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Exposure to Wind as a Threat to the Sustainable Development of Small Towns in the Zhambyl Region (Kazakhstan)

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Abstract: Currently, global urbanization trends offer various development models, but their main goal is to create a comfortable and safe environment for city residents. Most cities in Kazakhstan are small in scale and face several pressing problems, such as limited infrastructure, inadequate public services, economic challenges resulting in unemployment, environmental problems, and housing shortages. In this article, using the examples of the towns of Zhanatas and Karatau, an attempt was made to indicate the threat posed by wind to the sustainable development of monocities in the Zhambyl region. The working hypothesis of our study is that state policy supporting the sustainable development of small towns is insufficient and should be changed. Theoretical, empirical, and cartographic methods were used during the research, depending on the specificity of the analyzed territories. The unique climatic features of the cities of Karatau and Zhanatas, which are located in the study area, were taken into account and unfavorable meteorological phenomena were analyzed. The collected data were used to assess the impact of climatic conditions on the sustainable development of small towns in the study area. The research's results allow one not only to determine the impact of wind exposure on the sustainable development of small towns in the Zhambyl region, but also constitute a basis for assessing, more generally, the opportunities and threats relevant to small towns.

Keywords: small towns; sustainable development; threat; wind; Zhambyl region

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1. Introduction

1.1. Sustainable Cities and Towns

The Sustainable Development Goals (SDGs) adopted by the UN are the basis for ensuring sustainable development at the global level. The 11th SDG, "Making cities open, safe and sustainable", is closely linked to other goals, since cities are considered the main form of spatial organization of human society [1]. The International ICLEI (Local Authorities for Sustainable Development) asserts that sustainable cities create an ecologically, socially and economically healthy and sustainable living environment for the current population and do so without compromising the ability of future generations to experience the same [2]. The sustainability of cities is determined by various parameters, and its assessment system includes quantitative, qualitative, and descriptive criteria related to many areas [3–5].

A sustainable city is a socially, ecologically, and economically harmonious and stable system, the harmonious development of which is usually considered to be a balancing of this fundamental triple dimension of sustainability [6–10]. At one point, Davidson and other scientists [11] proposed a model for assessing sustainable urban development, noting, based on Australian studies, that the three-pronged approach to assessing sustainability oversimplifies a complex problem. Special attention is paid to environmental indicators

in order to ensure usability, accessibility, equity, and conservation of resources. Following the same approach, Ding et al. [12] proposed going beyond the three-pronged approach and taking into account spatial, chronological, and logical dimensions when assessing the sustainability of cities.

However, Michalina et al. [13], who analyzed the global and European systems of specific indicators of urban sustainability (USIF) in terms of similarities and differences, aspects of sustainability, categories, and classified indicators, found that in developed countries, environmental categories and indicators have priority, while in the categories of developing countries, as we have noticed, socio-economic indicators will be in the first place. The effort towards sustainable cities needs to pay more attention to social and environmental issues, and social and environmental security should become the main focus of urban development [14].

For a long time, empirical observation of the dynamics of urban ecosystems has been dominant, and gradually an adaptive approach to these changes, for management purposes, has become important. Dynamic relations between humanity and nature form socio-ecological systems (SES); currently, the concept of SES is based on the study of the interrelationships of social and environmental changes, as well as their impact on the achievement of sustainable development goals [15–18]. Of course, many of these connections may be less obvious in big cities than in small settlements. However, multilevel, complex socio-ecological systems provide residents of every city with food, water, energy, and recreation services. When solving the tasks associated with the sustainable development of the city, not only positive changes in the socio-economic situation of the population are taken into account, but also their emotional connections with the environment, that is, values and memories associated with a certain natural environment. From this point of view, the collective values of a society and the recognition of oneself as a part of nature are the first steps in planning and implementing sustainable development solutions [19].

Nováček and Mederly [20] focus on whether we should strive to create an optimal set of sustainability indicators or take into account only those indicators that can be tracked historically and conduct an assessment more based on practice. In general, due to the lack of a unified system for assessing urban sustainability [3,13,21,22], assessments do not take into account the spatial locations or the scales, types, and functions of cities. Therefore, while being guided by general principles, it is also necessary to take into account a comprehensive set of local indicators. This is especially true for single-industry towns that have local features. Taking into account the changes taking place in the modern world, the New Leipzig Charter adopted in 2020 focuses on the development of small and convenient heterogeneous cities. It is emphasized here that cities need flexibility and the ability to withstand various external destructive events. This, in turn, requires that urban development plans and projects contain various scenarios for forecasting environmental, economic, and climate-based risks [23].

1.2. Threats to the Sustainable Development of Cities and Towns

In the modern world, the study of the problems associated with the sustainable development of small towns is aimed at identifying local conditions (natural, environmental, social, and economic) that contribute to their development and factors that inhibit their development (blocking factors), as well as the development of new development models. As a rule, the functions of most small towns are limited, and often they are even monofunctional: small towns are characterized by resource, transport and logistics, industrial, etc., concerns.

