GIS-based multicriteria decision analysis for settlement areas: a case study in Canik

Cem Kilicoglu

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Abstract
In addition to global population growth due to migration from rural areas to urban areas, population density is constantly increasing in certain regions, thereby necessitating the introduction of new settlements in these regions. However, in the selection of settlement areas, no sufficient preliminary examinations have been conducted; consequently, various natural disasters may cause significant life and property losses. Herein, the most suitable settlement areas were determined using GIS (geographic information systems) in Canik District, where the population is continuously increasing. Therefore, this study aimed to incorporate a new perspective into studies on this subject. Within the scope of the study, landslide and flood risks, which are among the most important natural disasters in the region, were primarily evaluated, and high-risk areas were determined. Elevation, slope, aspect, curvature, lithology, topographic humidity index (TWI), and proximity to river parameters were used to produce flood susceptibility maps. A digital elevation model (DEM) of the study area was produced using contours on the 1/25,000 scaled topographic map. The elevation, slope, aspect, curvature, and TWI parameters were produced from the DEM using the relevant analysis routines of ArcGIS software. The raster map of each parameter was divided into 5 subclasses using the natural breaks classification method. In the reclassified raster maps, the most flood-sensitive or flood-prone subclasses were assigned a value of 5, and the least sensitive subclasses were assigned a value of 1. Then, the reclassified maps of the 7 parameters were collected using the “map algebra” function of ArcGIS 10.5 software, and the flood susceptibility index (FSI) map of the study area was obtained. The flood susceptibility map of the study area was obtained by dividing the FSI into 5 subclasses (very low, low, moderate, high, and very high) according to the natural breaks classification method. Thereafter, suitable and unsuitable areas in terms of biocomfort, which affects people’s health, peace, comfort, and psychology and is significant in terms of energy efficiency, were determined. At the last stage of the study, the most suitable settlement areas that were suitable in terms of both biocomfort and low levels of landslide and flood risks were determined. The calculated proportion of such areas to the total study area was only 2.1%. Therefore, because these areas were insufficient for the establishment of new settlements, areas that had low landslide and flood risks but were unsuitable for biocomfort were secondarily determined; the ratio of these areas was calculated as 56.8%. The remaining areas were inconvenient for the establishment of settlements due to the risk of landslides and floods; the ratio of these areas was calculated as 41.1%. This study is exemplary in that the priority for the selection of settlement areas was specified, and this method can be applied for selecting new settlements for each region considering different criteria. Due to the risk of landslides or flooding in the study area, the areas unsuitable for establishing a settlement covered approximately 41.1% of the total study area. The areas that had low flood and landslide risks but were suitable for biocomfort constituted only 2.1% of the study area. In approximately 56.8% of the study area, the risk of landslides or floods was low, and these areas were unsuitable in terms of biocomfort. Therefore, these areas were secondarily preferred as settlement areas. The most suitable areas for settlements constituted only 0.19% of the total study area, and these areas will not be able to meet the increasing demand for settlement area. Therefore, it is recommended to select areas that do not have the risk of landslides and floods but are unsuitable for biocomfort. This study reveals that grading should be performed in the selection of settlement areas. When choosing a settlement area in any region, possible natural disasters in the region should be identified first, and these disasters should be ordered in terms of their threat potential. Moreover, biocomfort areas suitable for settlements should be
considered. In the next stages of settlement area selection, the criteria that affect the peace and comfort of people, such as distance to pollution sources, distance to noise sources, and proximity to natural areas, should also be evaluated. Thus, a priority order should be created for the selection of settlement areas using various other criteria.

**Keywords** Canik · Settlement area selection · Landslide · Flood · Biocomfort

**Introduction**

The industrial revolution that occurred in the last century caused many problems worldwide. The industrial revolution, mechanization, modernization in agriculture, and changes and diversification in the industry and service sectors have reduced the need for labor in agricultural areas but have increased opportunities in urban centers. This process has caused people to migrate from rural areas to urban areas, and population density has started to increase rapidly in urban centers where there are more job opportunities (Cetin 2016a, b, 2020a, b; Sevik et al. 2020; Türkylıma et al. 2020; Cetin et al. 2020; Bozdogan Sert et al. 2021).

