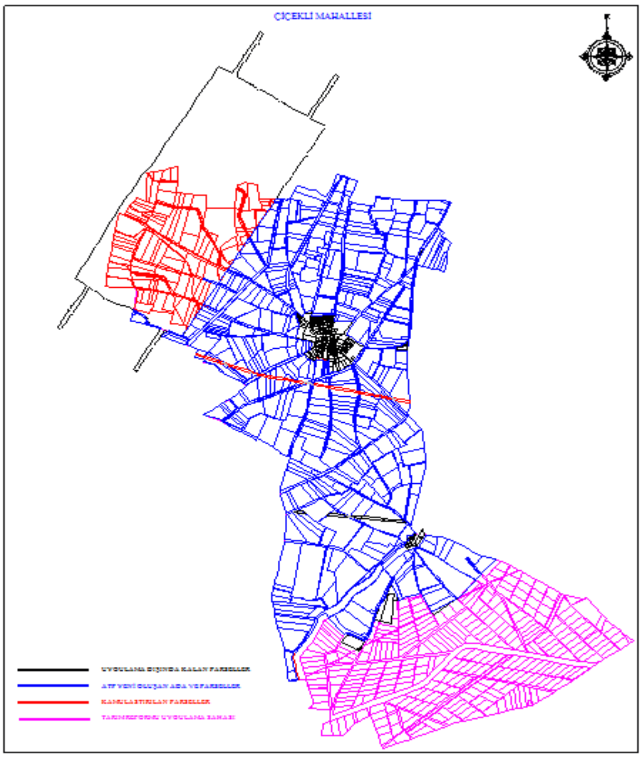

Figure 5. Çiçekli neighborhood old and new situation map.

Agrarian Reform; It is defined as a set of measures aimed at eliminating fundamental problems, prioritizing technological development and economic efficiency, and aiming to increase farmer incomes (Türker 2010). Agricultural Reform (Official Gazette 1984) application area was carried out on the land arrangement in the irrigation areas numbered 3083 in the project area, and then it came under the responsibility of DSI.

If we compare the old and new situation maps, it is observed that the parcels have been brought to the appropriate shape and size, the deformed parcels have been made square and rectangular in order to minimize the area losses, and new roads have been created to increase the transportation and agricultural labor value. A farmer's agreement has been achieved by making the same deductions from all of them for the new roads and canal shares to be created from the parcels in the project area. By specifying fixed points on the parcel borders, border conflicts between the owners are eliminated in this way. The total consolidation area is 17783429.14 m ^{2}. Flowering The total number of cadastral parcels in the neighborhood was found to be 926, the number of owners 878, the number of islands 125, the number of parcels 497, and the average index value was 0.7700.

3.4. Kargılı District Topographical Situation and New Property Analysis

Kargılı District is located within the boundaries of Mersin Tarsus Plain Land Consolidation and T.İ.GH project. Premium farmland is painted light green on the map. It indicates fertile land with flat, well-drained, deep and fertile soils suitable for growing all kinds of plants growing in the region, with few limiting factors that would make land use difficult (URL_2). The airport project received its first tender in 2011 and its first foundations were laid in 2013, and the completion process has been extended to the present day. The reason for this is that Kargılı neighborhood is first class agricultural land. The submitted EIA report was suspended for a while and then work continued with the approval given.

While the parcel information of Kargılı Neighborhood, whose consolidation has been completed, was in the suspension announcement, it was subjected to re-examination by the Consolidation Administration as a result of the objections made by the owners. Therefore, its registration has not been completed and the net area cannot be specified. According to the approximate value obtained from the TKGM parcel query system, the total area of Kargılı District is 1931.93 hectares (Figure 6).

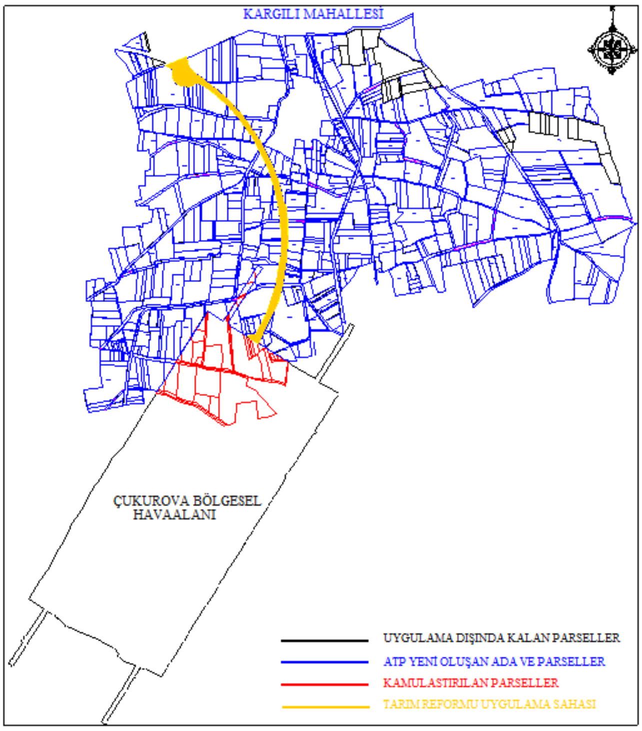

Figure 6. Kargılı District newly formed island-parcel and expropriated parcels.

3.5. Karsavuran District Topographical Situation and New Property Analysis

The topographic structure of Karsavuran District is slightly inclined and the total area is 1010 hectares. The areas remaining within the project site have been expropriated. The area outside the project area has been consolidated in order to facilitate the transportation of all parcels within the neighborhood and to remove the irregularly shaped parcels.

There are no fixed facilities affecting the project in Karsavuran District. There is no registered or unregistered site. The deduction calculation was calculated by dividing the total value of the parcels entering the project area by the total value of the parcels after subtracting the value of the newly created blocks, and the same deduction was made for the new roads and channels formed.

Land consolidation plays a key role in solving existing structural problems, developing rural areas, successfully implementing other basic elements used, and fulfilling new tasks undertaken by rural areas in line with their intended purpose. In the study carried out in Karsavuran District, the production and working conditions of the landowners were improved, increasing the productivity in agriculture, and with this benefit, the cultivation of our land, which is the most important factor that will contribute to the Turkish economy, has been facilitated. Net area after consolidation 5063771,26 m ^{2} has been. The total number of cadastral parcels in Karsavuran District was 218, the number of owners 463, the number of islands 58, the number of parcels 127, and the average index value was 0.7900 (Figure 7).

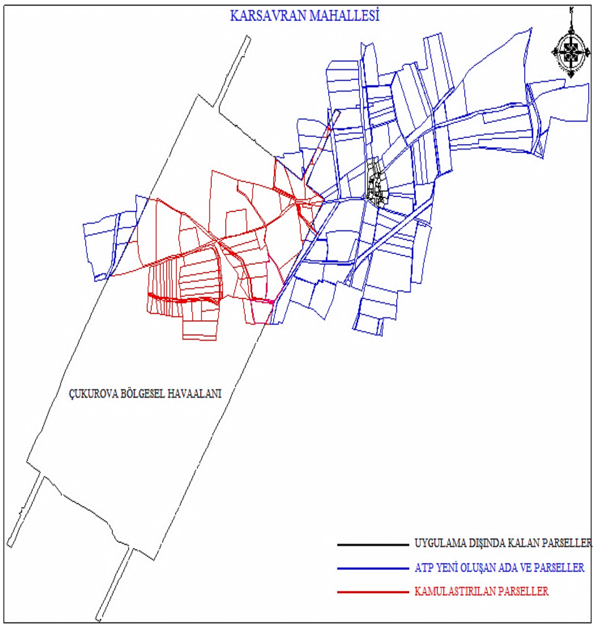

Figure 7. Karsavuran Neighborhood newly formed island-parcel and expropriated parcels.

4. CONCLUSION

• Due to the location conflict of the project in the determined neighborhoods of the project site, the consolidation was made and the social and economic problems that may occur were tried to be minimized.

• The average index values of the consolidation neighborhoods and the parcel value numbers of the parcels were determined precisely, and real values were created. DSI 's Land Consolidation list is prepared as a new block parcel sequential file; AT 8 main headings are shown in Table 1 and Table 2.

• Thanks to the Çukurova Regional Airport Project, in addition to the benefits of consolidation in the Çicekli, Karsavuran, Ballıca, Kargalı and Çağbaşı Districts, which are within the project area, it has provided an important solution to the air transportation problems that occur with the increase in population and to air cargo transportation throughout the country.

• With the implementation of the project, new job opportunities have already been created for the people of the region.

• With this work, everyone has benefited equally from common areas such as roads and canals, and productivity in agricultural lands is increased.

• Hostility between owners, complaints and migration from village to city have been reduced.

• Consolidation of fragmented land parcels, bringing together the fragmented lands of the shareholders, transportation problems arising from deformities have also disappeared simultaneously.

• The economic analysis of the old and new situation of the project region has been made and an academic base has been created for similar projects to be made in the future.

Table 1. Table title showing the old and new status of the parcels (based on registration)

Enterprise Number	TR. Identif. number	Name	Surname	Father name	Blok Number	Parcel Number	Area (m^2)	Share of	Shared Area (m^2)	To editing	
										Unregulated Part (m^2)	Regulated Part (m^2)

Table 2. Table title showing the old and new status of the parcels (based on registration)

Parcel Index	PVC	Downtime Rate	Deduction Amount	Deserving	New Block Index	New Parcel Value No.	Block No.	New Parcel No.	New Parcel Area	Share Ratio in the New Parcel	Area Per Share in New Parcel

Author contributions

The authors declare that they have contributed equally to the article.

Conflicts of interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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3D Modeling and Land Management in Protected Areas: Fethiye-Göcek SEPA

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Keywords
Land Management,
Protected Area,
Photogrammetry,
3D Modeling,
Climate Change.

ABSTRACT

The increase in the world population cause a decrease in natural resources. In Protected Areas, which are the assurance of sustainability, effective land management should be ensured. It is aimed to protect the natural, cultural, social and economic values of the protected areas holistically, to plan and manage the terrestrial and marine areas in an integrated manner. On the other hand, the identification of spatial uses has traditionally been accomplished by drawing on paper and using digital maps based on two-dimensional information. With the developing technology, the use of remote sensing and three-dimensional (3D) models in mapping and zonning has become increasingly widespread, and besides data content and rich visualization, query and analysis functionality has made 3D maps a basic base for planning and monitoring. In this case, it is aimed to provide three-dimensional maps as a base for the research, planning, monitoring and management of protected areas. Fethiye-Göcek Special Environmental Protection Area, where forest lands, agricultural areas and coastal areas will be under the settlement pressure and where integrated coastal and land management will be carried out, has been determined as the study area. The study includes displaying the surface information with reality values and high resolution in a three-dimensional model, and performing customized spatial and statistical analyzes on the model. It is aimed to demonstrate the potential advantages of using high resolution digital terrain model and 3D model in protected areas. Land management, illegal building, determination of the changing natural areas, agricultural uses, changing village-urban uses, temporal display of changes were carried out. Effective decision support tools are provided to decision makers in land use planning by using land use changes density. The study showed that the 3D terrain model is an important decision support tool in land management and will support nature conservation efforts.

1. INTRODUCTION

The development of a worldwide network of protected areas is one of the greatest conservation achievements of the twentieth century. As the world's population increased and the demand for natural resources increased, protected areas became more important (Secretariat of the Convention on Biological Diversity, 2008).

For many years, protected areas have been defined as "parts of land and sea that are established and managed by law and other effective means to ensure the continuity and conservation of biodiversity, natural and cultural resources" (IUCN, 1994). Later, the definition was reconsidered as "clearly defined geographical locations established, sanctioned and managed by laws and other effective means to protect nature in the long term with ecosystem services and cultural values" (Dudley, 2008). Researhers carried out many academic studies on the

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protection of terrestrial and marine protected areas, and they created awareness by creating continuous reports on the need to protect areas (IUCN, 2018).

In 1978, the Mediterranean states signed the Barcelona Convention to protect the Mediterranean from pollution. This agreement established the legal framework for the implementation of the Mediterranean Action Plan (MAP). The Barcelona Convention was a tool for Mediterranean countries to monitor the state of the sea, to identify environmental problems and their sources. By this convention, Mediterranean countries are called upon to take all necessary measures to minimize marine pollution and protect the marine environment. Turkey, a Mediterranean country, ratified the Barcelona Convention in 2002. 21 countries and the European Union are parties to the convention. In order to protect the Mediterranean, each Mediterranean country tries to fulfill its protection activities in the most economical and effective way as per the contract. Turkey is divided into three regions, two terrestrial (Caucasus and Mediterranean) and one marine (Mediterranean) area, with its important biodiversity values, and is located in 200 ecological regions. These areas are shown among the most important ecological regions of the world in terms of the protection values they carry. Efforts are being made to establish an integrated management system for protected areas. It is aimed to reduce the impact of climate change on protected areas, to establish and manage marine protected areas, to improve marine, coastal and terrestrial ecosystems, to ecosystem-based planning, to expand the ecosystem network with ecological corridors and to establish a protected areas monitoring network.

Fethiye-Göcek Special Environmental Protection Area (PA) was declared in 1988 and has a very rich biodiversity. Many researches and studies have been carried out in the region until today.

The United Nations Aichi strategies aim to explore the underlying causes of biodiversity loss, reduce pressures on biodiversity, promote sustainable use, protect ecosystems, species and genetic diversity, and increase benefits for all from biodiversity and ecosystem services. It is desirable to develop practices through participatory planning, knowledge management and capacity building.

Emphasizing the importance of high ecological value areas based on ecosystem services in protected areas; It is aimed to make ecosystem-based planning and to create structures suitable for social and cultural texture in the planned regions.

This study investigates using high-resolution digital terrain model and 3D model in protected areas for evaluating the effectiveness of management actions. Monitoring provides information and feedback loops about the protected area for adaptive land management (Nichols and Williams 2006). Monitoring is critical to determine trends in the protected area. The investigations have been performed over Fethiye-Göcek SEPA in Mugla Province, Türkiye. The 3D city model of the area has been generated in PA which has been described in section 2. The study includes displaying the surface information with reality values and high resolution in a three-dimensional model, and performing customized spatial and statistical analyzes on the model. Land management, illegal building, determination of the changing natural areas, agricultural uses, changing village-urban uses, temporal display of changes were carried out. Effective decision support tools are provided to decision makers in land use planning. In Section 3, an overview of the study area and the datasets is provided. The study is concluded in the last Section.

2. MATERIAL AND METHOD

2.1. Spatial Datasets

Fethiye- Göcek Special Environmental Protection Area; It is located in southwestern Turkey between 36,15° and 37,00° north latitudes and 28.50 and 29.50 degrees east longitudes. Covering an area of 817 km^2, the region includes 12 settlements. The southern coast of the region is covered with steep mountains that rise out of nowhere. As a result of intense tectonic movements in the region, new bays and headlands have emerged with collapses and elevations. As a result of the collapses, the valleys opened by the rivers were filled with sea water, and the intermediate and side valleys turned into coves and gulfs that were well inserted into the land. The study area is shown in Fig 1.

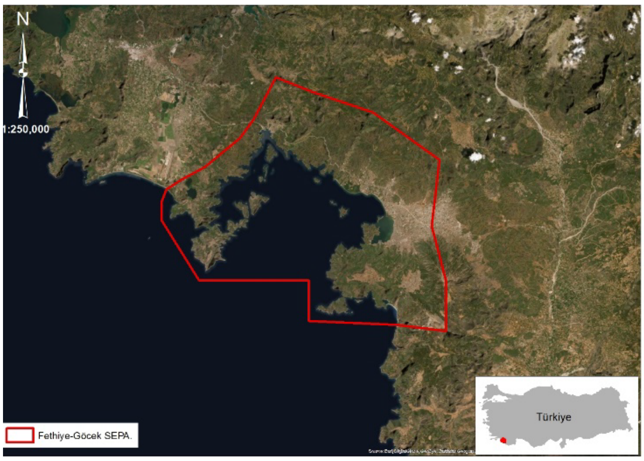


Figure 1. Study area.

Fethiye Beach is one of the breeding areas of Caretta caretta and Chelonia mydas species, which are protected by the Bern Convention and CITES (MoEUCC, 2022). Fethiye-Göcek Special Environment Protection Area is rich and interesting in floristic diversity. As a result of floristic studies conducted in the field, 408 plant species belonging to 71 families had been identified. 52 plant species are endemic to Turkey. 17 mammal species had been found in the region and there is no endemic species among the species. All species except Myotis capaccinii (long-fingered bat) are in Low Risk (LC) status according to IUCN categories of threat. Myotis capaccinii is in Vulnerable (VU) status. 126 bird species had been identified within the boundaries of the protected area. Garrulus Corasias is in the status of Near Threatened (NT) IUCN categories of threat. Other species are in Low Risk (LC) status. The area homes to 6 species of amphibians and 18 species of reptiles. Lyciasalamandra fazilae (Göcek Black Salamander) is an endemic species and its threat categories is Endangered (EN). This species is spread only in the region between Gökbel-Dalyan and

Fethiye. Testudo graeca (tortoise) is in Vulnerable (VU), Pseudepidalea variabilis (tailless frog) is in Data Deficient (DD) and the others are in Low Risk (LC) status according to IUCN categories of threat (MoEUCC, 2022).

In protected areas, it is aimed to make ecosystem-based planning based on ecosystem services and to provide sustainable protection.

Digital Aerial Photography (Flight) and Orthophoto Production, Digital Vector Data Production from Orthophotos, Fethiye-Göcek Special Environmental Protection Area, analysis and design studies for 3D modeling, Pre-planning studies, Advanced spatial analysis and calculations on the developed 3D Model The methodology was followed in the form of temporal representation of the studies created within the scope of SEPA, taking into account the historical data. The formats, sources, and the accuracies of datasets evaluated in the study are given in Table 1.

