

## A Digital-based Model Proposal for Optimum Building Orientation in Architecture in Ecological Context

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*In order to make optimum use of the heat energy coming from the sun and the cooling effect of the wind, it is very important that the buildings are positioned on the land in positions that can provide the highest level of user comfort with minimum energy consumption. Determining the layout of the building is a critical design parameter that affects energy consumption. However, when there are vistas such as sea, forest, etc. that are desired to be seen from the first degree interior volumes around the building, this factor becomes decisive in the building orientations. As a result of this, climatic comfort factors such as natural ventilation provided by wind and heat energy from the sun are ignored. While the orientation of the interior spaces towards the landscape is preferred by the users, the climate element and the comfort it provides should be the priority in the architectural design. In this study, an orientation optimization model has been proposed for building orientation based on utilizing vista and climatic data in the context of passive design. With the parametric and numerical-based approach developed in the study, the way to use the vista factor, which has a multivariate and complex structure, as an “input data” has been investigated. In order to test and verify the developed optimization model, “The Canal Istanbul” artificial waterway project area, which is a very up-to-date subject, was chosen as the plot research area. The Canal feasibility studies have been prepared by the authorities. The data obtained from these reports were used quantitatively in the model. In this context, the technical and ecological data of the canal route were investigated from the reports prepared for the Canal Istanbul route. Thus, as a result of the data accessed from various sources, the climate type and ecological characteristics of the region have been moved to a quantitative dimension as numerical data. An optimization model has been developed for optimum building orientation in terms of regional climate, taking into account the zoning decisions and basic planning criteria determined in the focus of these data. The developed model primarily places the building in the desired point position over the 1000 and 5000 zoning plans of the region, with the vista as priority. Afterwards, the model perceives the vista spline that enters the field of view of the building. Then, staying within the boundaries of this spline, it turns the structure in alternative directions and analyzes it according to each direction. At this stage, the model presents a mathematical dataset by comparing the alternative orientations of the building with the “optimal direction”, “prevailing wind direction” and “north direction” angles. Finally, these data are optimized within the model and suggestions are made to the designer to make a choice, based on the results obtained.*

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## Introduction

The loss of life and property for many years due to ship accidents in the Bosphorus has prompted the authorities to take measures to prevent these accidents. However, despite the measures taken, it is known that ships still pose a danger in the strait. It was decided by the authorities to open an alternative artificial waterway to the Bosphorus, for reasons such as protecting the historical center of Istanbul, ensuring the safety of the Bosphorus and relieving traffic.<sup>1</sup> For this reason, the Canal Istanbul Project, which is planned to be built, has emerged as an artificial waterway project that will connect the Black Sea and the Sea of Marmara in parallel with the Bosphorus by digging the mainland on the north-south axis on the European side of Istanbul. The project area is divided into 7 stages and as of 2022, the zoning plan for 3 stages has been prepared. In this article, a model has been proposed in order to interpret and qualify the vista-oriented building orientation that will occur in the region with Canal Istanbul, with climatic comfort parameters.

As it is known, “comfort” is a very important component to meet human needs. Arrangements made in the artificial environment significantly affect the indoor comfort and cause positive or negative results for the building-indoor occupant. When the decisions taken at the upper scale are sustainable, energy-conserving designs emerge. The location of the building, the distances between the buildings, its form, volume, building elements and orientation are the most important parameters that affect energy conservation. Buildings built by considering these parameters are also described as “clean energy”.<sup>2</sup>

Energy consumption is increasing in direct proportion to the increase in industrialization and population in the world, and this causes air pollution, an increase in temperature, and subsequently the melting of glaciers and a rise in the water level. Continuing to use fossil fuels poses a danger to the ecosystem. With the widespread use of renewable energy sources, it may become possible to prevent ecological problems. The use of natural energy resources in building designs based on an energy efficient system and the selection of building components in this direction provide environmental sensitivity.<sup>3</sup>

It can be said that one of the most important parameters leading to climate change is urbanization. Both the most affected and the most affected areas are cities. People who migrated from rural areas to cities for economic, social and political reasons started the unplanned and uncontrolled urbanization process. When the number of people living in cities is examined worldwide since the industrial revolution, a significant increase is observed. While the urban

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1. Kesici, Ö. “İstanbul Boğazı varken neden kanal istanbul?” (Why Canal Istanbul when there is the Bosphorus?) 4. In *Uluslararası Bilimsel Araştırmalar Kongresi* (s. 227-252). Ankara: Sosyal Bilimler, 2019.

2. Manioğlu, G. “Geleneksel Mimaride İklimle Uyumlu Binalar: Mardin’de Bir Öğrenci Atölyesi.” (Climate Compatible Buildings in Traditional Architecture: A Student Workshop in Mardin.) In VIII. Ulusal Tesisat Mühendisliği Kongresi, 79-92. İzmir, Turkey, 2007.

3. Mangan, S. D. Akıllı binalarda alt sistem değerlendirmesi: İstanbul örneği. (Subsystem evaluation in smart buildings: İstanbul example.) İstanbul: İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Mimarlık Anadilim Dalı, Çevre Kontrolü ve Yapı Teknolojisi, 2006.

population, which was 14% in the 1900s, increased to 47% in the 2000s, it is predicted that it will be 60% in 2030.<sup>4</sup>

Increasing population brings with it many problems. Insufficient housing areas have led to a decrease in green areas over time. In this context, Odul and Cagdas (2019)<sup>5</sup> investigated whether structural changes have an impact on the climate by considering the Inkilap, Madenler and Site Areas of Umraniye district of Istanbul. Using GIS and Remote Sensing methods, they examined Landsat thermal satellite images of the last 16 years before 2019 and determined that the structural changes in the natural topography changed the climate structure. This study has been taken into consideration in order to discuss whether the construction after the canal construction will give similar results.

High structures or low but close-range structures have a significant share in the warming effect. While the construction of pavements, roads and living spaces instead of vegetation creates more warming in the region, it is thought that the structures or landscaping that are not made according to the climatic characteristics of the region cause meso-micro climate change in the region. It is very important to protect the natural vegetation around the buildings and to increase the green areas in order to reduce the negative effects of unplanned and uncontrolled construction on the temperature. It is possible to prevent the increase in temperature by creating air corridors by constructing structures that do not prevent air currents and making the forms, heights and layouts of the buildings in a planned manner. It is known that the structures built by the sea prevent the sea breezes that serve to clean the air.<sup>6</sup>

The wind parameter also affects the climate and this situation changes according to the topography. When it is desired to take advantage of the cooling effect of the wind; It is very important in terms of climatic comfort that the long facade of the building is oriented according to the prevailing wind direction, and when it is desired to benefit from the radiant heat of the sun, the places where the building will spend the most time are directed towards the south facade. It is necessary to place the areas where the most time is spent during the day, such as the living room, bedrooms and kitchen, which are in the 1st degree volume group, to the south and near the south, and the wet areas such as the bathroom and toilet, which are in the 2nd degree volume group, to be placed according to the other aspects of the building in terms of heat gain. It is necessary to use sunshade elements for sun protection.<sup>7</sup>

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4. Çobanyılmaz, P., and Yüksel, Ü. D. "Kentlerin iklim değişikliğinden zarar görebilirliğinin belirlenmesi: Ankara örneği." (Determining the vulnerability of cities to climate change: Ankara example.) Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi 3, no. 17 (2013): 39-50.

5. Ödül, H., and Ç. K. Kentsel alanda iklimsel değişimin incelenmesi: Ümraniye örneği. (Examining climatic change in urban areas: Ümraniye example.) Ankara: TMMOB 6. Coğrafi Bilgi Sistemleri Kongresi, 2019.

6. Şimşek, Ç. K., and B. Şengezer. İstanbul metropoliten alanında kentsel ısınmanın azaltılmasında yeşil alanların önemi. (The importance of green areas in reducing urban warming in the Istanbul metropolitan area.) Megaron 7, no. 2 (2012): 116-128.

7. Balcıoğlu, A. Geleneksel ve modern bağ evi örneklerinin soğutma enerjisi korunumunda etkili olan tasarım değişkenleri açısından değerlendirilmesi. (Evaluation of traditional and modern vineyard house examples in terms of design variables effective in cooling energy conservation.)

The effect of the distance to be left between the buildings according to the climatic characteristics is also important. The distance is directly proportional to the building heights. In the temperate-humid climate zone, the distance between buildings can be determined at the rate of H-5H in the prevailing wind direction and 2-3H according to the sun (north-south direction).<sup>8</sup> In the literature, it is recommended to use free building forms and cruciform forms in temperate-humid climatic regions. The ratio of building lengths to widths of 1.6 provides optimum comfort effect. While the building form is optimum with a ratio of 1:1.6 on the east-west axis, it is stated that the maximum ratio should be 1:2.4.<sup>9</sup>

The orientation of the building is as important as its shape and form. In their study, Umarogullari and Cihangir (2019)<sup>10</sup> analyzed Edirne Binevler (1st Section) houses located in the temperate-humid climate zone according to the climate-balanced design parameters, and calculated whether 40 building blocks with A, B, C types could meet the optimum value in building orientation, and it was determined that 40% of the 40 blocks could meet the optimum value. He found that 70 of them were not positioned according to proper orientation.

Keskin and Engin (2019)<sup>11</sup> conducted a research in Cukurcayir, a new and dense settlement of Trabzon, which has a temperate-humid feature. In the research, they determined two housing units from the north, east and west directions and examined the distance, orientation and passive system decisions of the buildings for six housing units. In this research, it has been determined that the housing estates are not directed to benefit from or be protected from the sun and wind, and that the decision for an energy efficient passive system is not taken when there is a possibility.