The present research analyzed the threats to the sustainable development of Zhanatas and Karatau. Research on threats to sustainable development already has a very rich scientific literature. In the Web of Science database, searching the last five years alone, you can find over 14,000 scientific papers on threats in the context of sustainability [24]. However, the vast majority of them are devoted to the issues of insecurity, economic or political instability, and, in recent years, the COVID-19 pandemic. On a spatial scale, mainly countries or regions are presented, and the issue of threats to the sustainable development

of cities is rarely discussed. The research we undertook expands the known research area to include the topic of wind-based threats to the sustainable development of cities. Therefore, the work is innovative in the field of research on the threats to sustainable development of small towns in Kazakhstan. It can be considered that it fits into the trend of research on "securitization", which moves from international security issues to local security issues [25,26]. The added value of the research is not a new theoretical approach to securitization. The work also has practical significance. It shows important problems that need to be solved for the good of the local community as part of sustainable development.

Zhanatas and Karatau, due to their dominant industrial functions (extractive industry), can be described as monocities [27,28]. The regional importance of these cities also deserves attention. With the support of the central authorities, and taking into account the large distances between cities in Kazakhstan, they should act as regional growth poles [28–30]. The latter function dates back to the period of industrialization in the former Soviet Union, and, according to some researchers, it is still unfairly downplayed [31]. The scientific literature indicating threats to the sustainable development of Kazakhstan's monocities is scarce. Most researchers considering sustainable cities or smart cities focus on the capital cities of Kazakhstan: the current capital, Astana [32,33], and the former capital, Almaty [34]. Works devoted to the study of monocities and sustainable and smart cities emphasize the problems of their development [28], point to their uneven development [35], and emphasize the importance of the urbanization process as an accelerator of inclusive and sustainable development [30].

The literature in this area establishes that the sustainability of cities also varies depending on the nature of the specialization. The results of a study of the sustainable development of resource cities in Northeast China have shown that cities whose economy is based on forestry and metallurgy have much higher levels of sustainability than cities focused on oil and coal production [36].

In the contemporary context, the sustainable development of cities and towns globally is significantly influenced by the intricate interplay of economic factors, population growth, technological advancements, and the environmental repercussions of global climate change. As evidenced by studies in the literature, the matter of the impact of wind on urban life has been examined from various perspectives. However, some publications refer mainly to storm risks. These papers most often show the impacts of strong, stormy sea winds on cities located in the coastal zone [37–41] or focus on the impact of urban air on the health of residents [42,43]. In turn, in the category of the impact of wind on cities, large urban agglomerations, such as Delhi [44–47], are most often included. Researchers ignore cities that are local centers, which are especially important in countries with significant land areas and relatively low population densities. In turn, the literature on Central Asia, Kazakhstan, and northwestern China regarding the impact of wind focuses primarily on issues related to the wind erosion of soil [48,49] and the impact of dust winds on the environment [50–53]. With this in mind, we selected centers of local importance to study the impact of wind on the sustainability of small towns.

1.3. Kazakhstan Towns and the Aim of Study

In the case of Kazakhstan, which has a huge territory, rural residents perceive small towns as centers, because there are more opportunities and innovative industrial, consumer-based, and social institutions. But the serious consequences of a long-term monocentric economy, climate change, degradation of natural ecosystems, technological backwardness, systemic inequality, and poverty in the social sphere lead to instability in small towns. The sustainable development of small towns in the Republic has not been studied in terms of the sustainability criteria used at the international level. It is very important for the cities of Kazakhstan to realize the goals of sustainable development; the dissemination of ideas and solutions for sustainable development among the local population can lead to positive changes in the environmental, social, and economic spheres. For example, in small towns where the environmental situation is difficult and unemployment is flourishing, people may

be more eager for economic changes than for solutions to environmental problems. That is why it is very important to study the issues of sustainable development of small towns.

In resource-based cities such as Zhanatas and Karatau, natural and environmental problems, including climate change, are among the factors hindering economic diversification. As noted by Tong et al. [54], the city, long dependent on resource-intensive industries, is unable to adapt to economic development in the face of resource scarcity and environmental pollution. This, in turn, hinders the sustainable development of the city. Despite its relevance, little attention has been paid to the problem of the natural hazards associated with urban populations. The issue of the impact of climatic factors on the sustainable development of cities in Kazakhstan has not been sufficiently researched.

The aim of the article is to indicate the impact of wind conditions on the sustainable development of small towns in the Zhambyl region. Importantly, the Zhambyl region, due to its wind conditions, is considered to be a potential area for the location of wind farms [55,56]. The undertaken research considered wind conditions in the region. The effects of strong winds on the local community and the related problems associated with the sustainable development of the studied cities have been pointed out. For obvious reasons, natural resources are linked to location, but in both cases examined, insufficient efforts are being made to reduce the adverse impacts of wind on the quality of life of the cities' residents. In our research, we undertook work aimed at verifying this hypothesis.

This study, focusing on the impact of wind on sustainable development, utilized data from Zhanatas and Karatau weather stations, emergency statistics, and field research materials, and involved a two-stage approach: exploration of theoretical foundations via databases like Web of Science, Scopus, and Google Scholar, and analysis of collected area-specific data using comparative-historical and quantitative-statistical methods.

The results of the study were summarized in the form of assumptions regarding measures to ensure the sustainability of small towns in the Zhambyl region, taking into account the climatic risks of each city. It is emphasized that, since small towns are markets and cultural centers for adjacent settlements, the development of small villages associated with them will be possible due to the sustainable development of the cities.