The city model, DTM, tools and methods have been developed by the Ministry of Environment, Urbanization and Climate Change (2020). Building models were produced using aerial photogrammetric mission data from the entire region in 2020 (Figure 2). In total, 67 flight corridors were created in 4 different blocks, and a total of 7752 aerial photographs were taken. In the images obtained within the scope of the project, 77% side overlap and 59% side overlap rates were achieved after the overhead balancing works.

By using photogrammetric methods, Point Cloud at 26 Point/m2 density, 8cm resolution Digital Surface and Terrain Model (DSM and DTM), 8cm Resolution True-Orthophoto Generation data were used. The Digital Terrain Model was produced at 8cm resolution. All structures were automatically obtained from 3D vector data and dense point cloud. Buildings are automatically mapped (Buyukdemircioglu et al 2018).

Table 1. Formats, sources, and accuracies of the datasets evaluated in the study.

Data Type/Name	Data Source (Produced by)	Format (Vector/Raster)	Accuracy
Buildings	MoEUCC	Vector	0.10 m
Greenhouses	MoEUCC	Vector	0.10 m
Water Quality Points	MoEUCC	Vector	0.20 m
Sea Turtle Nesting Data	MoEUCC	Vector	0.20 m
Master Plan Data	MoEUCC	Vector	0.20 m
Orthophoto (2020)	MoEUCC	Raster	0.08 m
Quickbird-1 (2005)	MoEUCC	Raster	6.5 m
CORINE Data (2018)	MoEUCC	Vector	5 m

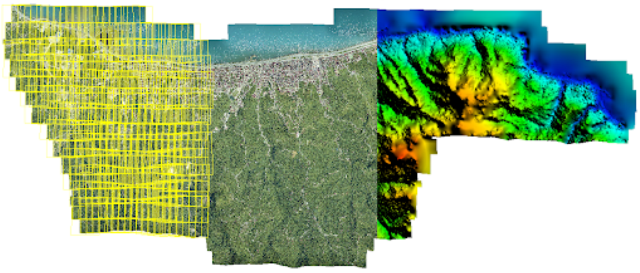


Figure 2. Photogrammetric Data Processing Steps.

For the study, QuickBird-1 satellite images from 2005 available in the Ministry of Environment and Urbanization were also used. Resolution in raw data of 60cm, resampling was done at 50 cm.

It is considered the most agile satellite among satellites. In addition to its high capacity feature, 60cm. It can provide local resolution panchromatic (black/white) images. QuickBird-1 has the ability to view an area of 200,000 km2 per day (60 cm. resolution) thanks to its ability to complete its tour in an average of 95 minutes. The satellite also has medium geometric accuracy, as well as fast shooting and stereo shooting features (Dial et al, 2003).

European Union countries determine their land assets, land use patterns and land cover types in the context of a project called CORINE (Coordination of Information on Environment) Environmental Information Coordination. The CORINE (Coordination of Information on the Environment) land cover program was initiated by the European Union Commission (CEC). The CORINE program was run by the European Commission. As of 1991, CORINE databases were created in 13 countries (Aydınoğlu and Yomralıoğlu 2009).

All data were converted and stored in the ESRI file geodatabase database in accordance with the TM30 WGS84 coordinate system. Raster data is stored in geotiff or ecw format. These databases have been converted to sqlite and geoJSON formats so that they can be transferred to the relevant 3D model. Non-spatial tabular data is also maintained in the ESRI file geodatabase.

2.2. Spatial Analysis Methods

Vector data of 2005 were produced from satellite imagery with 50 cm resolution and 6,5 m positional accuracy. Therefore, the spatial comparisons and vectorization results of 2005 were accepted as approximate and all spatial analyzes were carried out accordingly.

In the spatial analyzes made according to the satellite images of 2005, it has been determined that there are approximately 40315 buildings in the PA. The area covered by these structures is 529 ha. The density in Fethiye, Göcek and Ölüdeniz settlements, which are the most developed regions within the scope of the study area, is as shown in figure 4.

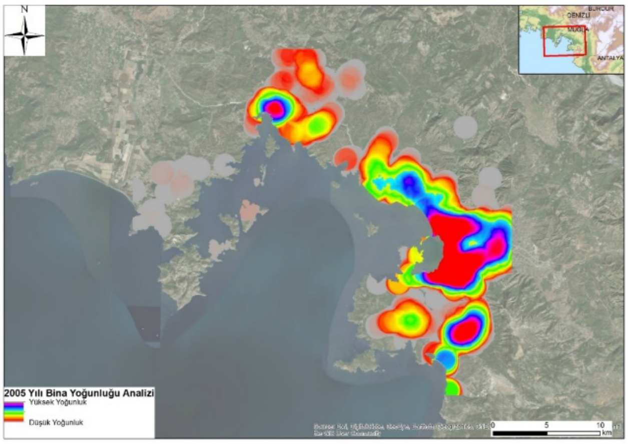


Figure 3. Building Density in 2005

Within the scope of the study area, the number and size of greenhouse areas in 2005 were analyzed and their distribution. In 2005, there were approximately 5036 greenhouses and these areas cover a total area of 534 ha. Greenhouses are concentrated in the Fethiye region, and the greenhouse density continues to decrease towards Göcek. Cultivated areas cover a total area of 534 ha in 2005.

When realizing the digitization works performed on orthophotos obtained with 8 cm resolution aerial photographs in the region, it has been concluded that there are approximately 48332 buildings and they cover an area of 693 ha. The density of building in Göcek and Ölüdeniz regions, especially in Fethiye, is higher than in other regions. Results show a local progression of the built-up areas of 20% in 15 years in PA.

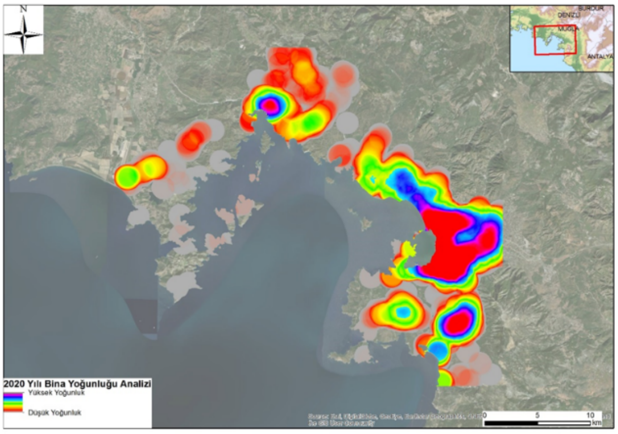


Figure 4. Buildings Density in 2020

The density map of building areas for 2020 is shown in figure 4. In 2020, the building density in Fethiye, Ölüdeniz and Göcek attracts attention. As a result of the analyzes on orthophotos for 2020, approximately 4591 greenhouses were identified, and the size of these areas is approximately 505 ha. Cultivated areas cover a total area of 872 ha in 2020. Fethiye-Göcek SEPA environmental master plan (approved in 2008) was taken from MoEUCC in vector data transformed to the database to be used in the three-dimensional model(figure.5).

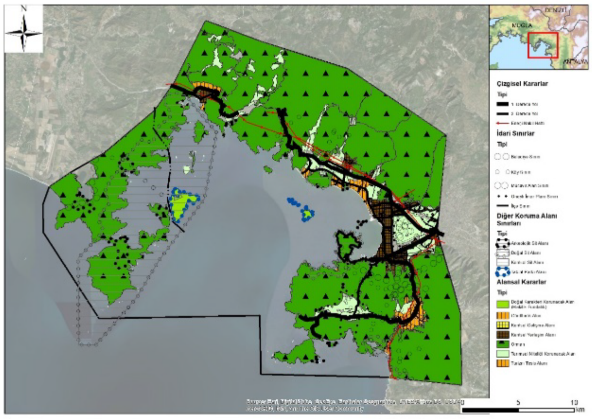


Figure 5. Environmental Master Plan of Fethiye-Göcek SEPA

In order to monitor physical, chemical and biological parameters in important rivers, lakes, drainage channels and sea areas in Special Environmental Protection Areas, to control pollution factors in order to prevent pollution and destruction of natural resources, to take necessary measures and to make use decisions, water quality is regularly monitoring studies are carried out. The efficiency of wastewater treatment plants operating in special environmental protection zones is also monitored within this scope.

For this purpose, physical, chemical and biological parameters are taken as monthly and periodic samples and analyzed at certain analysis points in important rivers, lakes and drainage channels, sea areas and wastewater treatment plants. Monthly data were combined annually and categorized as stream, sea, lake and treatment. They are stored in database for spatial analysis (Figure.6).

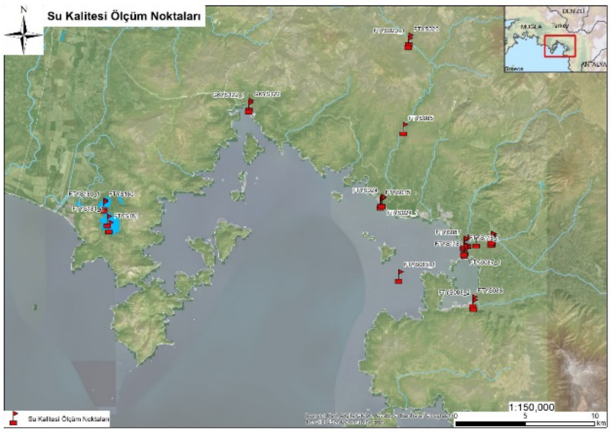


Figure 6. Water quality points in Fethiye-Göcek SEPA

The data received from MoEUCC regarding sea turtles are for the years 2017, 2018 and 2019. These data, taken in table format, were first adapted to the database for analysis, and then point data was created in the geographic information systems environment (Figure.7). The database design was made by organizing the layers of archived tabular data in line with the international and national legislation.

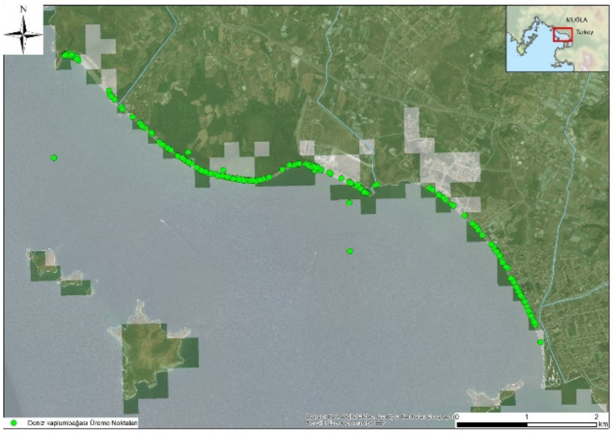
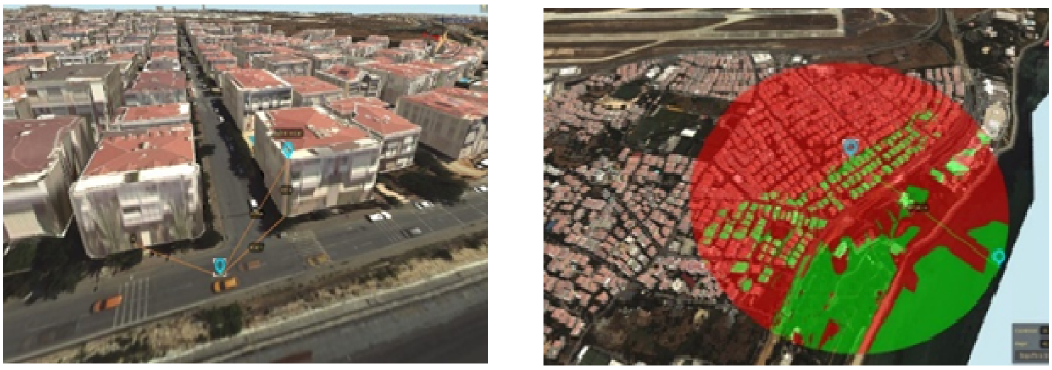


Figure 7. Sea Turtle Nesting points in Fethiye-Göcek SEPA.

Conservation plans are approved in order to protect the natural, cultural, social and economic values of the protected areas totally. Spatial analysis methods have been used for land management, illegal building, determination of land use changes, agricultural uses, changing village-urban uses, temporal representation of changes. Making decisions based on location on the data stored in the geographic information system is possible by querying, viewing and analyzing the geographic data. In the spatial analysis processes, new information sets are produced by making use of the existing data. In the study, overlay, proximity, density analysis, surface analysis and other spatial analysis were performed by means of ArcGIS software. CityGenius software was used to visualize the datasets produced within the scope of this study. This program also have visualization, and advanced spatial analysis tools like that building filters, terrain filter, field of view, shadow tool, viewshed tool etc. We use these tools to evaluate human use demands on the model and decide on land management. The building filter is a very effective tool to determine illegal building, especially for visualizing and mapping with terrain model in the PA.



(a) (b)

Figure 8. (a) and (b) are spatial analysis using CityGenius software on 3D model.

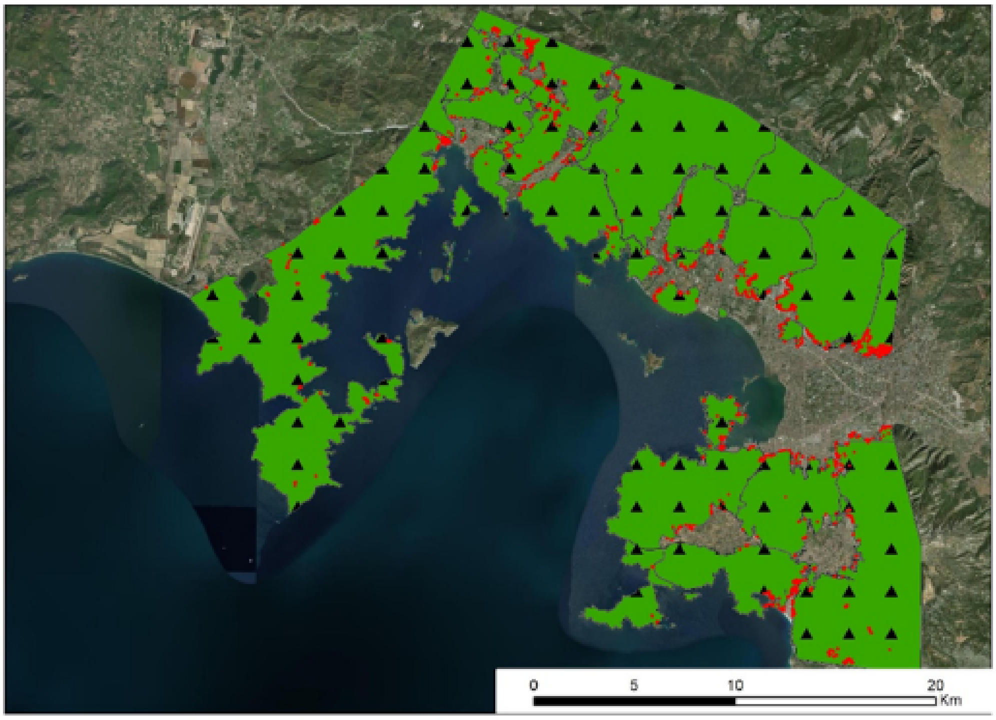


Figure 9. Illegal Buildings-Settlement pressure in forest areas

The 1/25000 scale environmental master plan, which was approved in 2008, and the vector data produced from orthophotos of 2020, were compared to develop land use plan.

3% of the buildings in the study area are in the forest area. This settlement pressure in the forest area has spread to the whole PA. 60% of the buildings are located in the Urban Settlement Area in accordance with the environmental master plan. 15% of the greenhouse areas remain within the settlement area. Most of the greenhouses in the settlement area are located in Fethiye.

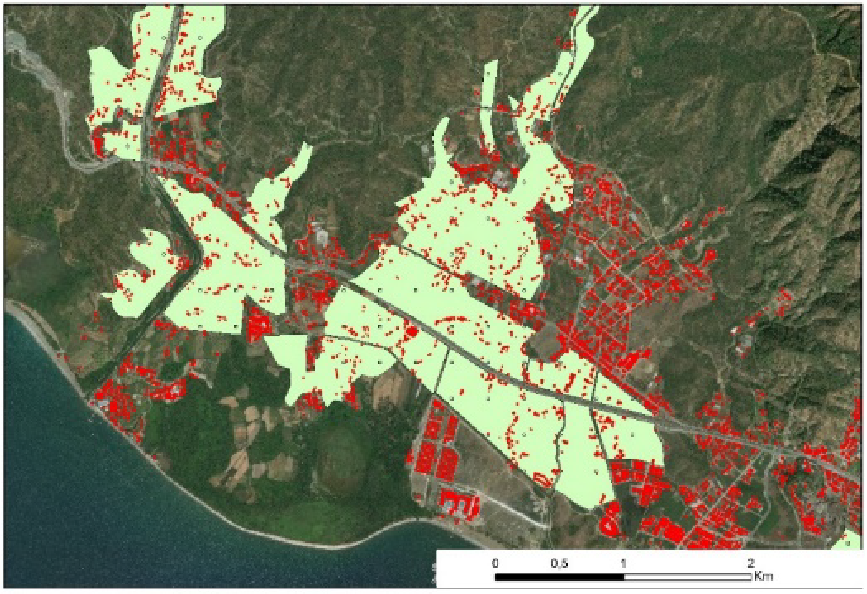


Figure 10. Illegal Building-settlement pressure in agriculture areas.