Meric, Manioglu and Aksit (2013)<sup>12</sup> analyzed the multi-storey houses of mass housing projects in Istanbul Maslak, which have the same characteristics but different orientation, in terms of energy. They determined that the effect of 4 houses on the same floor of a building having different orientations on climatic comfort is not only the result of the orientation of the building, but also changes

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İstanbul: İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Mimarlık Anabilim Dalı, Çevre Kontrolü Ve Yapı Teknolojileri Programı, Master's Thesis, 2013.

8. Ovalı, P. K. Biyoklimatik tasarım matrisi (Türkiye). (Bioclimatic design matrix (Türkiye).) *Trakya Üniversitesi Mühendislik Bilimleri Dergisi* 20, no. 2 (2019): 51-66.

9. Ovalı, P. K. *Türkiye iklim bölgeleri bağlamında ekolojik tasarım ölçütleri sistematığının oluşturulması "Kayaköy yerleşmesinde örneklenmesi"*. (Establishing a systematic of ecological design criteria in the context of Turkey's climate zones "Exemplifying in Kayaköy settlement".) Edirne: T.C. Trakya Üniversitesi, Fen Bilimleri Enstitüsü, Mimarlık Anabilim Dalı, Doctoral dissertation, 2009.

10. Umarogulları, F., and C. Cihangir. Toplu konutların iklimsel konfor tasarım parametrelerine göre değerlendirilmesi: "ılıman nemli iklim bölgesi: Edirne binevler (1.kısım) konut yapı kooperatifi örneği. (Evaluation of mass housing according to climatic comfort design parameters: "temperate humid climate zone: Edirne binevler (1st part) housing building cooperative example.) *Mimarlık ve Yaşam Dergisi* 4, no.1 (2019): 105-122.

11. Keskin, K., and N. Engin. "Toplu konutlardaki yerleşim kararlarının enerji etkin mimarlıktaki rolü." (The role of layout decisions in mass housing in energy efficient architecture.) *Mimarlık ve Yaşam Dergisi* 4, no. 1 (2019): 69-78.

12. Meriç, Z., G. Manioğlu, and Ş. F. Akşit. "Çok katlı konutların enerji korunumu açısından performansının değerlendirilmesi." (Evaluation of the performance of multi-storey houses in terms of energy conservation.) In 11. Ulusal Tesisat Mühendisliği Kongresi, (s. 1447-1456). İzmir, 2013.

depending on the form of the building. In his study, Varoglu (2017)<sup>13</sup> examined the optimum orientation and optimum shading in buildings located in hot climate regions and proposed a method for Cyprus, taking into account the total annual energy consumption of the building.

Topcu (2020)<sup>14</sup> examined the Istanbul Kayabasi Mass Housing Example in an ecological context. He stated that the buildings are oriented in accordance with the slope so that they do not block the vista of each other and can benefit from the sun to the maximum, and the buildings are positioned with a slope of 45% in order to reduce the wind speed. According to the information obtained from this study, which is thought to contribute to the article in terms of optimum orientation, it has been seen that shape, form and orientation provide gain in energy consumption by taking into account the climatic comfort parameters.

Turan (2019)<sup>15</sup> gave information about the location of the canal route and the geographical features of the area in his study. In addition, climatic parameters such as precipitation, temperature and wind were evaluated with tables, graphics and maps according to the data obtained from Kumkoy, Yalikoy, Florya, Buyukcekmece, Arnavutkoy and Cerkezkoy stations. This study was used to determine the geographical and climatic parameters of the area.

Aksin (2019)<sup>16</sup> examined the houses with a similar type of design, which are frequently found in Ankara. In research, he made a performance evaluation on the simulation built by Grasshopper3d with Ladybug, Honeybee and Octopus plugins by combining daylight and energy values in algorithm-based optimization methods. With the available data, he determined that the daylight performance improved by about 40% and reduced energy consumption by about 28% among the data he obtained as a result of the study, and he revealed a method. In this context, this research has been examined in order to contribute to the article in terms of connecting the building orientation to parametric data.

### Limitations and Assumption in the Case Study

This study proposes a decision support model to provide optimum orientation by evaluating the wind and vista components together for the new construction to

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13. Varoğlu, S. E. Sıcak iklim bölgelerindeki binaların optimum yönelme ve optimum gölgelemesi için bir yöntem. (A method for optimum orientation and optimum shading of buildings in hot climate regions.) Yakın Doğu Üniversitesi, Fen Bilimleri Enstitüsü, Mimarlık Anabilim Dalı, Doctoral dissertation, 2017.

14. Topcu, C. Toplu konut planlamasında ekolojik yaklaşım önerileri Kiptaş Kayabaşı Toplu Konut Örneği. (Ecological approach suggestions in mass housing planning Kiptaş Kayabaşı Mass Housing Example.) T.C. İstanbul Aydın Üniversitesi, Lisansüstü Eğitim Enstitüsü, Mimarlık Anabilim Dalı, Mimarlık Programı, Master's Thesis, 2020.

15. Turan, S. E. Kanal İstanbul mücavirinin mühendislik jeomorfolojisi. (Engineering geomorphology of Canal Istanbul adjacent.) İstanbul: Marmara Üniversitesi, Sosyal Bilimler Enstitüsü, Coğrafya Anabilimdalı, Master's Thesis, 2019.

16. Aksin, F. N. Yapı kabuklarının günışığı ve enerji bağlamında eniyilenmesinde parametrik modelleme ve evrimsel algoritma kullanımı. (Use of parametric modeling and evolutionary algorithms in optimizing building envelopes in terms of daylight and energy.) Ankara: Gazi Üniversitesi, fen bilimleri enstitüsü, mimarlık ana bilim dalı, Master's Thesis, 2019.

be formed within the Canal Istanbul impact area. It is known that the existing construction in the region will change after the canal is built and new structures will be built as a result of urban planning. Within the scope of this study, the canal project was investigated with an objective approach, and the climatic data of the region were revealed according to the information obtained from various sources. Using these data, a model was created to support the designer in the optimal orientation of the buildings to be built in the region in the context of vista and climatic conditions.

Using these data, a model was created to support the designer in guiding the new buildings to be built in the region. By determining the “predominant wind direction” and “optimal building direction” of the region, the canal vista factor was focused on for the orientation of the structures to be built on the canal route. In order to reveal the architectural structure, a building model was placed on the zoning plan announced by the state by parameterizing the number of floors, floor height and window width. The model is positioned in two directions according to the “closest” to the canal vista and the “last point” where the view can be seen, and the alternative orientations determined between these two directions are analyzed to measure how far the structure moves from the north and prevailing wind directions and how close it approaches the optimum direction. An “optimization experiment” was conducted to help determine the most ideal orientation over all the data obtained, and a “direction scoring” was tried to be revealed over the alternatives. In addition, only the natural air conditioning parameter is considered without using mechanical heating and cooling systems in the model.

Since the elevation of the region is 65 m on average and there is no significant elevation difference, the topographic slope of the region was ignored and not included in the calculations. Since a new landscape axis will be formed after the construction of the canal in the area, the orientation of the structures is limited to the view of the canal. Since the authorities in the region planned the construction to be horizontal architecture, the buildings in the model were considered as low-rise. It is known that the distance between the buildings is important, but due to the sparse construction strategy in the settlement close to the canal, a settlement pattern was not created and the analysis was evaluated on a single model. In the study, the effect of alternative building forms on the result was not taken into account. The focus is on optimum orientation of first-degree volumes, where the most time is spent.

### **Characteristic Investigation of the Canal Istanbul Project Area**

In many countries in the world, artificial waterways that shorten the routes have been created in order to ease the sea transportation and to enable the ships to reach the desired point in a shorter time. The canals have been effective in changing the texture of the cities, as well as easing trade and transportation. Functionality is at the forefront as other canals such as Suez, Panama, Corinth, and Kiel were built to shorten the route. They have developed with industrial

construction rather than housing projects.<sup>17</sup> In the canal area planned to be built in Istanbul, it is stated as a project where a new construction process will be started and at the same time the largest smart city in the world will be established.<sup>18</sup>

Although the idea of creating an alternative waterway to the Bosphorus has been considered for many years, it has been announced that it is planned to be built in 2011. While the project, which will divide the European side into two, is being implemented, the foundation of the Sazlidere Bridge was laid in 2021 and the works were started in this way, before the canal excavation works started.<sup>19</sup>



**Figure 1.** The Planned Route of Canal<sup>20</sup>

In the EIA Report, 5 different alternative routes determined for the project were compared with each other in terms of economic, ecological and technical aspects. It was decided that the route starting from the isthmus separating the Marmara Sea from Kucukcekmece Lake, continuing along the Sazlidere Dam Basin, and then passing the Sazlibosna Village, reaching the east of Dursunkoy and passing the Baklali Village, reaching the Black Sea in the east of Terkos Lake.

17. WWF. “Ya Kanal Ya İstanbul” Kanal İstanbul Projesinin Ekolojik, Sosyal ve Ekonomik Değerlendirmesi. (“Either Canal or İstanbul” Ecological, Social and Economic Evaluation of Canal İstanbul Project.) İstanbul, 2015.

18. T.C. Çevre ve Şehircilik Bakanlığı. Bakan Kurum: “Kanal İstanbul Bir Devlet ve Millet Projesidir”. (Minister Institution: “Canal İstanbul is a State and Nation Project”.) Ekim 22, 2021. tarihinde [csb.gov.tr](https://csb.gov.tr), 2021. <https://csb.gov.tr/bakan-kurum-kanal-istanbul-bir-devlet-ve-millet-projesidir-bakanlik-faaliyetleri-30900> adresinden alındı.

