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The Effect of Structural Density on Wind Speed in Urban Landscape Planning and Design; A Case Study of Duzce

Kentsel Peyzaj Planlama ve Tasarımında Yapısal Yoğunluğun Rüzgâr Hızına Etkisi; Düzce Örneği

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Abstract

Continuing throughout the history, one of the most important purposes of planning and design has been the enhancement of human comfort. Considering the needs of the environment as well as the demands of human beings, nature-friendly planning and design approach has developed and sustainable environmental studies have emerged. In this study, it is aimed to develop landscape planning and design proposals suitable for this comfort area by determining the extent to which the wind affects the human comfort level. In this context, in order to determine the basis of the relationship between urban landscape planning and wind Düzce City was chosen as the material. Local wind measurements were made with portable meteorology stations (Vantage Pro2) in the city area and statistical meanings were revealed by comparing with the simultaneous data obtained from Düzce Provincial Directorate of Meteorology. Basically, the hypotheses that "The mass-space (structural density) ratios of the city change the wind speed" were questioned. As a result; it was observed that the mass-gap ratios in the neighborhoods were inversely proportional to the wind speed. The results of the study will once again bring to the importance of the decisions taken at the planning stage while forming the cities.

Keywords: Urban landscape, Planning and design, Wind, ArcGIS, Düzce

Özet

Tarih boyunca devam eden planlama ve tasarımın en önemli amaçlarından biri insan konforunu artırmak olmuştur. İnsanoğlunun talepleri kadar çevrenin ihtiyaçları da dikkate alındığında, doğa dostu planlama ve tasarım anlayışı gelişmiş ve sürdürülebilir çevre çalışmaları ortaya çıkmıştır. Bu çalışmada, rüzgarın insan konfor düzeyini ne ölçüde etkilediği belirlenerek, bu konfor alanına uygun peyzaj planlama ve tasarım önerilerinin geliştirilmesi amaçlanmaktadır. Bu bağlamda kentsel peyzaj planlaması ile rüzgar arasındaki ilişkinin temelini belirlemek amacıyla materyal olarak Düzce İli seçilmiştir. Kent alanında taşınabilir meteoroloji istasyonları (Vantage Pro2) ile yerel rüzgar ölçümleri yapılmış ve Düzce İl Meteoroloji Müdürlüğü'nden alınan eş zamanlı verilerle karşılaştırılarak istatistiksel anlamlar ortaya konulmuştur. Temel olarak "Kentin kütle-boşluk (yapısal yoğunluk) oranları rüzgar hızını değiştirir" hipotezi sorgulanmıştır. Sonuç olarak; mahallelerdeki kütle-gap oranlarının rüzgar hızı ile ters orantılı olduğu gözlemlendi. Çalışmanın sonuçları, kentleri oluştururken planlama aşamasında alınan kararların önemini bir kez daha ortaya koyacaktır.

Anahtar Kelimeler: Kentsel peyzaj. Planlama ve tasarım, Rüzgar, ArcGIS, Düzce

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1. Introduction

Many urban design projects produced today make uniform suggestions for all urban spaces, without considering the design criteria and local data of the space. Cities, which are already struggling with density and unplanned urbanization, also struggle with negative microclimate results, revealing more uncomfortable usage areas. Even a small change in the location of the masses that change in the urban pattern can create big changes in the microclimate. For this reason, climate data should not be ignored in the design; It is important in terms of increasing the quality of life, reducing energy consumption and costly building environments.

Air quality is among the important parameters in the comfort of cities created with an effective planning and design approach. Sipahioğlu (1991) determined that the wind speed causes the dilution of pollutants in the wind direction and stated that the pollution concentration is inversely proportional to the wind speed (Barış, 1995). In addition, it is known that reasons such as dense urbanization, urban sprawl, topographic and meteorological conditions cause an increase in air pollution, especially in winter.

For example, the city of Stuttgart is considered among the settlements that are very problematic in terms of air pollution and a decrease in green areas in the second half of the 18th century. It was deemed necessary to carry out "Climate Planning" studies, especially to prevent or eliminate air pollution. For this purpose, as a result of the problems caused by the inability to push the stagnant polluted air accumulated in the city by the low-speed wind, microclimatic circulation and the protection of the urban landscape have been adopted as two important issues (Öztan, 2002; Yılmaz and Memlük, 2008). Similarly, Reed (2010) states that designs made in cooperation with the wind are considered more accurate designs. While designs are made that allow light winds in summer in humid regions; and adds that it is more correct to make designs by changing the direction of the wind or completely blocking the landscape design in winters in dry regions.

In cold climatic regions, the wind wall can be created with vegetative elements in the directions where the wind is effective. Such a form of protection reduces the heat changes that may occur from the building surfaces by convection. To ensure that the wind enters or does not enter the building, their height and distance from the buildings gain importance (Canan, 2008; Akın, 2011). Olgyay (1992) stated that in the behavior of the wind when it encounters a high obstacle, an upwind vortex will form on the windward side of the obstacle (Fig. 1). This is also called eddy/turbulence.

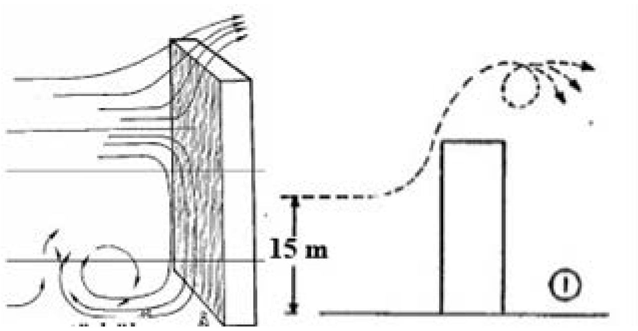


Figure 1. The behavior of the wind against a high obstacle (Olgyay, 1992; Akyel, 2007).

Turbulence; It is a complex or unsteady vortexing motion. When the wind is flowing or around an obstacle, the air pressure increases in the direction the wind blows in front of the obstacle and then decreases behind it. This results in at least one vacuum or low-pressure area downwind. This change in pressure allows air to be drawn in from the sides and the top down. Thus, the wind swirls (Reed, 2010).