2. Materials and Methods

2.1. Research Area

The studied cities of Karatau and Zhanatas, of the Zhambyl region located in the southern part of Kazakhstan, were taken as the research area (Figure 1). These cities are considered small single-industry towns, with economies based on a certain industry and small populations. Although the cities studied each have a small area, the region falls within the temperate desert zone, which is marked by low precipitation, high evaporation, and notable daily and annual temperature fluctuations. This leads to pronounced continentality, aridity, water scarcity, and adverse natural phenomena.

The city of Karatau is located 82 km northwest of the city of Taraz, on the northwestern spur of the Karatau mountain range, on the slope of Sholaqty, in the valley between Zhetimshoqy and Aqtau, at 543 m above sea level. The city covers an area of 22.8 km. In 1946, the village of Sholaktau appeared on the site of the current city of Karatau. Thanks to the development of local phosphorite deposits, the village grew rapidly, and in 1963 it was granted the status of a city. The name of the city is given in connection with the name of the nearby Karatau mountain range, which means "Black Mountain" in Kazakh.

The city of Zhanatas is located 170 km northwest of the city of Taraz, which is the administrative center of Zhambyl region, in the northern part of the Karatau mountain range. In connection with the development of a large phosphorus mine, a settlement arose in 1964, and in 1969, it became a settlement. In 1971, the rapidly growing settlement was granted the status of a city. The name of the city is associated with the development of mineral raw materials: translated from the Kazakh language, it means "New Stone". The presence of phosphorite deposits determined the formation of the cities of Zhanatas and Karatau as resource cities and the directions of their economic development.

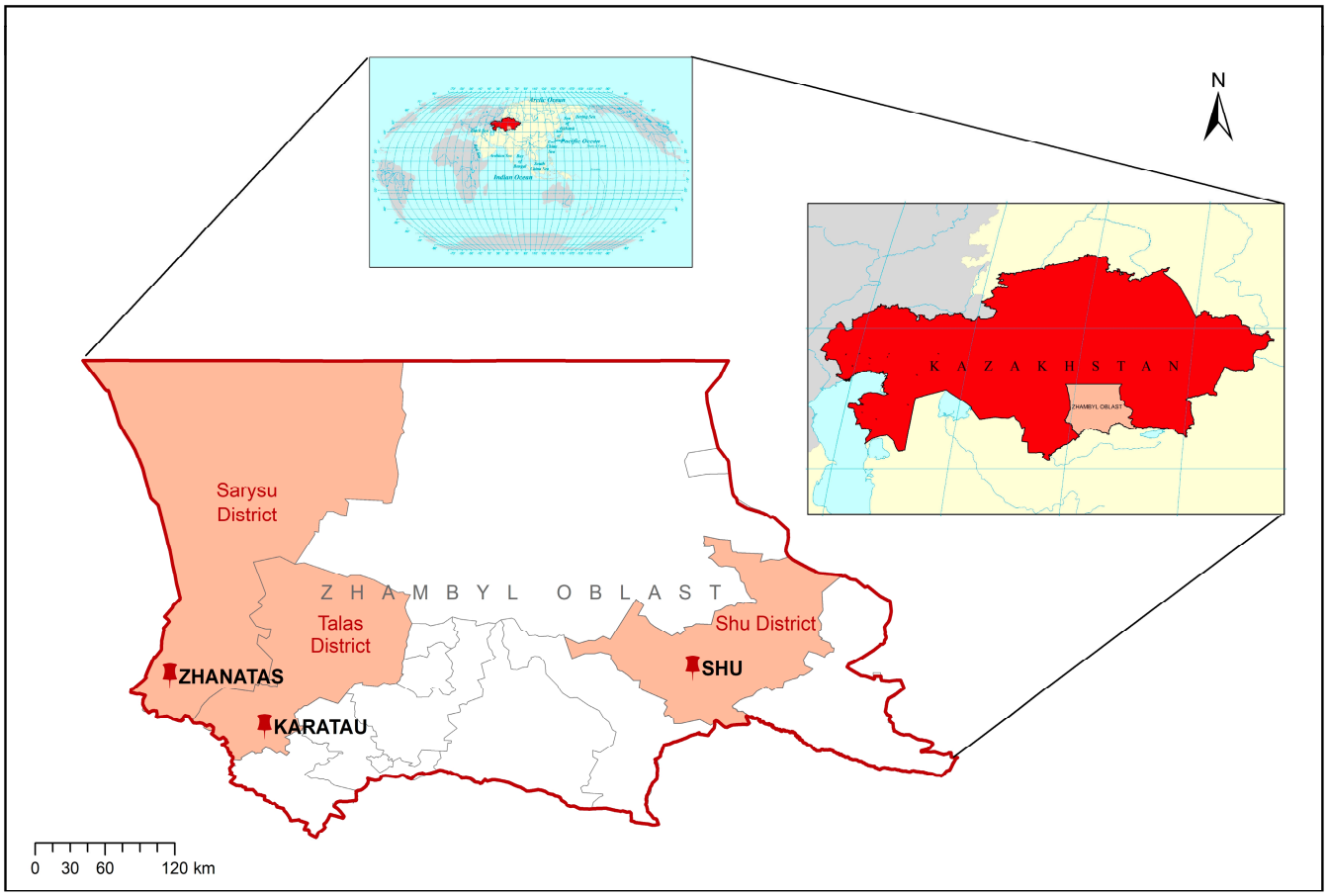

Figure 1. Zhambyl Region—research area.