19. DW. Kanal İstanbul'un ilk köprüsünün temel atma töreni yapıldı. (The groundbreaking ceremony of the first bridge of Canal İstanbul was held.) Ağustos 20, 2021 tarihinde [www.dw.com](https://www.dw.com/tr/kanal-istanbulun-ilk-k%C3%B6pr%C3%BCs%C3%BCn%C3%BCn-temel-atma-t%C3%B6reni-yap%C4%B1ld%C4%B1/a-58056499): <https://www.dw.com/tr/kanal-istanbulun-ilk-k%C3%B6pr%C3%BCs%C3%BCn%C3%BCn-temel-atma-t%C3%B6reni-yap%C4%B1ld%C4%B1/a-58056499> adresinden alındı.

20. González, R. P. (2021, Nisan 29). Erdogan's "crazy" canal rejected by Turkish banks. Atalayar: <https://atalayar.com/en/content/erdogans-crazy-canal-rejected-turkish-banks> adresinden alındı

Canal; It is planned to have a length of 45 km, a floor width of 275 m and a canal depth of 20.75 m. On the route of the project as seen in Figure 1; It is stated that it will pass through the districts of Avcılar, Kucukcekmece, Basaksehir and Arnavutkoy.<sup>21</sup>

Murat Kurum, Minister of Environment and Urbanization of Turkey, said, "The project will be based on horizontal architecture, and healthy and safe living spaces will be planned at the human scale, protecting the ancient values, while at the same time eliminating the risk of disasters."<sup>22</sup>

The project area has been divided into 7 stages in order to plan the construction and landscaping, and the 3 stages of the area covering Basaksehir and Arnavutkoy districts have been approved as of 2021. It is stated that 52% of the total area in these stages is reserved for green areas, roads and social facilities. It has been announced that a ground floor and a maximum of 4 floors will be built for the housing projects to be built on the basis of horizontal architecture, and a total of 4 and 5 floors, including the ground floor, for the structures to be built in the social reinforcement areas, and high-rise buildings will not be allowed.<sup>23</sup> There is currently no focused landscape component in the region. It is thought that the landscape will be a water element in the orientation of the structures that are within sight of the canal.

The Catalca region, which has an undulating topography with an average elevation of 65 meters, shows similarity in the study area of the climate since there is no significant difference in elevation and aspect. It is stated that the temperature and precipitation values are average due to the fact that the region is surrounded by seas.<sup>24</sup>

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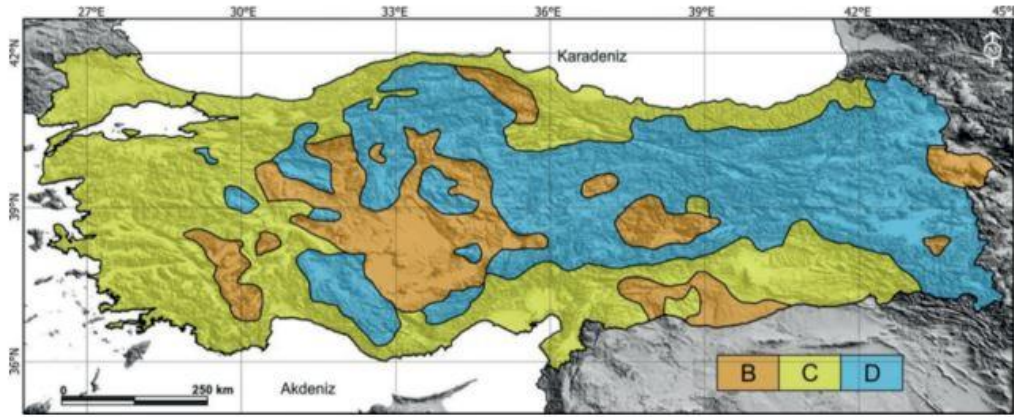
21. Çınar Mühendislik Müşavirlik A.Ş. Kanal İstanbul projesi, çevresel etki değerlendirmesi raporu. (Canal İstanbul project, environmental impact assessment report.) Ankara: T.C. Ulaştırma ve Altyapı Bakanlığı, Altyapı Yatırımları Genel Müdürlüğü, 2019.

22. Gündoğmuş, Y. N. (2018, Kasım 21). Ocak 3, 2021 tarihinde aa.com.tr: <https://www.aa.com.tr/tr/turkiye/cevre-ve-sehircilik-bakani-kurum-kanal-istanbul-projesinde-yatay-mimari-esas-alinacak/1317357> adresinden alındı

23. T.C. Çevre ve Şehircilik Bakanlığı. (2020, Ocak 15). Akıllı Şehir Uygulamalarında İlk Örnek Kanal İstanbul Olacak. (Canal İstanbul will be the first example in Smart City Applications.) Ocak 2, 2021 tarihinde Türkiye Cumhuriyeti Çevre ve Şehircilik Bakanlığı: <https://csb.gov.tr/akilli-sehir-uygulamalarinda-ilk-ornek-kanal-istanbul-olacak-bakanlik-faaliyetleri-29695> adresinden alındı.

24. Turan, S. E. Kanal İstanbul mücavirinin mühendislik jeomorfolojisi. (Engineering geomorphology of Canal İstanbul adjacent.) İstanbul: Marmara Üniversitesi, Sosyal Bilimler Enstitüsü, Coğrafya Anabilimdalı, Master's Thesis, 2019.





**Figure 2.** Main Climate Types of Turkey

Since Istanbul is surrounded by sea on three sides, it has natural ventilation corridors, and also has advantageous climatic features with its forested areas and different elevations. The Bosphorus also has an important effect on the formation of the natural air corridor.<sup>25</sup> Although it is stated in the literature that the prevailing climate in Istanbul is temperate-humid climate<sup>26</sup>, as seen in figure 2, it is located in the temperate climate zone according to Koppen.<sup>27</sup> It is also stated in the literature that it has a transitional climate showing the effects of the Black Sea and the Mediterranean. In addition, it is observed that the winds coming from the north are the most effective.<sup>28</sup>

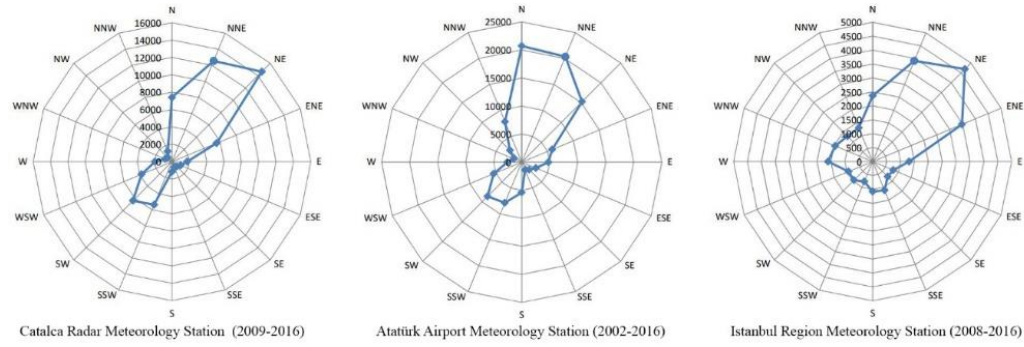
16-way wind data were obtained from Catalca Radar, Ataturk Airport, Istanbul Region and Kartal Meteorology stations. (Figure 2) As a result of this, first order prevailing wind directions; Catalca Meteorology Station has been determined as N (north) according to the blow numbers, Catalca Radar Meteorology Station has been determined as NE (northeast) according to the blow numbers, Ataturk Airport Meteorology Station has been determined as N (north) according to the blow numbers, and Istanbul Regional Meteorology Station has been determined as NE (northeast) according to the blow numbers.

25. Şimşek, Ç. K. "İstanbul'un mezo ve mikro iklimsel değişiminin kuzey ormanları ve kent içi yeşil alanlar ile ilişkisi." (The relationship of Istanbul's meso- and microclimatic change with northern forests and urban green areas.) In *Ekosistem, İklim ve Kentsel Büyüme Perspektifinden İstanbul ve Kuzey Ormanları* (s. 96-109). Türkiye Ormancılar Derneği, 2020.

26. Ovalı, P. K. Biyoklimatik tasarım matrisi (Türkiye). (Bioclimatic design matrix (Türkiye).) *Trakya Üniversitesi Mühendislik Bilimleri Dergisi* 20, no. 2 (2019): 51-66.

27. Özmen, E., and Ş. Beşiroğlu. "Aynı iklim sınıfında farklı iki ülkenin enerji etkin bina kavramı bağlamında ele alınması: İspanya ve Türkiye." (Considering two different countries in the same climate class in the context of the energy efficient building concept: Spain and Türkiye.) XIV. *Mimarlıkta Sayısal Tasarım Ulusal Sempozyumu* (2020): 129-140.

28. Gürel, A., and A. E. Gündüz. İstanbul'un ekolojik yapısı üzerine bir araştırma. (A research on the ecological structure of Istanbul.) *Marmara Sosyal Araştırmalar Dergisi* 1 (2011).



**Figure 3.** Wind Diagram According to Blow Numbers

In the EIA Report (2019), a model study was conducted using 2014 data to determine the climatic characteristics of the project route (Figure 3). In this study, the wind blow numbers and speeds in the long-term bulletin obtained from Catalca Radar Station numbered 17047 in the northern part of the project and Florya Station numbered 17636 in the south of the project were compared with the monthly wind blowing numbers of the last 10 years. The first order prevailing wind direction of Catalca Radar Station was calculated as NE (northeast) with a blow number of 1531, NNE (north-northeast) with a second order blow number of 1513, and N (north) with a third degree blow number of 1252. The same results were found for Florya Station.<sup>29</sup>

Turan (2019) determined the prevailing wind direction in the north of the canal as NNE (north-northeast) according to the data obtained from Kumkoy Station in the north and Florya Station in the south. In addition, he determined that the weather corridor is between NNE-SSW (north-northeast-south-southwest), although there are strong winds in the NNW (north-northwest) direction. He also stated that the dominant wind direction in the south of the canal is NNE (north-northeast).<sup>30</sup>

Although there are studies in the field of law about the project in the literature, studies in the field of “architecture” are almost non-existent. Within the scope of the article, researches on the ecology and physiology of the region were made and various data that could be input to architectural design were obtained. Based on these data, parametric and numerical design principles and methods were used in order to suggest the optimum building orientation in the structuring of the region. With these techniques, a “model” has been developed, taking into account the existing zoning plans of the region where there is no construction yet.