Wind speed varies with altitude and terrain. As the altitude increases, the wind speed increases (Fig. 2). This rate decreases as the terrain become rougher. In other words, while the wind speed is much more uninterrupted and faster in open areas and rural environments, the speed decreases as obstacles increase in urban centers. This increase creates the profile of the wind, and as a result, the wind speed can vary in different terrains with the same height (Anonymous, 2021).

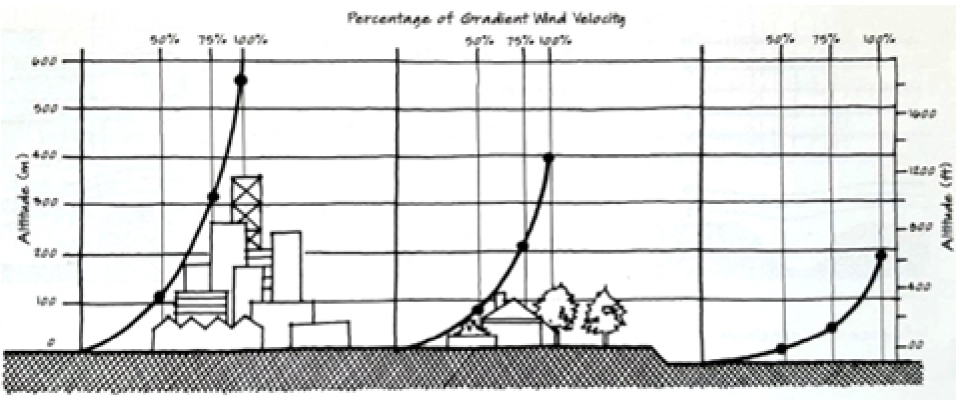


Figure 2. Elevation and wind speed ratios (Brown and Decay, 2001).

In this context, it is necessary to direct/use the effect that changes with height as desired. The quality of life of the city can be increased with urban design studies based on the circulation of the wind in the city. The wind must be in motion in the city, otherwise, artificial microclimates are formed in the settlements and negatively affect life. At this point, it makes no difference whether the average temperature of the settlement is high or low. The motionless wind can create undesirable urban spaces by creating hot or cold microclimates (Coşkun, 2013).

In addition, hierarchical arrangements are also important for the continuity of wind circulation. In the absence of this arrangement and scattered constructions, pressure differences will cause the wind to enter turbulence (Fig. 3). A similar effect can be achieved with a plant design that includes a full composition, as well as structural arrangements.

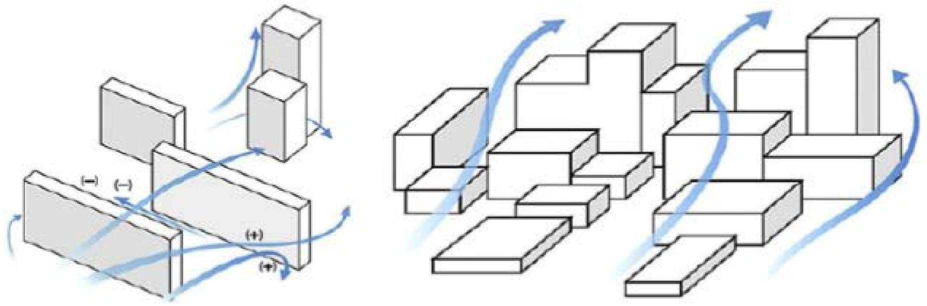


Figure 3. The importance of hierarchical design in wind circulation (Ng, 2009).

Similarly, a measure taken to avoid the turbulence effect is shown in Figure 4. In the design example here, terracing systems have been developed and hierarchy has been provided and the continuity of wind circulation has also been achieved.

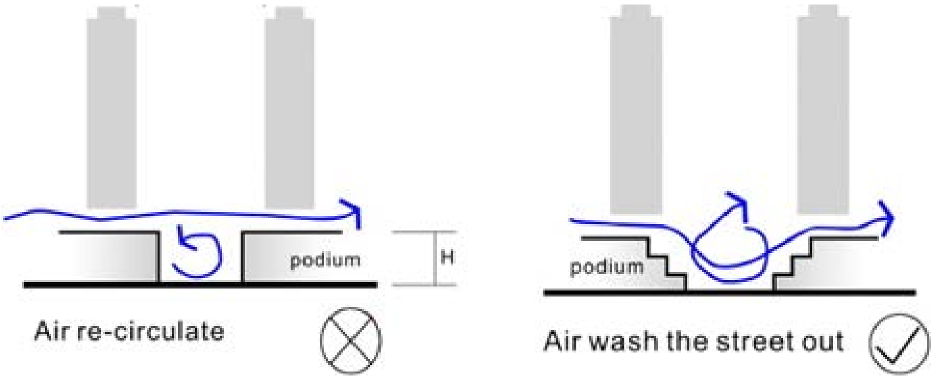


Figure 4. The importance of terrace systems in reducing the effect of turbulence (Ng, 2009).

As indicated in Fig.5; There are four different types of airflow: laminar, split, turbulent, and vortical. However, as a result of examining these factors and knowing their characters, effective natural ventilation can be realized (Çakır, 2003).

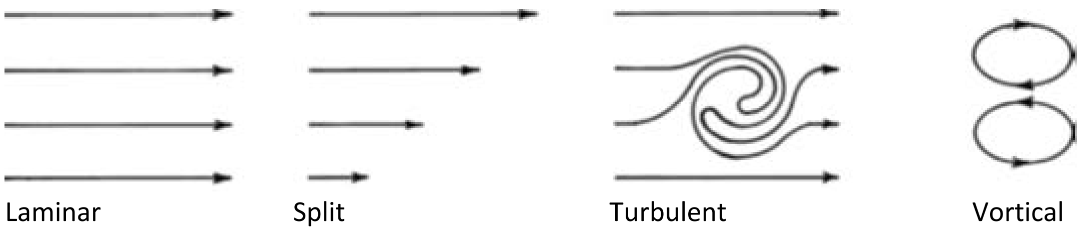


Figure 5. Airflow types (Bowen et al., 1981; Lechner, 2015).