In addition to global population growth, migration from rural areas to urban areas has led to congestion in urban areas. The total world population in the 1900s was only approximately 700 million, and approximately 9% of the population lived in urban areas; conversely, the world population exceeded 7.8 billion in 2020, and the proportion of the population living in urban areas increased to 56%. It is estimated that the global population will exceed 8.5 billion by 2030, and the proportion of the population living in urban areas may reach 90%. In Turkey, the proportion of the population living in urban areas has reached 92.5% (Cetin 2019; Şen et al. 2018; Cetin 2020a, b; Aricak et al. 2020; Sevik 2020).

The population concentration in urban areas has reached such a serious level in the twenty-first century, and the world faces two major irreversible and inevitable problems: climate change caused by human activities and unrestricted urban sprawl (Cetin 2015a,b,c, 2016a,b; Cetin and Sevik, 2016; Bozdogan Sert et al. 2019; Ozel et al. 2020, 2021; Varol et al. 2021; Cetin et al. 2019a, b; Cetin et al., 2018a, b). Moreover, planning deficiencies in urban areas cause many problems, such as infrastructure problems, unhealthy living conditions, high traffic density, and environmental pollution (Aricak et al. 2019; Kılıçoğlu et al. 2020; Cesur et al. 2021). One of the most significant problems caused by unplanned urbanization is the loss of life and property as a result of various disasters. Natural disasters are the greatest threat to the supply of safe shelters. A disaster is a situation that disrupts, interrupts, or stops the normal functioning of natural and cultural resources and people. Despite the current development, disasters can cost hundreds of lives and billions of USD in financial losses every year (Kılıçoğlu et al. 2021).

Many researchers study landfills worldwide using the MCDM (multi criteria) technique and combine it with other methods using efficient GIS tools for environmental and urban planning (Cetin 2015a,b,c; Cetin 2016a,b; Zarin et al. 2021; Khan et al. 2020; Sinha et al. 2008; Sundaram et al. 202; Cetin et al. 2019a,b; Cetin et al. 2021; Sahin et al. 2021; Pekkan et al., 2021; Onac et al. 2021). The relevant map of each factor was prepared using fuzzy methods. The fields that are suitable were based on the literature review, and the appropriate method was not used in the comparison of different criteria and sub-criteria factors. Therefore, the probability of positive factors exceeding the least positive factors was at a maximum (Zarin et al. 2021; Khan et al. 2020; Cetin et al. 2021; Sahin et al. 2021; Pekkan et al., 2021; Onac et al. 2021).

Recent researchers have used the analytical hierarchy process using geographic information systems to study processes such as landslides, seismic hazard assessments, and floods; and maps have been separately created and combined further to create a multi-hazard map that shows and evaluates the potential suitability map for urban development (Bathrellos et al. 2017). Bathrellos et al. (2012) used GIS in Trikala Thessaly, Greece, to determine natural hazard maps and geological-geomorphological parameters for land uses (Bathrellos et al. 2012) in the in-depth application of GIS, and RS technique is an important technical tool for identifying sediment transport processes at different spatiotemporal scales and provides more reliable predictions of water and soil erosion that determine the important physical mechanisms and describe the identification of heavily eroded terrains and the spatial processes of erosion (Cetin et al. 2021; Wu et al. 2021; Sundaram et al. 2021; Sahin et al. 2021; Pekkan et al., 2021; Zeren Cetin et al. 2020).

Davoudi Moghaddam et al. (2020) reported that the validation stage of the model’s results stems from the fact that there might not be a precise and generalizable concept of a suitable landfill site in the first place. In other words, validation of the landfill suitability map can be carried out by identifying actual landfill sites that have been proven to be perfectly selected in terms of geo-topological criteria and resident qualification metrics (Davoudi Moghaddam et al. 2020).

Planned urbanization is one of the most effective methods against natural disasters. Through the use of preliminary studies, performing risk analyses in each...
region to establish settlement units in the most risk-free areas in terms of natural disasters will prevent the loss of lives and property in the event of a disaster. This study attempted to identify criteria that can be considered for determining the most suitable areas to be introduced as new settlements in the Canik District of Samsun Province, where the population has started to increase significantly in recent years. Within the scope of the study, areas at risk of floods and landslides, i.e., the most important disaster types in the region, were primarily determined. Thereafter, suitable areas were determined in terms of biocomfort, which directly affects human comfort and well-being and is highly effective in terms of energy consumption. Consequently, the most suitable potential areas for settlements depending on these parameters were determined.

