

Determining the bioclimatic comfort in Kastamonu City

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Received: 11 May 2015 / Accepted: 9 September 2015 / Published online: 24 September 2015
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Abstract Bioclimatic comfort defines the optimal climatic conditions in which people feel healthy and dynamic. Bioclimatic comfort mapping methods are useful to urban managers and planners. For the purposes of planning, climatic conditions, as determined by bioclimatic comfort assessments, are important. Bioclimatic components such as temperature, relative humidity, and wind speeds are important in evaluating bioclimatic comfort. In this study of the climate of Kastamonu province, the most suitable areas in terms of bioclimatic comfort have been identified. In this context, climate values belonging to the province of Kastamonu are taken from a total of nine meteorological stations. Altitude (36–1050 m) between stations is noted for revealing climatic changes. The data collected from these stations, including average temperature, relative humidity, and wind speed values are transferred to geographical information system (GIS) using ArcMap 10.2.2 software. GIS maps created from the imported data has designated the most suitable comfort areas in and around the city of Kastamonu. As a result, the study shows that Kastamonu has suitable ranges for bioclimatic comfort zone. The range of bioclimatic comfort value for Kastamonu is 17.6 °C. It is between a comfort ranges which is 15–20 °C. Kastamonu City has suitable area for bioclimatic comfort.

Keywords Bioclimatic comfort · Landscape planning · Ecological balance · Kastamonu · Effective temperature · Climatic parameters

Introduction

Landscape planning, which is directly related to our life nature and ecology, requires long periods of study to efficiently use planning in development as a method of forming ideas and models. In determining natural landscape and ecology, the power of nature has to be considered as one of the most important factors in the climate. Planning and design for the most efficient models can be created, detailing the analysis of climate within a measurable system. Climatic data, the selection of new residential areas, creation of recreational areas, agricultural land, and open green space planning, in landscape design and placement, should be considered in the process. It is possible with a balance climatic planning and design process. The process of this has been analyzed in detailed. A wide range of planning and design issues related to users to examine, analyze, and solve the price field is created. Meteorological, ecological, functional, aesthetic, and economic aspects to take into account the sensitivity of user's claims should be created evocative visual and sensory appreciation of comfort zone. This phase will occur in accordance with meteorological, ecological, functional, aesthetic, and economic that will reveal a space synthesis. It will be different for monitoring step in the process result in a livable comfort zone, and it can be accomplished by

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synthesizing each other. Landscape architecture and landscape design with all meteorological parameters has an important role to guide urban planning. A new residential area as well as the use of single-use requirements of the meteorological-derived parameters in the selection is extremely necessary. Locations and bioclimatic map using sensed temperature that people can feel more comfortable may be appointed as the new settlements. Bioclimatic determinations made for existing settlements arguable on how to be more comfortable. At the same time, this map can be used to calculate the areas of people's lives and how much energy we need to bring to the favorable climatic conditions. The map obtained from the analysis of meteorological parameters, planning the right way to use a number of factors, can help design the landscape. For example, the detection could be used as a productive couple of days in the year designing a swimming pool in an open area that can only be identified with meteorological parameters (Synnefa et al. 2007; Topay 2013; Milne 2013; Gumus 2012; Cetin 2015a).

Planned urbanization predicting physical and social-economical development is one of the main indicators. Planned urbanization, in terms of the appropriate regions for human health, should be evaluated, where bioclimatic comfort emerges as one of the most important parameters.

Structures, landscape, natural environment, and infrastructure impact bioclimatic comfort, meaning it is necessary to include these items when evaluating a given area. Design planning works best when evaluating the small-scale urban and regional planning and subsequently scaling up using integrated methods. Important contributing factors of geometry and spatial strategy, materials and equipment, as well as functional use, resource consumption, greenhouse gas emissions, and the overall negative environmental impact, significantly impact the overall values for a given area (Cetin et al. 2010; Cetin 2015a, b). The area needs to determine the bioclimatic comfort for comforting people's health. For this purpose, there is a design for evaluating the bioclimatic comfort area.

