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Determination Of Flood Risk Areas And Carbon Sink Areas In The Scope Of Climate Change Adaptation And Mitigation: Case Study Of Çiğli, İzmir

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ÖZET

Sanayi devrimiyle birlikte kentsel ve kırsal alan sınırları genişlemiş ve belirgin olan kırsal çeper ortadan kalkmıştır. Yapısal alanlar ve ulaşım ağları kentlere hâkim olmuş ve doğal karaktere sahip mekânlar yıpranmaya başlamıştır. Bunun temelinde, artan ağır metaller ve doğanın kendini yenileyememesi iklim değişikliği olgusunu gündeme getirmeye başlamıştır. Kentlerdeki yeşil alan oranının azalması, doğal karakteri güçlü sulak alanların işlevini yitirmeye başlaması ekosistem hizmetlerinin kent ve kır genelinde devam etmemesine neden olmuştur.

Çiğli İlçesi; hızlı sanayileşme ve konutlaşmaya maruz kalmış olması ve önemli Ramsar Alanı içermesi nedeniyle doğal çevre ile yapılı çevrenin etkileşimin incelenebilmesi için önemli bir örnek olarak ortaya çıkmaktadır. Günümüzde Çiğli'nin en büyük sorunları artan karbon miktarı ve taşkın riskidir. Çalışma kapsamında da, Çiğli ilçesi genelinde taşkın riski taşıyan alanlar belirlenmiş buna ek olarak karbon salımının en yüksek olduğu alanlar tespit edilerek çözüm önerileri sunulmuştur.

Anahtar Kelimeler: İklim Değişikliği, Taşın Analizi, Karbon Yutak Alanları

ABSTRACT

With the industrial revolution, the boundaries of urban and rural areas have expanded and the rural periphery has disappeared. Structural areas and transportation networks have dominated the cities and the spaces with natural character have begun to wear out. On the basis of this, increasing heavy metals and the inability of nature to renew itself have started to bring the phenomenon of climate change to the agenda. The decrease in the rate of green areas in cities and the loss of function of wetlands with strong natural characteristics have caused the ecosystem services not to continue throughout the city and countryside.

Çiğli District emerges as an important example for analyzing the interaction between the natural environment and the built environment, as it has been exposed to rapid industrialization and housing and contains an important Ramsar Site. Today, the biggest problems of Çiğli are the increasing amount of carbon and the flood risk. Within the scope of the study, areas with flood risk throughout Çiğli district were determined, in addition to this, the areas with the highest carbon emissions were determined and solution suggestions were presented.

Keywords: Climate Change, Flood Risk Analysis, Carbon Sink

1. INTRODUCTION

Climate change is one of the major problems of our time. The phenomenon causes to devastating effect on human life and settlements (Balaban,2010). Human emissions of greenhouse gases from fossil fuel combustion, deforestation, and agricultural practices have caused global warming and climate change since Industrial Revolution. Climate change relates to science and society, challenges international governance institutions, and triggers new social movements (Riedy, 2016). Most urban regeneration projects are adapted to climate change phenomena. Floods are one of the dangerous natural disasters associated with socio-economic losses and environmental impacts. Many urban areas are affected, especially critical infrastructure such as electrical substations, bridges and drainage systems (Cea & Costabile, 2022). Floods can be defined to affect the safety of human life, economic construction, and sustainable development (Duan, ve diğerleri, 2022). Damage from flooding is expected to increase in the future due to adaptation efforts (Yu & Jung, 2022). Environment Agency has determined the causes of flooding which consist of river flooding, coastal flooding, surface water flooding, sewer flooding, and groundwater flooding (Environment Agency, 2009). Within the scope of the study, surface water flooding is analyzed in Çiğli District.

<u>The Madrid Plan – MAD-RE</u>

It is an important study in which nature-based solutions are applied in order to reduce carbon emissions in urban transformation areas. It is the project of the municipality of Madrid, prepared under the title of "Nature and Madrid", which consists of the philosophy of transformation and innovation on the basis of nature-based solutions, and brings a new perspective to the city (Hurtado, 2021).