2.3. Visualization of Land use changes between 2005-2020

Land use criteria include property rights, which is a main problem sustainable conservation. Determination of land use criteria with conservation planning is an effective tool to ensure the balance between protection and use in protected areas. The creation of land use planning bases with the required accuracy facilitates collaboration with all stakeholders. 3D maps can serve as a foundation for conservation planning and monitoring. 3D modeling and visualization has become an important component, especially for the effective land management. Topographic data and terrain visualization are essential for land management.

A model was created for the three-dimensional representation and analysis of Fethiye-Göcek Special Environmental Protection Area in order to develop the potential of using high-resolution data sets, digital terrain model and three-dimensional model needed in the research, planning, monitoring and management stages of protected areas.

It includes displaying the surface information of Fethiye-Göcek Special Environmental Protection Area in three-dimensional environment with reality values and high resolution and performing customized analyzes on the data.

For land management, visulation and mapping the land use in detail, the reflections of the changing village/urban and urban/village relationship on land use, examining the land use changes, periodic analysis of the trends (agricultural structuring-coastal structuring) for effective planning is very important.

Detection of illegal buildings in the protected area, determination of forest, agricultural areas and village settlements and settlement areas and processing of building details facilitate planning. For sustainable biodiversity and sustainable agriculture, it is necessary to determine the land use values and monitore the changes.

In the study area, by providing a temporal display of the changes from the past to the present, it will be ensured that the approaches related to land use planning and the principles of area protection and monitoring will be revealed.

Land use changes in residential areas between 2005 and 2020 were analyzed. The results of these analyses, the structures in the protected area increased by 20% over a 15-years period. In particular, the buildings in Kayaköy have increased more than in other regions in the last 15 years. The land use change in settlement centers and coastlines draws attention. The structures (fishing huts, etc.) on the islands in the bay affect the analysis results.

By land use change analysis in greenhouse areas, greenhouse areas decreased by 5% between 2005 and 2020. Most of the greenhouse areas have turned into residental area in the last 15 years. There may be many different reasons for the reduction in greenhouse areas between 2005 and 2020. The areas that were greenhouse areas in 2005, which have now turned into residental, were investigated. According to this analysis, 7% of the existing buildings in 2020 had greenhouses in 2005. Most of these greenhouse areas, which have been converted into building, are designated as "Agricultural Area" according to the 1/25000 Environmental Master Plan.

Density maps of greenhouse areas varying between 2005 and 2020 were produced. The most change occurred in the east of Fethiye centre.

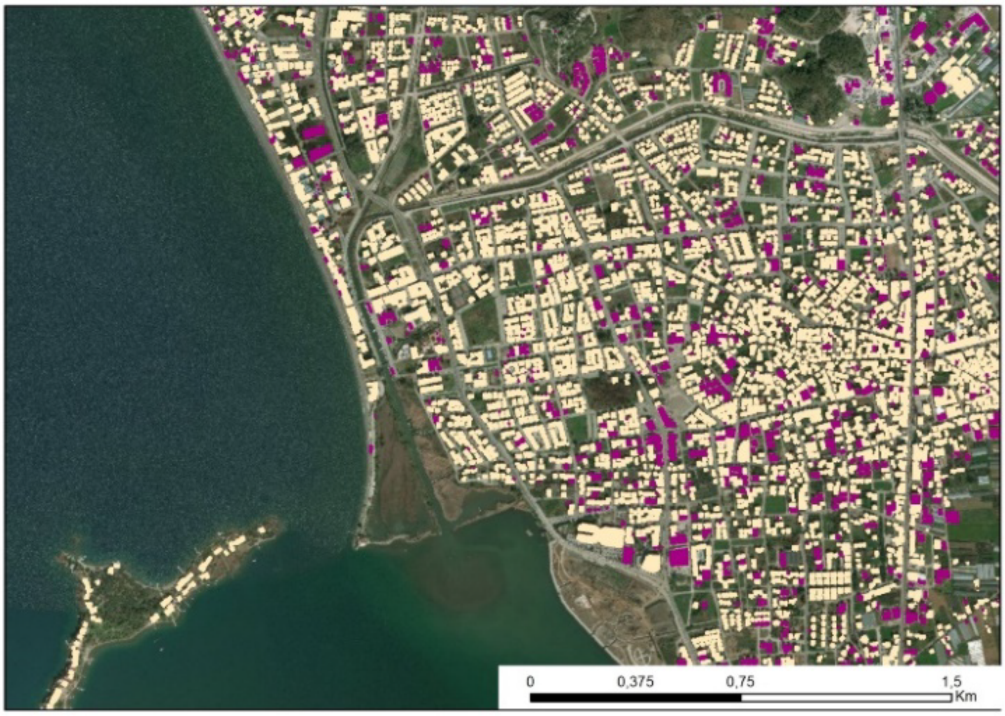


Figure 11. Between 2005 and 2020, buildings area in the PA increased by 20%.

Figure 12. Between 2005 and 2020, coastal area changes in the PA.

Land use status determination using remote sensing techniques is a low-error and calculable method. However, there are many remote sensing data analysis and evaluation methods that have been introduced independently of each other. For this reason, common standards have been tried to be brought to the classification criteria used in remote sensing studies within the framework of the CORINE program (Yılmaz and Erdem 2011).

European Union countries determine their land assets, land use patterns and land cover types in the context of a project called CORINE (Coordination of Information on Environment) Environmental Information Coordination. The CORINE (Coordination of Information on the Environment) land cover program was initiated by the European Union Commission (CEC). Studies on the CORINE project, which was initiated by the European Commission in 1985 and then carried out under the responsibility of the European Environment Agency, started in 1998 in Turkey. The CORINE program was run by the European Commission. As of 1991, CORINE databases were created in 13 countries (Aydınoğlu and Yomralıoğlu 2009).

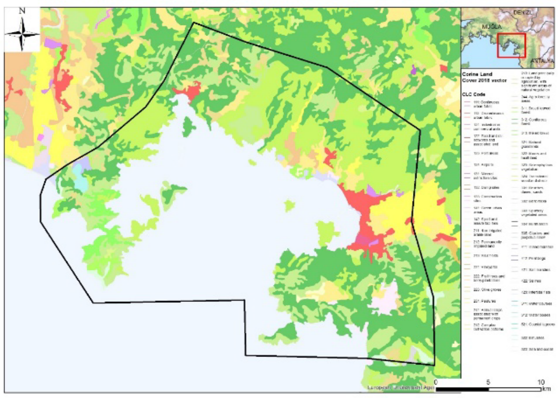


Figure 13. CORINE-2018 map for Fethiye-Göcek PA.

CORINE-2018 land use and orthophoto-2020 structures, agriculture and tourism land use patterns were analyzed together. Land use patterns were found to be similar.

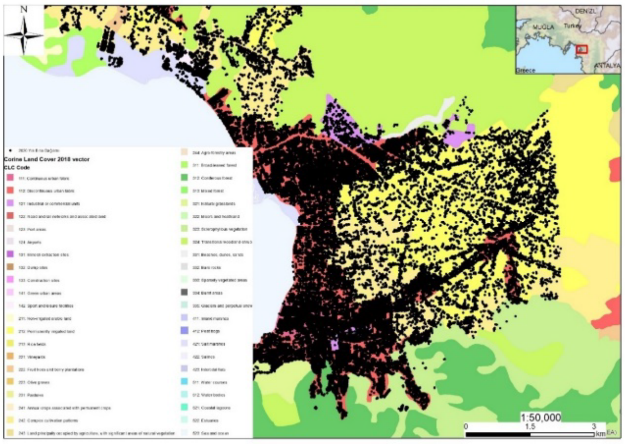


Figure 14. CORINE-2018 and Buildings-2020.

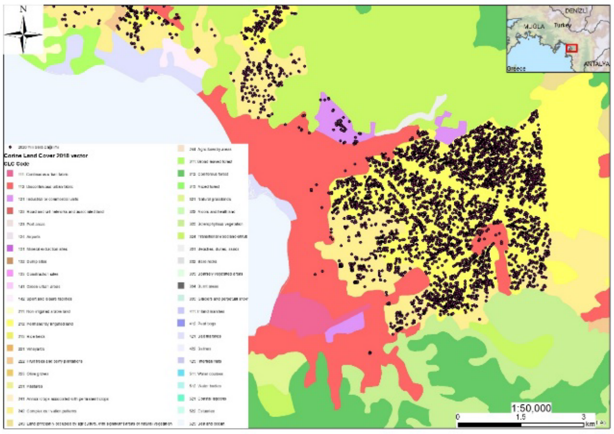


Figure 15. CORINE-2018 and Greenhouses-2020.

3. DISCUSSION AND RESULTS

The study includes displaying the surface information with reality values and high resolution in a three-dimensional model, and performing customized spatial and statistical analyzes on the model. It is aimed to demonstrate the potential advantages of using high resolution digital terrain model and 3D model in protected areas. Land management decicions, illegal building, determination of the changing natural areas, agricultural uses, changing village-urban uses, temporal display of changes were carried out.

There are five land use classes defined by the 1/25000 scale Environmental Master Plan of Fethiye Göcek Special Environmental Protection Area (Table.3). 84.25% of the study area is forest area. The area it covers within the total protected area is approximately 38333 ha. The protected area boundary is 45500 ha excluding the sea surface. 7.56% of the study area is agricultural area, 4.98% is urban settlement area, 2.21% is tourism facility area.0,99% of study area is natural area which is strictly protected area.

Table 3. Land use class of Fethiye-Gocek SEPA Environmental Master Plan (2005-2020).

Land use	Area (ha)
Natural Area	452
Settlement Area	2266
Forest	38333
Agricultural Area	3442
Tourism Area	1007

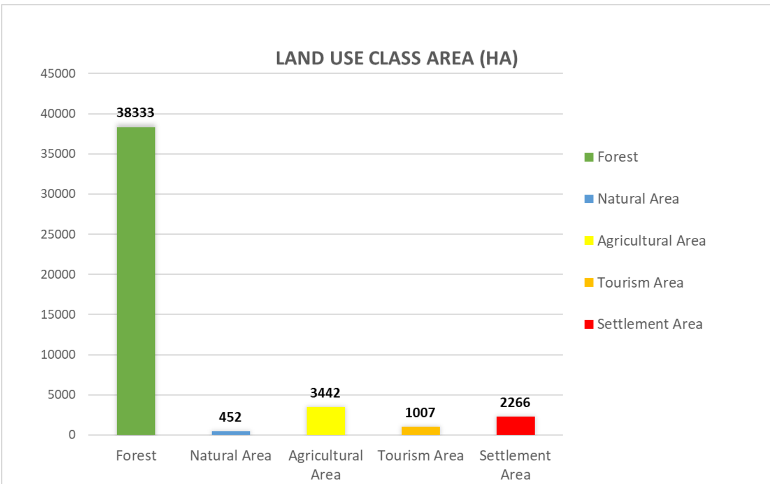


Figure 16. Land use class areas in Fethiye-Göcek PA.

Table 4. Land use class of Fethiye-Gocek SEPA with buildings number and percentage.

Land use	Area (ha)	Number of buildings (2020)	Building Density (number per hectare)
Natural Area	452	4832	10.69
Settlement Area	2266	29000	12.80
Forest	38333	1450	0.04
Agricultural Area	3442	5800	1.69
Tourism Area	1007	7250	7.20

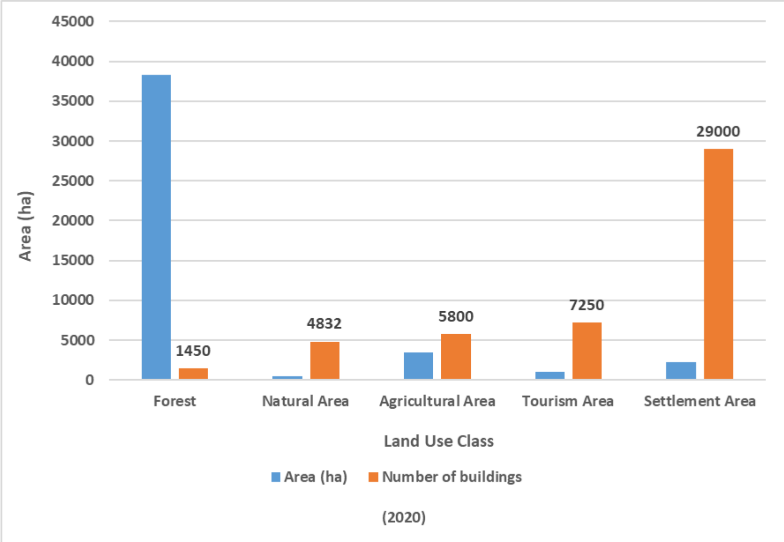


Figure 17. Number of Buildings for each Land Use Class in Fethiye-Göcek PA.

Number of buildings have determined from the orthophotos of 2020.Then number of buildings in each land use class have determined and calculated the number per hectare for all class, realized building density analysis and land use change analysis (Theobold, 2005).

We mapped land use changes using heat map analysing tool of ArcGIS software. A heat map uses the features in the layer to calculate and display the relative density of points on the map as smoothly varying sets of colors ranging from cool (low density of points) to hot (many points) – hence the name heat map(www.esri.com). So heatmap is the most usefull thematic map for small scale planning stages.

Land use change density map has shown in figure 18. When the planning studies to conservation of natural areas in Fethiye-Göcek PA, this thematic map which shown high and low land use changes provides to comprehend settlement pressure and hot spots in PA.

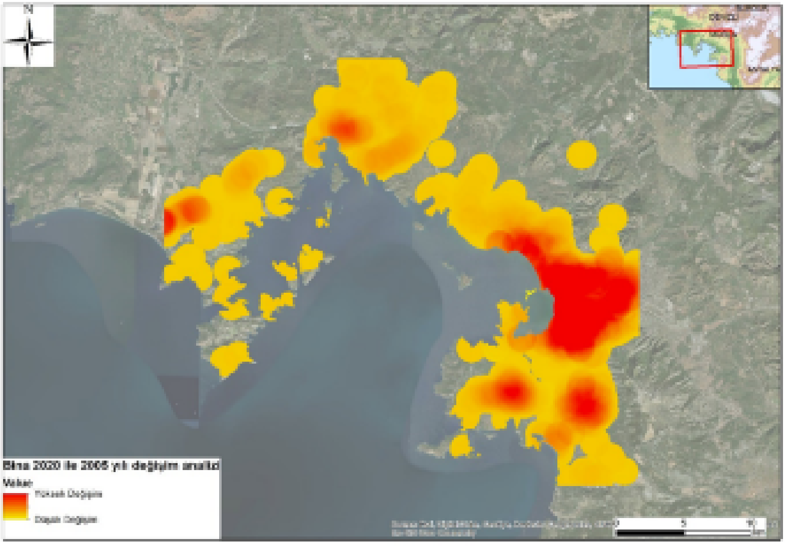
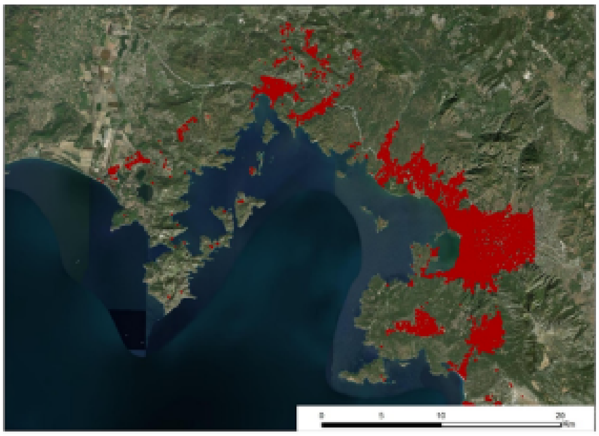
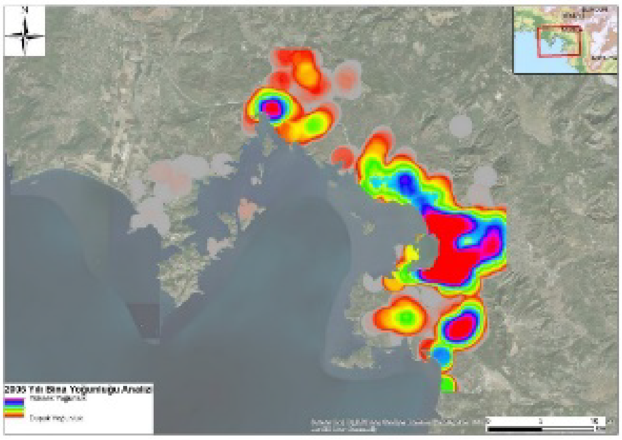
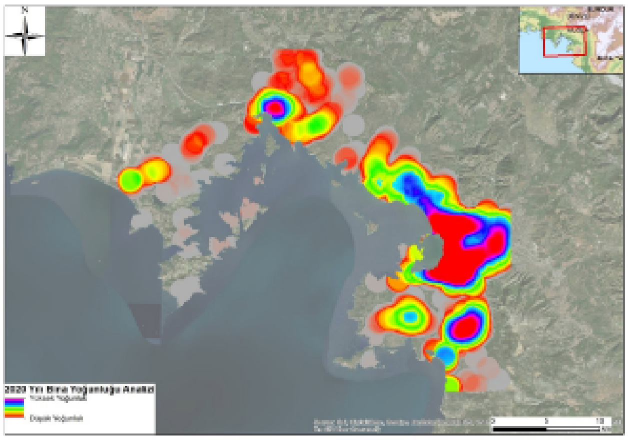
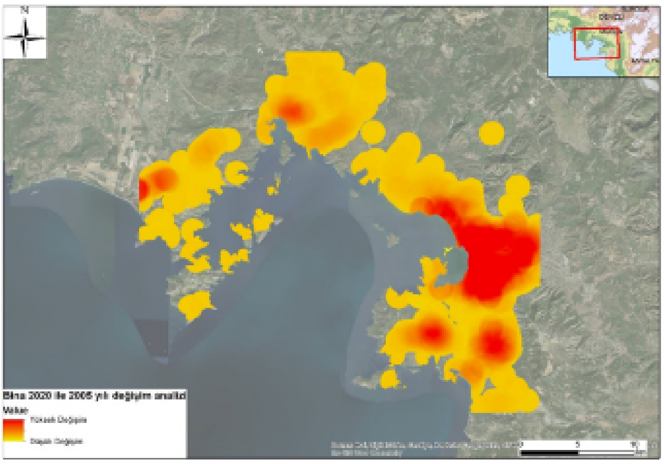


Figure 18. Land use changes density in Fethiye-Göcek PA.