**Materials and methods**

**Study area**

This study was conducted at the scale of Canik District, which is one of the most important districts in Samsun and one of the largest cities in Turkey. Canik is very attractive due to its location and social opportunities. The population is constantly increasing because of its highly favorable climate conditions. Therefore, introducing new settlement areas in this district is imperative. The geographical location of Canik District, which was chosen as the study area due to the abovementioned factors, is shown in Fig. 1. According to the Address-Based Population Registration System, the population of Canik was 101,253 in 2020, and the annual growth rate of the population was 21%. The district is between 41°
4′ 4.5″–41° 16′ 44.6″ N and 36° 12′ 2.89″–36° 24′ 13.35″ E and has an area of 262 km².

Methods

Within the scope of the study, landslide susceptibility maps of the study area, followed by flood susceptibility and biocomfort suitability maps, were created. In the last stage, areas that were suitable and unsuitable for settlement due to landslides and floods were determined. Moreover, these areas were combined with the biocomfort maps, and the final settlement area suitability map was created.

The elevation, slope, aspect, curvature, lithology, topographic humidity index (TWI), and proximity to river parameters were used to produce flood susceptibility maps. A digital elevation model (DEM) of the study area was produced using contours on the 1/25,000 scaled topographic map. The elevation, slope, aspect, curvature, and TWI parameters were produced from the DEM using the relevant analysis routines in ArcGIS software. The raster map of each parameter was divided into 5 subclasses using the natural breaks classification method. In the reclassified raster maps, the most flood-sensitive or flood-prone subclasses were assigned a value of 5, and the least sensitive subclasses were assigned a value of 1. Then, the reclassified maps of the 7 parameters were collected using the “map algebra” function in ArcGIS 10.5, and the flood susceptibility index (FSI) map of the study area was obtained. The flood susceptibility map of the study area was obtained by dividing the FSI into 5 subclasses (very low, low, moderate, high, and very high) according to the natural breaks classification method.

Creation of landslide susceptibility maps

In this study, the 1:100,000 scale geological and 1:25,000 scale landslide inventory maps obtained from the General Directorate of Mineral Research and Exploration and the 1:25,000 scale topographic maps obtained from the General Directorate of Mapping were used. A 10-m resolution digital elevation model (DEM) of the study area was produced in ArcGIS 10.5 using contour lines on digital topographic maps. Thematic maps of the factors used in the creation of the landslide susceptibility maps were derived from this DEM. The model that was used to produce the landslide susceptibility maps was processed in R 3.6.3.

Landslide inventory maps are the basic data for landslide susceptibility analysis. A landslide inventory map is a systematic map that contains information about the spatial distribution and type of landslides. To predict the landslides that may occur in the future, first, the basic features of the landslide areas shown in the inventory map should be determined (Erener and Düzgün 2010). Three basic methods named statistics, software (soft computing), and the combination of index maps (Akgun et al. 2012) are used to produce medium-sized landslide susceptibility maps using GIS. In the present study, a 1/25,000 scaled landslide inventory map produced by the General Directorate of Mining Research and Exploration (GDMRE) in 2007 was used. With regard to their activities, 13 of the 20 landslide polygons shown in the landslide susceptibility map were considered old landslides, and 7 of them were considered active landslides.

Figure 2 shows eight different lithological units in the study area. The oldest unit in the field is the Upper Cretaceous Cankurtaran Formation (Kc); it comprises the alternation of sandstone, marl, and shale. The Upper Cretaceous–Paleocene Akveren Formation (Kta) includes limestone, sandy limestone, marl, sandstone, siltstone, claystone, mudstone tuff, tuffite, and dacite units. The Atbaşı Formation (Tpea), which is a unit comprising sandstone, shale, marl, and mudstones, dates back to the Upper Paleocene–Lower Eocene.