2.2. Data Collection Methods, Concept, and Stages of Research

A reconnaissance survey was conducted to describe the situation in the study area. During the survey, a general overview of the research object was made, a description of the negative effects of climatic factors on the area was compiled, measurements were taken of meteorological indicators of the atmosphere, and conversations with the local population were conducted. In the general overview of the research object, satellite images from the SAS Planet program, as well as thematic maps of the research object, digital photo equipment, and GPS navigators were used. To measure the meteorological indicators, an AZ 8905 thermal anemometer (AZ Instrument Corp., Taichung City 427, Taiwan), a DT-625 hygrometer–thermometer (Shenzhen Everbest Machinery Industry CO., LTD, Shenzhen, China), and an aneroid barometer were used.

The opinions of the local populations of the cities of Karatau and Zhanatas as to the natural, climatic, and ecological features of the area were determined by conducting interviews. This study helped to identify the intensity of climatic factors affecting the sustainable development of the objects of study, while anticipating further, more detailed, studies.

The data collected during the study allowed us to establish once again that the most intense climatic factor affecting the sustainable development of the objects of study is the impact of wind. The methods are described in more depth in the following:

The climatic indicators of the Zhanatas and Karatau weather stations were collected and analyzed based on the stock materials and available institutional resources of Kazhydromet [57] and the portal ‘meteoblue.com’ (accessed on 22 April 2023). Data processing was carried out in Excel (Excel Microsoft Office LTSC Professional Plus 2021). Meteorological data for a certain period of time were converted into Excel summary tables. They were then classified into groups. Means and frequencies of the data were also determined.

- The statistics associated with adverse natural phenomena and accidents in the study area were studied using the resources of the Department of Emergency Situations of the Zhambyl Region.
- Analysis of materials collected during field research was performed.

To summarize the research assumptions presented above, the following order of work was adopted to achieve the research objectives and verify the hypothesis:

(1) Preliminary field research in the Zhambyl region;
(2) Analysis and assessment of the possibility of using existing research results, based on the collected literature, on the selected topic of the studied cities, and related to determining the sustainable development of urban areas;
(3) Defining the theoretical framework for researching the threats associated with the development of sustainable monocities;
(4) Conducting further field research aimed at the examination of wind conditions and the effects of strong winds on the inhabitants and infrastructure of the studied cities, using quantitative and statistical methods;
(5) Assessment of state policies aimed at supporting the sustainable development of cities in Kazakhstan, based on research and analysis of the literature;
(6) Verification of the research hypothesis.

3. Results

3.1. Climatic Conditions

Natural conditions and resources play crucial roles in the evaluation of the sustainability of a city. Achieving urban sustainability requires the consideration of a combination of interdependent indicators from various groups [58]. An examination of scientific papers on the subject revealed that ensuring the sustainable development of small towns in the Zhambyl region necessitates the consideration of climatic conditions, including climate change.

The climate of the research area is continental, with large seasonal and daily temperature fluctuations, and precipitation from 330 mm (Zhanatas) to 233 mm (Karatau). In general, relative humidity is low throughout the year; on average, for 170 days per year, this indicator does not exceed 30%; a relative humidity of at least 80% is observed in the city of Zhanatas for 80 days each year, and in the city of Karatau for 47 days (Table 1).

Table 1. Relative humidity and precipitation, 2022 (compiled by the authors, based on Kazhydromet data [57]).

Station	Relative Humidity, Number of Days		Precipitation, mm		
	Less than 30%	Less than 80%	Annual Quantity	Daily Maximum	Date
Zhanatas	174	80	332.9	20.2	26 March
Karatau	169	47	233.9	25.8	17 January

The average annual temperature in Zhanatas is +12 °C, with the highest recorded temperature reaching +42 °C in July, and the lowest recorded temperature dropping to −31.8 °C in January. Such temperature fluctuations contribute to a decrease in climatic comfort in cities, especially in combination with winds and dry weather. The average duration of the period with frosts is about 100 days, although warm weather is more common. In the research area, the cold period lasts about 1 month (Table 2).

Table 2. Temperature regime in small towns of the Zhambyl region, 2010–2022 (compiled by the authors, based on Kazhydromet data [57]).

Station	Average Temperature °C	abs. max °C	abs. min. °C	Last Frosts	First Frosts	Number of Days without Thaws	Number of Frosty Days
Zhanatas	12.0	42.0	−31.8	30 March	1 October	34	103
Karatau	13.0	41.2	−35.3	30 March	2 October	26	98

If we take into account the fact that the strongest winds in the region are observed during the cold period, it can be seen that the small towns of the Zhambyl region are constantly at risk of being left without heat and electricity during the heating season. Also, wind speed changes the actual, felt temperature. This is called perceived temperature. In 2001, a group of scientists and doctors in Canada and the United States developed the current wind chill index. The wind chill index is based on heat loss from the face. In winter, strong winds with speeds above 11 m/s reduce the perceived temperature by 6 °C. In sustained winds over 50 km/h (13.9 m/s), frostbite can occur faster than indicated [59].

When determining the average wind speed, the wind speed indicators recorded every 3 h in the studied cities are taken as a basis. Due to the lack of regular weather observations over a long period, data were selected from the Kazhydromet database for 2010–2022. For the city of Zhanatas, 37,992 wind speed indicators were recorded during this period, and for Karatau—37,884. Wind speeds for this period were processed in the Excel application. We grouped the data into 11 groups, according to the wind speed (Table 3).