Evaluating bioclimatic comfort is accomplished by one of the most widely used methods, developed by Olgyay, namely the "bioclimatic comfort table." According to Olgyay (1973), ideal bioclimatic comfort values range from 21 to 27.5 °C in temperature and 30–65 % relative humidity. For example, in the middle latitudes of Turkey, ideal bioclimatic comfort rankings

include temperature, humidity, and wind speeds, with a range of 17 to 24.9 °C considered to be the sensed temperature value (Topay and Cinar 2008; Attia and De Herde 2009; Bezlova and Doncheva-Boneva 2011; Topay 2012a; Tsiourlis et al. 2012).

The range of bioclimatic comfort rankings are shown in Turkey. These ranges give people good conditions for their health. Climatic conditions affect people's ability to feel relaxed and comfortable and are dependent on multiple factors, including some with meteorological parameters such as wind, humidity, and radiation. Clothing, health, and types of activity are also contributing factors. Comfortable temperature ranges are defined as the period of time people will feel comfortable in a "sensed" temperature environment (Kaya et al. 2009; Topay 2012b; Cetin 2015a, b).

In this study for Kastamonu, detailed meteorological and climatic analysis and the results are evaluated and a database of landscape planning and design has been created for those interested. This database uses a bioclimatic rating to put forward the creation of other criteria, such as planning and design, climate-balanced planning, and design criteria.

Materials and methods

The research area, Kastamonu province and its immediate surroundings, constitutes the climate values. As the research indicates, Kastamonu province encompasses both a rural and urban landscape, forming the climate potential. The existing meteorological data suggests that the location is favorable in terms of bioclimatic comfort. By studying the data collected from nine meteorological stations situated in the province of Kastamonu, a climate-based landscape planning assessment can be made (Kastamonu 2013).

Kastamonu, in the north of Turkey, is situated between 41° 22' 20" North latitude and 33° 46' 16" East longitude. Kastamonu is surrounded by the Black Sea to the north. The Kastamonu's global location is shown Fig. 1. Kastamonu is at an elevation of 775 m. The area of Kastamonu is 131,081 km². Kastamonu is composed of mostly rugged terrain, located north of the Western Black Sea Mountains, parallel to the Black Sea coast lie the Kure Mountains. The Ilgaz Mountains are in the south of the province. These mountains are high and continuous. In the north of Kastamonu are the Gokirmak and Arac rivers. The province is bordered by the Devrez



Fig. 1 Showing the Kastamonu’s global location

stream valleys on the south, with its highest point being Catalilgaz peak (2565 m). Kastamonu is mountainous in general, and there are no broad plains. Kastamonu summers are hot and dry, while winters are mild and rainy. In the mountainous parts of the region, both inside and away from the sea, due to the climate and the height, a continental climate is more dominant.

In this study, a database is created for processing information, for demonstration, to produce maps, to analyze, and to model. The graphic map features geographically referenced data linked with a computer system, utilizing the geographic information systems (GIS) ArcView software.

This work was conducted primarily within the scope of the research areas in which the climatic data was collected. Data was converted to an annual average value for display on the associated maps. First, annual temperatures, humidity, and wind speed maps

have been created. Considering the theoretical basis of the study, the province of Kastamonu has been evaluated in terms of the climatic elements related to bioclimatic comfort.

In this study, climatic data provides the most accurate map of the area. In formulating the mapping, ESRI software within ArcView GIS “kriking” interpolation with a “universal linear” option is used. Kastamonu and its climatic factors were compared, and bioclimatic suitable areas have been identified in terms of evaluated comfort levels.

In the Western Black Sea region of Kastamonu City, nine meteorological stations collected temperature and relative humidity data between the years of 1975 and 2013 (measured at 14:00) by Turkish State Meteorological Service, Kastamonu (TSMS 2015). In this study, higher temperatures (typically above 21 °C air temperatures), based on the level of humidity-sensed

temperatures, have been reported and calculated as follows in Eq. 1 (Steadman 1979).

$$\begin{aligned}
 T_e = & -42.379 + (2.04901523 \times T) + (10.1433127 \times RH) \\
 & - (0.2247554 \times T \times RH) - (6.83783 \times 10^{-3} \times T^2) \\
 & - (5.481717 \times 10^{-2} \times RH^2) \\
 & + (1.22874 \times 10^{-3} \times T^2 \times RH) \\
 & + (8.5282 \times 10^{-4} \times T \times RH^2) \\
 & - (1.99 \times 10^{-6} \times T^2 \times RH^2)
 \end{aligned}
 \tag{1}$$

where T_e is the effects of temperature, T is the ambient dry-bulb temperature (in degrees, Fahrenheit), and R_h is the relative humidity (percentage value between 0 and 100).