Among these factors that affect the speed and direction of the wind, especially the topography changes and the mass effects that cause the pressure difference, are the factors that should be considered in the urban design process.

In this study, the contribution of the wind, which is one of the climate elements, in the orientation and shaping of the city, accordingly, is aimed to increase the quality of life of the city. Considering this purpose and information; As a result of the landscape planning and design to be made in the city, it is based on which direction the wind can be directed more accurately.

2. Material and Method

The main material of the study is the urban area within the borders of the adjacent area of Düzce City (Fig. 6). This city is located in the Western Black Sea region. Covering about 61% of its territory, the mountains rise from north to south and from west to east. In the west, they lose their parallelism to the coast and become sparse. Valleys and plains enter between these mountain ranges (Düzce Provincial Environmental Status Report, 2011). 86% of the province's land (approximately 2.200 km²) is rugged and mountainous. Düzce plain forms the remaining 14%. The average elevation of the Düzce plain is around 140 meters and it is surrounded by mountains (Düzce Municipality Strategic Plan, 2014). Most of the Düzce City neighborhoods (the study area) are in areas that can be described as flat. The height differences around it show that it is an example of a bowl-shaped city type.

Figure 6. Location of Düzce City and the boundary of the study area (Özdede, 2017).

Since Düzce City is within the borders of the Black Sea Region, the effects of the Western Black Sea climate are seen in its general characteristics. However, in addition to the Black Sea climate, it also shows a transition feature between Mediterranean and Continental climates. The summers are hot, the winters are mild, and it is rainy in all seasons; Most precipitation occurs in autumn and winter. There are about two droughts in summer (TUİK, 2013).

Annual average wind frequency diagrams obtained from Düzce Meteorology Provincial Directorate (2013) show that the prevailing wind direction is on the northeast-southwest (NE-SW) axis. The seasonality factor is also important for wind measurements. When analyzed seasonally, it is seen that there is no difference in direction with the general wind frequency diagram (NE-SW). However, in terms of frequencies, it is observed more in the winter season, in the southwest than in the northeast, compared to the other three seasons. This means that the prevailing wind in winter is from the southwest. When the general wind speed data are examined; In Düzce Municipality Strategic Plan (2014); It is stated that the average wind speed in Düzce City is 0.7 m/s.

To determine the basis of the relationship between urban landscape design and wind, it is necessary to look at the effect of urban building density (mass-gap ratios) on wind speed. In this context, wind measurements during area studies were carried out using the "Vantage Pro2 Meteorology Station" and the results were obtained with WeatherLink 6.0.2 software. At the same time, minute wind data were obtained from Düzce Meteorology Provincial Directorate (2013) and used as auxiliary materials. ArcMap 10.3 software was used in the process of processing the data and combining it with the Düzce City Zoning

Plan. In the evaluation of the study results, using SPSS 22.0 software; Photoshop CS6 software was used for editing maps and tables.

As a method, the classical research method consisting of "Analysis-Synthesis-Evaluation" was used. It generally consists of five stages. In the first stage, resource research and data acquisition related to the field were carried out. In the second stage, the building density ratios in the city were determined based on neighborhoods and neighborhood density maps were created regarding the urban building density. The importance of the mass-gap analysis obtained stems from the thought that the structural densities of the neighborhoods to be measured are different from each other and will require different numbers of measurements accordingly. With the results of the "Sample number determination formula" (Kaya et al., 2008) used here, the number of measurement point distributions in the neighborhoods was revealed. The weight of a neighborhood in the total of all neighborhoods is found by dividing the total mass-gap ratio of each neighborhood (~440) by the total ratio of 48 neighborhoods. After this process, the value obtained is multiplied by the total value of 385, and how many measurements should be made from which neighborhood. When the measurement points, which were determined as 385 in total, were entered on the map, the number of points was reduced to 300 due to the presence of neighboring points. The repetition of the measurements made at the border of the two neighborhoods was deemed unnecessary and therefore considered a common point. In the third stage, a field study was conducted and wind measurements were obtained from 48 neighborhoods by using the "Random Sampling Method". 300 measurement point values were processed according to their coordinates in ArcMap 10.3 software as wind speed and wind direction on a seasonal basis. With these values, the "Kriging interpolation" process was used to create the average wind speed and wind direction map for Düzce City. In the fourth stage, meteorological data and area data were compared and wind maps were drawn. In the last stage; By evaluating all data, the relationship between structural density areas and wind measurements was statistically revealed in line with the study's argument. In the study, the hypothesis that the mass void ratios of the city change the wind speed has been questioned.

3. Results and Discussion

In Düzce Municipality Strategic Plan (2014); It is stated that the average wind speed in Düzce City is 0.7 m/s. However, the optimum wind speed that should be according to bioclimatic comfort is 3-5 m/s (Olgyay, 1963). In this context, the fact that the wind, which should circulate in the city, has such a low speed, causes compression and affects the quality of life negatively. For this reason, it is revealed that wind is an important parameter in Düzce City and it is necessary to carry out studies to increase circulation.

In a study conducted by the Düzce University Faculty of Medicine, it was revealed that the percentage of patients with Pharyngitis and Bronchitis caused by air pollution increased in Düzce City (5.8% in August, 10.5% in January) (Güleç Balbay et al., 2012). Similarly, in Düzce Provincial Environmental Status Report (2011); It has been stated that air pollution is intense in the city, especially in winter, because the wind is less in Düzce City and therefore air circulation cannot be provided.

Evaluation of Studies on Urban Building Density

Separate mass-gap values for all neighborhoods were extracted from the Düzce City 2013 Zoning Plan. At this point the mass values are only buildings; The gap value is the area of the neighborhood boundary excluding the mass, and the mass-gap ratio is the ratio of these two values to each other. Accordingly, by applying the "Sample Number Determination Formula", the distribution of the number of measurement points in 48 neighborhoods obtained with the Duzce City Development Plan data is shown (Table 1).