A 3D model is created for the three-dimensional representation and analysis of Fethiye-Göcek Special Environmental Protected Area, to investigate the potential of using high-resolution data sets, digital terrain model and three-dimensional model for planning, monitoring and land management.

The 3D model enabled the surface information of Fethiye-Göcek Special Environmental Protected Area to be displayed in three-dimensional environment with reality values and high resolution, and customized spatial analyzes were made on the data.

Table 5. Land use changes and building density (2005-2020).

	2005	2020
Buildings		
Greenhouses		
Density		
Land Use Changes		

4. CONCLUSION

Spatial use criteria include property rights, which is a fundamental right. Determination of spatial use criteria with conservation planning is an effective tool to ensure the balance between protection and use in protected areas. With the developing geographic information technologies, land use planning bases can be determined accurately. Thus, the cooperation of all stakeholders in the field management is provided more easily. The use of remote sensing and three-dimensional models in land management and planning has become increasingly widespread. 3D maps can serve as a foundation for conservation planning and monitoring. 3D modeling and visualization has become an essential component for effective land management. Topographic data and terrain visualization play important roles in protected area land use planning. In addition to the data content and visualization of the 3D model, the query and analysis functionality is also very important for planning and monitoring.

For nature conservation and protected area monitoring to collect all spatial and non-spatial data regularly is important to create effective spatial analysis. There are many applications and tools that can be used for error-free collection and storage of data from the first source. With the online application, it is possible to evaluate, import, analyze and report large-scale environmental data. Applications should be used to verify monitoring data at the time of collection.

As a result of the land use change analysis, it is noteworthy that the areas where the settlement pressure is determined, they are agricultural areas, forest areas and natural areas. On the other hand, according to the environmental plan, it is seen that there is a propensity to do agriculture in the places specified as settlement areas. To comphere buildings characteristic (hotel, residence, site, etc.) in the tourism areas, field works should be realized.

The 3D model which was developed in this study also is provided as the main base for conservation of coastal and marine ecosystems, coastal planning and coastal management studies in protected areas. Thanks to the 3D model and spatial analyzes, the water quality and the submarine biodiversity monitoring studies also is supported. It also supports the efforts to protect the seagrass meadows, which are the carbon sink areas and defined as the forests of the seas.

Land use changes density map provides to desicion makers an effective tools for land management in the Fethiye-Göcek protected area. The study showed that the 3D terrain model is an important decision support tool in land management and will support nature conservation efforts. Biodiversity changes about protected area vulnerability should also be investigate by geograhic information technologies.

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Author contributions

The authors declare that they have contributed equally to the article.

Conflicts of interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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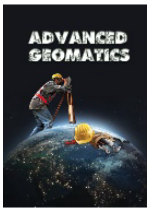

Monitoring urban sprawl in Atakum district using CORINE data

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Keywords
Land Cover,
Change Detection,
Urban Sprawl,
CORINE,
GIS.

ABSTRACT

Population growth leads to the growth of cities and the destruction of natural areas. Urban growth triggers changes in land cover. Determining the change effects in land cover is essential for sustainable policies. In this study the temporal data were produced from the CORINE data for the years 1990, 2000, 2006, 2012 and 2018 for evaluating and understanding the land cover change for Atakum distrct. It is seen that, the study area is under intense urbanization pressure. Also, the land cover change data have an increase of 251.75% with +13.289,91 da in the artificial surfaces class. In addition to these, it has a dense urban structure especially in seaside districts such as Esenevler, Denizevleri, Mimarsinan and Cumhuriyet neighborhoods; It has been determined that Yenimahalle, Mevlana, Küçükkolpınar, Güzelyalı, Körfez and İncesu Yalı neighborhoods are under the pressure of urbanization.

1. INTRODUCTION

Land cover change, which affects the natural resource value, is accepted as one of the most important environmental problems globally (Guan et al. 2011; Veldkamp and Lambin 2001; Arslan and Örücü 2019). With the increasing population and developing technology, the pressure on natural resources is increasing. The determination and analysis of urban sprawl is important for effective management and planning. The degree, causes and consequences of urban sprawl is very important in order to taking necessary precaution. (Uyar and Ozturk 2019).

Urban growth is a complex socio-economic process that transforms the built environment and rural areas into urban settlements with the increasing population, and also shifts the spatial distribution of the population from rural areas to urban areas (BM 2019). Land cover, on the other hand, refers to the soil layer, including the natural vegetation covering the surface of the land, agricultural products and human structures (Verburg et al. 2009; Başara and Şişman 2022). The occurrence of urban growth triggers land use as cover changes.

In this study, temporal land cover changing in Atakum district of Samsun (Turkey) were investigated. Atakum district has got 41°19'48.4176'' North and 36°17'32.9172'' East coordinates, 7 kilometers away from Samsun city center and located in border Black Sea (Fig. 1). The residential areas of Atakum has changed in recent years due to its long coastline, university potential and tram line, which has an important place in urban transportation. The study area, consisting of the central areas of Atakum district along the coast, was select as of 70,937 km^2 (Figure 1).

2. MATERIAL AND METHOD

While the land use/cover does not change for many years in rural areas, on the contrary, in urban areas, significant changes can be seen about it due to the pressure created by rapid population growth. The regions where this change is most rapid and evident are urban development areas (Ozturk et al. 2010).

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Research Article

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CORINE (Coordination of Information on the Environment) data was used to determine the land cover change. CORINE Land Cover (CLC) is a 1:100,000 scale land cover map for European Union (EU) member states and all partner countries. The project was initiated by the European Union Commission in 1985 and carried out by the Commission until 1990, during which an environmental information system was established (Bruttner et al. 2000). Source attributes of CORINE data is given in Table 1.

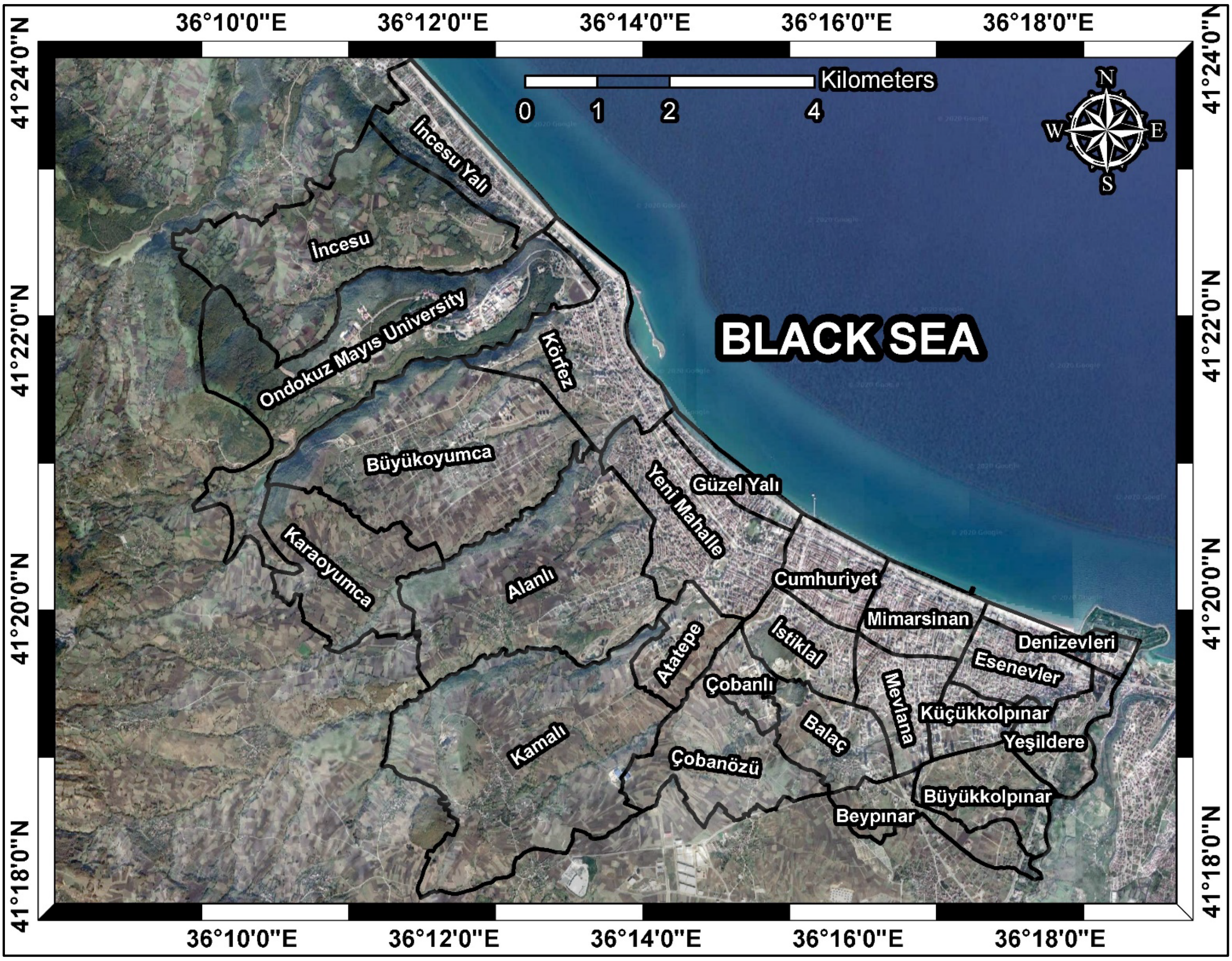

Figure 1. Study Area

Table 1. CORINE Data Sources (Falťan et al. 2020)

Dataset	Spatial Resolution	Source	Format
CLC1990	$\leq 50m$	Landsat-5 MSS/TM	Vector
CLC2000	$\leq 25m$	Landsat-7 ETM	Vector
CLC2006	$\leq 25m$	SPOT-4/5, IRS P6 LISS III	Vector
CLC2012	$\leq 25m$	IRS P6 LISS III, RapidEye	Vector
CLC2018	$\leq 10m$	Sentinel-2, Landsat-8	Vector

The standard European CLC nomenclature is hierarchical, including three levels of thematic detail in five major groups (Heymann et al. 1993): artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands, water bodies.

Level-1 and Level-2 classes of CORINE land cover classes are given in Table 2.

Table 2. CORINE Land Classes (Uyuk et al. 2020)

Level-1	Level-2
1.Artificial Surfaces	1.1.Urban Fabric 1.2.Industrial, commercial and transport units 1.3.Mine, dump and construction sites 1.4.Artificial, non-agricultural vegetated areas
2.Agricultural Areas	2.1.Arable land 2.2.Permanent crops 2.3.Pastures 2.4.Heterogeneous agricultural areas
3.Forest and Semi Natural Areas	3.1.Forest 3.2.Scrub and/or herbaceous associations 3.3.Open spaces with little or no vegetation
4.Wetlands	4.1.Inland wetlands 4.2.Marine wetlands
5.Water Bodies	5.1.Inland waters 5.2.Marine waters

The aim of CLC-Change creating is to produce a map of real land cover changes describing an evolution process taking place in the environment (e.g. urban sprawl, forest clearcut). Changes should be interpreted regardless of their position (Fig. 2). Change polygons should: have size at least 50 da, have width at least 100 m, describe a real evolution process that occurred between yearold and yearnew, and be detectable on satellite images.

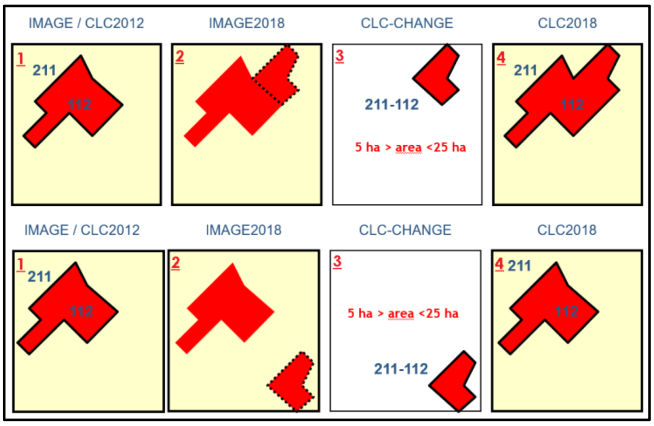

Figure 2. Consistent mapping of CLC Change

Upper row: growth of an existing settlement. Lower row: birth of a new (isolated) settlement

- First boxes in both rows show the land cover status visible on IMAGE2012 and the polygon outlines in CLC2012 database.
- Second boxes show the land cover status visible on IMAGE2018 without polygon boundaries. Dashed outline marks patches that have changed.
- Third boxes show polygons to be drawn in the CLC-Change database.
- Fourth boxes show the polygons as present in CLC2018 database (as the results of GIS addition of CLC2012 and CLC-Change 2012-2018 (CORINE 2021).

Geographic Information System(GIS) is important for collecting and processing geographic data of objects. Transforming data into geographic information with geographic analysis and viewing geographic data helps to plan activities (Başara et al. 2021). GIS software was used as a method in examining the land cover change. “Zonal toolset” and “Tabulate Area” analysis was performed from the “Spatial Analyst toolbox” menu of ArcGIS software. Calculates cross-tabulated areas between two datasets and outputs a table (Fig. 3).

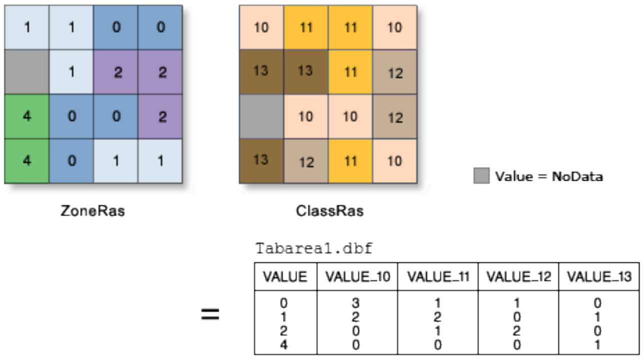

Figure 3. Tabulate Area Illustration

3. APPLICATION AND RESULTS

Land cover maps of the years 1990, 2000, 2006, 2012, 2018 were processed in accordance with the study area using GIS software according to CORINE Land Classes (Artificial surfaces, agricultural areas, forest and semi natural areas, wetlands and water bodies) given Table 2. The areal changes of study area were analyzed. The results of these analyses were given in Fig. 4-8 as land cover map and Table 3-7 as areal and percent.

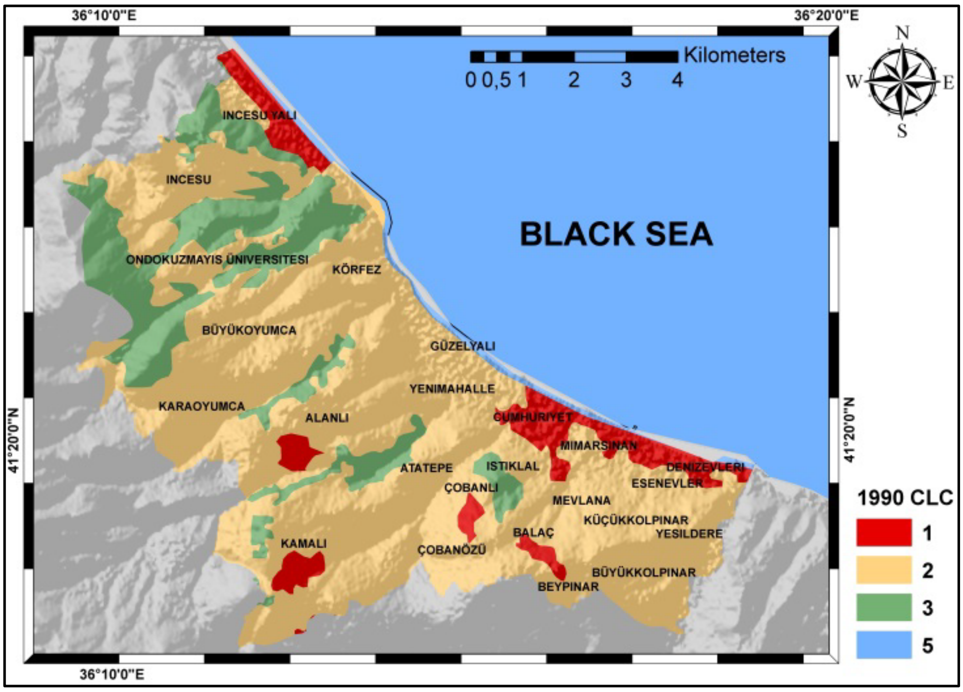

Figure 4. CORINE Land Cover Map of 1990

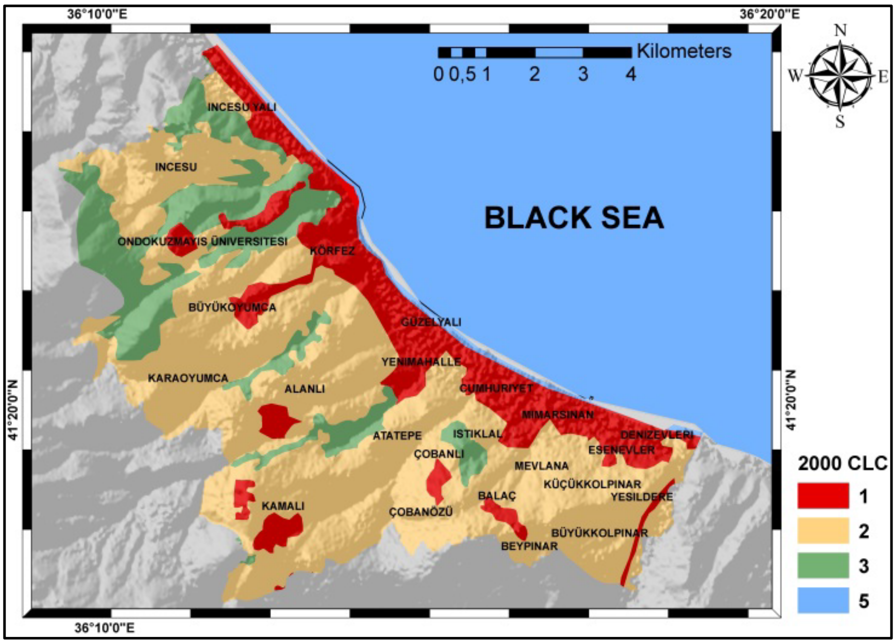

Figure 5. CORINE Land Cover Map of 2000

When the land cover data of 1990 were examined, wetlands class was not found. Artificial surfaces class is 7,44% with 5.279 da; agricultural areas class is 52.076 da with 73,41%; forest and semi natural areas class with 12.475 da, 17,59%; the water bodies class covers an area of 1.108 da and with 1,56%.