29. Çınar Mühendislik Müşavirlik A.Ş. Kanal İstanbul projesi, çevresel etki değerlendirmesi raporu. (Canal İstanbul project, environmental impact assessment report.) Ankara: T.C. Ulaştırma ve Altyapı Bakanlığı, Altyapı Yatırımları Genel Müdürlüğü, 2019..

30. Turan, S. E. Kanal İstanbul mücavirinin mühendislik jeomorfolojisi. (Engineering geomorphology of Canal İstanbul adjacent.) İstanbul: Marmara Üniversitesi, Sosyal Bilimler Enstitüsü, Coğrafya Anabilimdalı, Master's Thesis, 2019.

### Model Recommendation

The Canal, which is planned to be positioned as an artificial waterway project in the direction of the north-south axis of the European side of Istanbul, has brought architectural activities to the agenda. In this project, which is in every architectural or urban planning organization, some planning for design and operation is required. In addition to the EIA report of the region, the zoning plans of 1000 and 5000 for the three regions were prepared and approved. The zoning plans developed with the focus of the canal route include areas of activity such as housing, trade and social centers.

As it is known, it is a very general design principle to determine various criteria for the settlement of architectural structures in parcels and to maintain optimum viewing directions according to these criteria.<sup>31</sup> In this study, “a model” has been experienced to provide optimum building orientation according to the above principles for the zones to be opened for construction in the canal region.

The stream formed in the region with the construction of the canal has been evaluated as the determining criterion in the orientation of the building, as it will present a new “strait” appearance. In addition to this parameter, which is called “landscape direction” in the architectural literature, the “energy performance” of the buildings is also taken into consideration as a control parameter in the secondary plan. It is aimed to provide optimization in building orientation by establishing mathematical relations between “optimum direction”, “prevailing wind direction” and “north direction”. In this respect, the model provides an opportunity for the designer to evaluate alternatives in deciding the building orientation by producing correlations between design and ecological approaches.

### Determining Input Data for the Model

The data needed to find the optimum building direction in the ecological context of the buildings planned to be built in the Canal Istanbul project area were determined. Alternative “output data” is produced by using design and ecological “input data” for the model to operate. In this sense, it is important to determine and reveal the input data. Input data can be listed as building floors, prevailing wind direction, optimum direction, plan of the building, coordinate of the building, axis of the canal, viewing angle and spline lengths of the vista. The detection stages of each input data are as follows:

#### Building Floors

The construction in the region -as mentioned above- has been described as “horizontal architecture” by the authorized institutions. In this respect, it has been evaluated that the construction will be in the form of maximum 5-storey buildings. According to these data, the buildings to be used in the model are limited to 2-5

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31. Baydoğan, M. Ç. Tip imar yönetmeliğine uygun vaziyet planı üreten bir yapay zeka destek sistemi. (An artificial intelligence support system that produces site plans in accordance with typical zoning regulations.) İstanbul: İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Mimarlık Anabilim Dalı, Mimari Tasarım Programı, Doctoral dissertation, 2013.

floors.

### Prevailing Wind Direction

In the second part of the research, the physical and ecological characteristics of the region were revealed. According to these data, the prevailing wind direction in the Northern parts of the region was accepted as NE (Northeast) and the prevailing wind direction in the South coasts was NNE (North-Northeast).

**Table 1.** *Prevailing Wind Directions of the Region According to the EIA Report*<sup>32</sup>

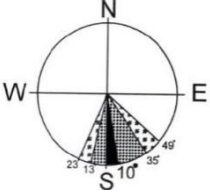
| Section          | Prevailing wind direction | Angle with north   |
|------------------|---------------------------|--------------------|
| Northern section | NE (Northeast)            | 202.5 <sup>0</sup> |
| South section    | NNE (Northnortheast)      | 225 <sup>0</sup>   |

In this case, the prevailing angle of incidence of the wind in the northern parts of the region with respect to the North is 202.50, and in the southern parts, the prevailing angle of incidence relative to the North is added to the calculations as 2250 (Table 1).

### Optimum Direction

The region is located in the “Temperate-Humid Climate” zone. Optimum building direction ranges of the temperate-humid climate zone are shown in Table 2.

**Table 2.** *The Optimum Building Orientation Diagram for the Temperate-Humid Climate Zone*<sup>33</sup>

|   |   |  |  |
|---|---|--|--|
|  | 1. Angle range                          | 2. Angle range                           | 3. Angle range                           |
|   | Between 0 <sup>0</sup> -10 <sup>0</sup> | Between 13 <sup>0</sup> -35 <sup>0</sup> | Between 23 <sup>0</sup> -49 <sup>0</sup> |

According to the research, between 00-100 is accepted as the optimum direction range. Between 130-350 is considered as the “secondary” and between 230-490 as the “tertiary” optimum direction range. This diagram, which Ovali brought to the literature as a result of their research, was accepted as a reference for the “optimal direction” in the study and the angular values on it were added to the calculations as input parameters (Table 2).

32. Çınar Mühendislik Müşavirlik A.Ş. Kanal İstanbul projesi, çevresel etki değerlendirmesi raporu. (Canal İstanbul project, environmental impact assessment report.) Ankara: T.C. Ulaştırma ve Altyapı Bakanlığı, Altyapı Yatırımları Genel Müdürlüğü, 2019.

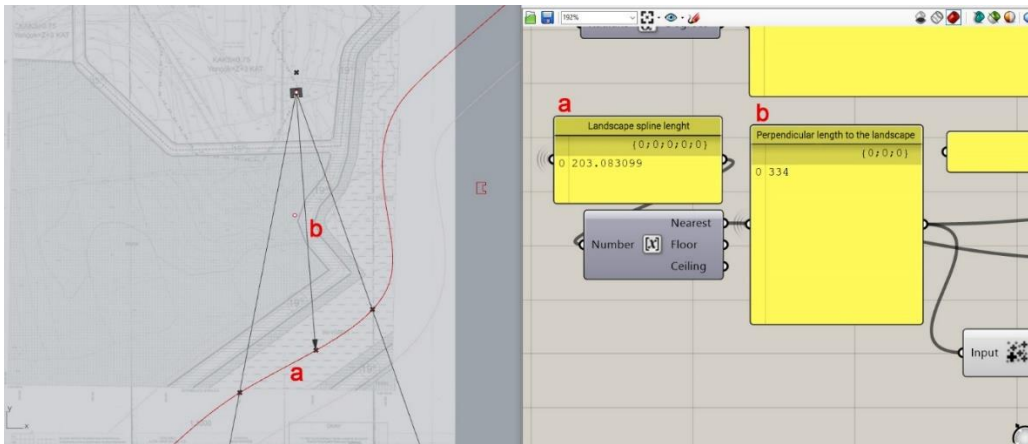
33. Ovalı, P. K. *Türkiye iklim bölgeleri bağlamında ekolojik tasarım ölçütleri sistematığının oluşturulması “Kayaköy yerleşmesinde örneklenmesi”*. (Establishing a systematic of ecological design criteria in the context of Turkey's climate zones "Exampling in Kayaköy settlement".) Edirne: T.C. Trakya Üniversitesi, Fen Bilimleri Enstitüsü, Mimarlık Anabilim Dalı, Doctoral dissertation, 2009.



**Figure 4.** Canal Axis (a), Building Coordinate (b) and Building Plan (c)

### Plan, Coordinate of the Building and Axis of the Canal

The developed model is designed with the ability to measure for the structure to be applied to any point of the study area. For this, first of all, the zoning plan of the region is visually transferred to Rhinoceros3D software. Then the water axis of the canal is drawn with a “spline” object. Afterwards, the plan projection of the building to be applied is determined by a “polyline” object and its coordinates by a “point” object. With these inputs, it is possible to work on real data (Figure 4).

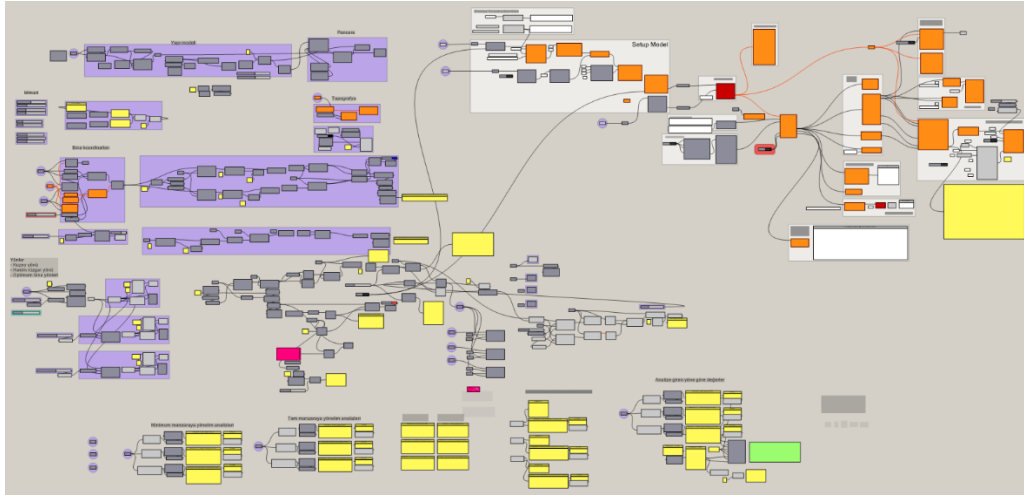


**Figure 5.** The Seen Vista Spline (a) and the Perpendicular Length to the Vista (b)

### Angle of View and View Spline Lengths

The determined data is transferred to Grasshopper3D, a Rhinoceros3D plugin. Using these data, it calculates the spline length it sees according to the coordinate and orientation of the structure. In the calculation, the “view angle” is parameterized to determine the building's point of view. In this way, the potential differences that the viewing angle, which changes according to different window widths, will create in the seen vista spline, is also taken under control. In addition to this spline length, the “vertical view distance to the vista” of the building is also calculated as an input data (Figure 5).