Sensed temperature change index values, with the help of this equation, can be calculated given the temperature and humidity data. The calculated values and results are 21—theoretically, all people perceived to be in a comfortable environment; 24—only half of the people perceive the sensed temperature to be comfortable; and 27—more than the majority of people are uncomfortable (Gumus 2012).

Results and discussion

In studies on human bioclimatic comfort usually tries to make distributions during the year of the terms of a comfort zone. After all, the appropriate period in terms of comfort, based on human activities such as tourism and outdoor recreation, is recommended. The advantage of the known periods can be comfortably laid on the exteriors of activity options. Thus, space utilization can be tailored to the appointed period.

Design features and meteorological parameters in a new residential location choice for the selection of materials to be used and to examine them with the GIS method to obtain the result of the new parameters are of great importance. Thus, bioclimatic comfort parameters and results were determined like evaluating temperature, humidity, and wind speed in studies of climatic elements. It is prepared in the study, and data maps presented in Figs. 2, 3, 4, 5 and 6 are prepared by applying the Kastamonu province and its environs to around nine stations to observe their daily maximum temperature 14:00 measurements between 1975 and 2013 the sensed temperature of the above formula.



Fig. 2 Locations of meteorological stations in the study area

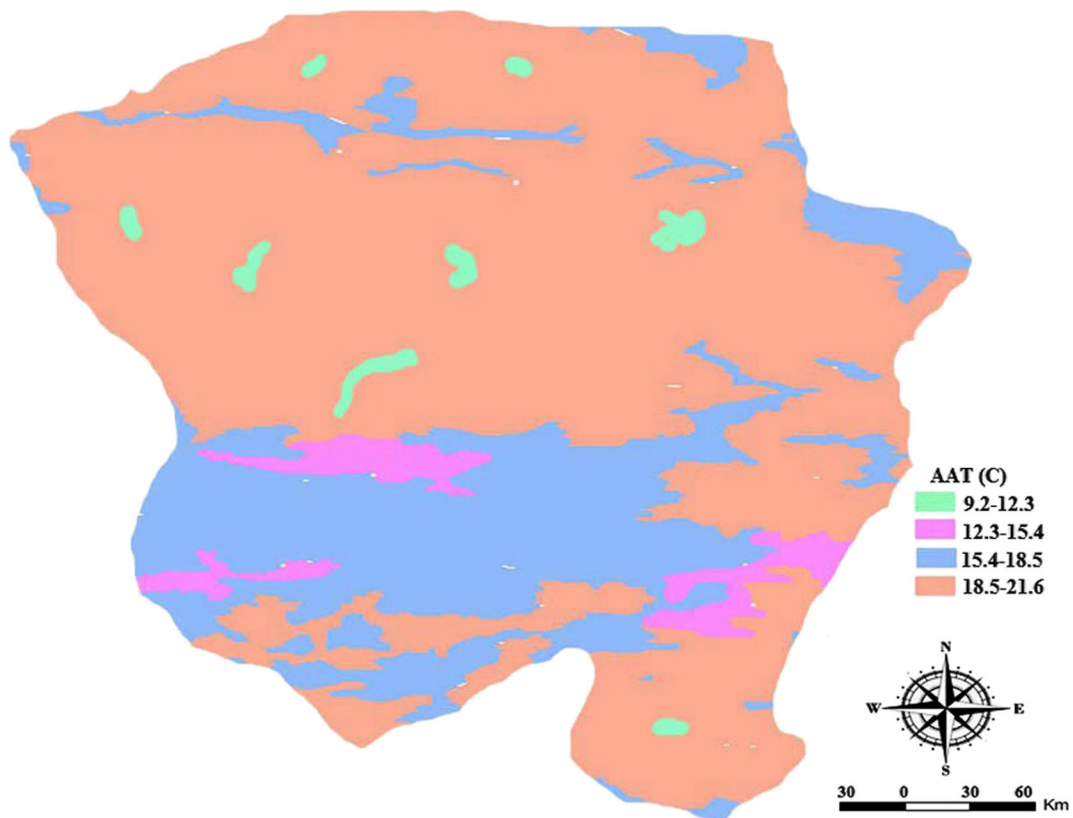


Fig. 3 Annual average temperature map of Kastamonu province

According to the formulation with values, data map using by GIS is prepared. Analysis of the results for the entire month has been determined that the sensed temperature may affect the comfort level between June to September, and the findings were presented this month. At the same time still derived by formulating the monthly average humidity values of the average month temperature of 1975 to 2013 period sensed temperature values as a result of the creation of day-night temperature stability, values are below the limits that may affect the comfort level for all time.

The nine climate data collection stations in Kastamonu province reveal the structure within the administrative boundaries of the area that provides the values of the derived data. Stations were selected from different heights and regions in order to get the most accurate distribution of climatic values. Climate data was selected from observations belonging to the same year. Mapping of the distribution of the stations in the area are also given (Fig. 2).

Kastamonu province with the name of each station, altitude, and mean annual temperature values. These values are measured to obtain the number of years (years

of observation) and are listed in Table 1. Figure 3 obtained “annual average temperature map.” ArcView 10 software was used in the creation of climate maps containing the “kriging interpolation.” The “universal linear” extension option in the field of climatic data was used because it provides the most accurate distribution.

Obtained according to this map of the study area, average annual temperature values vary between 9.2 and 21.3. The average annual temperature values of the elevations to the north to south shows the increase and decrease respectively.

The relative humidity values of stations are given in Table 2.

Figure 4 obtained “annual average relative humidity map,” according to the relative humidity values of the stations. Figure 4 obtained according to this map of the study area relative humidity values that range from 44 to 78 %. Relative humidity percentage values increase toward the southern area because of the Black Sea.

Table 3 shows mean wind speed values at stations and observation years. Figure 5 obtained “annual average wind speed map.” Average wind speed map of the