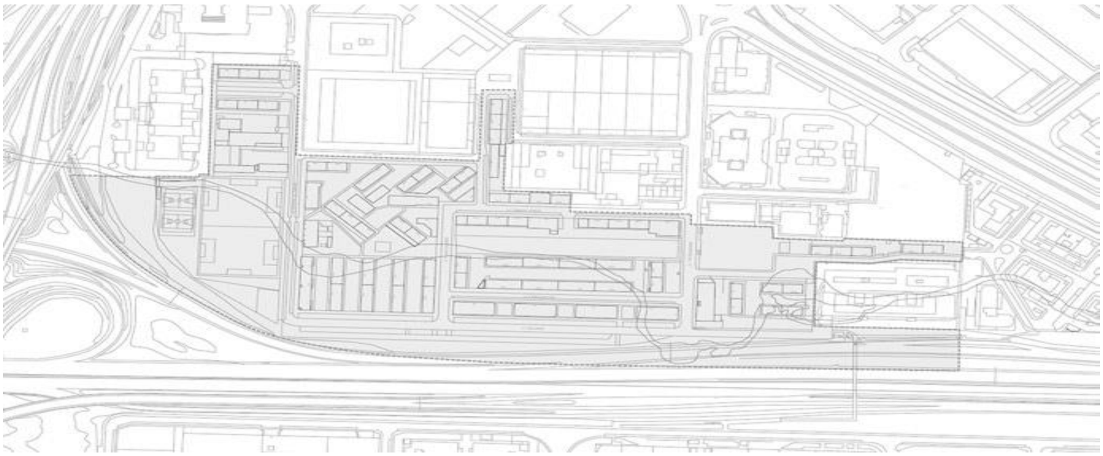


Figure 1. The Madrid Plan

<u>Padua, Italy</u>

The works of the city of Padua on urban regeration are developing on the flood and heat island effect. Additionally, the study highlights the importance of soil conservation. It encourages actions that will ensure urban growth without damaging the soil texture. There are urban axes and multifunctional green areas that will be redeveloped both morphologically and functionally within the transformation project (Peroni, Pristeri, Codato, Pappalardo, & Marchi, 2020).

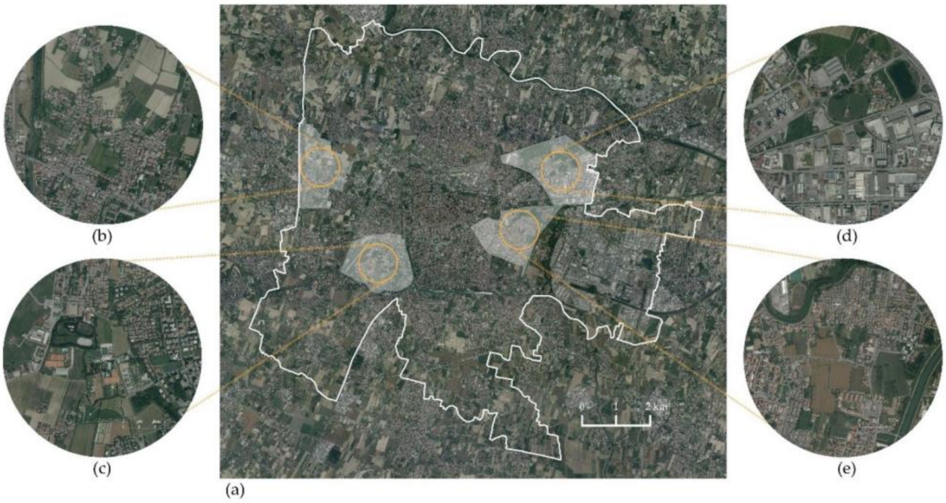
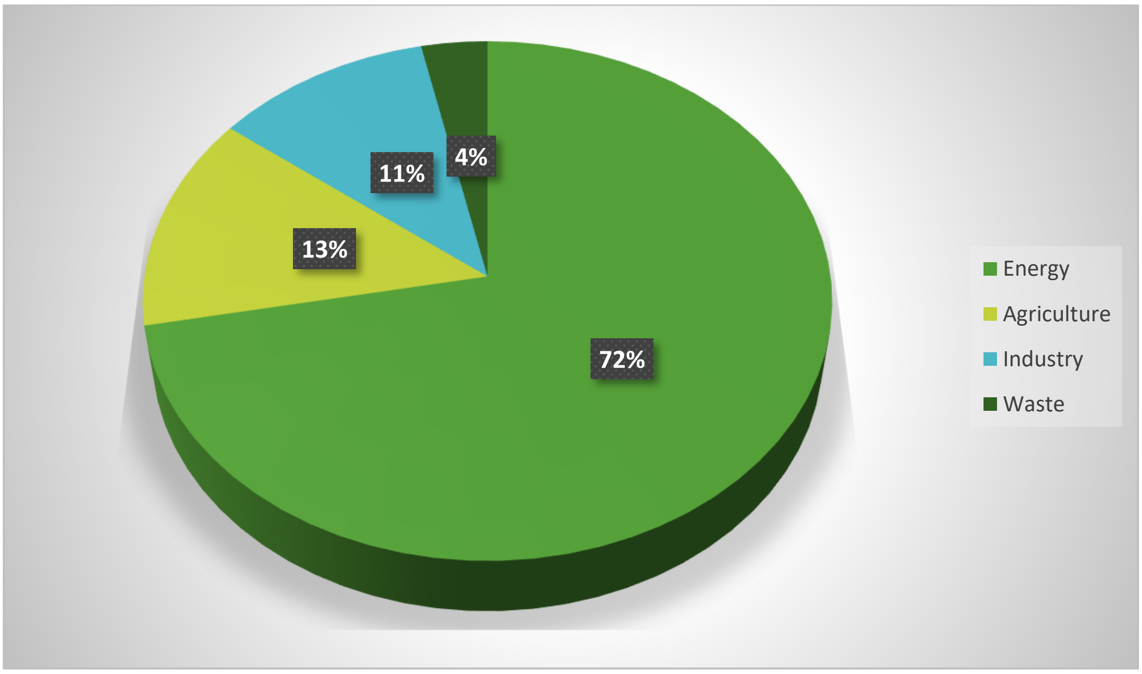