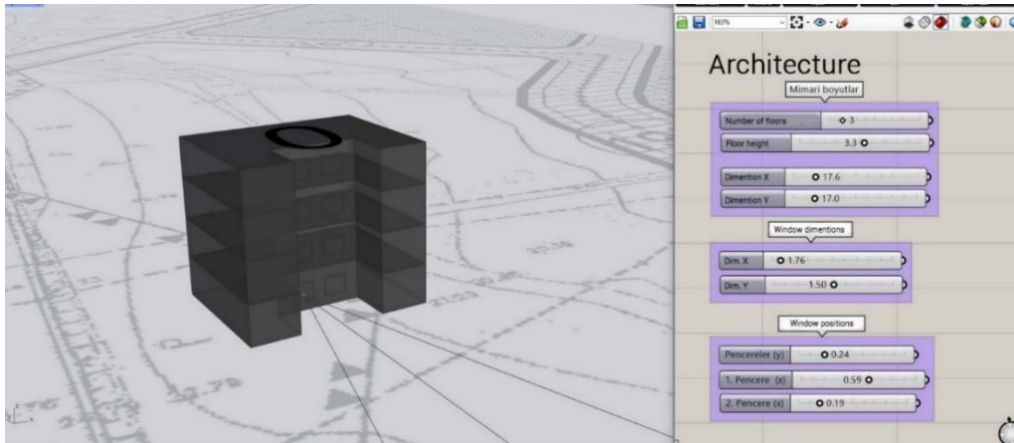




**Figure 6.** Grasshopper3D Screen where the Model is Developed

### Development of the Model

With its parametric structure, Grasshopper3D has been evaluated as an ideal data processing platform in this research, as in many similar studies. In this context, a script was developed as a model to process the input data in the Grasshopper3D medium (Figure 6).



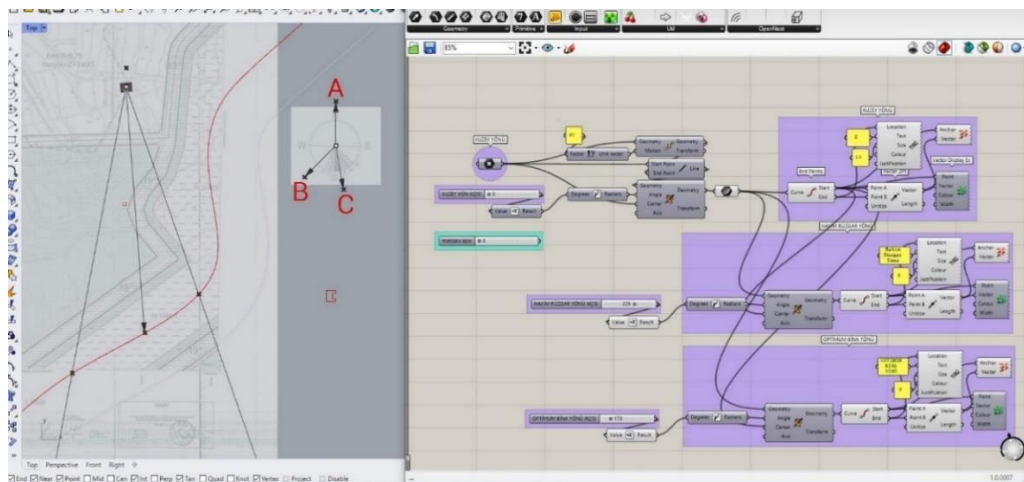
**Figure 7.** Overlaying the Plan Contour on the Zoning Plan and Parameterizing the Architectural Components

First of all, the plan contour is superimposed on its point position on the zoning plan and the building model is produced. At this stage, the number of floors, floor height and window width of the building are parameterized. The aim here is to enable the model to calculate buildings in each plan type according to their different characteristics (Figure 7).

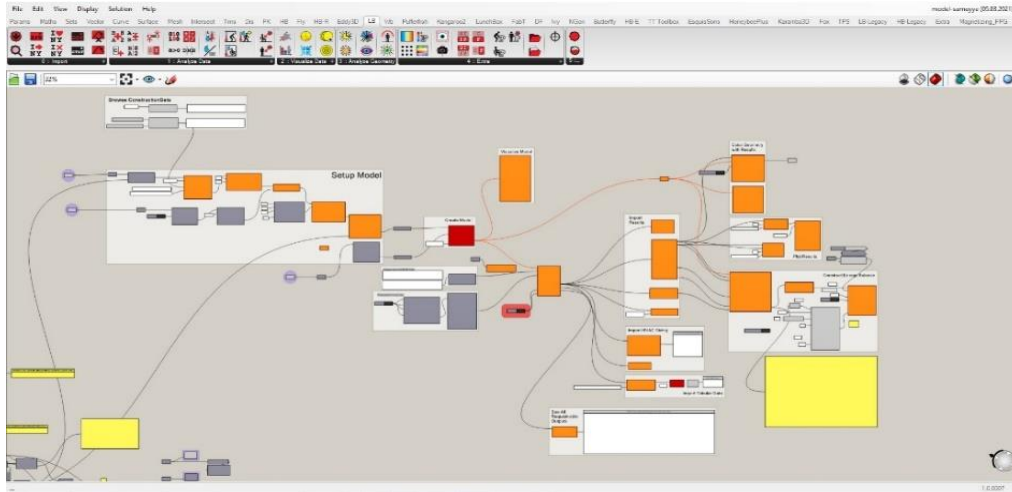
**Table 3.** Layering of the structural components used in the model

| Parameter Name   | Description                        | Value  |
|------------------|------------------------------------|--|
| U Exterior Wall  | Conductivity of the walls          | 0,599 W/m <sup>2</sup> K   |
| U_Window         | Conductivity of the windows        | 1,687 W/m <sup>2</sup> K   |
| U Roof           | Conductivity of the roof(top)      | 0,208 W/m <sup>2</sup> K   |
| U Interior Floor | Conductivity of the interior slabs | 2,014 W/m <sup>2</sup> K   |
| U Ground Floor   | Conductivity of the ground slab    | 0,394 W/m <sup>2</sup> K   |
| Activity         | Activity Conditions of Building    | Midrise Apartment<br>Occupancy: 0,04 p/m <sup>2</sup><br>Clo: 1,0<br>Met: 0,90 met |
| HVAC Settings    | Building HVAC Conditions           | (Variable air Volume)<br>chiller gas boiler reheat                                 |

The intended structural characteristics for the building models used in the analysis are provided in Table 3. For the model, the total thermal transmittance (U-value) of the external wall layer was taken as 0.599 W/m<sup>2</sup>- K, the internal floor as 2.014 W/m<sup>2</sup>-K, the roof as 0.208 W/m<sup>2</sup>-K, and the windows as 1.687 W/m<sup>2</sup>-K. Additionally, it was assumed that each analyzed building had mechanical HVAC systems using “VAV (Variable air Volume) chiller gas boiler reheat”.

**Figure 8.** Establishing the Correlation between North Direction (A), Prevailing Wind Direction (B) and Optimum Building Directions (C)

Afterwards, a mathematical relation was established between “North direction”, “prevailing wind direction” and “optimal building directions” considering the input data determined above. By parameterizing this relation, it is possible to process data that varies according to any region of the canal area. For example, while the wind direction is NE in the northern parts of the canal axis, it is NNE in the southern parts. This difference in between can be processed into the system via Grasshopper3D over the angle of the wind with the north (Figure 8).



**Figure 9.** The Section Developed with the LadyBug Plugin

In addition, another section has been considered in Grasshopper3D by using the LadyBug plugin in order to compare the amount of energy consumption according to alternative building orientations. This section was developed based on the residential/apartment type building with a wall thickness of 25 cm and the Istanbul, Yeşilköy EPW file obtained from Energyplus. Alternative plan types, window sizes and floor elevations are other input parameters used in this section (Figure 9).