Table 3. Wind speed in small towns of the Zhambyl region, 2010–2022 (authors' elaboration, based on Kazhydromet data [57]).

Station	Wind Speed, m/s		Number of Cases by Gradations of Speed										
	Average	Max	0–1	2–3	4–5	6–7	8–9	10–11	12–13	14–15	16–17	18–20	20<
Zhanatas	2.5	30	16,031	10,926	6081	2654	1070	792	196	162	45	27	8
Karatau	1.3	27	24,650	8599	2706	1087	372	188	122	85	46	24	5

As the data in Table 3 show, in the city of Zhanatas, the average wind speed is higher (2.5 m/s), compared to the city of Karatau (1.3 m/s). The maximum wind speed in Zhanatas is also higher (30 m/s, compared to 27 m/s in Karatau). Both cities have a greater number of cases with low wind speed (0–1 m/s), but Zhanatas has a more significant number (4954) of cases with high wind speed (above 6 m/s), which can negatively affect climate comfort. Meanwhile, the frequency of winds over 6 m/s in Karatau over the same period was 1929.

In the study area, we measured wind speed and other indicators in different places and different seasons of the year. The collected data were recorded in an observation log and analyzed, together with the Kazhydromet data. As a result of field research, we concluded that changes in the topography of nearby territories due to the development of phosphorite ores lead to changes in the direction and speed of winds (Figure 2).

For example, in the fall, measurements of wind speed using an AZ 8905 portable thermal anemometer showed significant differences (in Karatau, 4.1 m/s; in Zhanatas, 1 m/s) in the indicators, depending on the location (Table 4).

Since it was more convenient to display data for 1 year graphically, we arbitrarily selected 2022 from the meteorological database available to us. To construct a wind rose, data on wind direction were selected, and during their processing, the number of days for each wind direction was calculated; then, the averaged wind directions were derived in accordance with the wind rose model we had chosen (we chose a model with 8 points). Next, we summed up the number of days corresponding to each averaged wind direction. The petal chart of the wind rose was constructed in Excel (Figure 3).

Figure 2. Wind speed measurements in the area of ore dumps in Zhanatas (photos by D. Aliaskarov, Sh. Laiskhanov).

Table 4. Meteorological field data.

	Measuring Point Location	Time	Wind Direction and Speed	Air Temperature	Atmosphere Pressure
Karatau	North-west (2.2 km from the city) 43.14575 N. 70.43071 E.	29 November 2023 13:15 p.m.	Wind direction: from south to north, average speed 16.6 m/s	19.3 °C	96 Pa
	Southern part of the city (near abandoned multi-story buildings) 43.16445 N. 70.48087 E.	29 November 2023 12:45 p.m.	Wind direction: from south to north, average speed 12.5 m/s	18.9 °C	95.7 Pa
Zhanatas	South-west of the city (3 km from the city—location of waste heaps) 43.52389 N. 69.69833 E.	29 November 2023 16:10 p.m.	Wind direction: from southwest to northeast, average speed 8.9 m/s	9.8 °C	94.8 Pa
	City center 43.55679 N. 69.72476 E.	29 November 2023 15:40 p.m.	Wind direction: from southwest to northeast, average speed 7.9 m/s	9.2 °C	94.5 Pa

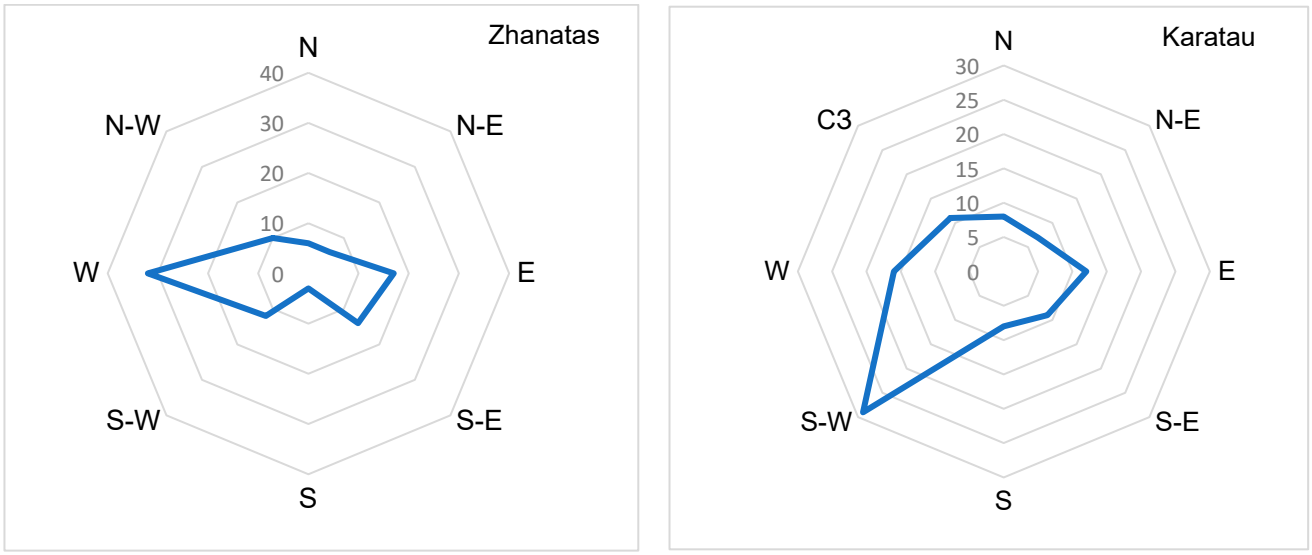

Figure 3. The wind roses for the cities of Zhanatas and Karatau, 2022 (compiled by the authors, based on Kazhydromet data [57]).