It is seen that the artificial surfaces class changed 13.677 da with 19,28%; the agricultural areas class changed 44.261 da with 62,39%; the forest and semi natural areas class changed 16,76% with 11.892 da; the water bodies and the wetlands classes don't change for the land cover data of 2000.

Table 3. Distribution of CORINE Land Cover in 1990

Land Cover	Area (da)	Percent (%)
1.Artificial Surfaces	5.279	7,44
2.Agricultural Areas	52.076	73,41
3.Forest and Semi Natural Areas	12.475	17,59
4.Wetlands	0	0,00
5.Water Bodies	1.108	1,56

Table 4. Distribution of CORINE Land Cover in 2000

Land Cover	Area (da)	Percent (%)
1.Artificial Surfaces	13.677	19,28
2.Agricultural Areas	44.261	62,39
3.Forest and Semi Natural Areas	11.892	16,76
4.Wetlands	0	0,00
5.Water Bodies	1.108	1,56

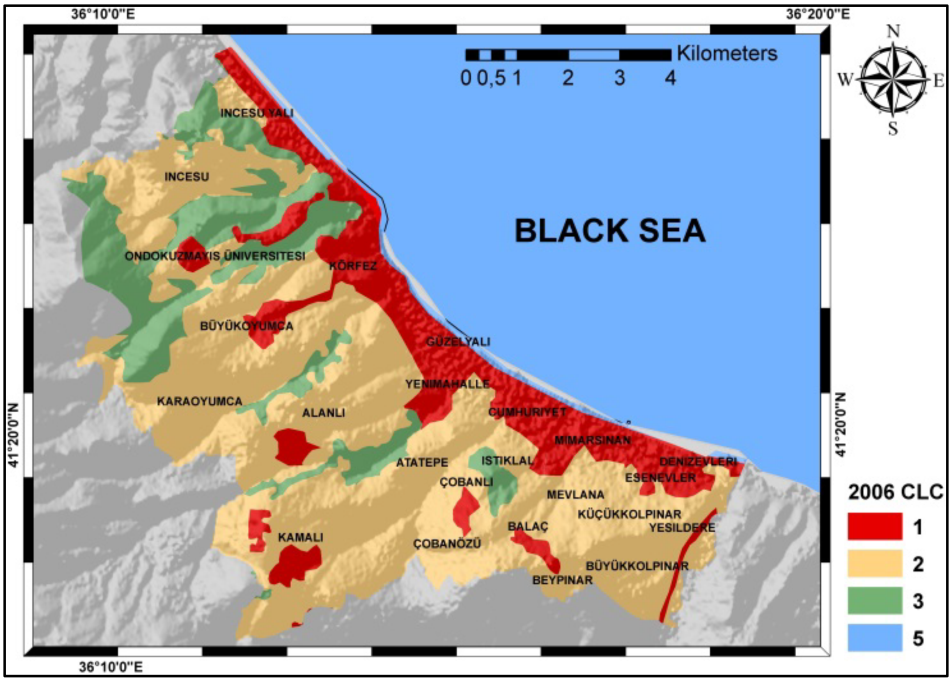

Figure 6. CORINE Land Cover Map of 2006

Also, the land cover data of 2006 were examined, the artificial surfaces class was 13.679 da with 19,28%; agricultural areas class was 44.267 da with 62,40%; the forest and semi natural areas class was 11.881 da with 16,75%; the water bodies and wetlands classes were the same in 1990 and 2000.

Table 5. Distribution of CORINE Land Cover in 2006

Land Cover	Area (da)	Percent (%)
1.Artificial Surfaces	13.679	19,28
2.Agricultural Areas	44.267	62,40
3.Forest and Semi Natural Areas	11.881	16,75
4.Wetlands	0	0,00
5.Water Bodies	1.110	1,56

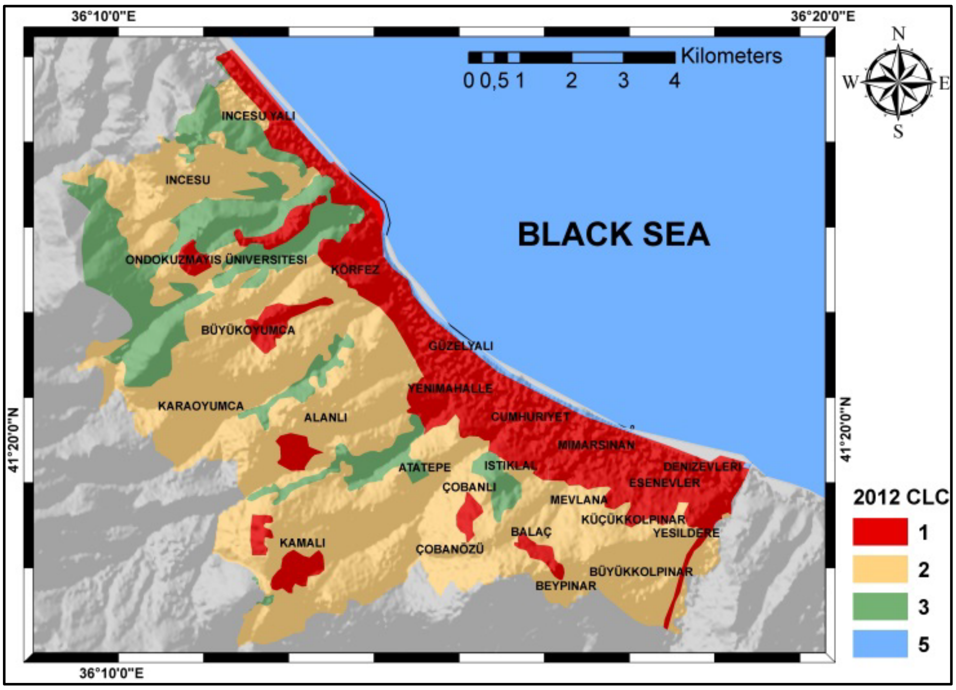

Figure 7. CORINE Land Cover Map of 2012

When the land cover data of 2012 were examined, the artificial surfaces class was 16.987 da with 23,95%; the agricultural areas class is 40.865 da with 57,61%; the forest and semi natural areas class was 12.114 da with 17,08%; the water bodies class covered an area of 971 da and 1,37% and the wetlands class was the same.

Table 6. Distribution of CORINE Land Cover in 2012

Land Cover	Area (da)	Percent (%)
1.Artificial Surfaces	16.987	23,95
2.Agricultural Areas	40.865	57,61
3.Forest and Semi Natural Areas	12.114	17,08
4.Wetlands	0	0,00
5.Water Bodies	971	1,37

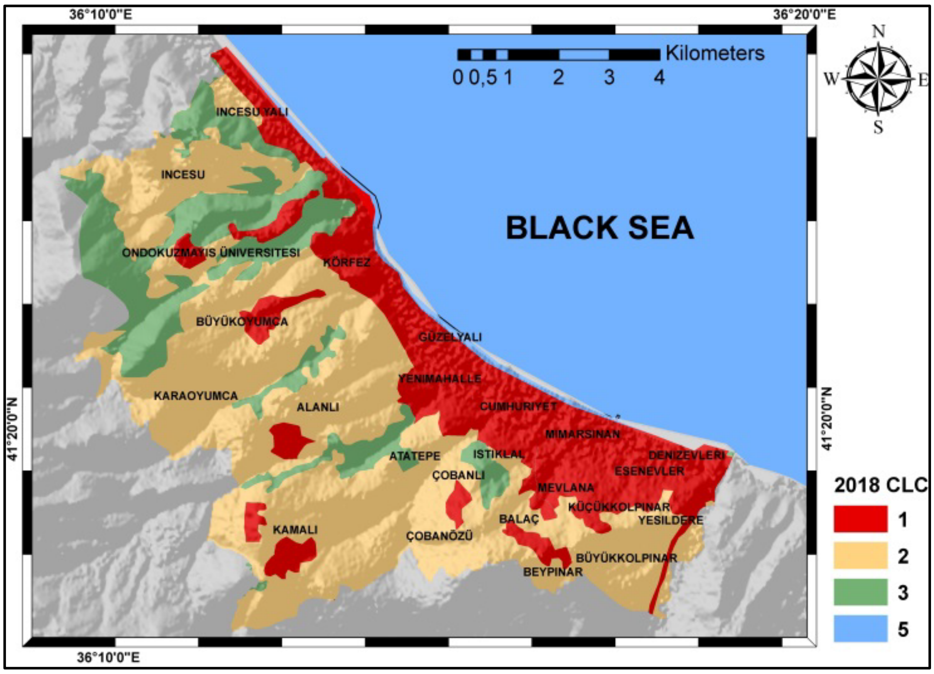

Figure 8. CORINE Land Cover Map of 2018

It is seen that the artificial surfaces class changed 18.569 da with 26,18%; the agricultural areas class changed 39.283 da with 55,38%; the forest and semi natural areas class changed 12.127 da with 17,10%; the water bodies and wetlands classes were nearly the same the others for the 2018 land cover data analysis,

Table 7. Distribution of CORINE Land Cover in 2018

Land Cover	Area (da)	Percent (%)
1.Artificial Surfaces	18.569	26,18
2.Agricultural Areas	39.283	55,38
3.Forest and Semi Natural Areas	12.127	17,10
4.Wetlands	0	0,00
5.Water Bodies	958	1,35

4. DISCUSSION

The urban sprawl and land cover change of Atakum district were analyzed using CORINE data for 1990-2000-2006-2012-2018 (Table 8). Wetlands class was not found in the study area between 1990-2018. At the end of these analyzes, it was observed that an increase of 13.290 da with 251,75% in the artificial surfaces class. Also a decreases of 12.793 da and 24,57%; 347 da and 2,78% ; 149 da and 13,49% in the agricultural class, the forest and semi natural class, the water bodies class were detected, respectivelly.

Table 8. Land Cover Change

Land Cover	Difference	Percent (%)
1.Artificial Surfaces	+13.290 da	+251,75
2.Agricultural Areas	-12.793 da	-24,57
3.Forest and Semi Natural Areas	-347 da	-2,78
4.Wetlands	0 da	0,00
5.Water Bodies	-149 da	-13,49

The results obtained showed that the study area is under intense urbanization pressure.

In addition, the urbanization pressure for Atakum district was examined on a neighborhood basis. As a result of this examination, the data in Table 9 were obtained. Urbanization rate data for the years 1990, 2000, 2006, 2012, 2018 are given in Table 10.

When the data are examined, it is seen that the urban sprawl has increased rapidly in Atakum district. As a result of the study, the city atlas produced by using the CORINE data of Atakum district in the study area is given in Figure 9.

Table 9. Urban Area Quantities (da)

Neighbourhood	Total Area (da)	1990 Urban Area (da)	2000 Urban Area (da)	2006 Urban Area (da)	2012 Urban Area (da)	2018 Urban Area (da)	Difference (da)	Percent (%)
Alanlı	6.727,370	408,785	408,785	410,983	402,192	402,192	-6,593	-1,61%
Atatepe	1.318,661	(-)	28,571	28,571	26,373	28,571	No change observed	
Balaç	1.727,446	235,161	235,161	235,161	228,568	426,367	191,206	81,31%
Beypınar	1.393,385	63,735	94,504	94,504	98,900	199,997	136,262	213,79%
Büyükkolpınar	1.777,995	(-)	85,713	85,713	81,317	87,911	2,198	2,56%
Büyükoyumca	7.248,241	(-)	654,935	654,935	648,342	648,342	-6,593	-1,01%
Cumhuriyet	1.490,087	982,403	1.239,542	1.239,542	1.369,210	1.369,210	386,807	39,37%
Çobanlı	758,230	123,075	123,075	123,075	120,877	120,877	-2,198	-1,79%
Çobanözü	2.909,846	147,251	147,251	142,855	142,855	142,855	-4,396	-2,99%
Denizevleri	749,439	514,278	514,278	514,278	731,857	731,857	217,579	42,31%
Esenevler	1.494,483	340,654	999,985	999,985	1.461,516	1.461,516	1.120,862	329,03%
Güzelyalı	817,570	(-)	523,069	520,871	536,256	536,256	13,187	2,52%
İncesu	6.615,284	(-)	(-)	(-)	(-)	(-)	No change observed	
İncesu Yalı	2.329,635	1.210,971	1.228,553	1.230,750	1.232,948	1.232,948	21,978	1,81%
İstiklal	1.540,636	4,396	105,493	105,493	569,222	676,913	672,517	15300,00%
Kamalı	8.696,571	534,058	797,790	799,988	793,395	793,395	259,337	48,56%
Karaoyumca	3.318,631	(-)	(-)	(-)	(-)	(-)	No change observed	
Körfez	3.369,179	(-)	2.158,209	2.158,209	2.114,254	2.114,254	-43,955	-2,04%
Küçükkolpınar	988,996	(-)	(-)	(-)	380,214	681,308	301,094	79,19%
Mevlana	1.527,449	109,888	127,471	127,471	437,356	1.134,049	1.024,160	932,00%
Mimarsinan	1.599,976	593,398	1.239,542	1.239,542	1.494,483	1.494,483	901,085	151,85%
OMÜ	7.573,511	(-)	1.008,776	1.010,974	982,403	982,403	-26,373	-2,61%
Yenimahalle	3.657,087	6,593	1.828,544	1.828,544	2.606,554	2.775,782	2.769,189	42000,00%
Yeşildere	1.307,672	4,396	127,471	127,471	527,464	527,464	523,069	11900,00%

Table 10. Urban Area Rate (%)

Neighbourhood	Total Area (da)	1990 Urban Area	2000 Urban Area	2006 Urban Area	2012 Urban Area	2018 Urban Area
Alanlı	6.727,370	6,08 %	6,08 %	6,11 %	5,98 %	5,98 %
Atatepe	1.318,661	(-)	2,17 %	2,17 %	2,00 %	2,17 %
Balaç	1.727,446	13,61 %	13,61 %	13,61 %	13,23 %	24,68 %
Beypınar	1.393,385	4,57 %	6,78 %	6,78 %	7,10 %	14,35 %
Büyükkolpınar	1.777,995	(-)	4,82 %	4,82 %	4,57 %	4,94 %
Büyükoyumca	7.248,241	(-)	9,04 %	9,04 %	8,94 %	8,94 %
Cumhuriyet	1.490,087	65,93 %	83,19 %	83,19 %	91,89 %	91,89 %
Çobanlı	758,230	16,23 %	16,23 %	16,23 %	15,94 %	15,94 %
Çobanözü	2.909,846	5,06 %	5,06 %	4,91 %	4,91 %	4,91 %
Denizevleri	749,439	68,62 %	68,62 %	68,62 %	97,65 %	97,65 %
Esenevler	1.494,483	22,79 %	66,91 %	66,91 %	97,79 %	97,79 %
Güzelyalı	817,570	(-)	63,98 %	63,71 %	65,59 %	65,59 %
İncesu	6.615,284	(-)	(-)	(-)	(-)	(-)
İncesu Yalı	2.329,635	51,98 %	52,74 %	52,83 %	52,92 %	52,92 %
İstiklal	1.540,636	0,29 %	6,85 %	6,85 %	36,95 %	43,94 %
Kamalı	8.696,571	6,14 %	9,17 %	9,20 %	9,12 %	9,12 %
Karaoyumca	3.318,631	(-)	0,00 %	0,00 %	0,00 %	0,00 %
Körfez	3.369,179	(-)	64,06 %	64,06 %	62,75 %	62,75 %
Küçükkolpınar	988,996	(-)	(-)	(-)	38,44 %	68,89 %
Mevlana	1.527,449	7,19 %	8,35 %	8,35 %	28,63 %	74,24 %
Mimarsinan	1.599,976	37,09 %	77,47 %	77,47 %	93,41 %	93,41 %
OMÜ	7.573,511	(-)	13,32 %	13,35 %	12,97 %	12,97 %
Yenimahalle	3.657,087	0,18 %	50,00 %	50,00 %	71,27 %	75,9 %
Yeşildere	1.307,672	0,34 %	9,75 %	9,75 %	40,34 %	40,34 %