Figure 2. Padua Project

Population, energy usage, and economic production are all concentrated in cities across the world. Cities are thus carbon hotspots, with significant fossil fuel CO_2 emissions from energy use, ground transportation, and residential and commercial structures. Furthermore, industrial activity has increased around and inside cities in various locations, contributing to CO_2 emissions. Cities have the unique potential to minimize fossil fuel consumption by managing energy and materials among residences, companies, infrastructure, and industries in close proximity. A growing proportion of the world population is moving to cities, and this trend, which is especially prominent in emerging countries, will contribute to rising CO_2 emissions in the future decades. Mitigation in cities relies heavily on planning, technology, and behavioral changes. As a result, global cities are important locations to concentrate on in order to reduce global CO_2 emissions (Dhakal, 2010; Davies et al, 2011; Lahde and Di Marino, 2019).

The main causes of greenhouse gases that cause global climate change are the transition to modern social life after the industrial revolution and the use of fossil fuels, land cover/use change with the urbanization process, and waste production. According to the IPCC study report, the biggest greenhouse gas factors causing global warming are electricity, warming, industry, and transportation factors. The common point of these factors is that they lead to fossil fuel production. In this respect, the main determinant causing the use of fossil fuels is the need for energy and transportation (Ersoy Mirici, 2021).

The main cause of carbon emissions in Turkey is energy consumption as well as the rest of the world as presented on Graph 1. When the areas with the highest energy consumption in cities of Turkey are examined, it is seen that the industrial areas are responsible for the highest rate of energy consumption (Kahraman, 2019; TUIK, 2021).



Graph 1. Carbon emmissions according to the sectors in Turkey (2019)

Long-term removal, capture, or sequestration of carbon dioxide from the atmosphere to delay or reverse atmospheric carbon dioxide pollution and attenuate or reverse global warming consequences is known as carbon sequestration or carbon dioxide removal.The methods of carbon sequestration are (Baurov, 2021):

- Terrestrial Sequestration
- Ocean Sequestration
- Geologic Sequestration
- Mineral Sequestration
- Hydrodynamic Trapping

In cities, the amount of carbon emissions differ according to the land use types. It is a well known fact that industrial sites and transportation areas are both the most energy consumer and the carbon releaser components of the cities. Capturing the carbon released by these areas and breaking the spreading network of adverse effects caused by these are of great importance. The sites producing the greatest amount of carbon must be seperated from the other components of cities (Francis, 2013).

The most prevalent and natural means of collecting and storing carbon is through terrestrial sequestration. The entire procedure is carried out through photosynthesis. Plants take carbon dioxide from the air as they absorb and alter various important components for their growth. The carbon dioxide is then digested and stored in the plant's roots and stems. The carbon that is not used is eventually stored in the soil. Carbon is twice as abundant in a plant's stems and roots as it is in the air. The soil may also store up to 2.5 times the carbon that is found in living organisms. After the plant dies, the carbon cycle continues, and carbon mixes with oxygen as it joins the components of air. It returns to the atmosphere as carbon dioxide, which is utilised by other plants (Baurov, 2021).

More trees should be planted for two key reasons in order to minimize carbon emissions in the atmosphere: Trees take up more CO_2 from the atmosphere than smaller plants. Trees take a long time to release carbon into the atmosphere. As a result, trees are the most popular technique for combating global warming (Song et al, 2012).

2. MATERIALS AND METHODS

The study area is Çiğli district, located in the north of İzmir. Çiğli is located in the north of İzmir's gulf. It is surrounded by Menemen and Karşıyaka districts. The reason for choosing Çiğli district is that Atatürk Organized Industrial Zone, one of the important organized industrial zones of Izmir, Sasalı Bird Sanctuary, that is of great importance for our country, ramsar sites and residential areas of different qualities are located together.