The prevailing wind directions during the year are shown here; Table 5 shows the average wind speeds in the prevailing directions.

Table 5. Wind directions in the cities of Zhanatas and Karatau, 2022 (compiled by the authors, based on Kazhydromet data [57]).

Station	N		N-E		E		S-E		S		S-W		W		N-W	
	* F	** S	F	S	F	S	F	S	F	S	F	S	F	S	F	S
Zhanatas	6	2.4	6	2.2	17	2.5	14	3.1	3	2.6	12	4.3	32	4.2	10	2.7
Karatau	8	2.2	7	1.8	12	1.7	9	1.7	8	2.2	29	3.6	16	2.5	11	2.0

* F—frequency of direction, %; ** S—average speed, m/s.

South-westerly winds prevail in Karatau, and they are also the strongest. The duration of winds with speeds of more than 17.2 m/s is 6 h per year, and the duration of winds with speeds of more than 13.9 m/s is 19 h/year. Phosphorite deposits and associated waste-rock dumps are located in the south and southwest of the city, so strong winds from the southwest carry dust from the quarries (Figure 4).

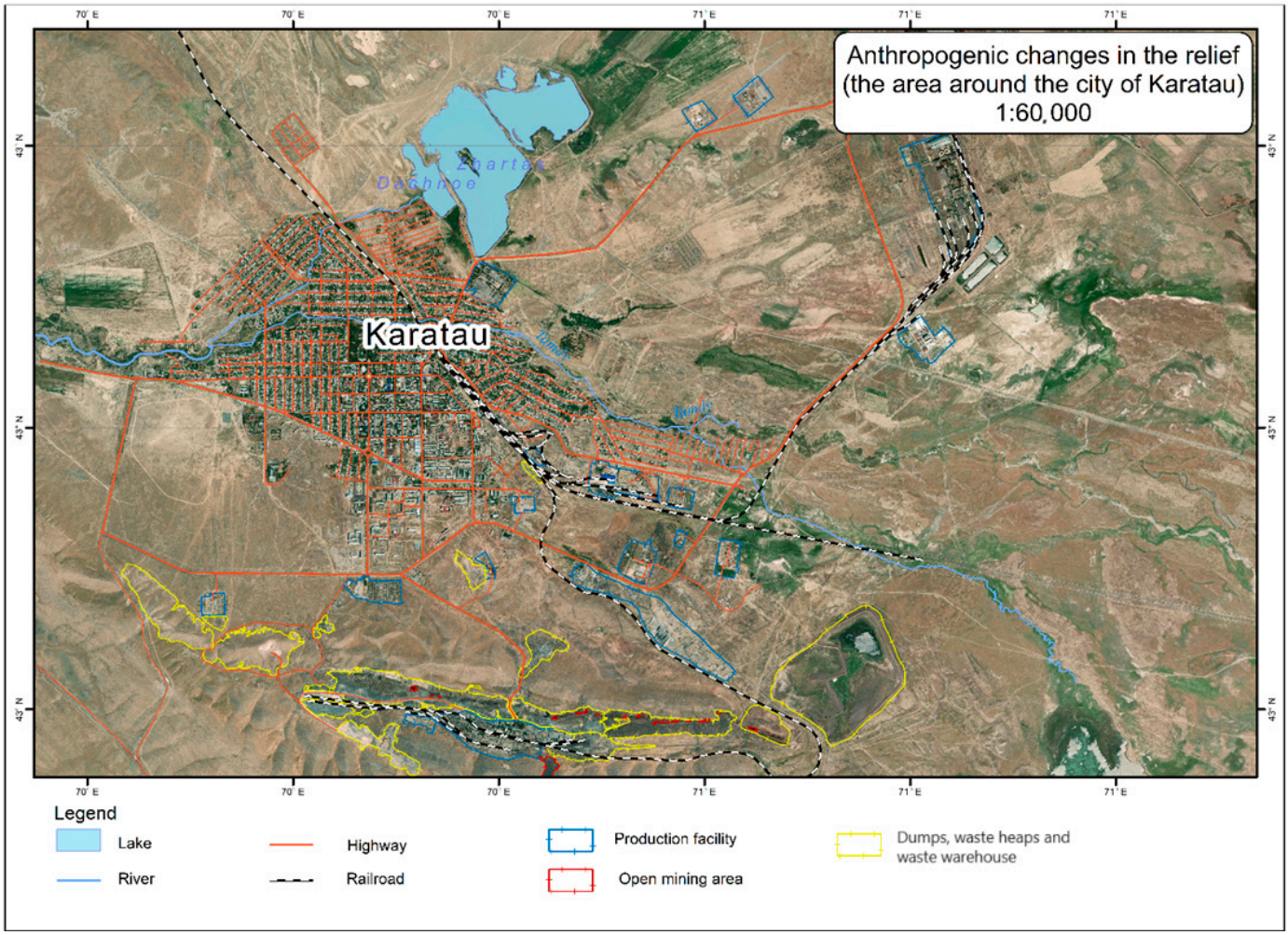

Figure 4. Deposits and waste-rock dumps in the south of Karatau.