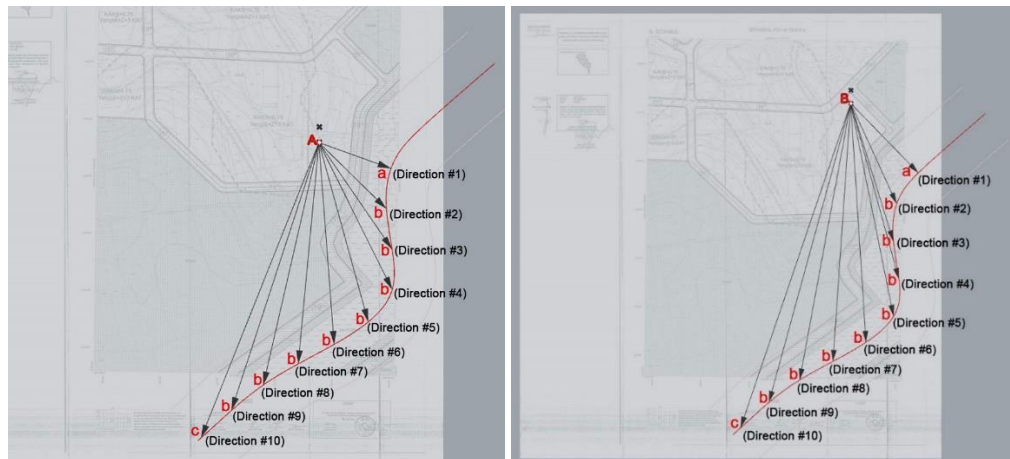
### Operation of the Model

The model first reveals the building form according to the number of floors and window sizes over the determined plan contour and location. It then makes the user select the “canal axis”. It expects the region (North or South) to be preferred in order to calculate the prevailing wind direction from behind. After these initial inputs are completed, the system determines “two directions” by positioning the building according to the “closest” point to the vista and the “furthest” point, which is the last distance from which the vista can be seen. Then, it determines intervals according to the number of analyzes from the area between these two directions and extracts alternative orientations. Each orientation intersects with a slice of the vista spline according to the conical point of view. The system makes calculations on both these intersecting curves and the viewing distances to the vista, and translates how much each orientation benefits from the vista into mathematical data.

According to the vista factor, these alternative orientations of the building are transferred to another analysis to be compared on the “prevailing wind direction”, “north direction” and “optimal directions”. At this stage, it is measured how far the building moves from the north and prevailing wind directions and how close it is to the optimum direction. Then, in the section added to the system with the “LadyBug” plugin, energy consumption calculations are made for each alternative orientation. The data obtained after all these calculations are presented to the user in the form of a table in order to be able to choose among alternative orientations.



## Calculation Examples



**Figure 10.** Determination of Nearest (a), Farthest (b) and Intermediate Directions (c) for A and B Position

**Table 4.** Data Obtained from the Orientation of the Structure According to 10 Different Angles and Two Different Locations

| Directions (Position A) | With the North direction (Degrees) | Deviation from the optimum direction (Degrees) | With the prevailing wind direction (Degrees) | Distance perpendicular to the vista (Meters) | The seen vista spline (Meters) | District Cooling (kWh) | District Heating (kWh) | Energy Per Conditioned Building Area (kWh/m <sup>2</sup> ) |
|-------------------------|------------------------------------|--|--|--|--------------------------------|------------------------|------------------------|--|
| Dir. #1                 | 110 <sup>0</sup>                   | 60 <sup>0</sup>                                | 93 <sup>0</sup>                              | 127  | 71                             | 4677.08                | 6875.79                | 76.62  |
| Dir. #2                 | 134 <sup>0</sup>                   | 36 <sup>0</sup>                                | 68 <sup>0</sup>                              | 156  | 148                            | 4333.27                | 6291.44                | 70.46  |
| Dir. #3                 | 146 <sup>0</sup>                   | 24 <sup>0</sup>                                | 57 <sup>0</sup>                              | 214  | 193                            | 3975.75                | 6002.61                | 66.18  |
| Dir. #4                 | 154 <sup>0</sup>                   | 16 <sup>0</sup>                                | 49 <sup>0</sup>                              | 272  | 206                            | 3712.10                | 5829.64                | 63.28  |
| Dir. #5                 | 165 <sup>0</sup>                   | 5 <sup>0</sup>                                 | 38 <sup>0</sup>                              | 307  | 192                            | 3402.23                | 5659.16                | 60.09  |
| Dir. #6                 | 176 <sup>0</sup>                   | 6 <sup>0</sup>                                 | 27 <sup>0</sup>                              | 334  | 203                            | 3224.11                | 5588.13                | 58.44  |
| Dir. #7                 | 185 <sup>0</sup>                   | 15 <sup>0</sup>                                | 17 <sup>0</sup>                              | 367  | 275                            | 3098.95                | 6162.43                | 56.50  |
| Dir. #8                 | 193 <sup>0</sup>                   | 23 <sup>0</sup>                                | 10 <sup>0</sup>                              | 411  | 262                            | 3150.17                | 6210.45                | 57.10  |
| Dir. #9                 | 198 <sup>0</sup>                   | 28 <sup>0</sup>                                | 4 <sup>0</sup>                               | 466  | 227                            | 3213.22                | 6262.11                | 57.80  |
| Dir. #10                | 202 <sup>0</sup>                   | 32 <sup>0</sup>                                | 1 <sup>0</sup>                               | 525  | 199                            | 3277.02                | 6315.61                | 58.52  |
| Directions (Position B) | With the North direction (Degrees) | Deviation from the optimum direction (Degrees) | With the prevailing wind direction (Degrees) | Distance perpendicular to the vista (Meters) | The seen vista spline (Meters) | District Cooling (kWh) | District Heating (kWh) | Energy Per Conditioned Building Area (kWh/m <sup>2</sup> ) |
| Dir. #1                 | 136 <sup>0</sup>                   | 34 <sup>0</sup>                                | 67 <sup>0</sup>                              | 188  | 104                            | 4171.04                | 6794.52                | 66.90  |
| Dir. #2                 | 155 <sup>0</sup>                   | 15 <sup>0</sup>                                | 47 <sup>0</sup>                              | 215  | 299                            | 3571.93                | 6381.59                | 60.72  |
| Dir. #3                 | 163 <sup>0</sup>                   | 7 <sup>0</sup>                                 | 40 <sup>0</sup>                              | 281  | 343                            | 3344.57                | 6259.08                | 58.59  |
| Dir. #4                 | 165 <sup>0</sup>                   | 5 <sup>0</sup>                                 | 38 <sup>0</sup>                              | 354  | 354                            | 3298.52                | 6235.83                | 58.16  |
| Dir. #5                 | 169 <sup>0</sup>                   | 1 <sup>0</sup>                                 | 34 <sup>0</sup>                              | 422  | 376                            | 3219.42                | 6198.48                | 57.45  |
| Dir. #6                 | 176 <sup>0</sup>                   | 6 <sup>0</sup>                                 | 26 <sup>0</sup>                              | 465  | 408                            | 3127.80                | 6161.02                | 56.67  |
| Dir. #7                 | 184 <sup>0</sup>                   | 14 <sup>0</sup>                                | 19 <sup>0</sup>                              | 502  | 371                            | 3097.52                | 6159.57                | 56.47  |
| Dir. #8                 | 190 <sup>0</sup>                   | 20 <sup>0</sup>                                | 12 <sup>0</sup>                              | 546  | 325                            | 3123.41                | 6187.37                | 56.80  |
| Dir. #9                 | 195 <sup>0</sup>                   | 25 <sup>0</sup>                                | 7 <sup>0</sup>                               | 602  | 279                            | 3172.77                | 6228.96                | 57.36  |
| Dir. #10                | 199 <sup>0</sup>                   | 29 <sup>0</sup>                                | 4 <sup>0</sup>                               | 666  | 244                            | 3228.16                | 6274.50                | 57.97  |

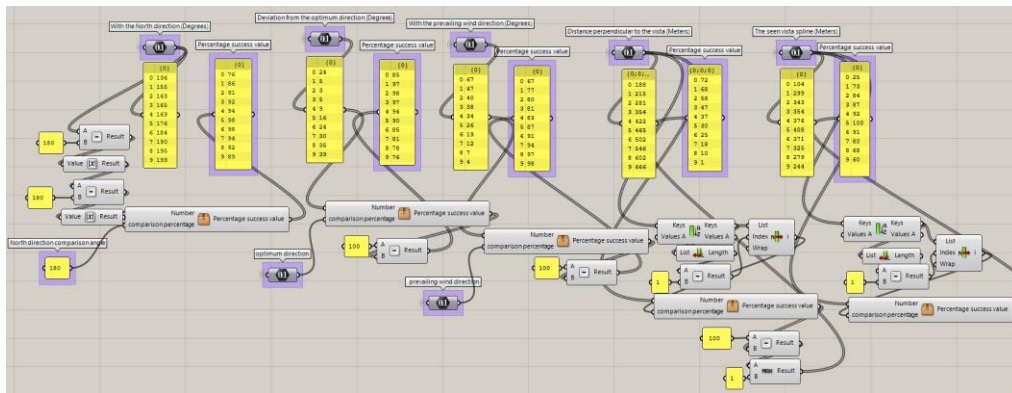
Two example calculations are presented in Table 4. For these examples, a point close to the Southern parts of the canal was chosen as the location of the structures. As can be seen in Figure 10, a total of 10 alternative directions were determined, with the closest

and farthest perpendicular points to the vista axis. The resulting values from each orientation are shown in the table. According to the data, for example, orientation number 6 at position A is the most concealed orientation from the North direction compared to the others, and it is one of the orientations closest to the “optimal direction”.

In this orientation, there is a 27 degree angle difference between the structure and the prevailing wind direction of the region. Assuming that zero (0) degree is the most sheltered orientation from the prevailing wind, it is thought that the value obtained can give an idea about the success of the orientation. In this 6 orientation, the building has a vertical vista distance of 334 m and the spline it sweeps as a vista is 203 m. As another example, it can be said that orientation number 5 in position B has the least amount of deviation from the optimum direction compared to the others. However, this direction is far behind in terms of vertical distance orientation to the vista.

It is thought that similar evaluations made on these data can give the user an idea for an ideal orientation. However, it is predicted that connecting these data to a certain set of mathematical rules and thus directing a quantitative evaluation will be a more accurate and scientific trend in the decision-making process. In this context, an “optimization experiment” was conducted to help determine the optimum orientation over all the data obtained, and a “direction scoring” was tried to be put forward through the alternatives.