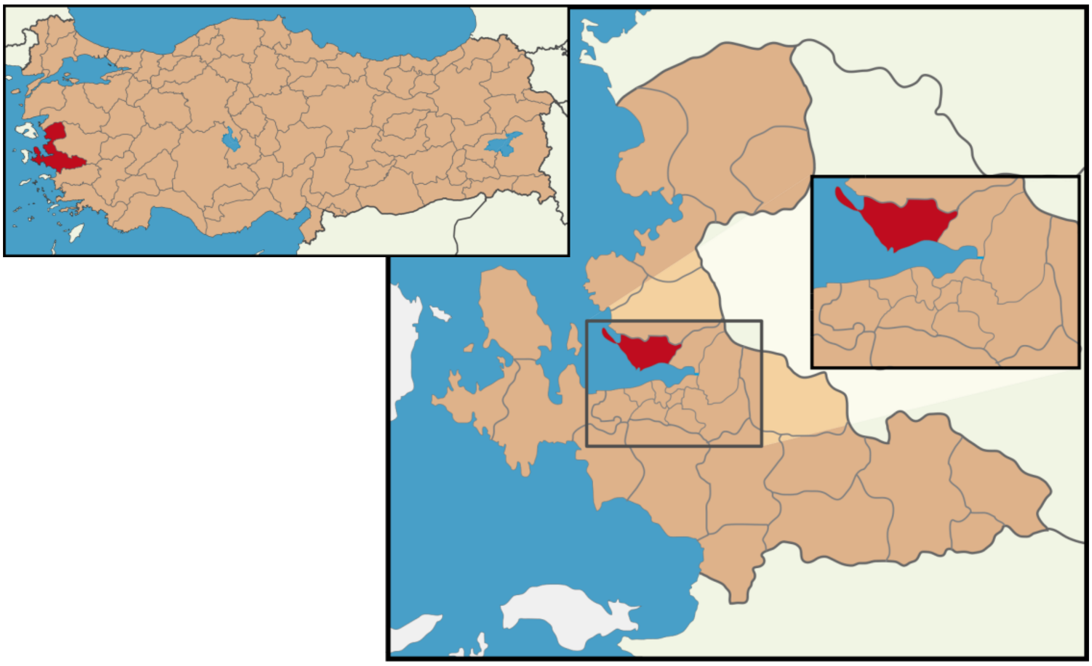


Figure 3: Study area

Carbon pollution is one of the main problems of urbanized areas, which leads to urban heat islands and serious diseases along with. Establishing carbon wells in suitable places in urban areas may reduce the amount of carbon and urban heat island effect in a region, which is a multifunctional way of mitigating climate change effects.

Çiğli district is a good sample to investigate the ways of reducing carbon amounts as the district has a combination of multiple land use types including residential and industrial areas, and the district has a wide range of new urbanizing areas and also it is reported that the air pollution values of the district is above the limits. Therefore, the purpose of this study was to provide a site selection plan of suitable areas for carbon wells using geographical information systems. Within the scope of the study, the contaminated areas were classified according to the contamination rates, and the areas with the need of carbon wells were mapped. Results of the study showed that it is possible to create multifunctional open green spaces that can serve as carbon wells in some parts of the district; however, in the majority of contaminated areas, the best solution is to improve the ecosystem services quality of existing open green areas.

Materials used for this study are Corine Land Cover 2018 data, Open Street Map road network, and Arcmap 10.4.1 for suitability analysis.

The study consists of 4 phases. The first phase is geodatabase design. In the first phase, we design geodatabase, Corine data, and Open Street Map data that are downloaded, clipped and reclassified for the study area. In the second phase, criteria are determined to locate carbon sinks. In the third phase, Rasters and fuzzificated maps are composed for every criterion taking into account the distance from landuses. And in last phase criteria combined and areas that need carbon well have been identified (Figure 4).

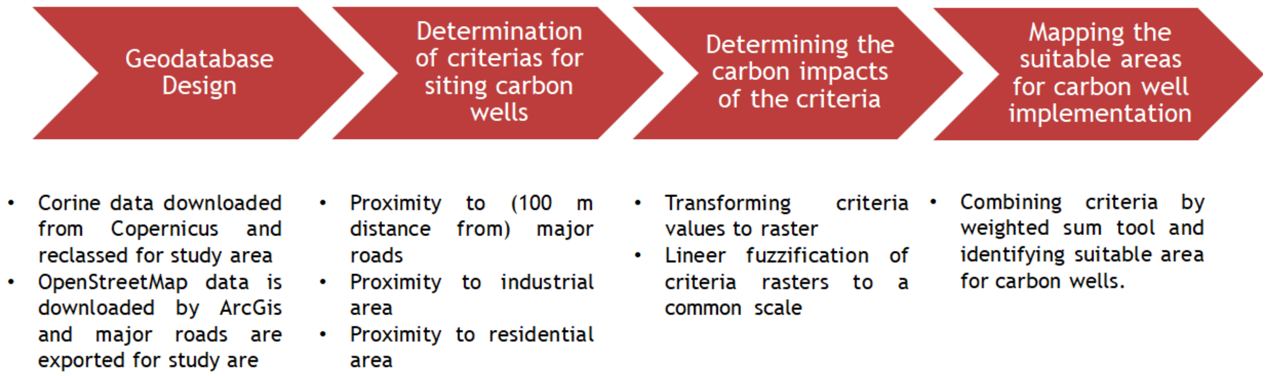


Figure 4: Phases

The study area for flood analysis was determined as Gediz Micro Basin and its surroundings, which is one of the most important wetlands. There are lagoons (Homa, Çilazmak, Kırdeniz), salt marshes on this area. Firstly, the digital elevation model (DEM) data with a resolution of 12.5 m was downloaded from the Alos Palsar data and the study area was revealed as the watershed boundary. After the watershed boundary was created, the micro-watershed boundary was determined by hydrology analysis using the Spatial Analyst Tool. With these data, soil, land use, lithology, precipitation, distance to the stream, elevation, slope and aspect data were prepared. Based on these, "reclassify" data was prepared. After the eight maps were created with the reclassification method, the areas with the highest flood risk were determined by the weighted overlay method using the ArcGIS 10.4 program.