A model of wind speeds in Karatau was created using the portal meteoblue.com [60], using long-term data; it indicates how many hours per year the wind blows from a certain direction. The Karatau wind rose reflects the frequency and speed of the winds (Figure 5).

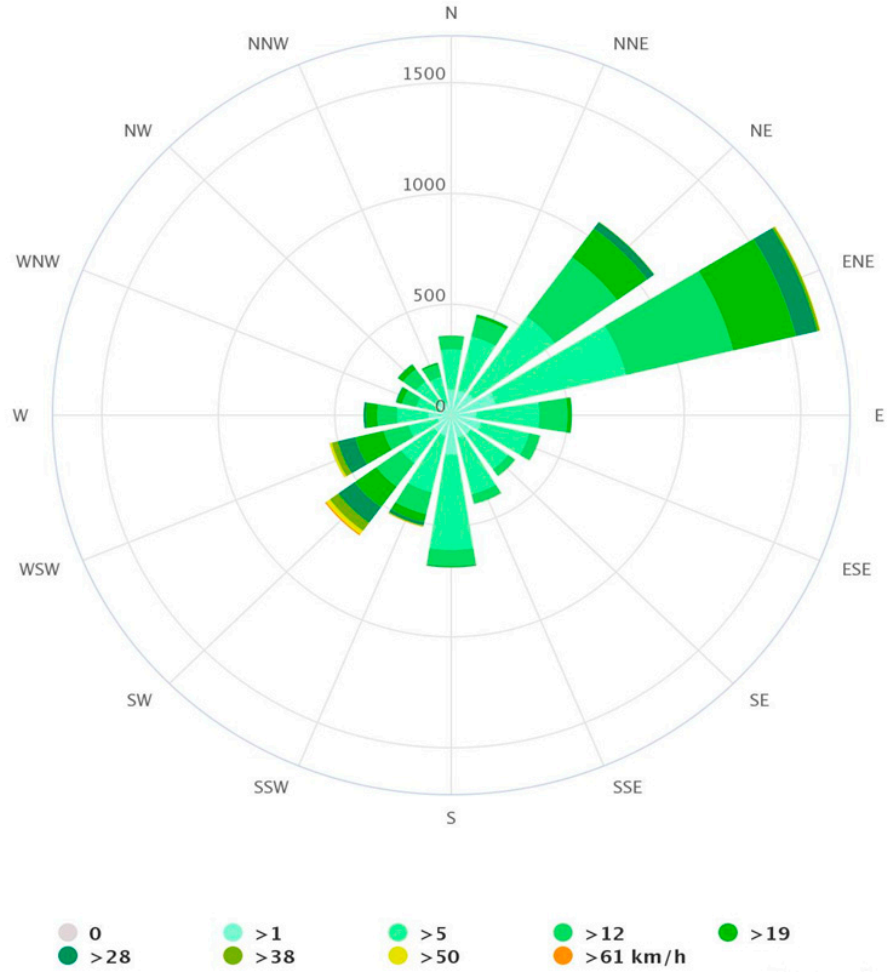

Figure 5. The rose of wind speeds in the city of Karatau.

The wind speed rose shows the durations of different wind speed intervals in hours within the total time period and indicates their direction. The winds that blow from the northeast are mostly weak and of average speed (3.4–8 m/s); their duration during the year is 750 h.

The city of Zhanatas is influenced by mountain–valley winds. Westerly, north-westerly, and south-westerly winds prevail here (54%); the average wind speed in this direction exceeds 4 m/s. According to the portal meteoblue.com [60], the yearly duration of south-westerly winds with a speed of over 17.2 m/s is 5 h, with a speed of over 11 m/s recorded for 73 h during the year (Figure 6).

Given the location of the mines and landfills on this side of the city, with strong winds, the risk of dust storms and pollutants entering the city increases (Figure 7).

Figure 7 shows the locations of high-rise buildings and the main social facilities of the city, which are both located in the southwest of the city. Therefore, it can be reasoned that dust storms caused by strong winds could severely affect people's lives. Storms and strong winds not only bring sand, but also carry all of the dust and gas pollution related to mining activity in the city's surroundings. This is particularly harmful in the absence of work on the recultivation of mine areas used in the past, as well as work on neutralizing the negative impacts of post-mining waste landfills.