Table 1. Mass-gap ratios and distribution of measurement points in Düzce City Center-Neighborhoods.

	MASS (m^2)	GAP (m^2)	RATIO (%)	DISTRIBUTION
1. **Ağaköy Neighborhood**	68.619	2.493.976	2,75	**2**
2. **Akınlar Neighborhood**	96.378	2.471.865	3,90	**3**
3. **Akpınar Neighborhood**	19.394	115.306	16,82	**11**
4. **Arap Çiftliği Neighborhood**	75.039	2.752.957	2,73	**2**
5. **Aziziye Neighborhood**	160.705	1.457.983	11,02	**7**
6. **Azmimilli Neighborhood**	137.364	851.865	16,13	**10**
7. **Bahçelievler Neighborhood**	64.856	792.879	8,18	**5**
8. **Beyciler Neighborhood**	127.040	2.825.210	4,50	**3**
9. **Burhaniye Neighborhood**	66.956	161.942	41,35	**27**
10. **Camikebir Neighborhood**	57.018	174.314	32,71	**21**
11. **Cedidiye Neighborhood**	98.487	268.137	36,73	**24**
12. **Cumhuriyet Neighborhood**	113.820	492.116	23,13	**15**
13. **Çakırlar Neighborhood**	41.462	2.585.982	1,60	**1**
14. **Çamköy Neighborhood**	72.610	3.211.868	2,26	**1**
15. **Çamlıevler Neighborhood**	15.066	725.958	2,08	**1**
16. **Çavuşlar Neighborhood**	49.324	1.415.871	3,48	**2**

17. **Çay Neighborhood**	190.175	830.725	22,89	**15**
18. **Darıcı Neighborhood**	111.051	4.501.763	2,47	**2**
19. **Dedeler Neighborhood**	16.366	682.051	2,40	**2**
20. **Demetevler Neighborhood**	41.139	622.501	6,61	**4**
21. **Derelitütüncü Neighborhood**	82.577	1.165.492	7,09	**5**
22. **Esentepe Neighborhood**	45.286	389.189	11,64	**8**
23. **Fatih Neighborhood**	36.168	387.842	9,33	**6**
24. **Fevziçakmak Neighborhood**	173.402	811.199	21,38	**14**
25. **Güzelbahçe Neighborhood**	93.673	703.728	13,31	**9**
26. **Hamidiye Neighborhood**	99.919	636.814	15,69	**10**
27. **Karaca Neighborhood**	101.478	370.286	27,41	**18**
28. **Karahacımusa Neighborhood**	38.690	718.264	5,39	**3**
29. **Kazukoğlu Neighborhood**	46.693	2.801.128	1,67	**1**
30. **Kiremitocağı Neighborhood**	79.762	330.456	24,14	**16**
31. **Koçyazı Neighborhood**	95.289	1.919.338	4,96	**3**
32. **Körpeşler Neighborhood**	70.120	1.249.904	5,61	**4**
33. **Kuyumcuhacıali Neighborhood**	12.690	1.220.045	1,04	**1**
34. **Kültür Neighborhood**	222.606	689.725	32,27	**21**
35. **Mergiç Esen Neighborhood**	30.398	1.475.762	2,06	**1**
36. **Nalbantoğlu Neighborhood**	35.525	1.380.485	2,57	**2**
37. **Nusrettin Neighborhood**	102.447	286.747	35,73	**23**
38. **Sallar Neighborhood**	35.254	1.061.162	3,32	**2**
39. **Sancaklar Neighborhood**	97.235	1.170.530	8,31	**5**
40. **Sarayyeri Neighborhood**	29.586	3.108.602	0,95	**1**
41. **Şerefiye Neighborhood**	86.161	169.168	50,93	**33**
42. **Şıralık Neighborhood**	121.943	1.960.214	6,22	**4**
43. **Tokuşlar Neighborhood**	64.685	1.559.209	4,15	**3**
44. **Uzunmustafa Neighborhood**	111.713	382.982	29,17	**19**
45. **Yahyalar Neighborhood**	48.079	2.658.386	1,81	**1**
46. **Yeni Neighborhood**	60.763	358.421	16,95	**11**
47. **Yeşiltepe Neighborhood**	39.241	560.446	7,00	**5**
48. **Yukarı Yahyalar Neighborhood**	26.137	1.508.318	1,73	**1**
TOTAL	3.684.252	58.960.793	593,81	**385**

In Fig. 7, the distribution of the number of measurement points according to the boundaries of the Duzce City Neighborhood is given. It is also possible to interpret this map as an urban building density map. Because the number of measurement points is handled according to the urban building densities (mass-gap ratios). Whereas, it is seen that the densest measurements are in the central neighborhoods with the highest mass-gap ratios.