3. RESULTS

3.1. Carbon Sinks in Çiğli

Corine 2018 data was collected from Copernicus and reclassified for the Çiğli district in the research. In Figure 5, large areas east and west of Cigli are green, agricultural and wetlands with no carbon emission effect. However, industrial and residential area, located in the middle of the district, are having a significant impact on these zero carbon landuses.

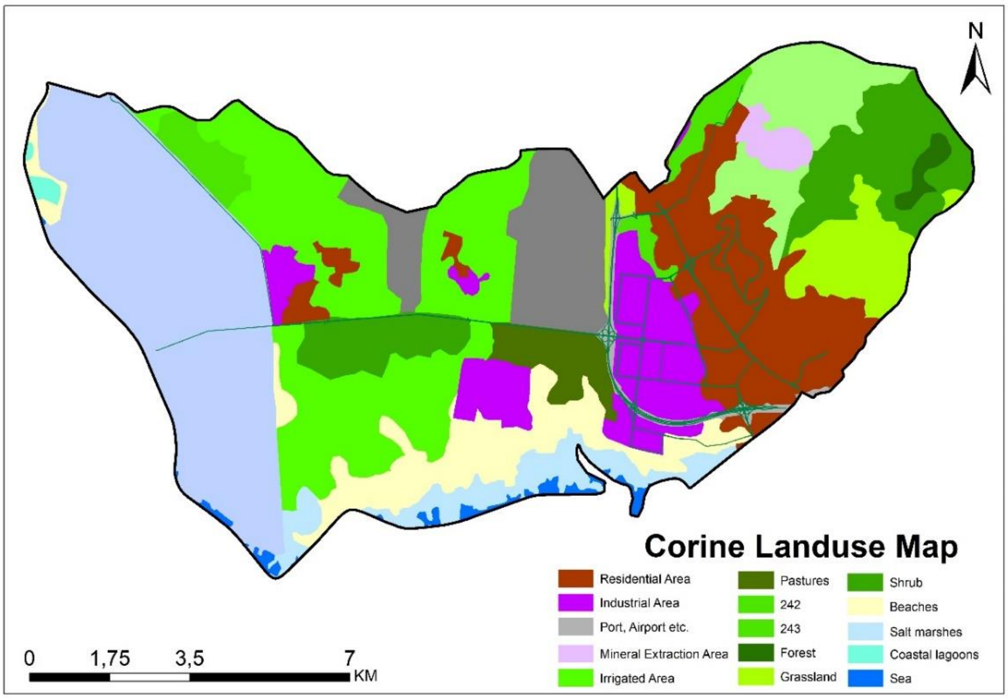


Figure 5: Corine Landuse Map

In the second phase, the location selection criteria of carbon sinks / land uses with high carbon emissions were determined as follows in line with the data available;

- Major roads carbon impact
- Industrial area carbon impact
- Residential area carbon impact.

Carbon impact maps of these criteria prepared by using the euclidean distance tool (Arcgis) to take into consideration the distance. Each criteria was transformed to raster. By using the linear function, it is assumed that the carbon effect decreases, when the distance increases from the land use that have high carbon emission.

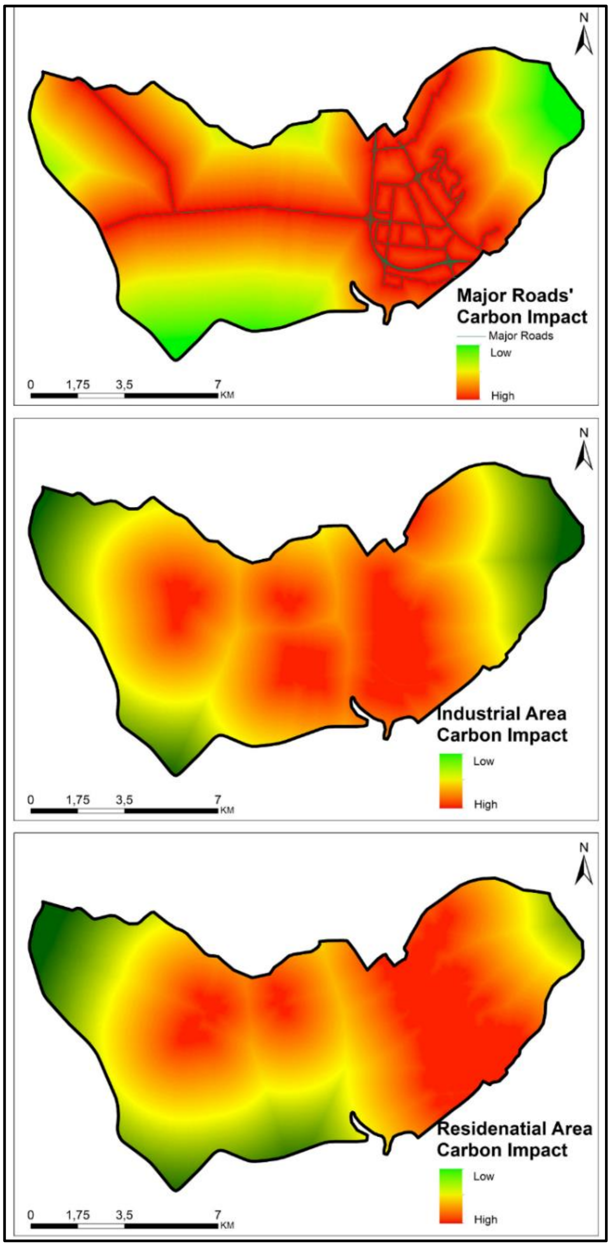


Figure 6: Carbon impact maps of criteria

In figure 6, the areas that are most impacted by carbon are depicted in red, while the areas that are least affected by carbon are displayed in green.