The Middle Eocene-aged Kusuri Formation (Tek) comprises marl, sandstone, siltstone, limestone, and calcareous sandstone. Moreover, the Middle Eocene-aged Tekkeköy Formation (Tet) was observed in the field with interbedded basalt, andesite, tuff, agglomerate, tuffite, sandstone, marl, and siltstone levels. Upper Miocene–Pliocene-aged Mahmurdاغ Volcanites (Tmplm) were observed in the study area as basalt, andesite, agglomerate, and tuff, as well as dikes and sills. Two Quaternary units exist in the study area: Qal, with clay, silt, sand, and gravel; Qt represents the current flood plain (Keskin 2011; Akinci et al. 2017).

Nine different parameters were used in the study: elevation, slope, aspect, TWI, curvature, lithology, distance from a drainage network (m), and distance from roads (m). The factor maps prepared in ESRI ArcGIS 10.5 were converted to raster format with a spatial resolution of 10 m. Factor maps are presented in Figs. 3 and 4.

Landslide susceptibility assessment using a random forest (RF) model

Breiman (2001) was the first to develop the classification and use of several decision tree models simultaneously in regression problem solving and apply them to collective learning algorithms. RF methods have been frequently used in GIS-based landslide susceptibility mapping studies (Youssef
et al., 2016; Taalab et al. 2018; Kim et al. 2018; Hong et al. 2019; Nhu et al. 2020).

To apply the RF model in this study in ESRI ArcGIS 10.5 software, all factor maps were converted to raster format with a cell size of 10 m × 10 m. For the training and validation of the model, “landslide (or positive)” and “landslide-free (or negative)” samples were created. In the study area, the same numbers of “landslide” and “landslide-free” samples were randomly selected. Positive samples were given a value of “1”, and negative samples were given a value of “0” (Akinci et al. 2020). Seventy percent of this dataset was used for training the model, and the remaining 30% was used for the validation of the model. The RF model was implemented in R 3.6.3 using the caret package (Kuhn 2008).

**Creation of flood susceptibility maps**

Climate change, which has a global impact, has increased flood risks; and especially in the last decade, this increase has necessitated urban flood risk analysis. The rapid increase in irregular urbanization has negatively affected social life and caused loss of economy and lives (Lee et al. 2012; Yin et al. 2015; Rahmati et al. 2016; Gigović et al. 2017). In recent years, flood susceptibility maps have been produced using various GIS-based methods (Bapalu and Sinha 2005; Sinha et al. 2008; Samanta et al. 2018; Wang et al. 2019a,b; Souissi et al. 2020). Floods are not only destructive but also trigger landslides. Therefore, appropriate site selection and planning are necessary by producing combined hazard susceptibility analyses using multi-hazard susceptibility assessment and GIS (Skilodimou et al. 2019; Yanar et al. 2020).

In the study area, on July 04, 2012, 12 people lost their lives due to the overflowing waters of Yılanlı Creek, a branch of the Mert River; moreover, as a result of İncirli Creek overflow, the shopping center built on the creek was flooded. In this study, flood susceptibility maps were obtained from a 1/25,000 scaled standard topographic map. Stream and contour lines on the topographic map were digitized using ArcGIS 10.5, and primarily, a DEM of the study area was produced. After the DEM was converted to the ESRI GRID format, the elevation aspect and topographic humidity index maps of the study area were produced. Thereafter, maps were produced based on a 250-m buffer.
zone for the stream digitized from the 1/25,000 scaled standard topographic map.

While determining the limit weight values of the regions in the susceptibility model, a natural breaks classification method was used. The study area was divided into five classes: “very low (1), low (2), medium (3), high (4), and very high (5).”

**Creation of biocomfort suitability maps**

To create biocomfort maps, long-term climate parameters were obtained from all meteorology stations in and around the study area. Wind speed, humidity, and temperature data obtained from the meteorology stations were processed using ArcGIS 10.5, and climate maps were created with an
interpolation method using the inverse distance weighted (IDW) command in this software.