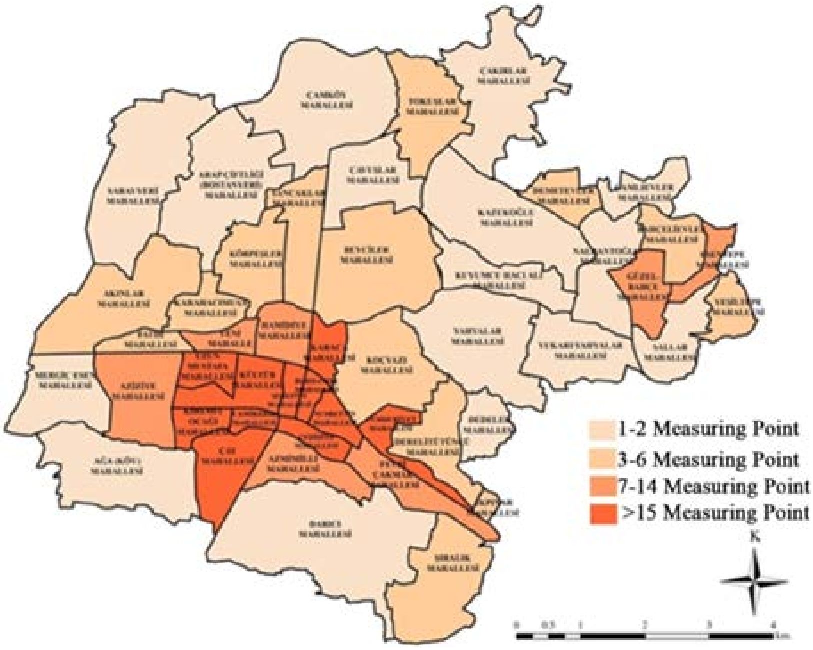
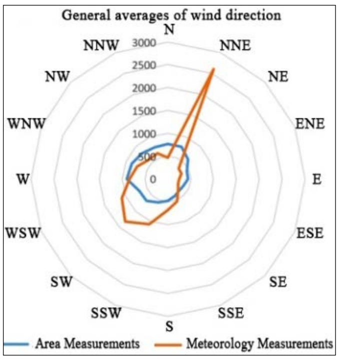


Figure 7. Density of Düzce City Neighborhoods according to the distribution of measurement points.

In the result of the study, the most common wind direction was west (903 times), and the wind direction with the lowest frequency was found to be southeast (358 times) (Table 2) in the Düzce City. However, in general terms, a homogeneous distribution is observed in terms of directions. It is seen in the frequency diagram that the data in the area studies do not coincide with the measurements taken from the General Directorate of Meteorology made from a single point. According to meteorological measurements, the prevailing wind direction is north-northeast (2600 times), while the least common wind direction is east (246 times) and southeast (246 times). Although the general Duzce City wind frequency distribution is determined as north-northeast (NNE) direction, areal measurements show that the west-northwest (WNW) direction is more.

Table 2. General wind directions, blow numbers, frequency diagram of field measurements, and meteorological measurements.

	Area Measure-ments	Meteorology Measure-ments		Area Measure-ments	Meteorology Measure-ments
N	769	472	**S**	472	678
NNE	763	2600	**SSW**	551	1076
NE	614	330	**SW**	669	1318
ENE	450	322	**WSW**	674	1096
E	437	246	**W**	903	840
ESE	369	246	**WNW**	864	724
SE	358	314	**NW**	801	594
SSE	395	532	**NNW**	751	612



In this context, the fact that measurements taken from a height of 10 meters and a single point show different results with areal measurements is an indicator of how effective all structural and vegetative elements in the city are to the wind direction. Area measurements are obtained from 2 meters, and meteorological data are obtained from 10 meters. However, these two heights can be converted to each other with the Hellman formula. Better results were obtained by using this formula in the comparison of the measurements.

The formulas for calculating the measurements taken from a height of 2 meters and which value can be obtained at a height of 10 meters have been calculated in various sources. According to the data received from the General Directorate of Meteorology, this Hellman formula is defined as *"the formula used to increase the wind value to 10 meters in cases where the automatic wind measurement system sensors cannot be installed at 10 meters depending on the location of the square"*.

Hellman Formula;

$$V_h=V_{10}\,[0,233+0,656\,\log_{10}(h+4,75)]$$

V_h = Wind Speed at Height of Wind Measurement

V_{10} = Wind Speed Value at 10 Meters

h = Wind Measurement Height

This formula is a conversion formula, and in this study, the meteorological data at a height of 10 meters was reduced to 2 meters.

According to the results obtained from the area; When the wind speed was compared according to the seasons, it was determined that the highest wind speed was measured in the spring season (Table 3). In addition, these measurements were found to be much higher in spring and summer than in autumn and winter. This shows that air pollution in winter is a situation that can be associated with the absence of wind circulation.

Table 3. Descriptive statistics of wind speed (m/s) according to seasons.

Season	Arithmetic Average (Standard Deviation)	Highest Value	Lowest Value	Median Value (Median)
Spring	2.6 (2.4)	17.7	0	1.6
Summer	2.8 (2.6)	16.1	0	1.6
Sonbahar	1.3 (1.3)	6.4	0	0
Winter	1.2 (1.4)	6.4	0	0

In the areal results evaluated according to the seasons; wind speed varies according to seasons ($p<0.05$). While the average wind speed in spring is lower than in summer, it is higher than in autumn and winter. There is no difference in the effect of wind speed between the autumn and winter seasons. However, from spring to summer measurements; spring season measurements were found to be higher than autumn and winter (Table 4).

Table 4. Evaluation of wind speed according to seasons.

ANOVA					
Wind Speed (Study Area)	Sum of Square	Degree of freedom	Mean Square	F Value	P value
Between groups	5011,931	3	1670,644	341,263	,000
Within groups	48254,669	9857	4,895		
Total	53266,600	9860			

Multiple Comparisons

Dependent Variable: Wind Speed (Study Area)

Tukey HSD

(I) Season	(J) Season	Mean Difference (I-J)	Standart Deviation	P value	95% Confidence Interval	
					Upper Limit	Lower Limit
Spring	Summer	-,178(*)	,061	,019	-,335	-,020
	Autumn	1,319(*)	,063	,000	1,155	1,482
	Winter	1,370(*)	,059	,000	1,218	1,523
Summer	Spring	,178(*)	,061	,019	,020	,335
	Autumn	1,497(*)	,067	,000	1,323	1,671
	Winter	1,548(*)	,063	,000	1,384	1,713
Autumn	Spring	-1,319(*)	,063	,000	-1,482	-1,155
	Summer	-1,497(*)	,067	,000	-1,671	-1,323
	Winter	,051	,066	,864	-,118	,221
Winter	Spring	-1,370(*)	,059	,000	-1,523	-1,218
	Summer	-1,548(*)	,063	,000	-1,713	-1,384
	Autumn	-,051	,066	,864	-,221	,118

In the study, it was determined that there was a weak positive but significant relationship between wind speed and altitude ($r = 0.054$, $p<0.001$) (Gedik et al, 2022). In this sense, as the altitude increases, the wind speed also increases and this is an expected result. The reason why the relationship between these two data is weak is due to the dynamical structure of the elements it contains, apart from the physiological structure of the city. A strong relationship is expected when the only variable is altitude. However, the elements contained in the city change the wind speed in the city regardless of the altitude.