## Optimization Experiment



**Figure 11.** Conversion of All Values to Percentages on Grasshopper3D

First of all, this issue was approached as a multivariate function. A value calculation over 100 points was made for all the data obtained. According to this calculation, the orientation with the most hidden front from the North direction approached 100 points more. Likewise, the orientation closest to the optimum direction and the orientation most hidden from the prevailing wind direction also approached 100 points in their own field. In addition, the direction with the closest vertical orientation to the vista and the orientation with the most vista spline were also rated within themselves and approached 100 points (Figure 11).

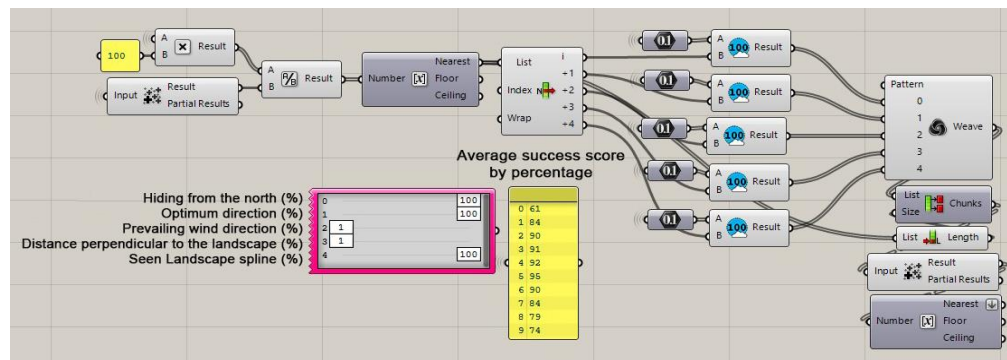
**Table 5.** *Percentage Success Values of the Obtained Data*

| Directions<br>(Position A) | Hiding from<br>the north<br>(Degrees) | Deviation from<br>the optimum<br>direction<br>(Degrees) | With the<br>prevailing wind<br>direction<br>(Degrees) | Distance<br>perpendicular<br>to the vista<br>(Meters) | The seen vista<br>spline (%) |
|----------------------------|---------------------------------------|---|---|---|------------------------------|
| Direction #1               | 61                                    | 69  | 54  | 76  | 26                           |
| Direction #2               | 74                                    | 84  | 66  | 70  | 54                           |
| Direction #3               | 81                                    | 91  | 72  | 59  | 70                           |
| Direction #4               | 86                                    | 96  | 76  | 48  | 75                           |
| Direction #5               | 92                                    | 97  | 81  | 42  | 70                           |
| Direction #6               | 98                                    | 90  | 87  | 36  | 74                           |
| Direction #7               | 97                                    | 84  | 92  | 30  | 100                          |
| Direction #8               | 93                                    | 79  | 95  | 22  | 95                           |
| Direction #9               | 90                                    | 76  | 98  | 11  | 83                           |
| Direction #10              | 88                                    | 74  | 100   | 1   | 72                           |
| Directions<br>(Position B) | Hiding from<br>the north<br>(Degrees) | Deviation from<br>the optimum<br>direction<br>(Degrees) | With the<br>prevailing wind<br>direction<br>(Degrees) | Distance<br>perpendicular<br>to the vista<br>(Meters) | The seen vista<br>spline (%) |
| Direction #1               | 76                                    | 85  | 67  | 72  | 25                           |
| Direction #2               | 86                                    | 97  | 77  | 68  | 73                           |
| Direction #3               | 91                                    | 98  | 80  | 58  | 84                           |
| Direction #4               | 92                                    | 97  | 81  | 47  | 87                           |
| Direction #5               | 94                                    | 94  | 83  | 37  | 92                           |
| Direction #6               | 98                                    | 90  | 87  | 30  | 100                          |
| Direction #7               | 98                                    | 85  | 91  | 25  | 91                           |
| Direction #8               | 94                                    | 81  | 94  | 18  | 80                           |
| Direction #9               | 92                                    | 78  | 97  | 10  | 68                           |
| Direction #10              | 89                                    | 76  | 98  | 1   | 60                           |

In Table 5, an example calculation is presented based on the data obtained from points A and B. In this calculation, in the comparison of “Hiding from the north” in the second column, it was examined how much the orientations reflect the 180-degree difference between them and the North direction. Likewise, in the comparison of “Deviation from the optimum direction” in the third column, the amount of directions approaching 160, which is the optimum direction degree of the Temperate-Humid Climate, was examined. In the fourth column, the question of how much the directions are hidden from the prevailing wind direction was converted into a score out of 100. In the fifth column, 1 point is given to the furthest point where the building placed on the point has a perpendicular view to vista, and other directions are scored according to this furthest direction. In the last column, each direction is scored by making a ratio according to the length of the spline that intersects the area scanned by the conical point of view. According to this approach, the success of the first orientation at point A with 110 degrees from the North direction is 61%. However, the success rate of orientation 6, whose angle with the North is 176 degrees on the same point, is 98%. According to this calculation, it can be said that orientation number 6 is 37% more successful than orientation number 1 in terms of “Hiding from the north”.

In the next step, all percentages obtained are compared with each other in order to compare these new data and reach an average “success score” for each orientation. At this stage, it is left to the user to determine the percentage values to be used in comparison of all data (Figure 12). This is because the component that

each user prioritizes is “subjective”. For example, according to some users, being closer to the vista may be a priority and valuable because the spline distance of the vista is longer. Or, the optimum orientation may override the prevailing wind direction factor, according to some users.



**Figure 12.** *Obtaining the Average Success Score by Proportioning the Data with Each Other in Grasshopper 3D*

**Table 6.** Success Scores Obtained as a Result of the Preferences of 4 Different Users

| Directions<br>(Position A) | User #1's<br>achievement<br>score<br>(%) | User #2's<br>achievement score<br>(%) | User #3's<br>achievement score<br>(%)    | User #4's<br>achievement score<br>(%) |                                       |
|----------------------------|--|---------------------------------------|--|---------------------------------------|---------------------------------------|
| Values entered             | % 100-% 100-<br>% 100-% 100-<br>% 100    | % 100-% 100-% 1-% 1-<br>% 100         | % 1-% 100-% 1-<br>% 100-% 1              | % 8-% 50-% 10-<br>% 80-% 50           |                                       |
| Direction #1               | 57                                       | 51                                    | 71                                       | 60                                    |                                       |
| Direction #2               | 70                                       | 70                                    | 75                                       | 70                                    |                                       |
| Direction #3               | 75                                       | 80                                    | 74                                       | 72                                    |                                       |
| Direction #4               | 76                                       | 85                                    | 71                                       | 71                                    |                                       |
| Direction #5               | 76                                       | 85                                    | 68                                       | 67                                    |                                       |
| Direction #6               | 77                                       | 86                                    | 62                                       | 65                                    |                                       |
| Direction #7               | 81                                       | 93                                    | 56                                       | 68                                    |                                       |
| Direction #8               | 77                                       | 88                                    | 49                                       | 62                                    |                                       |
| Direction #9               | 72                                       | 82                                    | 43                                       | 53                                    |                                       |
| Direction #10              | 67                                       | 77                                    | 37                                       | 46                                    |                                       |
| Directions<br>(Position B) | User #1's<br>achievement score<br>(%)    |                                       | User #2's<br>achievement<br>score<br>(%) | User #3's<br>achievement<br>score (%) | User #4's<br>achievement<br>score (%) |
| Values entered             | % 100-% 100-% 100-% 100-% 100            |                                       | % 100-<br>% 100-% 1-<br>% 1-% 100        | % 1-% 100-<br>% 1-% 100-<br>% 1       | % 8-% 50-<br>% 10-% 80-<br>% 50       |
| Direction #1               | 65                                       |                                       | 61                                       | 77                                    | 64                                    |
| Direction #2               | 80                                       |                                       | 84                                       | 81                                    | 79                                    |
| Direction #3               | 82                                       |                                       | 90                                       | 76                                    | 78                                    |
| Direction #4               | 81                                       |                                       | 91                                       | 71                                    | 74                                    |
| Direction #5               | 80                                       |                                       | 92                                       | 64                                    | 71                                    |
| Direction #6               | 81                                       |                                       | 95                                       | 59                                    | 69                                    |
| Direction #7               | 78                                       |                                       | 90                                       | 54                                    | 64                                    |
| Direction #8               | 73                                       |                                       | 84                                       | 49                                    | 57                                    |
| Direction #9               | 69                                       |                                       | 79                                       | 43                                    | 50                                    |
| Direction #10              | 65                                       |                                       | 74                                       | 38                                    | 43                                    |

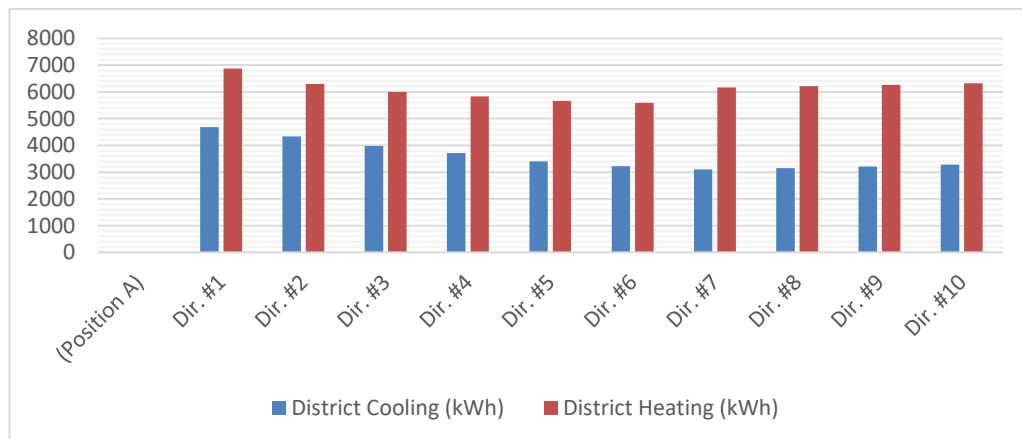
In Table 6, the preference of sample percentage values belonging to four different users and the success scores for each orientation are given.