Fuzzy membership functions were used to rank factor layers within themselves in the preference analysis. Linear fuzzy membership function with proper parameters were performed to convert each preference factor to a common scale, as shown in Figure 7. Using the fuzzy membership tool, the carbon well need level is rated between 1 and 0 according to each criterion. The areas that are most suitable / need carbon sinks most are depicted in green, while the areas that are least suitable / need carbon sinks least are displayed in red.

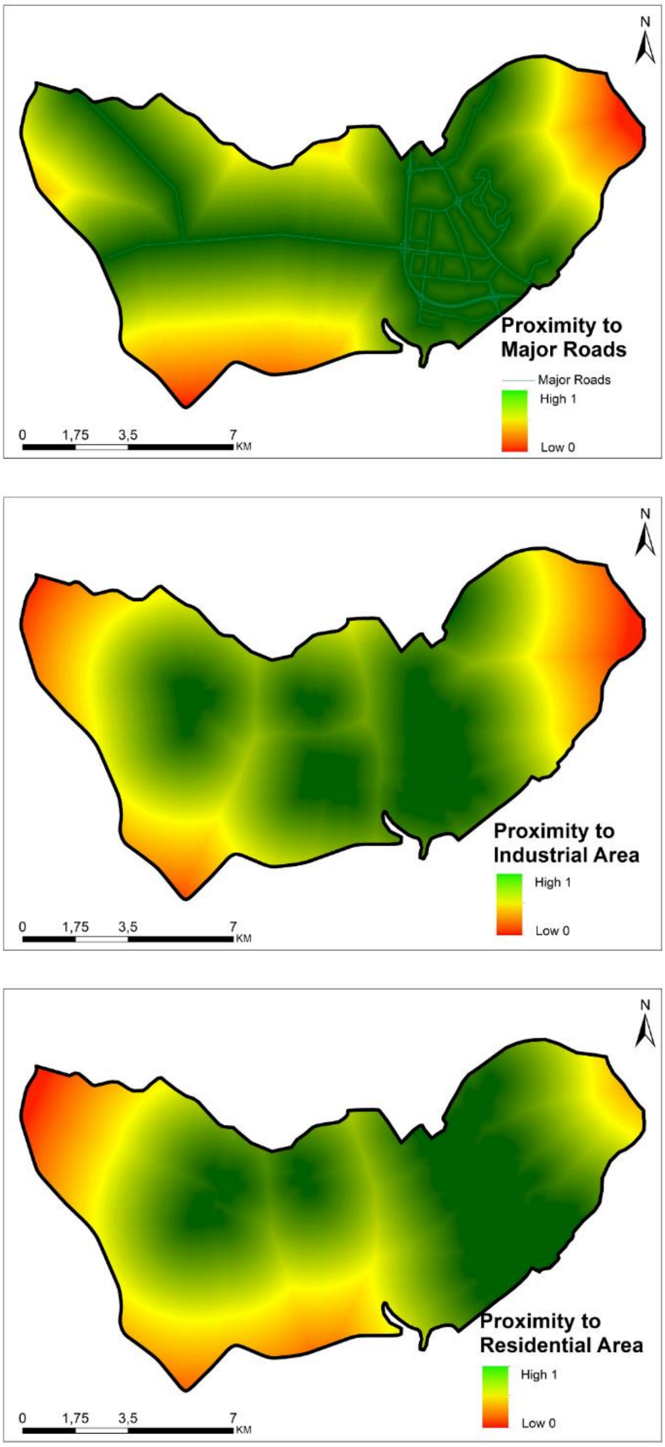


Figure 7: Fuzzied criteria maps

The weighted sum tool in ArcGIS was used to aggregate all of the criteria and build a suitability index map. The final land suitability map was in raster format with 5 m cell size resolution since the input fuzzified rasters were prepared in 5 m cell size resolution. The regions over the suitability index threshold value were then identified as carbon well sites.

At suitibility phase all criteria have been accepted with equal weight. The index of the areas that need carbon well most has been realized as 3 and the index of the areas that need it least has been realized as 0. Accordingly, in figure 8, areas with an index greater than 2.5 are mapped as areas that need carbon well.