When the wind speed measurements in the area are compared with the data obtained from the Düzce Meteorology General Directorate, a significant correlation is observed. This correlation was made for a kind of calibration (measurement) purpose. As indicated in Table 5, the measurements are directly proportional ($r=0.484$, $p<0.001$). Although the 10-meter data from meteorology has been reduced to 2 meters and a stronger positive relationship is expected in this sense, the numerical value of the relationship is below the expected rate due to the reasons arising from the dynamic structure of the city. This again reveals the differences between meteorology measuring from a single fixed point and the different measuring points obtained from area work.

Table 5. Comparison of wind speed according to areal and meteorological data.

	Correlation	Wind Speed (Study Area)	Wind Speed (Meteorology)
Wind Speed (Study Area)	Pearson Correlation	1	,484(**)
	P-value (2-tailed)		,000
	Number of Samples	9861	9447

Another finding obtained in the area measurement is that the mass-gap ratios in the neighborhoods are inversely proportional to the wind speed ($r=-0.066$, $p<0.001$). In this context, considering the average of the four seasons, it has been determined that the wind speed is lower in dense building areas.

While there is no difference between the average wind speed values of those with building densities between 0-3% and 3-6.99%, the average values of those with building densities between 0-3% are 7-16%, 16-30% and 30-51%. Similarly, there is a difference between those with density between 3-6.99% and those with 7-16%, 16-30% and 30-51%. The wind speed was higher in the 3-6.99% ones. There is no difference between the wind speeds of neighborhoods with a building density of 7-16% and between 16-30% and 30-51%. There is a difference between the average wind speeds of the neighborhoods with a building density of 16-30% and a building density of 30-51%.

When the wind speed data obtained from the area studies and the meteorological data are compared seasonally, the data that is lower than the meteorological data are indicated in red in Fig. 8. However, the situation that is important in this context is the fact that the Düzce meteorological data is already below the optimum conditions, and these marked areas are also below the determined optimum conditions. The fact that the elevation values of the "Kalıcı Konutlar Zone", located in the NE direction of the city, are higher than the central districts, is another positive factor in terms of wind circulation.

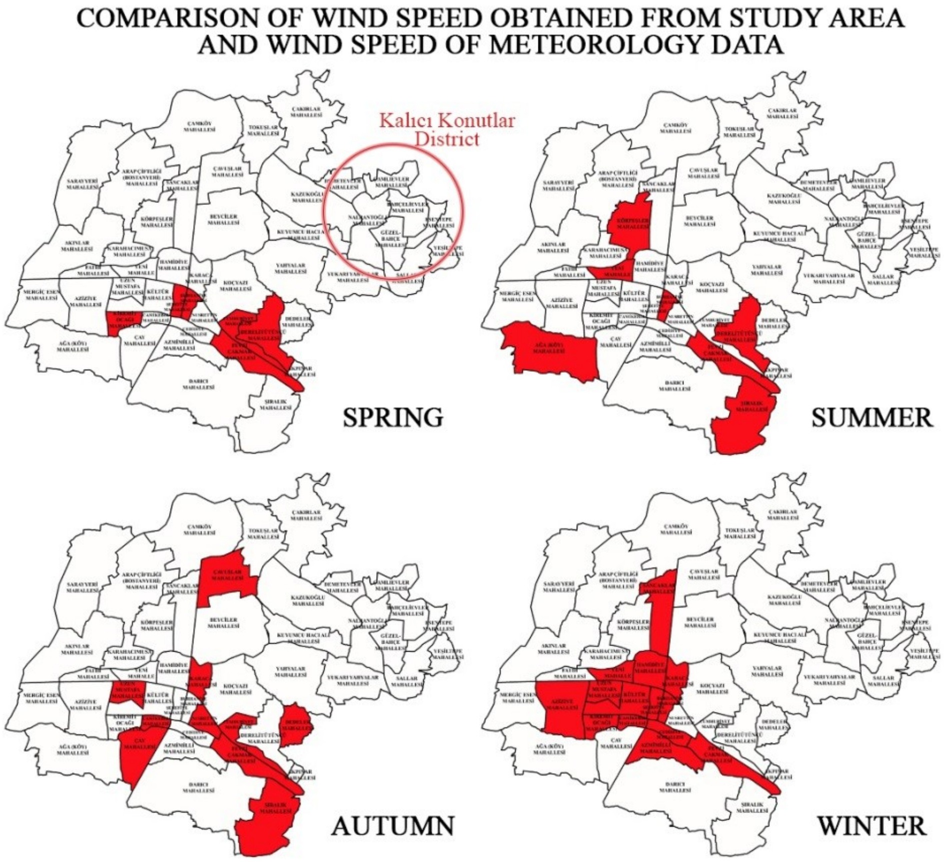


Figure 8. The areas where the wind speed data in the study area according to the seasons are lower than the meteorological data.

A general comparison emerges with the overlapping of the seasons (Fig. 9). Although Düzce Meteorology Station is located in the city center and the necessary calibrating (what the measurement data from 10 meters should be at 2 meters) procedures were completed during the area measurements, the reason why the wind speed is even lower than the general meteorological measurements is that the wind effect was not taken into account in urban planning and design approaches. The important thing here is that the meteorological data also has a low speed in terms of optimum wind circulation and the areas that are lower than these measurements are concentrated in the city center.