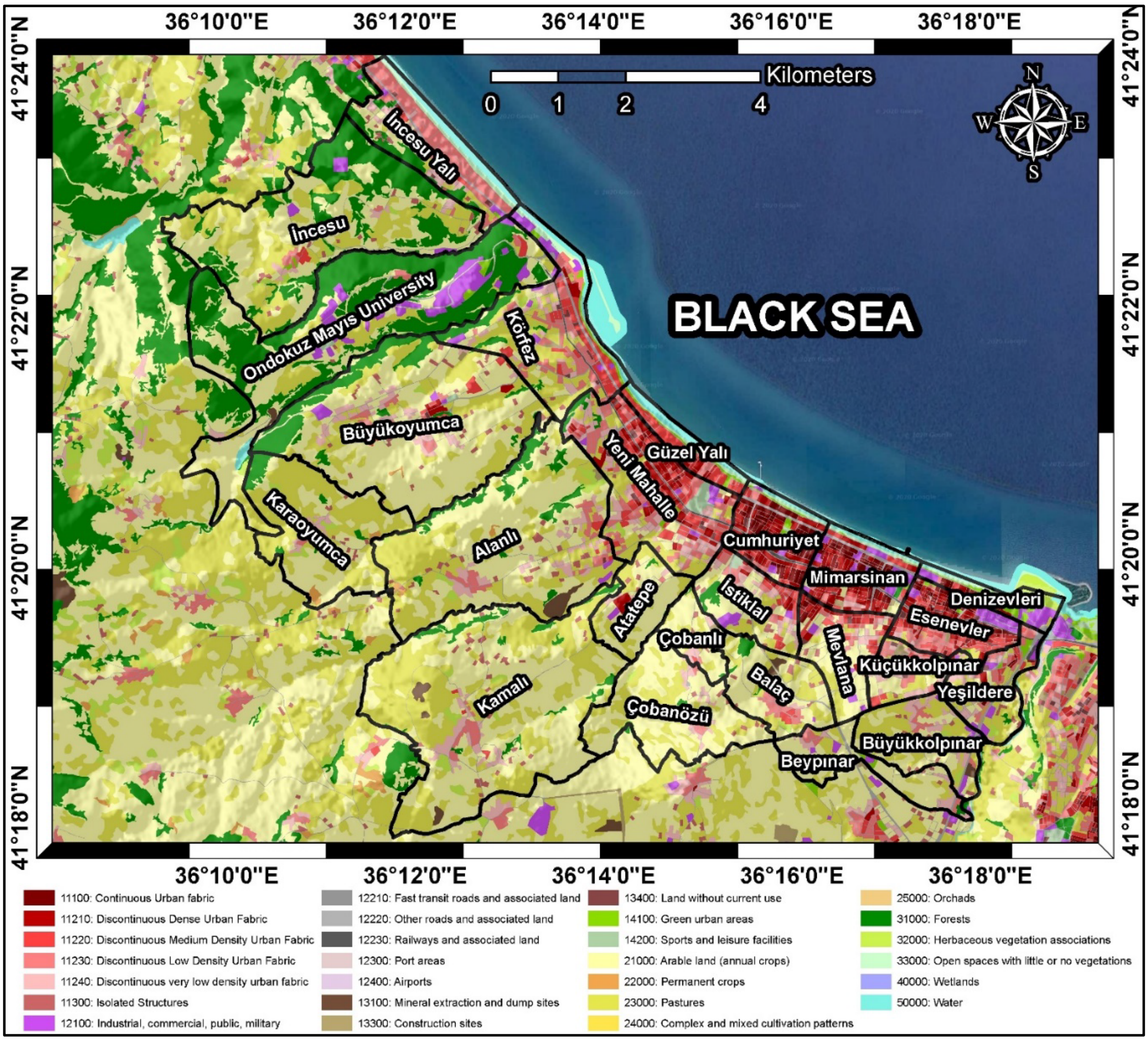

Figure 9. Study Area Urban Atlas (2018)

5. CONCLUSION

It was observed that neighborhoods with dense urban structure in 1990, such as Esenevler, Denizevleri, Mimarsinan and Cumhuriyet neighborhoods, turned into a dense urban structure of over 90%. In these neighborhoods, it has been determined that the rate of urbanization has increased very rapidly in the last 10 years, compared to the rate of urbanization in previous years.

The urbanization rates of Yenimahalle, Mevlana, Küçükkolpınar, Güzelyalı, Körfez and İncesu Yalı neighborhoods were quite low in 1990. These neighborhoods have rapidly urbanized in recent years and have an urban structure of more than 50%.

Monitoring and interpreting urban changes and taking necessary precautions are of great importance for the cities developments. In this way, it will be possible to prevent environmental problems. Changes in the land cover should be examined periodically. The urban areas changing, agricultural areas, forest areas and water resources is important for planning activities. Examination of the factors that cause urban sprawl and the consequences are among the important research topics today.

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Author contributions

1st Author: Conceptualization, Methodology, Software, Data Curation, Writing-Original Draft Preparation, Validation and Visualization
2nd Author: Methodology, Software, Writing and Original Draft Preparation
3rd Author: Writing, Original Draft Preparation, Validation, Visualization
4th Author: Conceptualization, Reviewing and Editing

Conflicts of interest

The authors declare no conflicts of interest.

Statement of Research and Publication Ethics

The authors declare that this study complies with Research and Publication Ethics

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A Correlation Study for Determination Risk Area of Dengue Fever and Dengue Hemorrhagic Fever: a Case Study of Sisaket Province, Thailand

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Keywords
Geographic information system,
Dengue fever,
Dengue Hemorrhagic fever,
Risk zone map,
Correlation.

Abstract

This study has purpose on analyzing risk zone area in Sisaket province, Thailand, by using the subdistrict-level (Tumbon) data in sick ratio, average temperature, maximum temperature, minimum temperature, relative humidity, precipitation, population density, and housing density. The meteorological data are acquired from POWER, NASA. The data is stored in points, griding by 30 minutes of latitude and longitude, going through the inverse distance weighting tool to interpolate the meteorological data into each Tumbon. The physical socio data are from government authority, are population from each Tumbon by monthly and housing amount from each Tumbon by yearly. The authority of meteorological data in Thailand officially only has the weather measuring stations in the middle of the province. The surrounding province also do not have sufficient station to interpolate the weather data, as well as the southern of the province is Thai-Cambodia border area with no station or data, leaving the vast area in the south has no data. Statistic yearly results show that average maximum and minimum temperature are significantly positive correlated with sick ratio while average relative humidity and precipitation are significantly negative correlated. Meanwhile, monthly results show that average temperature and average maximum temperature are significantly negative correlated with sick ratio while average minimum temperature, relative humidity and precipitation are significantly positive correlated. In both yearly and monthly results, population density and housing density are not significantly correlate with the sick ratio, as well as the average temperature in the yearly result.

1. INTRODUCTION

Nowadays, many diseases are obvious problems for public health. To prevent the spread, from food, water, air, and vector borne, we need to find the originated source or location of spreading. Especially, the transmitter in tropical and subtropical zone since high temperature and humidity are suited habitat for various type of insects. Many of insects transmit deceases such as Malaria and Chikungunya, damaging in lives and medical funds that lead to economical loss in many countries, including Thailand.

Sisaket province is a province in Thailand, locating about 600 km. afar from the Bangkok, country's capital. The province is geographically involved with the mountain line in the southern area of the province, which is the natural Thai-Cambodian border line. The overall landscape of the province is a wide low plain with scattering of streams. Mun river flows through the province from the northeast to the southwest. Recently, rising of Dengue fever (DF) and dengue hemorrhagic fever (DHF) incidence cases had been reported. The number of cases is raised and dropped every 1 – 2 or 3 years. People in the province are quite insufficient on

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funds and times to spend on medical diagnosis, also there are unregistered population such as foreigners and labors.

Dengue fever (DF) and dengue hemorrhagic fever (DHF) are vector-borne diseases which Aedes Aegypti transmit the Dengue virus. DF/DHF cases was first detected in 1779 in Asia, Africa, and North America. Thailand had first case of DF/DHF in 1949 and a widespread epidemic in 1958 in Bangkok and Thonburi area. Since 1958, the trend of infection increases and has many forms such as every other year, 2 years then stop for 1 or every 2 years. Most of patients are 0-14 years old, with most fatal symptoms in 5-9 years old. DF/DHF cases could be found along the year, yet the highest months are in rainy season (May-August) The effects of DF/DHF could lead to radical complications. Some patients are suffered from failure of circulatory system, shocking from leaking of plasma. Without correct medical treatment, the patient might be death in 12-24 hours.

By many factors, these diseases could spread through increasing crowding rate, mosquito's habitats and lacking healthcare and sanitation. The spreading rate increase in rainy season, from the middle of April to August and the highest point is in July. By the way, in November, the rate drop. Dengue fever is a re-emerging disease and a worldwide problem. To control the disease is to control the transmitter (Vector control), by find hot spots, interrelationship between land use and land cover factors and provide preventive measures. Geographic Information System (GIS) can be applied to analyze and to estimate the breeding ground, assisting in public healthcare planning.

Although many organizations by public and government have increasingly focused on the disease's prevention. Yet is not applied by agencies, GIS could assist in decision, planning and solving the problems by managing, storing, and analyzing information of spatial, medical, and public health as well.

GIS is a systematic tool that gather, adapt, and display spatial data as well as their attributes. In public healthcare, GIS could be used to display epidemics and estimate the diseases factors. The system could display the information in various forms such as maps, 3D models and statistic table. Spatial information shows the locations of events on earth's surface in layers form by overlaying information. The relation between human and biological environment integrates the knowledges in diseases prevention. GIS helps increasing the efficiency of preventive process and cover the correct areas, deescalating the infection and death rates. The benefits from applying GIS and statistical analysis to study about the diseases can be presented to relevant agencies such as provincial public health center and hospitals.

2. Method

The patient's data from public health agency of Sisaket province, Thailand. from 2010 – 2019 The data stored in spreadsheet with headers consisting of age, gender, DF or DHF, defined date, Amphoe (district), Tumbon (subdistrict), and result of treatment (recover/dead). The data is acquired from Sisaket's public health office, ministry of public health. Population and housing data is acquired from department of provincial administration (DOPA), Ministry of Interior. Meteorological data (temperature, relative humidity, precipitation) is acquired from prediction of worldwide energy resources project (POWER), National Aeronautics and Space Administration (NASA). The used tools are ArcMap 10.5 (Hotspots Analysis (Getis-Ord Gi*), Inverse Distance Weight (IDW), Zonal Statistics as Table), JASP 0.15 (Pearson's correlation analysis), and Microsoft Excel.

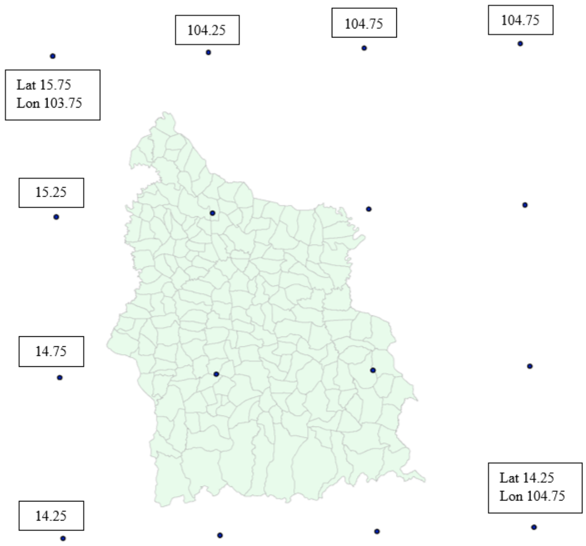

Figure 1. Meteorological Data's Coordinates

2.1. DF/DHF in Sisaket, 2010 – 2019.

Dengue Fever (DF) and Dengue Hemorrhagic Fever (DHF) are found in Thailand and other south-east-Asia countries, being a radical problem for public health service and medical treatment due to the massive number of patients annually. The patients might be shocked and rapidly die if right treatment have not been given.

DF/DHF cause by Dengue Virus, which has ribonucleic acid as its genetic material, or called RNA Virus. The virus is in Flaviviridae family with 5 serotypes. All serotypes have some similar antigens that lead to occur cross reaction and protection in a short period. This mean if the patient was infected by a type of the virus, the body will produce permanent immunity in that type of virus' serotype and other 3 types will be partial immune about 6 – 12 months.

DF/DHF's transmitter is Aedes Aegypti mosquito. In the daytime, female Aedes take a blood meal from an infected person. The virus in the blood spread into mosquito's stomach, implanted on cells of the stomach's wall. When the number of the virus grow, it transmits to the mosquito's saliva and the next bitten person consequently. After been bitten for 5 – 8 days, the patient starts to express the symptoms

The DF/DHF data is classified into 2 forms for separate results: yearly correlation, monthly correlation. Yearly data is the summarized number of DF/DHF incidence cases through each year in the province, and monthly data is summarized number of the disease's incidence cases through each month from studied years.

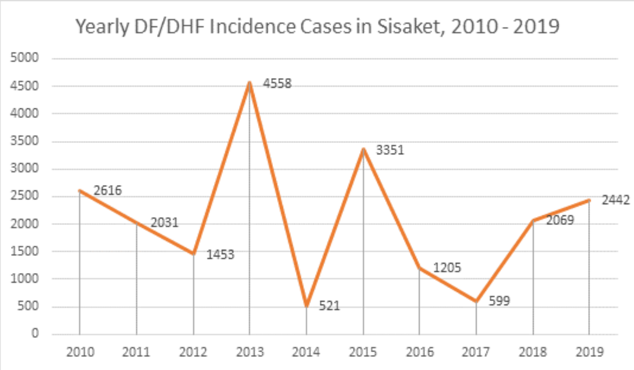

Figure 2. Yearly DF/DHF Incidence Cases in Sisaket, 2010 – 2019

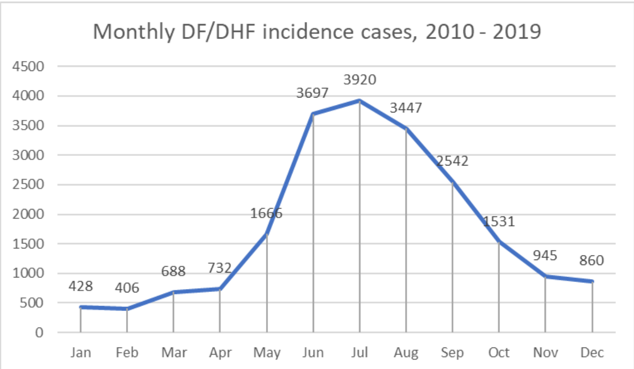

Figure 3. Monthly DF/DHF Incidence Cases in Sisaket, 2010 – 2019

2.2. Correlation Analysis

Correlation (Pearson's) tells if variables are positively related (they move in the same direction) or negatively correlated (they move in opposing directions).

$$r = \frac{\mathbf{n(\sum xy) - (\sum x)(\sum y)}}{\sqrt{(n\sum x^2 - (\sum \mathbf{x})^2)(n\sum y^2 - (\sum \mathbf{y})^2)}}$$

r = r value (how much the data correlated, 1 is the highest)
x = variable 1 value (variables)
y = variable 2 value (sick ratio)

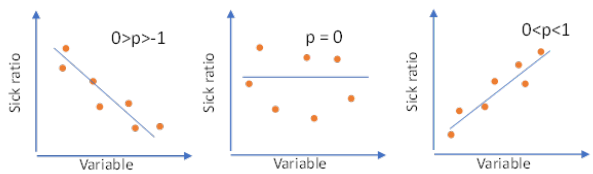

Figure 4. Definition of Correlation Analysis

Insert variables: sick ratio, average temperature, maximum temperature (average), minimum temperature (average), relative humidity (average), precipitation amount (total/average), housing density.

2.2.1. Rating of variables' values

Rating by define the effect of each variable, 1 is for the lowest effect and 4 is for the highest effect. Find the mean value of entire data ($\bar{x}$) and its Standard Deviation (S.D.)

Table 1. Variables' values rating definition

Rating	Observed Value
4	More than $\bar{x}$ + 1 S.D.
3	Between $\bar{x}$ and less than $\bar{x}$ + 1 S.D.
2	Less than $\bar{x}$ but more than $\bar{x}$ - 1 S.D.
1	Less than $\bar{x}$ - 1 S.D.