The IDW technique is an interpolation technique used to determine the cell values of unsampled points using the values of known sample points. The cell value is calculated by considering various point distances from the relevant cell and subjecting the increase in the distance. The estimated values are a function of the distance and size of the neighboring points, and as when the distance increases, the importance and effect on the cell to be estimated decrease. The formula used in the calculations is given below (Mueller et al. 2004; Taylan and Damçayırı 2016; Cetin 2019, 2020a,b; Cetin et al. 2018a):

$$z(x_0) = \frac{\sum_{i=1}^{n} z(x_i) d_{r0}^{-r}}{\sum_{i=1}^{n} d_{r0}^{-r}}$$

The location $X_0$ for which the estimations are performed is a function of neighbor measurements ($z(X_{0i})$ and $i = 1, 2, ..., n$); $r$ is the exponent determining the assigned range of each observation; and $d$ is the distance separating the observed location $X_i$ from the estimated location $X_0$. The larger the exponent is, the smaller the assigned weight of observations that are distant from the estimation location. An increase in the exponent indicates that the estimations are very similar to the closest observations. The mathematical formulas were as described above; they were computed in the ArcGIS environment, which is GIS software, and the maps were produced. This method has also been used in several previous studies (e.g., Setianto and Triandini 2013; Taylan and Damçayırı 2016; Cetin et al. 2018a; Qu et al. 2019; Golla et al. 2019).

Furthermore, the climate maps obtained for the creation of biocomfort maps were reclassified using the Reclassify command in ArcMap 10.5. Comfortable areas were determined using the biocomfort index formula on the obtained classified climate maps. The index used by Cetin et al. (2018a) was considered a basis for the biocomfort index. According to this index, a region is considered comfortable if the temperature is 15–27 °C, the relative humidity is 30–70%, and the wind speed is below 5 m/s (Cetin 2020a, b).

![Fig. 4 Landslide-conditioning factor maps. a Topographic wetness index. b Distance to road map. c Distance to drainage map. d CORINE map](image-url)
General evaluation

In the final stage of the study, a settlement area suitability map was created by overlapping the landslide, flood, and biocomfort maps. At this stage, the areas that were at risk for landslides or floods were specified as unsuitable areas for settlements. Areas that had low landslide and flood risks but were suitable for biocomfort were specified as being fit for settlements, whereas areas that had low landslide and flood risks but were unsuitable for biocomfort were specified as areas where settlements could be established when necessary.

Results

The risk group maps created according to the landslide situation within the scope of the study are given in Fig. 5. When the landslide status of the study area was examined, approximately 99.03% of the study area was a landslide-free zone. Only 0.23% of the total area was an active landslide zone and 0.74% was a passive landslide zone. The areas at risk of landslides were in small groups, and they were concentrated in the northwestern part of the district. A map showing the flood susceptibility status of the study area is presented in Fig. 6.

In the study area, when the areas at the risk of flooding were examined, approximately 35.25% of the study area was of the 1st grade, 31.59% was of the 2nd grade, 22.32% was of the 3rd grade, 10.33% was of the 4th grade, and 0.51% was of the 5th grade lands. The flood risk was at a very low level in the 1st and 2nd class lands, at a medium level in the 3rd class lands. Areas with high or moderate flood risks were considered unsuitable for construction, and areas that were suitable and unsuitable for construction in terms of flood risks are presented in Fig. 6.

As shown in Fig. 6, most of the study area was unsuitable for construction, and the flood risk in these areas was high or moderate. According to the performed calculations, approximately 66.84% of the study area was unsuitable for construction because of the flood risks. The areas suitable and unsuitable for biocomfort in the study area are shown in Fig. 7. In the biocomfort map, the suitable and unsuitable areas were assigned pixel values of “1” and “5”, respectively.

As shown in the biocomfort suitability map of the study area, only a small part of the district, which is located on the northern side, was suitable for biocomfort; this area constituted only 2.3% of the total study area. Approximately 97.7% of the study area was unsuitable in terms of biocomfort. The landslide susceptibility, flood susceptibility, and biocomfort suitability maps in raster format were collected using the map algebra function in ArcGIS 10.5. On the obtained map, the index values varied between 3 and 15. The index value of this map was divided into three classes with equal intervals, and the settlement suitability map shown in Fig. 8 was obtained.

Due to the risk of landslides or flooding in the study area, the areas unsuitable for establishing a settlement covered approximately 41.1% of the total study area. The areas that had low flood and landslide risks but were suitable for biocomfort constituted only 2.1% of the study area. In approximately 56.8% of the study area, the risk of landslides or floods was low, but these areas were unsuitable in terms of biocomfort.
Therefore, these areas are secondarily preferred as settlement areas.