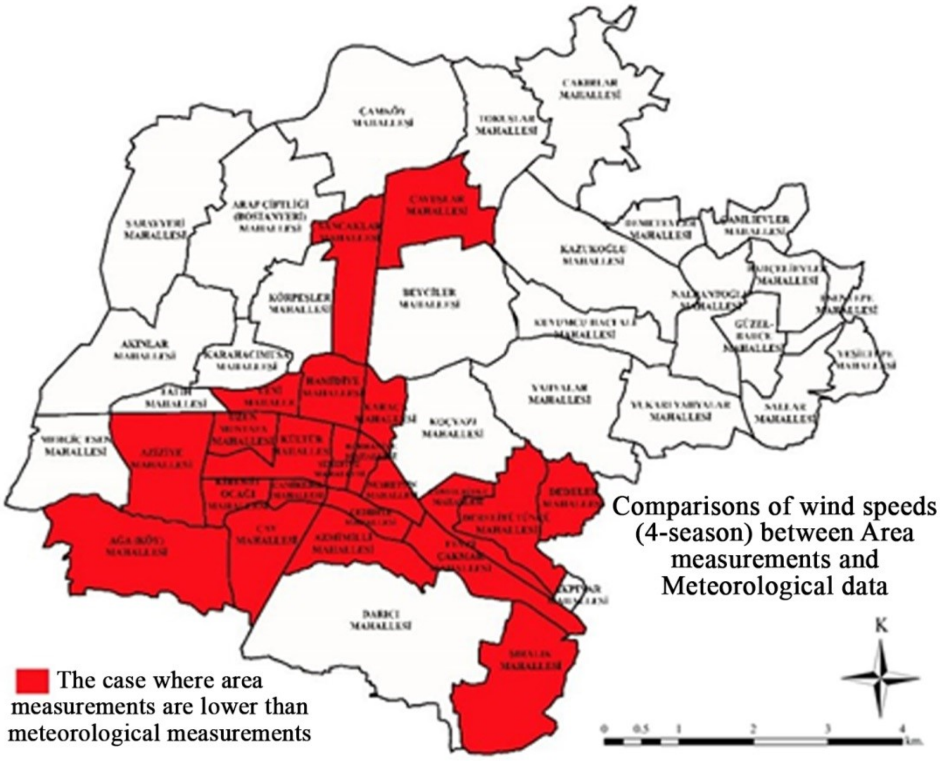


Figure 9. Areas where the wind speed data in the study area is lower than the meteorological data according to all seasons.

Evaluation of Wind Maps

The lowest and highest wind speed values in the neighborhoods were evaluated according to the seasons in the general maps obtained after the kriging interpolation process using ArcMap 10.3 software and combining the values of 300 measurement points realized in the study area with the Düzce City Development Plan.

While the green colors on the maps show the areas where the wind circulation is faster; red areas indicate areas where the wind is turbulent and losing speed. This situation is different from the color scale in literature. However, what is expected in this study is that wind permeability is the desired situation, and therefore, it is understood that there are areas where the wind is close to 0 m/s as we go towards the red areas.

In the general measurement results of the four seasons (Figure 10), it was observed that the month with the highest wind speeds was spring.

When the data obtained by the kriging process carried out for the winter season are examined; It is observed that the area consists of neighborhoods with a wind speed of 0 to 3.62 m/s. This season is the second month with the lowest wind speeds. It is observed that the speed maps are in lighter tones and reach speeds of 2.5 to 3.5 m/s. The axis stretching from the "Kalıcı Konutlar Zone" to the "Darıcı Neighborhood" has a more efficient circulation network in terms of wind flow compared to other areas.

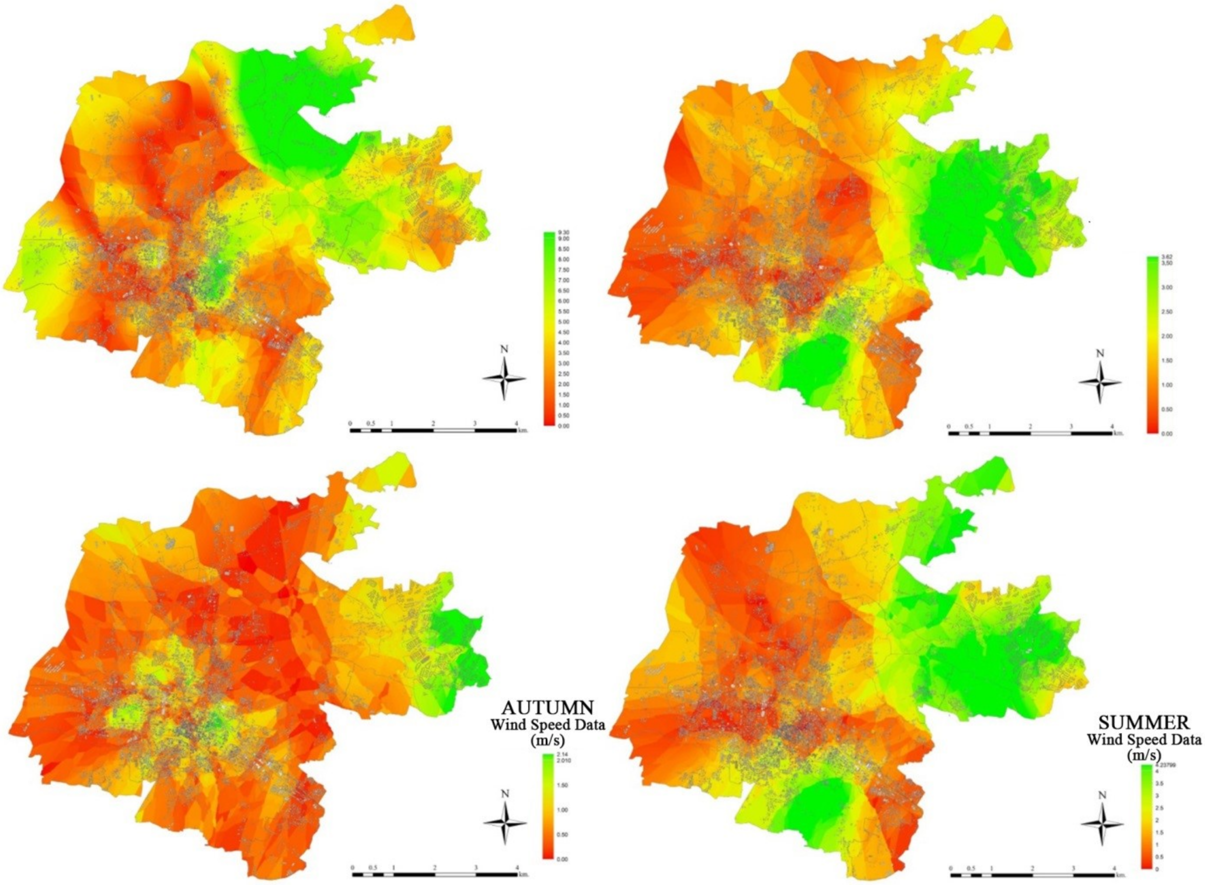


Figure 10. Wind speed values according to the seasons (study area).