3. Results

Land cover maps of the years 1990, 2000, 2006, 2012, 2018 were processed in accordance with the study area using GIS software according to CORINE Land Classes (Artificial surfaces, agricultural areas, forest and semi natural areas, wetlands and water bodies) given Table 2. The areal changes of study area were analyzed. The results of these analyses were given in Fig. 4-8 as land cover map and Table 3-7 as areal and percent.

$$Class\ Interval = \frac{\mathrm{Data}_{max} - Data_{min}}{\text{Amount of class}}$$

Table 2. Pearson's yearly correlation

Variable	r value	p value	n
Population	-0.015	0.503	
Avg. Temp.	0.006	0.795	
Max Temp.	0.169	< .001	
Min Temp	0.131	< .001	2060
Humidity	-0.229	< .001	
Precipitation	-0.11	< .001	
Housing	0.022	0.321	

Table 3. Pearson's monthly correlation

Variable	r value	p value	n
Population	-0.015	0.45	
Avg. Temp.	-0.088	< .001	
Max Temp.	-0.416	< .001	
Min Temp.	0.515	< .001	2472
Humidity	0.561	< .001	
Precipitation	0.658	< .001	

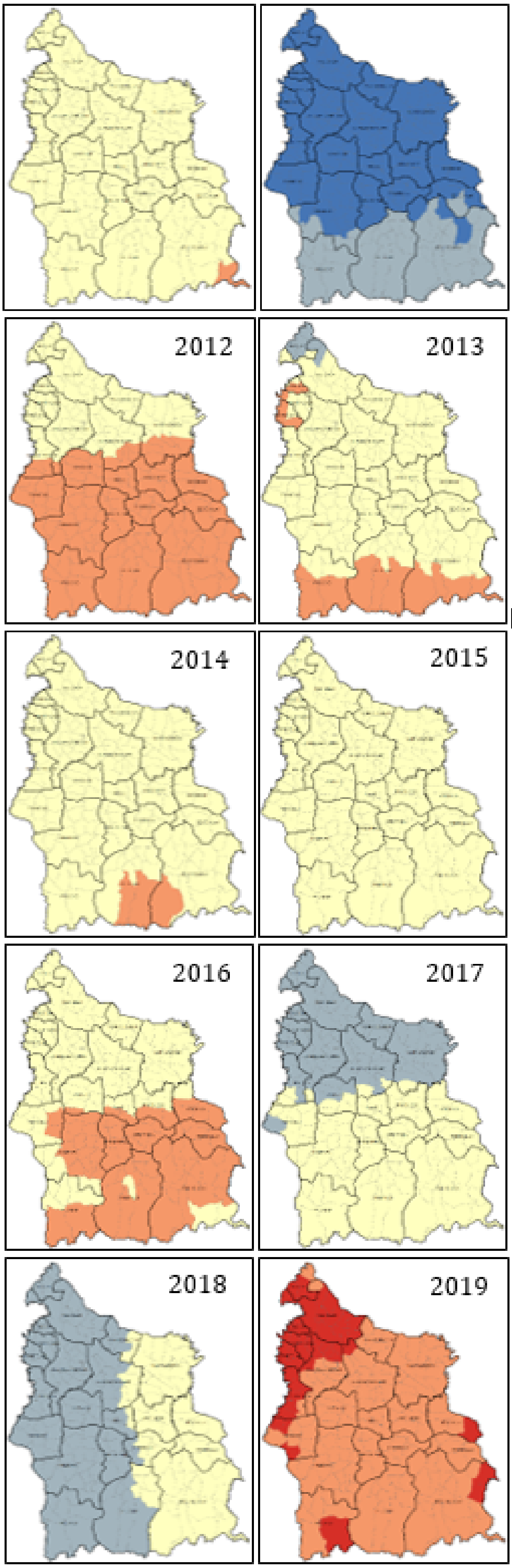

Figure 5. Risk zone maps of 2010, 2019, Sisaket Province, Thailand

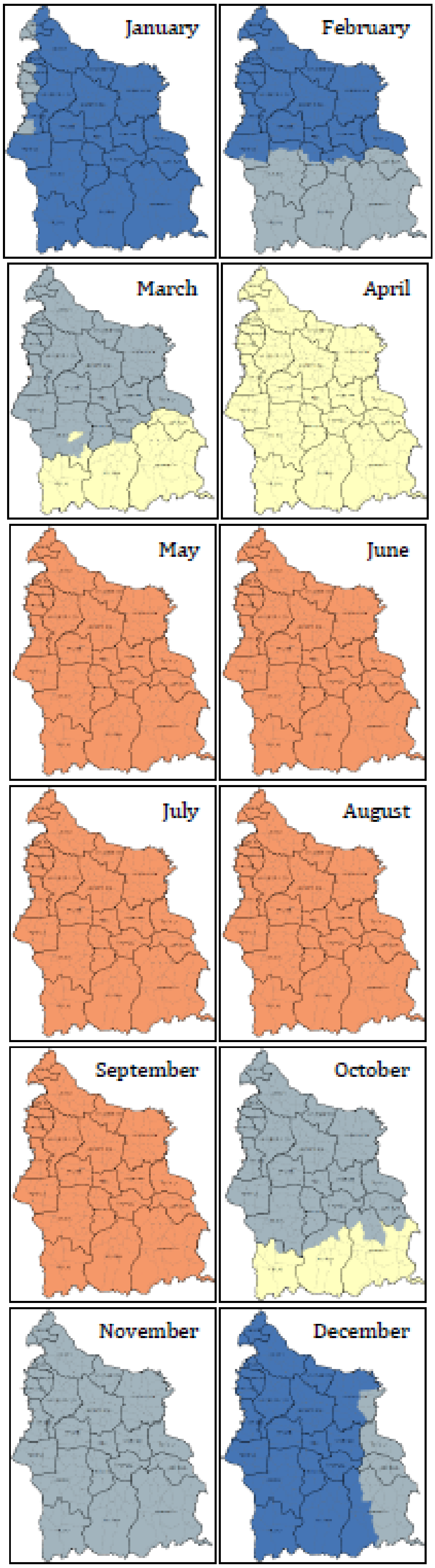

Figure 6. Risk zone maps of January - December, Sisaket Province, Thailand
Maps Legend

- High risk zone (Score 3.4 - 4)
- Moderate-high risk zone (Score 2.8 – 3.4)
- Moderate risk zone (Score 2.2 – 3.8)
- Moderate risk zone (Score 1.6 – 2.2)
- Low risk zone (Score 1.0 – 1.6)

Results are fully displayed in risk zone maps by years 2010 – 2019 and by months from studied years. The example figures (figure 3 and figure 4) show the comparison between the years and months with the highest sick ratio with the lowest.

Table 4. Correlation between yearly sick ratio and risk score

Year	Sick Ratio	Average Risk Score	r score	p value
2010	179.82	2.6210		
2011	139.86	1.7005		
2012	99.63	2.7474		
2013	311.76	2.5663		
2014	35.56	2.4568		
2015	228.15	2.6981	0.213	0.554
2016	81.95	2.6843		
2017	40.69	2.1679		
2018	140.46	2.1174		
2019	165.8	3.3073		

Table 5. Correlation between monthly sick ratio and risk score

Month	Sick Ratio	Average Risk Score	r score	p value
Jan	28.2	1.5508		
Feb	27.98	1.5076		
Mar	46.97	2.1720		
Apr	50.14	2.4219		
May	112.64	3.3879		
Jun	252.43	3.1727		
Jul	266.21	3.0612	0.799	0.002
Aug	231.39	3.2425		
Sep	168.43	3.2425		
Oct	100.39	2.1813		
Nov	61.29	2.1204		
Dec	53.96	1.3356		

4. DISCUSSION

The study of correlation and estimate risk area of DF/DHF by gathering data from agencies, has purpose for find relationship between factors and produce risk zone maps of Sisaket province. The studied data is 10-year long (2010 – 2019), is the DF/DHF incidence cases, had defined the factor that might cause the diseases. There are 6 variables involve in the study which are population density, average temperature, average maximum temperature, average minimum temperature, precipitation amount, and housing density (in monthly analysis used average precipitation instead of total amount and have no monthly housing density). For Tumbon (subdistrict) level, the meteorological data might not have wide range and much difference. The estimation from geoinformatics tools is not exactly accurate, unless the data are physically acquired from local area.

For statistical analysis results, yearly analyzing gave average maximum and minimum temperature 16.9% and 13.1% significantly positive correlate ($p<0.001$), as well as average relative humidity and precipitation 22.9% and 11% significantly negative correlate. Meanwhile, monthly analyzing gives average temperature and maximum temperature significantly negative correlate with 8.8% and 41.6%, while average minimum temperature, relative humidity and precipitation are significantly positive correlate with 51.5%, 56.1%, and 65.8%. ($p<0.001$). The results obviously show that monthly study provide stronger statistical correlations more than annually study. Moreover, the average risk scores show that the monthly study also provide more correlation than yearly study (79.9% and 21.3%, monthly and yearly).

5. CONCLUSION

The yearly correlation results in positive with maximum and minimum temperature and negative with relative humidity and precipitation, which all factor's trends are rising each year. Positive correlation r values are 16.9% and 13.1% and negative correlation r values are 22.9% and 11%. This phenomenon could lead to decrease of DF/DHF sick rate.

The monthly correlation show that maximum temperature and minimum temperature are respectively negative and positive correlated. This could lead to find the suitable temperature range for DF/DHF incidence. Moreover, the relative humidity and precipitation are both strongly positive correlated, summarizing that seasonal meteorological data are suited for study the correlation with the diseases. The most affected variables are precipitation, relative humidity, minimum temperature, and maximum temperature (negative correlated) respectively. These factors are more than 40% correlated with the sick ratio.

The monthly risk zone maps (which provide significant correlation with sick ratio) show that through the year, DF/DHF are riskier in the southern part of the studied area, Sisaket province. PHU SING, KHUN HAN, and KANTHARALAK Amphoes are the 3 Amphoes located in the south of the province, northern to the Thai-Cambodian border with a vast area of mountain forest. The study of correlation in monthly summarization provides more correlative results than yearly study. The office of provincial public health should consider in providing more density measurements in prevention and healthcare facilities.

Further study finds that at 32° - 34° C Ades could be grown up to adults in only a day which can seriously cause DF/DHF pandemic. People who live in 30° C environment could be 4 times riskier to be infected by DF/DHF Sisaket also has many non-register populations which are tourists and migrators since it is located near the border.

Recommendation

1. Meteorological study should be expanded to larger area, regional or country. Across province provide not obvious difference.
2. Land use and land cover are good choices to find long-term correlation.
3. House Index (HI) and Container Index (CI) of mosquitos' larva would provide much more accurate relationship, but also considered to be very high detailed data.
4. Further study about the diseases should be done in monthly or seasons would provide more statistical precision.
5. Authorities should public provide the epidemic information to raise awareness of locals.

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Author contributions

Nutchanon Chantapoh: Conceptualization, Methodology, Software, Field study, Writing-Original draft preparation, Field study Visualization, Investigation, Writing-Reviewing and Editing. **Shu Hong:** Principal advisor and Thesis' examiner member. **Phattraporn Soytong:** Co-advisor.

Conflicts of interest

The authors declare no conflicts of interest.

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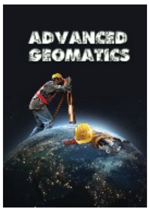

Determination of Stone Material Deteriorations on the Facades with the Combination of Terrestrial Laser Scanning and Photogrammetric Methods: Case Study of Historical Burdur Station Premises

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Keywords
Photogrammetry,
Terrestrial Laser Scanning,
Stone Material,
Material Deterioration,
Cultural Heritage.

ABSTRACT

Mapping the surface patterns of the stone is a non-destructive procedure, which has a critical importance for the qualitative and quantitative assessment of conservation status. Besides, the mapping technique, which is used to explain the segregation categories and to calculate the damage indexes, is a time-consuming task that is generally performed manually. Therefore, practical methods must be developed for the conservation specialists to automatize deterioration mapping without increasing the cost of diagnosis process significantly. Within this context, the aim of the study is to present a methodology, which combines the terrestrial laser scanner technology with the photogrammetric techniques, to investigate the damages on the stone materials that form the historical buildings. Methods of literature review, observational determination, terrestrial laser scanning, and photogrammetry were used in the study, in order to create the material deterioration analytic relievos of the facades of the specified building. The findings were assessed with the descriptive and systematic analysis methods. It is seen that the data required to assess the conservational status of the materials in the historical buildings can be obtained through obtaining a thematic map of the damages that affect the stone construction materials within the scope of the study. According to the findings, it is found that one of the main problems regarding this monument is the formation of plants.

1. INTRODUCTION

In recent years, an increase is seen in the material deteriorations of cultural heritage structures, which have been built from stone materials, in the world (Bal'awi et al., 2012; Price, 1996). When the studies, which address the material deteriorations of stone monumental structures in the world, are reviewed, it is observed that the sources causing an increase in the deteriorations are the factors such as the saline effect, increase of air pollution, and humidity that increases due to climate change (Corvo et al., 2010; Fort et al., 2004; Moroni et al., 2004; Spezzano, 2021; Webb et al., 1992). With the increase of material deteriorations, the need to determine the material deteriorations of the stone structures accurately and document them immediately has been increased (Alptekin et al., 2019a; Yakar & Alptekin, 2021; Kanun et al., 2022). Mapping the surface patterns of the stone is a non-destructive procedure, which has a critical importance for the qualitative and quantitative assessment of conservation status (Yılmaz & Yakar 2006; Yakar et al. 2014). Besides, the mapping technique, which is used to explain the segregation categories and to calculate the damage indexes, is a time-consuming task that is generally performed manually. Therefore, practical methods must be developed for the conservation specialists to automatize deterioration

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mapping without increasing the cost of diagnosis process significantly (Adamopoulos & Rinaudo, 2021).

Today, the use of various techniques in documentation has become necessary, because the manual documentation is insufficient and causes loss of time. Therefore, today it has become common to document the structures via various techniques such as photogrammetric and laser scanning methods in order to investigate and diagnose the damages on the materials forming the monuments, and to improve the production process of the thematic maps (Yakar 2010 et al. 2010; Lerma & Herráez, 1999). The non-destructive techniques are the subjects that many conservation and restoration specialists focus on importantly in the documentation of material deteriorations of historical structures (Genovese, 2005; Alptekin et al 2019b). Terrestrial laser scanning is a non-destructive technique, and today terrestrial laser scanning has made great advances in the field of documenting the architectural characteristics and material deteriorations of the structures, in which the direct contact is not involved (Alptekin et al. 2019c; Ulvi & Yakar 2014; Ulvi et al. 2014; Kanun et al.2021; Korumaz et al. 2010). Various studies in the literature verify that the technologies such as photogrammetric and laser scanning methods create great convenience and saving of time in the documentation of architectural and material problems (Alptekin & Yakar 2020a; Alptekin & Yakar 2020b). In the study conducted by Ercoli et al., (2012), which is a significant example, it was verified that terrestrial laser scanning may be an important alternative to the technique of determination on-site in the determination of material deteriorations for the monumental structures. As a result of the study, it was found that the information obtained via terrestrial laser scanning made the understanding of the textural features and experimental results easier and provided sufficient information to determine the material problems. Furthermore, it was proven that the terrestrial laser scanning was able to determine the segregation degree of the stone material in detail and it was more effective and cheaper than the direct measurements, which are potentially harmful for the worn surfaces. In another example, Armesto-González et al., (2010) have combined the terrestrial laser scanning technology with the digital image processing techniques in order to investigate the damages on the stone materials forming the historical buildings, and explained that the intensity data received from the terrestrial laser scanner is sufficient for the recognition and characterization of certain pathologies on the stone construction materials forming the historical buildings. In another example, Lanaro et al., (1998) have verified that important information may be obtained about the textural features (for example; micro fractures, micro roughness, rock porosity) on the material by using terrestrial laser scanner. Randazzo et al., (2020) have classified the types of stone material deterioration using photogrammetric methods in the determination of stone material deteriorations on the structure, and found that using the photogrammetric examination provides a higher resolution image collection for more advanced quantitative analysis and the relevant deterioration assessment of stone material deteriorations. Adamopoulos & Rinaudo, (2021) found in their study that applying the photogrammetric techniques to document the stone material deteriorations facilitates obtaining data, which simplify the extraction of thematic information and the development of deterioration maps. Bal'awi et al., (2012) have combined laser scanning and photogrammetry and a comprehensive approach that utilizes 2D-3D documentation of the structure with the results of laboratory analysis, and reached to a conclusion that data and digital images received from the laser scanner provide sufficient data to increase the visual quality of 3D surface details and cracks.

As explained also in the literature, terrestrial laser scanning and photogrammetry techniques provide great benefits in the diagnosis of material problems. Within this context, the aim of the study is to present a methodology, which combines the terrestrial laser scanner technology with the photogrammetric techniques, to investigate the damages on the stone materials that form the historical buildings. The data required to assess the conservation status of the materials in the historical buildings were obtained through obtaining a thematic map of the damages that affect the stone construction materials within the scope of the study. Thus, it was possible to suggest the acts appropriate for the restoration and conservation of the building. According to the findings, it is seen that one of the main problems regarding this monument is the damage of saline.

1.1. Location, History and Architectural Analysis of the Building

The building is located in central Burdur, Bağlar Neighbourhood, on Ofis Avenue. According to the land registration records it is located on Block 46, Plot Nr. 1.

Isparta – Burdur stations and their auxiliary structures have been built in 1936, within the period called early republic period, and are modern buildings, which have been built in the second national architectural character by using the modern construction materials of the period. The station buildings and their auxiliary structures are masonry constructions with reinforced girders in general, in which cut stones have been used on the main outer walls, turning to reinforced concrete carcass in some parts. In addition, local köfke stone (pumice stone), which is relatively processed easily, has been used on the exterior walls. Mosaic has been poured on all interior floors of the station building and its auxiliary structures, the interior walls and the ceilings have been whitewashed after plastering with a plaster containing cement and lime mortar. Marseilles tile has been selected as the roof covering material.

The station premises, which has been built with cut stone, is a complex building. The main station premises are consisted of a basement and ground floor. Two lodgings are located on the +3.28 elevation. On this floor, the lodgings have been separated by naming them as east and west. Finally, the single-storey hangar building, which is covered with hipped roof, is located on the east part adjacent to the station premises.