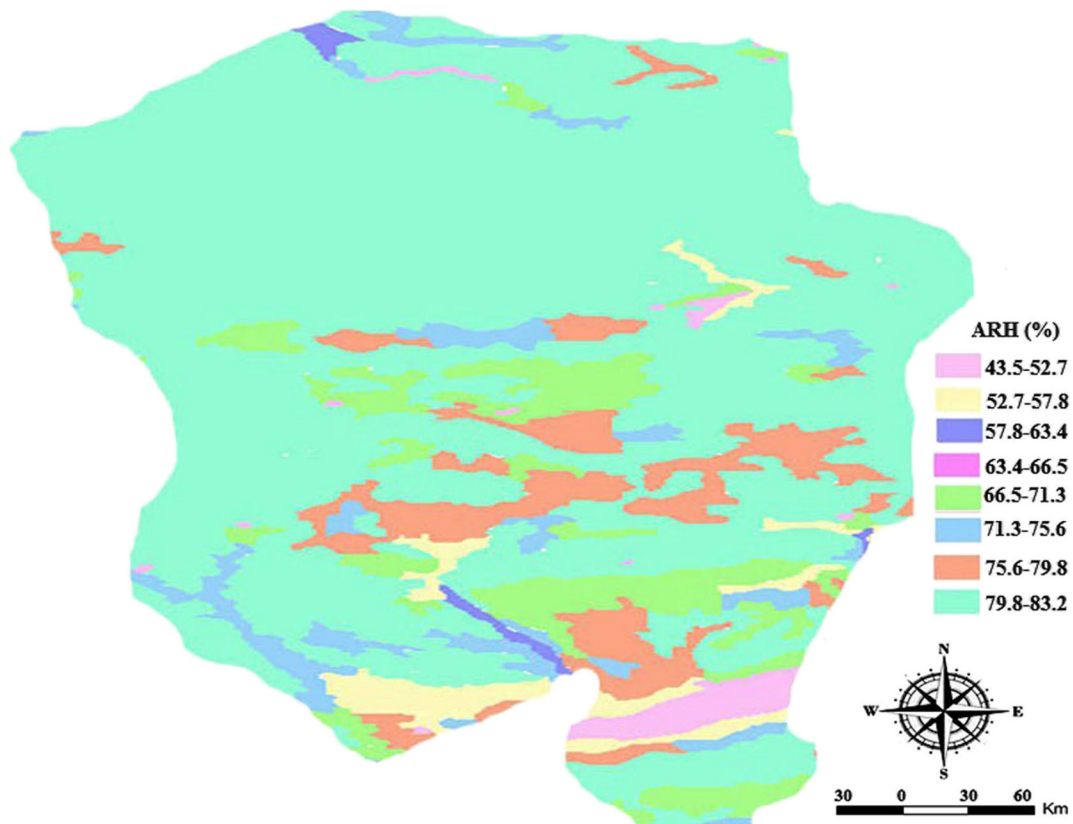


Fig. 4 Annual average relative humidity map of Kastamonu province

stations according to their values. Obtained according to this map of the study area, the average wind speed values vary between 1.12 and 2.30 m/s. Average wind speed values of the area increase toward the north and the midlands.

Conclusions

Comfort for every month of the year, classified according to the study maps, was obtained. Obtaining an average value for each area on the map of bioclimatic comfort conditions obtained considering 12 months were classified map overlapped allows obtaining the map of annual sensed temperature. Arc GIS raster data classified for 12 months in the program are evaluated using function. Thus, the average value for each 12-month value of every cell in the raster was computed. This map is obtained using the cell-based statistics function that is formed by cellular averaging method. The map is newly formed, and cell values are decimal values between

14.99 and 19.99. Annual sensed temperature map having values between 14.99 and 19.99 is subjected to grading process divided into two ranges. The uncomfortable area on the map is shown as not suitable. The comfort area is shown as suitable area.

Bioclimatic comfort values in the province of Kastamonu have been correctly identified in this study with the primary data of temperature, humidity, and wind speeds and plotted onto maps created in GIS. Table 4 shows climatic parameter ranges and corresponding bioclimatic comfort points. In determining the bioclimatic comfort zones, the following range of values for each climate element is used (Table 4). In general, the high temperature in the summer is the most comfortable area in Kastamonu province, Kastamonu, Ilgaz Mountain, Inebolu, Catalzeytin, and Cide that can be analyzed from bioclimatic map (Fig. 6).

According to the formula and GIS, bioclimatic comfort conditions were reduced comfort when questioned by dense settlements, while further decrease in the density of the settlements was concluded as the increased comfort.