When the data obtained by the kriging process carried out for the summer season are examined; It is observed that the area consists of neighborhoods with a wind speed of 0 to 4.2 m/s. While the area studies during this season determine the general prevailing wind direction as WNW, Meteorology considers general data as NNE. Nevertheless, another important thing to note here is that the "Kalıcı Konutlar" Zone, located in the northeast of the city, receives wind from the SSW-dominated direction. Because when considered in terms of direction, SSW and NNE axes are the same, they are linear. In this context, when considered in degrees, there are two important angles, 22.5°, and 292.5°, which will not cause turbulence to the circulation of the wind. And the 90 ° angle between them is complementary, and it will make it possible to consider the urban design in the grid system, in terms of increasing wind circulation.

When the data obtained by the kriging process for the autumn season is examined; It is observed that the area consists of neighborhoods with a wind speed of 0 to 2.14 m/s.

This season is the month in which the lowest wind speeds are observed and the general prevailing wind direction was observed as NNE during the area studies. At the same time, there is a prevailing wind direction situation that has the same direction as the meteorological data. Although the wind speed is very low, better observation of wind circulation in residential areas can be given as an example of the venturi effect in structural areas. Despite the density in the residential areas, the increase in the wind speed from place to place confirms this effect, which affects the wind outside the altitude.

The fact that the south of the city is fed by the winds coming from the WSW direction has affected the central neighborhoods, which are closer to the south, and the general corridor axis in the "Çay neighborhood" has provided these neighborhoods with a breathing opportunity. However, the green areas on the map have a better meaning than the rate of 0 m/s and the fact that the wind speed is very low in general should be taken into consideration.

4. Results

Within the scope of the study, the hypothesis of whether the urban building density has an effect on the wind effect in the wind measurements made in Düzce City Center was examined and it was statistically confirmed that it had an inversely proportional effect on these areas. In the direction of the wind in the city, it is necessary to deal with the structural elements first and to make use of the open areas in cases where the change of the wind is not desired and it is desired to continue at the same wind speed. However, it should be excluded from this situation that tall plants come together to create an alle effect and show a mass effect. Because it is revealed in the maps created in the study that alleles that are not in the wind direction affect the wind speed.

Considering the direction of the wind, the beltway (Düzce-Permanent Residences connection highway), which is the northeast axis of the city and forms a corridor between the new city and the old city, has a significant potential in terms of wind corridor. This axis, with its vegetative arrangement that will create a functional area for wind control, will both create a mass effect and create a continuity and turn into a qualified corridor that will provide integrity with the environment. In this context, Kazukoğlu, Kuyumcuhacıali, Yahyalar and Koçyazı Districts, which are prepared for intensive construction, are important in terms of creating a corridor axis integrated with both plant and structural elements in order to create a sustainable corridor, since they are located in the east and west of the beltway. In addition, wind speeds of these neighborhoods were found to be higher than other neighborhoods in the wind maps.

When the wind speed measurements in the study areas are compared with the data obtained from the Düzce Meteorology General Directorate, a significant correlation is observed. However, although the 10-meter data obtained from meteorology has been reduced to 2 meters, the reason why it is different from the area measurements is due to the dynamic structure of the city. Measurements taken from a single fixed point can reveal different results in a city with many variables. In this case, in the urban design scale, knowing the wind speed and direction values of the spatial measurements should be among the basic elements that can guide the design. The effects that these values, which should be determined and known in the site analysis, will bring to the city will reach a balance with the design with the climate in time.

As a result of the source investigations, it has been seen that the wind is mostly involved in the working areas of professions such as architecture, city and regional planning, mechanical, civil and environmental engineering. However, starting from the site analysis process of urban planning and design, it should not be overlooked that the wind, which is a priority issue, has a very important place in terms of the professional discipline of landscape architecture.

As Yerli (2012) also stated in his study; *"The professional discipline of landscape architecture, making land-use decisions, protecting the environment, protecting and improving the cultural landscape in urban areas; urban ecology, urban air corridors, site selection from housing scale to the neighborhood, district, district, city, and even regional scale, identifying problems, making analyzes, making landscape planning decisions with high ecological, economic, aesthetic and functional value in rural and urban terms, and designing them, are included in the implementation, maintenance and repair work"*. Increasing the quality of life, creating healthy and qualified living spaces and creating sustainable cities are among the objectives of the professional discipline of landscape architecture.

Correct planning decisions and correct design studies are only possible with a detailed analysis of the climate. Wind; although it is the focus of this study, it is only one of the climate elements. Detailed analysis of each of these elements in each design will make the space more livable.

The importance of planning and design decisions in the 21st century is much better understood in urban systems that are rapidly structuring and struggling with environmental problems, which are often the result of unplanned construction. In addition, with the entry into force of the "Energy Efficiency Law" No. 5627 (2011), by the General Directorate of Renewable Energy, recent scientific research has focused on the effective use of natural resources. In this study, it has been observed that structural elements or vegetative screening areas that create a mass effect cut the wind speed to a considerable extent. For this reason, it is the field of the professional discipline of landscape architecture that knows what kind of problem or solution each design to be created in the city will bring to the area at a higher scale, but knows its responsibilities towards the environment and humanity.

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