1.2. Facade Characteristics

The north facade of the station premises has been built by cut stones and the door and window apertures have been placed in line with certain symmetry on the facade. A decorative side-coating has been made in the height of three lines of cut stones from the ground elevation of the facade. The ground and first floors are seen on the facade and the floors have been separated via cut stone moulding. A wooden separator has been placed on the middle point of the facade on ground floor, and thus entrance to the station premises has been provided. The wooden separator has been covered with concrete soffit, and the metal signboard of Turkish State Railways (TCDD) is seen of the front face of the soffit. Two wooden door and one wooden window apertures have been placed on the west of the wooden separator. The door and window apertures having the same features and form have been placed also on the east of it. The door apertures are in rectangular form having cut stone jambs. On the upper floor, eight window apertures, in the same type, have been placed. Apertures have cut stone sills and cut stone jambs. Concrete soffit in a depth of 1.30 meters, metal rain gutter, Marseilles tile roof covering constitutes the upper elevation of the facade. In addition, plastered chimneys of the buildings are seen and the upper elevation of the building mass, which has been built adjacent to the main building on the west of the structure, ends with the cut stone wall coping.

The South facade of the station premises has almost the same characteristics with the north facade. The only difference from the north facade is the change on the door and window apertures opened. The ground floor is consisted of a wooden separator on the middle point, as on the north facade, and the door and window apertures placed on the east and west of the separator. There are rectangular-formed windows having iron railings, cut stone sills and lintels, and doors having cut stone jambs on both sides of the separator. There are nine windows on the first floor, which has been separated via cut stone moulding. Window forms and styles differentiate. The large rectangular window aperture, which is placed on the west of the facade, does not reflect the characteristic of the period. Two window apertures opened on the facade are seen on the building mass, which has been built adjacent to the main building on the west of the facade. The upper elevation of this building mass ends with cut stone wall coping. Concrete soffit in a depth of 1.30 meters, metal rain gutter, Marseilles tile roof covering constitutes the upper elevation of the facade, and in addition, plastered chimneys of the buildings are seen.

The east facade, which constitutes the rear facade of the hangar building, is built from cut stones, as on the other facades. There is one wooden window on the facade. Both sides of this unoriginal window aperture are closed with jerry-built wall. It is seen that this area had a rectangular-formed, almost square, window aperture originally. Wooden eaves plate, Marseilles tile and plastered chimney constitute the upper elevation of the facade.

The facade, which constitutes the west of the station premises, is made of cut stone. It is seen that upper elevation difference between the station premises and this building mass has been utilised as a terrace opening to the west of the main building. A decorative side-coating has been made in the height of two lines of cut stones from the ground elevation of the facade. Wooden window having cut stone lintel and cut stone sill and one wooden door aperture having cut stone lintel have been placed on the facade. The cut stone moulding, which we see on the north and south facades, has been continued also on this facade without interruption. Cut stone wall coping constitutes the upper elevation of the facade. In addition, two wooden window apertures of the first floor of station premises, which continues on the rear side of the facade, are also seen. Window apertures are original. Concrete soffit, metal rain gutter, Marseilles tile roof covering constitutes the upper elevation of the station premises.

2. METHOD

Methods of literature review, observational determination, terrestrial laser scanning and photogrammetry were used in the study, in order to create the material deterioration analytic relievos of the facades of the specified building. The findings were assessed with the descriptive and systematic analysis methods. In the first stage of the study, a situation analysis was conducted about the historical building, on which the case study shall be carried out, and the general information of the building was presented under an archive review. Besides, an observational analysis was carried out on the building in order to document the material deteriorations of the building, and the deteriorations determined on the materials were presented in Part 2.1 as a chart. The chart prepared under the study is chart regarding the determination and documentation of the stone material deteriorations on the facades (Chart 1). In the second stage of the study, the stages followed to prepare the facade drawings of the building and the analytic relievos regarding the material deteriorations occurred on the facades using the terrestrial laser scanning and photogrammetric methods were explained systematically in Part 2.2. and 2.3.

2.1. Determination of the Material Problems

In this stage, within the first step of evaluating the conservation status of the building, an observational investigation, which is consisted of damage mapping, was carried out. Stone material deteriorations occurred on the facades of the building were marked in ''Table 1.''.

Table 1. Stone material deteriorations on the facades of Burdur Station Premises

NATURAL STONE CONSTRUCTION ELEMENTS				PROBLEMS ENCOUNTERED ON CONSTRUCTION ELEMENTS MADE OF MASONRY MATERIAL IN BURDUR STATION PREMISES																				
																						Faulty Repairs		
				Loss of surface	Fragmentation	Formation of gap/ hole	Pitting	Cracks	Spalling	Foliation	Discharge of jointing	Surface contamination	Shell formation	Efflorescence	Crystallization	Formation of plant	Formation of moss	Corrosion (Rust stain)	Tear	Loss of form	Colour change	Use of cement	Fall of plaster	Other
VERTICAL BEARINGS	SINGLE BEARINGS	Leg		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Column		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	CONTINUOUS BEARINGS	Wall		X	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	X	X	X
HORIZONTAL BEARINGS	FLOORINGS	Flat		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Curvilinear -		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WALL OPENINGS		Window	Lintel/jamb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Sill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Door	Lintel/jamb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Sill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
		Arch		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AUXILIARY ELEMENTS		Network																						
		Moulding																						
		Gargoyle																						
		Chimney																						
		Element for passage to the cover																						

2.2. Scanning Procedure and Data Processing

Terrestrial laser scanning method was used in scanning procedure in this stage, in order to document the building as 3-dimensional. Exterior facade scanning was carried out by using laser scanning device (Faro Focus Laser Scanner), and point cloud of the building was obtained in the scanning procedure ("Fig. 1").

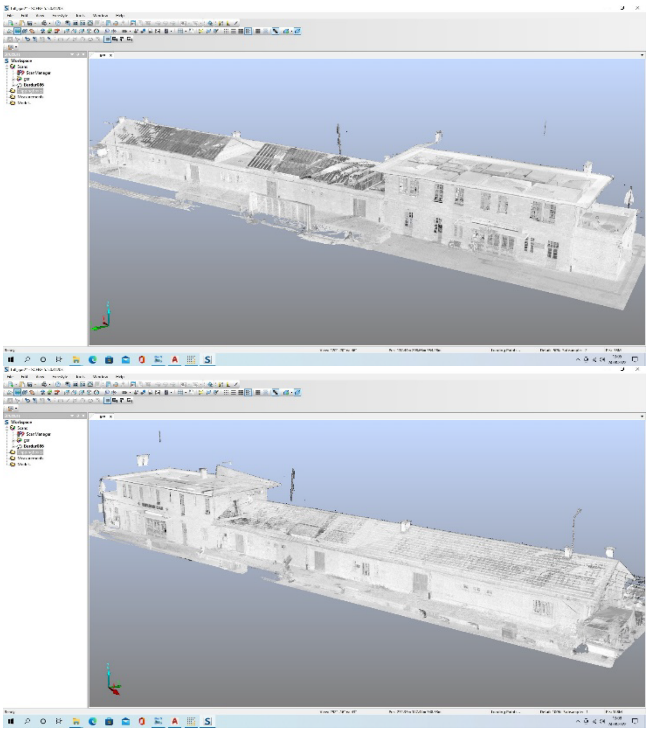

Figure 1. Point cloud obtained regarding the building

2.3. Obtaining the Orthophotograph Images

In this stage, orthophotograph images of the building were acquired from the point clouds obtained in the laser scanning procedure in the software named PointCab Origins 3.9 ("Fig. 2-7").

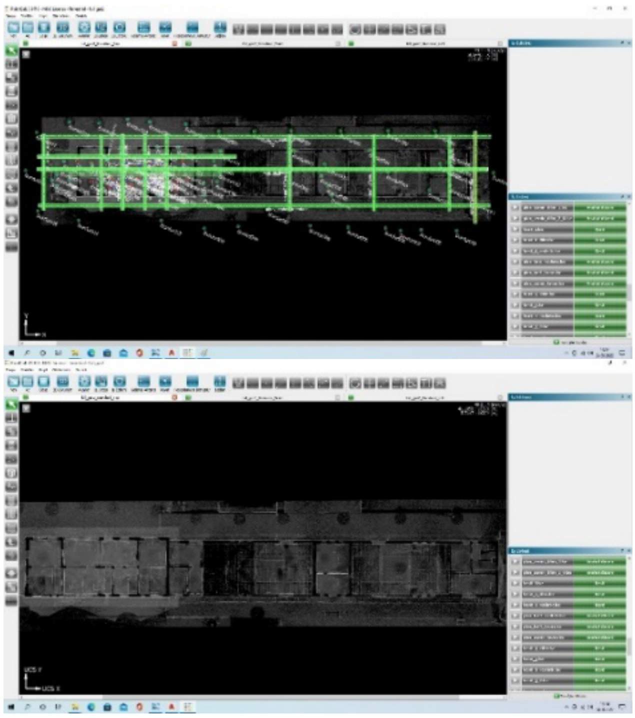

Figure 2. Scene of creating orthophotographs from the point cloud obtained from Terrestrial Laser Scanning, using the programme named PointCab Origins 3.9

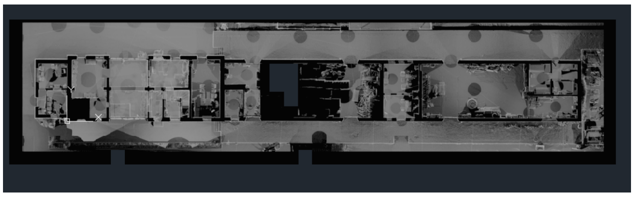

Figure 3. Orthophoto of ground floor plan

Figure 4. Orthophoto of west frontage

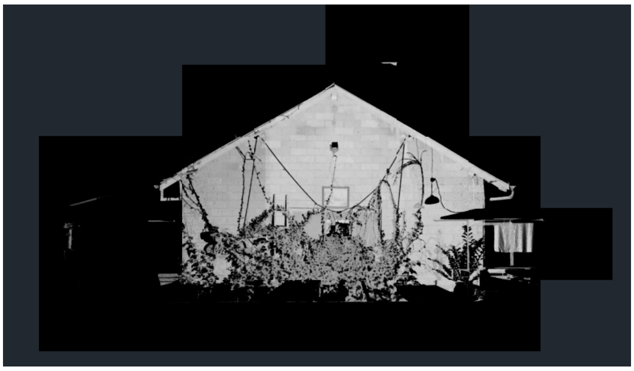

Figure 5. Orthophoto of east frontage

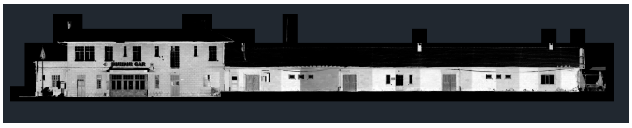

Figure 6. Orthophoto of south frontage

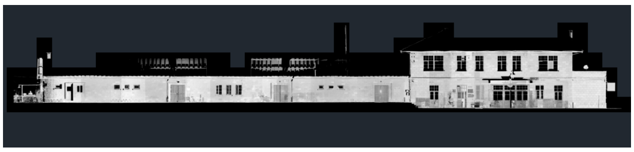

Figure 7. Orthophoto of north frontage

AutoCAD programme was used in the procedure of creating the drawings of the facades. Before commencing the drawing procedure, the orthophotograph images produced in the software named PointCab Origins 4.0 were transferred to AutoCAD environment. They can be transferred into AutoCAD media in the format of TİF file with tif. or .tiff extension, which is the common data format of AutoCAD software. Facade drawings of the building were obtained through AutoCAD programme, using the scaled orthophoto images obtained.

3. RESULTS

The material deteriorations, which were determined in Part 2.1. in "Table 1.", were processed on the drawings analytically. In this section, analytic relievo layouts, which were obtained regarding the material damages, are presented. The damage determination layouts prepared are mapped according to the colours specified in "Fig. 8".

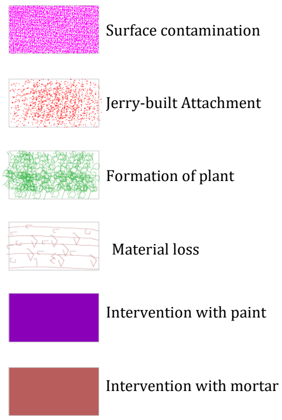

Figure 8. Legend regarding the material damage layouts

3.1. Analytic Relievos Regarding the Stone Material Deteriorations

Deteriorations and deformations such as intervention with reinforced concrete plaster, surface contamination, and material losses were observed on the cut stone surfaces, on the north frontage. Besides, jerry-built attachments such as the electric cables, speakers, and signboard are also present on the facade ("Fig. 9").

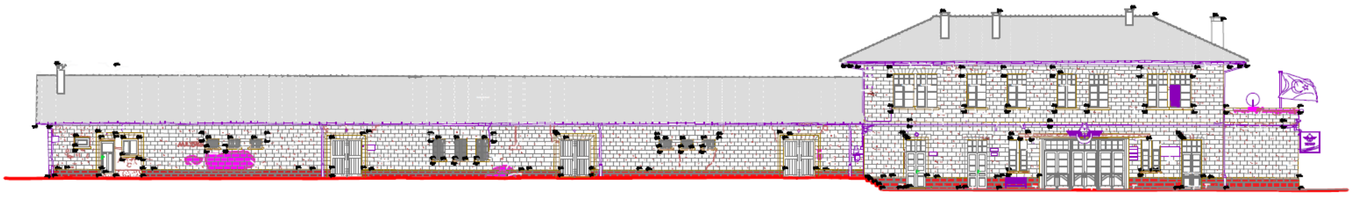

Figure 9. The north frontage

Deteriorations such as formation of plants, surface contamination, material losses on the window sills are seen on cut stone surfaces constituting the south frontage. Besides, there are numerous jerry-built attachments are present on the facade ("Fig. 10").

Figure 10. The south frontage

Majority of the east frontage is covered with ivy plant, and it is seen that the front of the facade is utilized as a cafe. Jerry-built attachments and deteriorations such as the surface contamination were observed (''Fig. 11'').

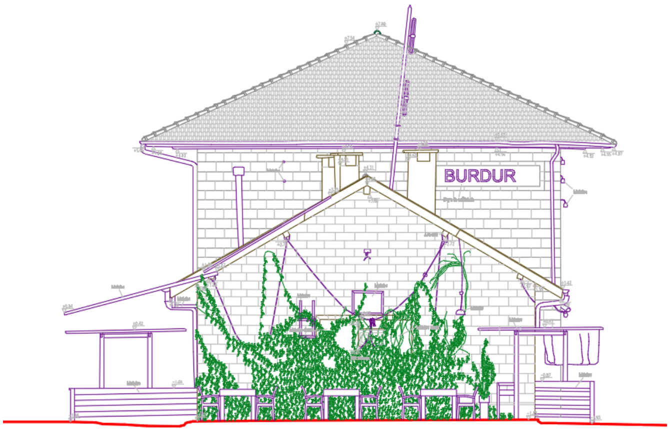

Figure 11. The east frontage

It is seen that intervention has been made on the sign plate within the rectangular frame created by cut stones with paint on the west frontage. Deformation and surface contamination, and various jerry-built attachments such as cables and antenna are seen on the surface of the cut stone facade (''Fig. 12'').

Figure 12. The west frontage

4. DISCUSSION

The aim of the study is to suggest a methodology that combines the terrestrial laser scanning with photogrammetric methods in order to investigate the damages on the stone materials, which constitute the historical buildings. The data required to assess the conservation status of the materials in the historical buildings were obtained through obtaining a thematic map of the damages that affect the stone construction materials within the scope of the study. Thus, it is possible to suggest the acts appropriate for the restoration and conservation of the building. According to the findings, it is seen that one of the main problems regarding this monument is the plant formation. It was seen that the water leaking from the surrounding resources have risen via capillarity, and caused formation of plants on the facades of the building. Another significant deterioration type is the surface contamination. It was determined that the factor causing surface contamination is the waters flowing from the roof of the building to the facade and causing contaminations on the surface. Within this scope, it is concluded that the greatest factor causing stone material deteriorations is water-originated, which affects the building reflexively.

In the study, it was enabled to document the architectural drawings and material deteriorations of the building through the method used by combining the laser scanning and photogrammetric techniques. This finding supports the studies, which emphasize that laser scanning and photogrammetric techniques provide sufficient data to document the architectural drawings and material deteriorations of the building. (Armesto-González et al., 2010; Bal'awi et al., 2012; Ercoli et al., 2012; Lanaro et al., 1998; Randazzo et al., 2020),

Furthermore, as a result of the study, it was found that determination and documentation of the material deteriorations can be carried out within a short period and obtaining data, which simplifies the development of deterioration maps, is facilitated. This finding supports the study results of Adamopoulos & Rinaudo (2021), which have determined that applying the photogrammetric techniques to document the stone material deteriorations facilitates obtaining data, which simplify the extraction of thematic information and the development of deterioration maps.

5. CONCLUSION

The data required to assess the conservational status of the materials in the historical buildings were obtained through obtaining a thematic map of the damages that affect the stone construction materials within the scope of the study. According to the findings, it is found that one of the main problems regarding this monument is the formation of plants and surface contamination. It is concluded that both stone deterioration types are water-originated, which affects the building reflexively. Within this scope, the most important point is that the excessive water, which affects the building, must be removed. The approaches intended only to repair the stone material, without eliminating this main problem, shall only save the moment, and cause greater problems for the building and greater damages on the stone materials due to not eliminating the problem completely. Within this context, in the study it is suggested that the water affecting the building must be removed. In the following stage, the problems of formation of plant and surface contamination must be cleaned mechanically and surface protective materials must be applied on the stone materials in accordance with the opinions of the specialists.

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Author contributions

Lale Karataş; Methodology, data collection, writing, control. Aydın Alptekin; Control. Murat Yakar: Edit the paper

Conflicts of interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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