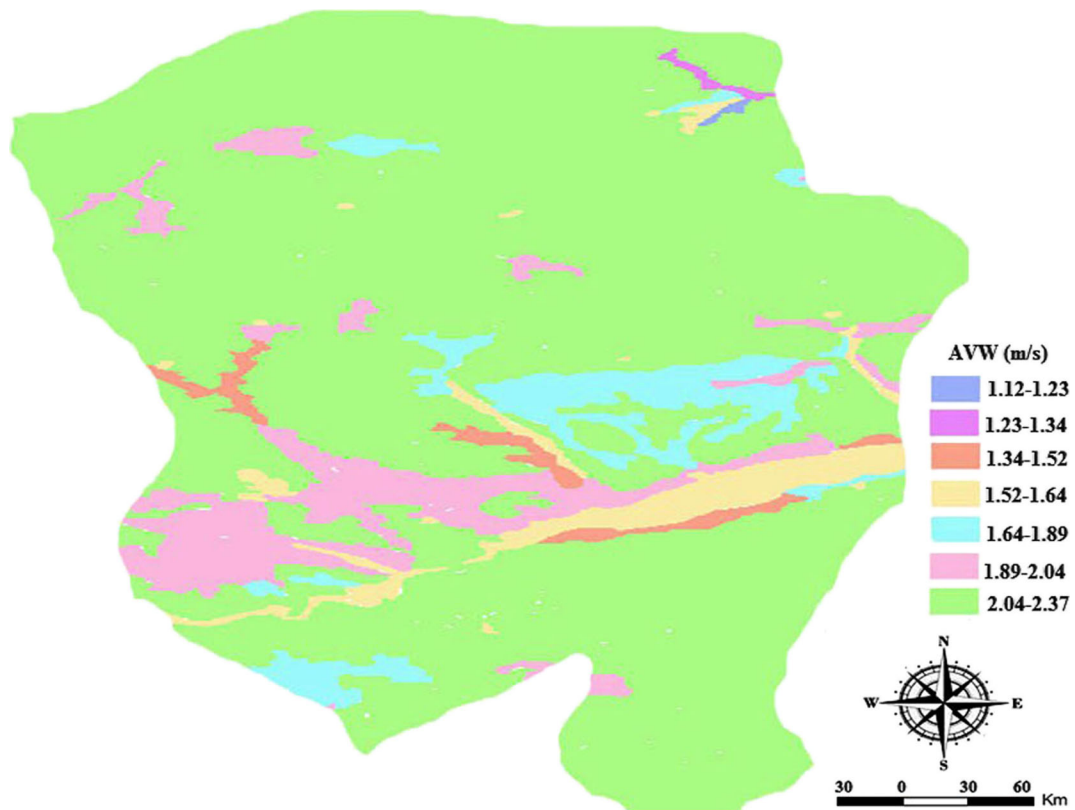


Fig. 5 Annual average wind speed map of Kastamonu province

The study was conducted using data from nine meteorological stations located in Kastamonu. Kastamonu provinces in the settlement of the region are intense and upgrade the map in order to be considered as more effective than the area which raises a more comprehensive work in the field can be established meteorological stations. Table 4 shows that the range of bioclimatic comfort value for Kastamonu is 17.6 °C. It is between a comfort ranges which is 15–20 °C. Also, the humidity of comfort for Kastamonu is 46 which are between a comfort ranges (Table 4). The result of formula and creating of GIS map demonstrates that the city of Kastamonu generally has suitable area for bioclimatic comfort except the town of Doganyurt, Devrekani, Tosya, and Arac. They have unsuitable area for bioclimatic comfort.

The purpose of this, in terms of the bioclimatic comfort of Kastamonu province, is to put all the fields that may be suitable. For this purpose, climate maps of Kastamonu province, mentioned above, detail bioclimatic comfort in terms of values and the regions studied (Fig. 6).

This map, derived from a large portion of the city of Kastamonu’s bioclimatic data, is considered to be representative in terms of comfort. These ideal areas are more widely distributed in the western and southern parts of the province. Favorable areas for bioclimatic comfort cover 10.564 km² of the total 13.208 km² in Kastamonu. Bioclimatic comfort areas with unfavorable values are located mostly in the northeastern part of the province. The total area evaluated as unsuitable, in terms of bioclimatic comfort, covers 2.644 km² of the province. The reason being the relative humidity in the area exceeds the appropriate range of values for bioclimatic comfort.

Bioclimatic comfort conditions can be improved with the implementation of the principles of landscape architecture and planning and design criteria. The plan and design every area of bioclimatic comfort requirements of the scheme in terms of landscape architecture and design made good for the areas to be distributed in a balanced way and