In the “Values entered” line in the table, respectively;

- Angle preference ratio with the north direction
- Angle preference ratio between optimum direction,
- Angle utilization ratio with the prevailing wind direction,
- Rate of use perpendicular to the vista,
- and the vista spline length utilization rate,

is shown as the preferred percentile.

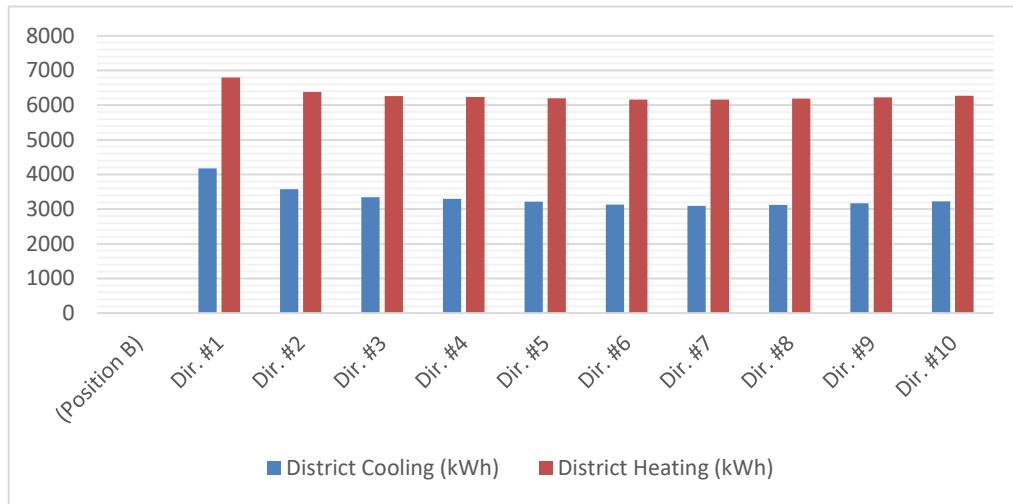
Accordingly, it is seen that the first user at point A prefers each value equally. As a result of this preference, direction #7 is the most successful direction with 81%. It is observed that the second user wants to hide the building at the maximum level from the North side and bring it as close to the optimum direction as possible. In addition, it is understood that this user does not care about the prevailing wind direction and the proximity of the perpendicular view distance to the vista, but still wants to see the vista arc at the maximum level. As can be seen in the table, 93% success rate is again direction #7 responding to these preferences. The third user, on the other hand, does not seem to be interested in other values that want to aim as much as possible in the optimum direction and to have maximum vertical closeness to the vista. Again, as seen in the table, it is observed that Direction #2 meets these preferences with a success rate of 75%. It is seen that Direction #7 responds to the preferences of the fourth example user, followed in the table, with a success rate of 68%. In the columns below, the calculation of the same user values over the B point is shared. The results are as seen.



**Figure 13.** Annual Heating-Cooling and annual energy data of Alternative Orientations in Position A

When the orientation states of which energy analysis is made in the case of Table 6 Position A are examined, the orientation situation that gives the best result in terms of cooling energy expenditure in summer energy efficiency is direction #7 with 3098.95 kWh. When the heating energy expenditure performances of the

orientation alternatives are examined for the winter period, it is seen that the orientation alternative showing the lowest energy expenditure is direction #6 with 5588.13 kWh. Direction #6 is the orientation alternative that makes the closest angle to the south direction with  $176^\circ$ . As the tendency towards the south in the winter period increases, the effect of solar radiation on the structure increases, thus creating a positive effect in terms of heating energy load. Direction #6 has a lower energy consumption in terms of heating energy load as it has a greater angular proximity to the south direction compared to other orientation alternatives (Figure 13).



**Figure 14.** Annual Heating-Cooling and Annual Energy Data of Alternative Orientations in Position B

When the orientation states of which energy analysis was made in the case of Table 6 Position B are examined, the orientation situation that gives the best result in terms of cooling energy expenditure in summer energy efficiency is direction #7 with 3097.52 kWh. When the heating energy expenditure performances of the orientation alternatives are examined for the winter period, it is seen that the orientation alternative showing the lowest energy expenditure is direction #7 with 6159.57 kWh. Direction #8 is the orientation alternative that makes the closest angle to the south direction with  $184^\circ$ . As the tendency towards the south in the winter period increases, the effect of solar radiation on the structure increases, thus creating a positive effect in terms of heating energy load. Direction #6 has a lower energy consumption in terms of heating energy load since it has a greater angular proximity to the south direction compared to other orientation alternatives (Figure 14).

## Conclusion

In recent years, environmentally sensitive building designs have been given more importance in the world than in the past, and various studies have been carried out in this field. Ways to get maximum efficiency with minimum damage from nature are being researched by designers with this sensitivity. With the

increase in the human population, the change in the perception of comfort or the effect of industrialization, the amount of permeable surface is decreasing while the construction is increasing day by day. While the haphazard positioning of the buildings causes more energy consumption and creates environmental pollution, it is possible to provide thermal comfort by directing the building according to the climatic conditions of the region. While the necessity of directing the building mass in the most appropriate way is obvious, the “vista” factor, which is an important user expectation, stands before us as another parameter that should be taken into account.

In this study, an “optimization model” has been developed by using parametric and numerical design principles in order to suggest the optimum orientation of the houses planned to be built within the project impact area according to their locations.

First of all, the current status of the project idea was investigated and the technical and ecological data of the project area were accessed. In these examinations made for the production of input parameters for the model developed within the scope of the study, “prevailing wind direction” and “optimal building direction” were determined by using the temperature and wind data of the region. Afterwards, the “vista” factor, which is an important component in the orientation of the buildings, was focused on and this factor was considered as a sub-context. As it is known, the vista has a complex structure with many parts and its valuation may vary from person to person. In this sense, it can be said that it is a very difficult component to determine based on quantitative data from a mathematical point of view. In the study, the vista was expressed with a “spline object” and was included in the model by being limited to two parameters: “closeness to the vista” and “spline of the seen vista”.

A and B directions to give the user an ideal orientation idea; It has been analyzed with the data of hiding from the north, deviation from the optimum direction, the angle between the prevailing wind direction and the seen spline of the vista. Alternative directions are derived on the model, vista spline and analyzes are made for each direction in the ecological/climatic contexts mentioned above. Afterwards, it offers an approach in which user priorities are taken into account for the optimization of the data obtained as a result of the analysis.

In this study, the data obtained from the optimization were evaluated according to four different users and the success scores obtained as a result of the preferences were obtained. The most successful orientation according to users for location A; Direction #7 for the first user, direction #7 for the 2nd user, direction #2 for the 3rd user, and direction #5 for the user 4. For position B; Direction #3 for User 1, direction #6 for User 2, direction #2 for User 3, and direction #2 for User 4 was determined to be the most successful orientation. The study has been tested for alternative aspects and different users, and it has answered the expectation as a decision support model.

The project, which is thought to be a new construction area with the development of these and similar systems, is clear that ecologically efficient and environmentally sensitive structures or building orientations can be realized. It is thought that this study has a unique quality, especially in terms of intersecting this

ecological sensitivity with the “vista” component. The study, which touches on a very wide research area, was kept within certain limits, as summarized above.

First of all, the “constraint” elements of the vista were ignored in the study. In order to get more accurate results, the vista components should be reviewed and the mathematical differences that these components will make on the system should be investigated.

It is thought that large-scale land use projects will cause urban heat island. In this context, the possibility of possible heat islands that will occur on a large scale of construction should be evaluated and the model developed within the scope of the article should be reviewed in this respect and its algorithm should be re-established. It is thought that considering the building orientation in the area together with the energy efficient building understanding is important in terms of sustainability. It is predicted that the developed model will yield more accurate results by reinterpreting it according to this association.

Migration from rural areas to cities is expected to continue in the world. If the population is not 500,000 as planned after the project, the building decisions should be reviewed and it is recommended to reevaluate the parameter inputs of the model developed with the increase in the housing areas required for the population to reside in the future studies. Since it is planned to have a large population mobility in the region after the construction, it should be investigated whether it will affect the climatic characteristics. The developed model should be revised according to these studies and new input parameters should be constructed.

The model developed within the scope of the study takes into account the climatic data and interprets the ideal building orientation through these data. In this context, the model should be reinterpreted after the landscape project of the project area is clarified, taking into account the possible changes in the climate of the plant population added to the area. It is thought that the sea breezes will not be interrupted with the recreation areas to be created by the sea after the project, and it is stated by the ministry that the construction will be built on the basis of horizontal architecture. In this context, it is recommended to consider the shared literature in determining the input parameters for the number of floors to be used in the developed model.

Calculations in the developed model were made on the planar canal close settlements of the project area. The algorithm of the model should be re-established by adding topographic data. The model created is designed to measure every building form. Considering these definitions in the literature on the ideal building form, the effect of the building form to be used in the model on the results should also be investigated. The distance factor between buildings was not taken into account in this study. However, it is presented as information in terms of guiding future studies.

The model developed within the scope of the article can measure on every building form. However, in this study, analyzes were not made on alternative forms. Considering this and similar literature information shared, the model, climate zone-building form intersection should also be investigated.



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