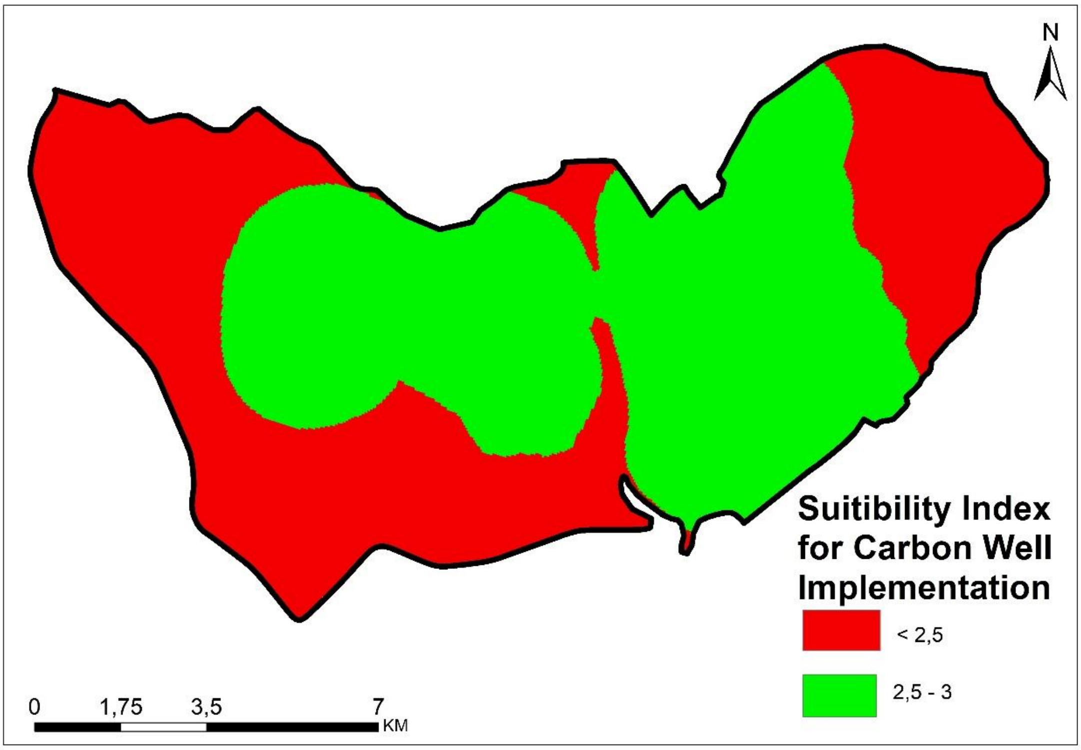


Figure 8: Suitibility index map

3.2. Flood Risk in Çiğli

The flood risk, which is one of the most important consequences of climate change, constitutes an important risk area throughout Çiğli district. There are flood risks arising from excessive rain, overflow of streams and seas. There is a risk of flooding due to excessive rain throughout Çiğli. Within the scope of the study, the flood risk calculations were prepared with the weighted overlay method in the ArcGIS 10.4 program according to the analytical hierarchy method of eight maps, including slope, aspect, elevation, soil, land use, lithology, distance to the stream and precipitation (Figure 9). According to these data, it has been observed that the rate of flood risk is high in a large part of the Çiğli district (Figure 10).