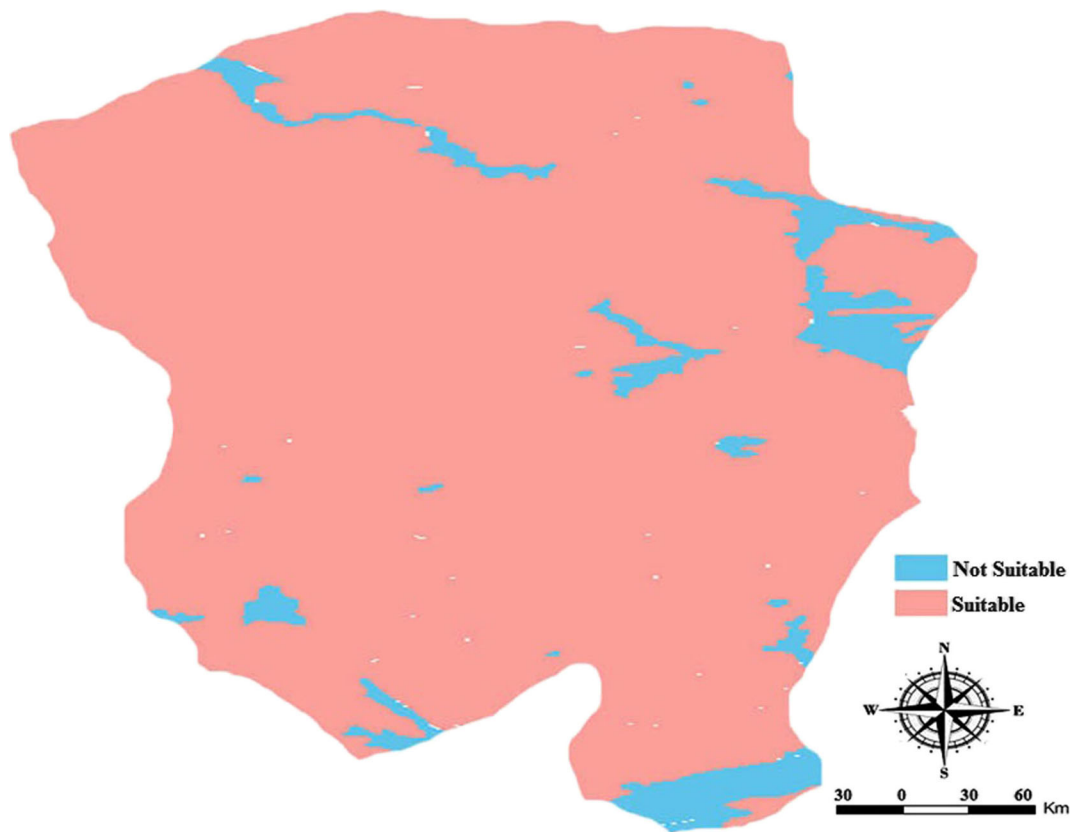


Fig. 6 Comfort in the province of Kastamonu in terms of bioclimatic status

Table 1 Information about the nine meteorological stations showing annual temperature values and years of observation

| Station name | Coordinates | Altitude (m) | Observation year | Annual average temperature (°C) | Main wind direction |
|---------------|---|--------------|------------------|---------------------------------|---------------------|
| 1 Arac | Latitude: 40,2400 N Longitude: 33,3300 E | 80 | 1975–2010 | 19.4 | SW |
| 2 Doganyurt | Latitude: 41,9597 N Longitude: 34,0037 E | 167 | 1975–2012 | 20.8 | SW |
| 3 Cide | Latitude: 41,8822 N Longitude: 32,9476 E | 36 | 1975–2011 | 21.3 | W |
| 4 Catalzeytin | Latitude: 41,9538 N Longitude: 34,2180 E | 75 | 1975–2013 | 9.2 | NW |
| 5 Devrekhami | Latitude: 41,5996 N Longitude: 33,8345 E | 1050 | 1975–2013 | 18.9 | SW |
| 6 Ilgaz dagi | Latitude: 41,0658 N Longitude: 33,7350 E | 1915 | 1975–2013 | 15.7 | W |
| 7 Inebolu | Latitude: 41,9789 N Longitude: 33,7636 E | 64 | 1975–2013 | 11.7 | NW |
| 8 Kastamonu | Latitude: 41,3710 N Longitude: 33,7756 E | 800 | 1975–2013 | 17.6 | SW |
| 9 Tosya | Latitude: 41,0132 N Longitude: 34,0367 E | 870 | 1975–2013 | 9.3 | SW |