**Conclusion and discussion**

The concentration of the global population in urban centers necessitates the introduction of new settlement areas in certain regions. However, the fact that natural disasters are not sufficiently considered when selecting new settlement areas causes thousands of people to die and causes enormous material damage. Landslides, one of the natural disasters of concern, cause great damage and loss of lives every year around the world.

When evaluated on a global scale, an area of 3.7 million km² is exposed to landslides, and approximately 300 million people live in these areas. When examining at the European and Central Asian scales, the highest number of people exposed to landslides live in Turkey. In the last 50 years, 13,494 landslides have occurred in Turkey, and the total number of disaster victims affected by landslides has been recorded as 59,345 (Fidan 2019).

The main reason why landslides are extremely dangerous is that they can occur in a short period of time and can cause many casualties. For example, on July 5, 1929, 148 people lost their lives as a result of the landslides that occurred around the districts of and Sürmene in Trabzon Province due to heavy rainfall that lasted for days (Fidan 2019). Although landslides can occur in almost every region of Turkey, the Black Sea region is the most susceptible to landslides. This is because the Black Sea region has a mountainous topography, receives heavy rainfall, and is close to the North Anatolian Fault Line (Kilicoglu et al. 2020).

Bathrellos et al. (2012) used GIS in Trikala Thessaly, Greece, and reported the potential suitability of Trikala Province (Thessaly, Central Greece) for urban growth and industrial development, and relevant maps were produced using natural hazard maps and geological-geomorphological parameters. Areas suitable for the land uses were determined (Bathrellos et al. 2012).

Floods, which were among the natural disasters evaluated within the scope of this study, are disasters that can affect extensive areas and cause great material damage. Approximately 3 million people lost their lives in flood events that occurred between 1900 and 2008 worldwide; additionally, 2 billion people were affected, and the cost of material damage was approximately 200 billion USD. Approximately 49% of the 560 thousand people who lost their lives as a result of various natural disasters (e.g., floods, earthquakes, fires, storms, and volcanic eruptions) in the last 20 years died due to floods and overflows (Dölek 2013).

Floods and overflows, similar to landslides, can cause the loss of several lives in a short period of time and result in great material damage. It has been reported that Hurricane Harvey and subsequent flooding in the USA damaged more than 204,000 buildings and caused approximately 125 billion USD in losses; the flood that occurred in Pakistan’s eastern Hindu Kush region in 2010 killed approximately 1800 people and cost tens of billions of USD; and the floods that occurred in China in 2010 caused approximately 50 billion USD in damage (Mukherjee and Singh 2020; Mahmood et al. 2019).
Floods and overflows are frequently seen in Turkey and can cause a significant loss of life and material. In the 695 flood events that took place in Turkey between 1975 and 2010, 634 people died, 810,000 ha of land was submerged, and approximately 3.7 billion USD of material damage occurred (Dölek 2013). Moreover, the frequency of flood and overflow events will increase in the coming years in Turkey, which is among the countries that will be most affected by global climate change (Demirbaş and Aydin, 2020; Cetin 2020a, b).

Although landslides, floods, and overflows threaten the safety of the life and property of people, flood and overflow risks are not adequately evaluated during the selection of settlement areas; consequently, significant material damage and loss of life may occur due to landslides, floods, and overflows. However, most of these losses can be prevented
by conducting preliminary studies on the selection of suitable settlement areas.

Another criterion to be considered in the selection of settlement areas is biocomfort. In short, biocomfort, which can be explained as the environmental conditions (temperature, wind speed, and humidity) in which people feel comfortable, is of great importance, especially in terms of energy consumption; moreover, it affects people’s health, comfort, productivity, and psychology (Adiguzel et al. 2020, 2021; Cetin 2019; Gungor et al. 2021).

People use various heating and cooling devices to create appropriate biocomfort conditions in their environment; consequently, the amount of energy spent varies significantly depending on the preferred biocomfort conditions. It is estimated that worldwide energy consumption will be approximately 60% higher in 2030 than it is today, and this increase will be 100% in Turkey. In this energy consumption, the amount spent on heating and cooling comprises a significant proportion (Cetin et al. 2018a; Zeren Cetin and Sevik 2020; Zeren Cetin et al. 2020; Adiguzel et al. 2020, 2021). Therefore, the establishment of settlement areas in places with suitable biocomfort is of great importance for energy efficiency as well as for human health, comfort, happiness, productivity, and psychology (Potchter et al. 2018).