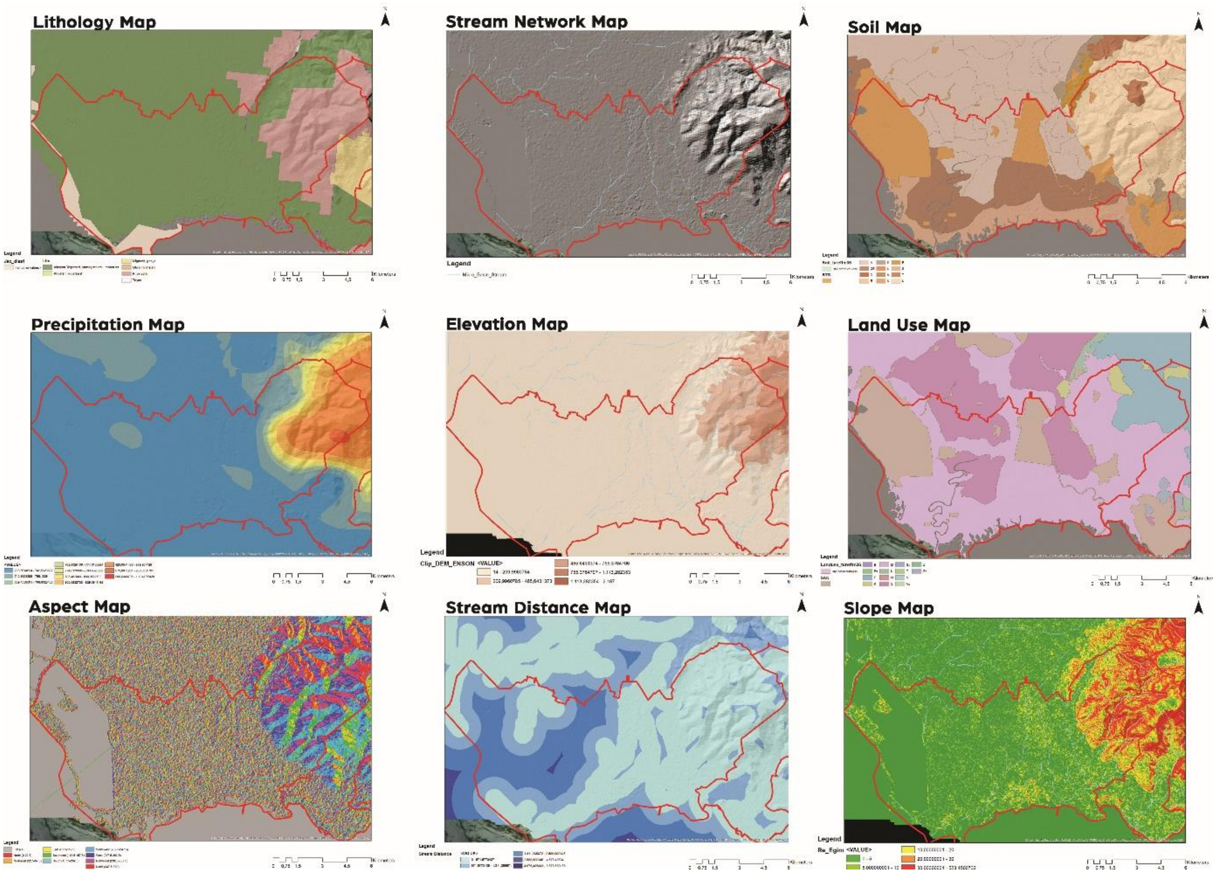


Figure 9: Slope, aspect, elevation, soil, land use, lithology, distance to the stream and precipitation

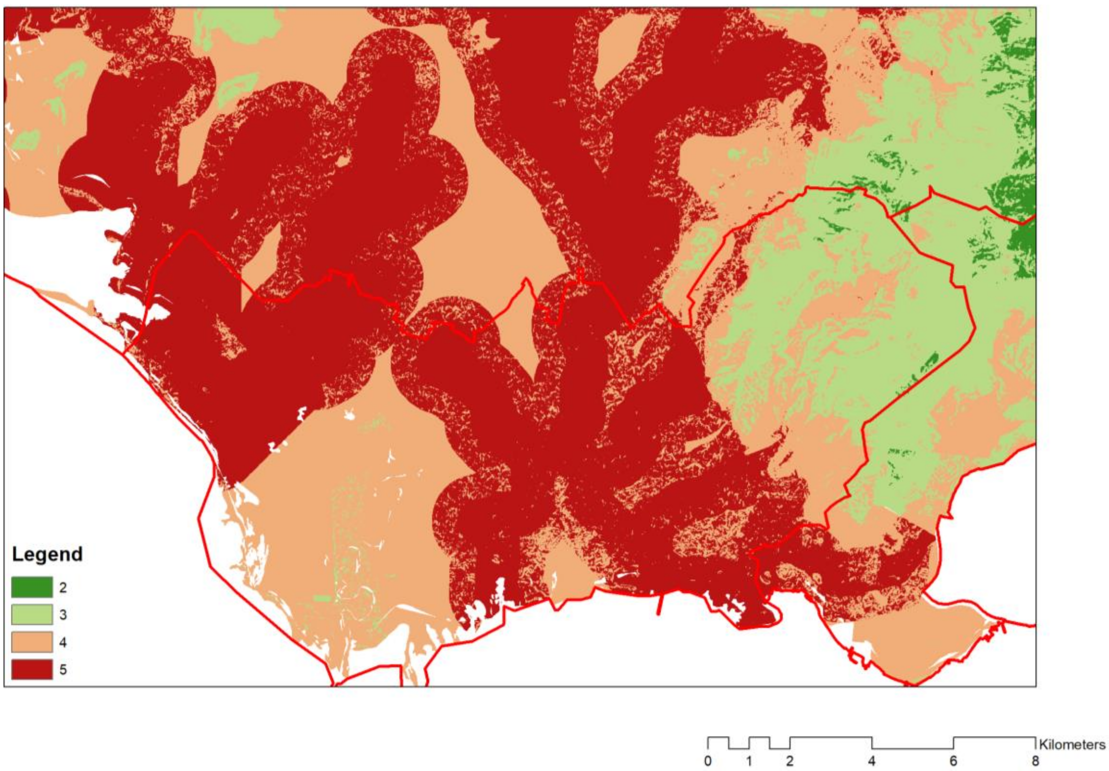


Figure 10: Flood Risk Area with weighted overlay method

4. CONCLUSION

Climate change is one of the most important dangers of this period. With this concept, the unlimited use of natural resources has begun to come to an end. Planning and design professional groups such as landscape architects, city planners and architects have started to produce designs suitable for nature. At the end of the 1800s until the 2020s, various movements were developed and project studies were carried out. In addition to these, landscape performance analyzes have increased in each important study. Spaces such as carbon areas, areas with heat island effect and flood areas throughout the city have been determined and design and planning studies have started to be prepared in accordance with these analyses. Within the scope of flood areas, the places with the highest flood risk in Çiğli district were determined. According to this analysis, some parts of Çiğli are areas where the flood risk is very high. Project works in which rain water is drained occupy an important place. Rain gardens, rainwater gardens, sponge parks, rainwater harvesting systems stand out as important design tools for flood reduction.

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