Table 2 Relative humidity values for the stations and observation years

| Station name | Coordinates | Altitude (m) | Observation year | Annual average relative humidity (%) | Main wind direction |
|---------------|---|--------------|------------------|--------------------------------------|---------------------|
| 1 Arac | Latitude: 40,2400 N Longitude: 33,3300 E | 80 | 1975–2010 | 68 | SW |
| 2 Doganyurt | Latitude: 41,9597 N Longitude: 34,0037 E | 167 | 1975–2012 | 74 | SW |
| 3 Cide | Latitude: 41,8822 N Longitude: 32,9476 E | 36 | 1975–2011 | 78 | W |
| 4 Catalzeytin | Latitude: 41,9538 N Longitude: 34,2180 E | 75 | 1975–2013 | 44 | NW |
| 5 Devrekhami | Latitude: 41,5996 N Longitude: 33,8345 E | 1050 | 1975–2013 | 66 | SW |
| 6 Ilgaz dagı | Latitude: 41,0658 N Longitude: 33,7350 E | 1915 | 1975–2013 | 53 | W |
| 7 Inebolu | Latitude: 41,9789 N Longitude: 33,7636 E | 64 | 1975–2013 | 78 | NW |
| 8 Kastamonu | Latitude: 41,3710 N Longitude: 33,7756 E | 800 | 1975–2013 | 46 | SW |
| 9 Tosya | Latitude: 41,0132 N Longitude: 34,0367 E | 870 | 1975–2013 | 58 | SW |

that basic release of open green space purposes it is also good in this line. The planning and design of bioclimatic comfort in the wrong conditions may become extremely adverse circumstances. Under natural conditions, few areas of heat or cold

stress, because of intensive construction and destruction of natural vegetation, can become inappropriate in terms of bioclimatic comfort. It can also be important in terms of making energy saving such a study in the regulation of the old plan

Table 3 Stations with approximate wind speed values and observation years

| Station name | Coordinates | Altitude (m) | Observation year | Annual the mean wind speed values (m/s) | Main wind direction |
|---------------|---|--------------|------------------|---|---------------------|
| 1 Arac | Latitude: 40,2400 N Longitude: 33,3300 E | 80 | 1975–2010 | 2.30 | SW |
| 2 Doganyurt | Latitude: 41,9597 N Longitude: 34,0037 E | 167 | 1975–2012 | 1.72 | SW |
| 3 Cide | Latitude: 41,8822 N Longitude: 32,9476 E | 36 | 1975–2011 | 1.95 | W |
| 4 Catalzeytin | Latitude: 41,9538 N Longitude: 34,2180 E | 75 | 1975–2013 | 1.12 | NW |
| 5 Devrekhami | Latitude: 41,5996 N Longitude: 33,8345 E | 1050 | 1975–2013 | 1.58 | SW |
| 6 Ilgaz dagı | Latitude: 41,0658 N Longitude: 33,7350 E | 1915 | 1975–2013 | 1.83 | W |
| 7 Inebolu | Latitude: 41,9789 N Longitude: 33,7636 E | 64 | 1975–2013 | 2.05 | NW |
| 8 Kastamonu | Latitude: 41,3710 N Longitude: 33,7756 E | 800 | 1975–2013 | 1.20 | SW |
| 9 Tosya | Latitude: 41,0132 N Longitude: 34,0367 E | 870 | 1975–2013 | 1.31 | SW |

Table 4 Climatic parameter ranges and corresponding bioclimatic comfort points

| | | |
|-------------------|----------|-------------------|
| Temperature | <15 °C | 0 (Uncomfortable) |
| | 15–20 °C | 1 (Comfortable) |
| | >20 °C | 0 (Uncomfortable) |
| Relative humidity | <30 % | 0 (Uncomfortable) |
| | 30–65 % | 1 (Comfortable) |
| | >65 % | 0 (Uncomfortable) |
| Wind speed | <0 m/s | 0 (Uncomfortable) |
| | 0–5 m/s | 1 (Comfortable) |
| | >5 m/s | 0 (Uncomfortable) |

were identified in the region with the most energy loss in the construction of the new development plan in our country.

In this study, the results of the Kastamonu province with bioclimatic comfort zones have been introduced. The data obtained as a result of this study is useful for future planning in the province. Planning, in accordance with bioclimatic comfort guidelines, will have to be produced for Kastamonu province to comfortably maximize the boundaries of region, population settlement, recreation, and so on. The area from the maps and forms used were developed in order to provide the most accurate distribution data, capable of taking human comfort into consideration when making sustainable planning decisions.

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