In the selection of settlement areas, identifying the safe areas relative to natural disasters in the region should occur first and then the suitable areas in terms of biocomfort should occur next. However, the number of studies conducted on the selection of settlement areas is almost nonexistent. In the case studies conducted on this subject, Kilicoglu et al. (2020) identified the risk of floods and overflows from natural disasters, protected areas, high-voltage energy transmission lines, and suitable areas in terms of biocomfort in Bafra; according to these criteria, he stated that only 1.96% of the total study area was suitable for use as settlement areas. In another study conducted in Atakum, after the calculations performed considering the landslide and flood risks and the consideration of high-voltage energy transmission lines and biocomfort, it was calculated that only 15.11% of the study area was suitable for use as settlement area (Kilicoglu et al. 2021). In contrast, the present study stands out as it is one of the first studies in which priority ranking is considered in the selection of settlement areas.

**Recommendations**

In addition to global population growth due to migration from rural to urban areas, population density is constantly increasing in certain regions, thereby necessitating the introduction of new settlements in these regions. However, in the selection of settlement areas, no sufficient preliminary examinations have been performed; consequently, various natural disasters can cause significant losses of life and property. In this study, the most suitable settlement areas were determined according to GIS in Canik District, which is a settlement area where the population is constantly increasing.

Within the scope of the study, areas at risk of landslides and floods, which are among the most likely natural disasters to occur in the region, were identified. Thereafter, suitable areas were determined in terms of biocomfort, which is highly important in terms of energy efficiency as well as human health, peace, and psychology, and the most suitable areas for settlements were determined. In the conclusion of the study, the areas that should not be established as settlements because of their high risk of landslides or floods in the region were identified. Moreover, the areas that had low landslide and flood risks that were also suitable for biocomfort, i.e., the areas that were most suitable for settlements, were determined. However, the most suitable areas for settlements constituted only 0.19% of the total study area, and these areas cannot meet the increasing demand for settlement area. Therefore, we recommend selecting areas that do not have risks of landslides and floods but may be unsuitable in terms of biocomfort.

This study reveals that grading should be performed in the selection of settlement areas. While choosing a settlement area in any region, possible natural disasters in the region should be identified first, and these disasters should be ranked in terms of their threat potential. Moreover, areas considered to have suitable biocomfort areas should also be considered for settlements. In the next stages of the selection of settlement areas, criteria that affect the peace and comfort of people, such as distance to pollution sources, distance to noise sources, and proximity to natural areas, can also be evaluated. Thus, a priority order should be created for the selection of settlement areas using various other criteria.

Such studies can be conducted at very low costs before settlement areas are selected, but in the following years, they can both minimize the loss of life and property in case of possible natural disasters and contribute to the fact that people can live in areas where they can be healthier and happier. However, unfortunately, the number of studies performed on this subject is very few, and the number of studies that are actually put into practice is almost nonexistent. Therefore, it is necessary to diversify and increase the number of studies on this subject, to execute research on regional and local scales, and to ensure their implementation by sharing these studies with the appropriate authorities.

**Author contribution** Cem Kilicoglu contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Cem Kilicoglu. The first draft of the manuscript was written by Cem Kilicoglu and commented on previous versions of the manuscript. Cem Kilicoglu read and approved the final manuscript.
Since the article is single-authored, the author Cem Kilicoglu has read and approved the final manuscript.

**Declarations**

**Ethics approval and consent to participate** Not applicable.

**Consent for publication** Not applicable.

**Data availability** The data that support the findings of this study are available from the corresponding author, Dr. Cem Kilicoglu, upon reasonable request.

**Competing interests** The author declares no competing interests.

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Authors and Affiliations

Cem Kilicoglu1

Cem Kilicoglu
cem.kilicoglu@samsun.edu.tr

1 Department of Architecture and Urban Planning, Kavak Vocational School, Samsun University, Samsun, Turkey