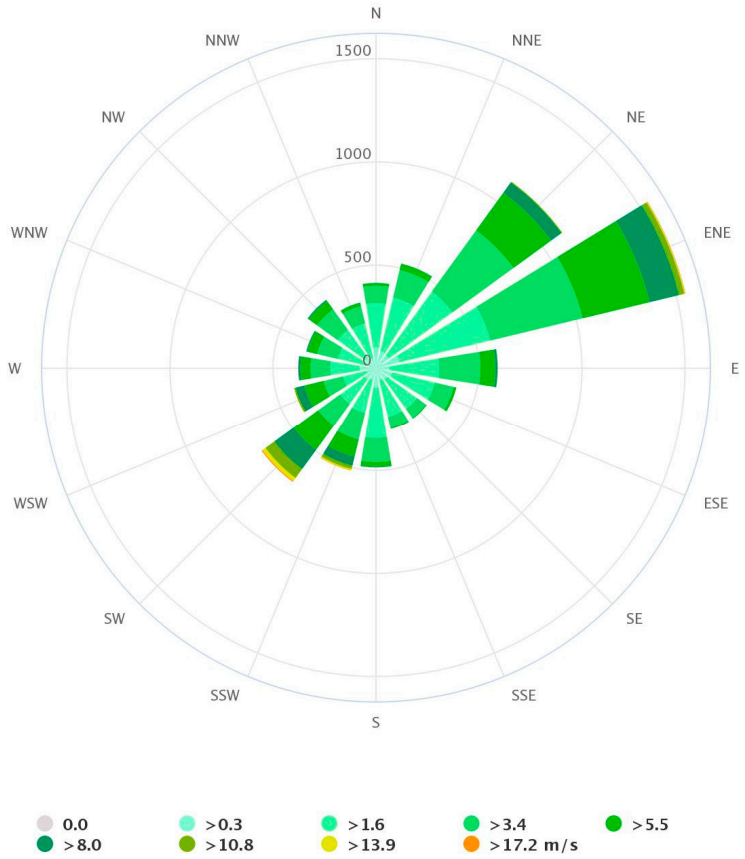

Figure 6. Rose indicating wind speeds in the city of Zhanatas.

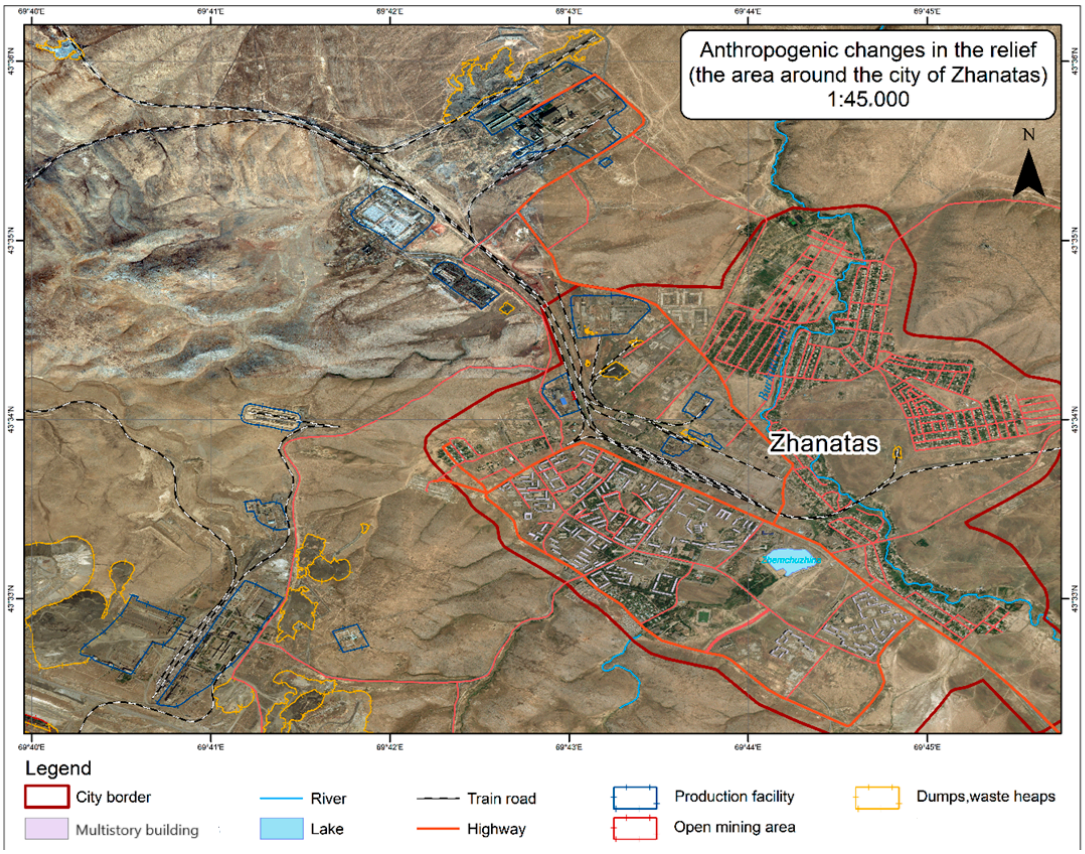

Figure 7. Mines and ore dumps in the west and southwest of Zhanatas.

3.2. Climate Change and Adverse Natural Phenomena

In recent years, the Zhambyl region has frequently experienced hazardous meteorological phenomena, such as strong winds, drought, and heat. Especially in the research area, the number of storm-level winds has increased. For example, the cities of Zhanatas and Karatau were severely affected by the hurricane wind that occurred on 2 January 2013 [61]. On that occasion, under the influence of a storm with wind speeds of 35–40 m/s, a 60-m pipe of the central boiler house collapsed in the city of Karatau, and power transmission poles fell and trees were uprooted (Figure 8).

Figure 8. The effects of the hurricane in the city of Karatau and its surroundings, 2013 (photo from the public domain).

On 24 March 2015, 17–18 November 2021, and 3 January 2023, the hurricane conditions in the cities of Zhanatas and Karatau were repeated, tearing off the roofs of buildings in the cities of Zhanatas and Karatau, and damaging communication stations and power lines. At those times, a state of emergency was declared in these areas due to the natural disasters (Figure 9).

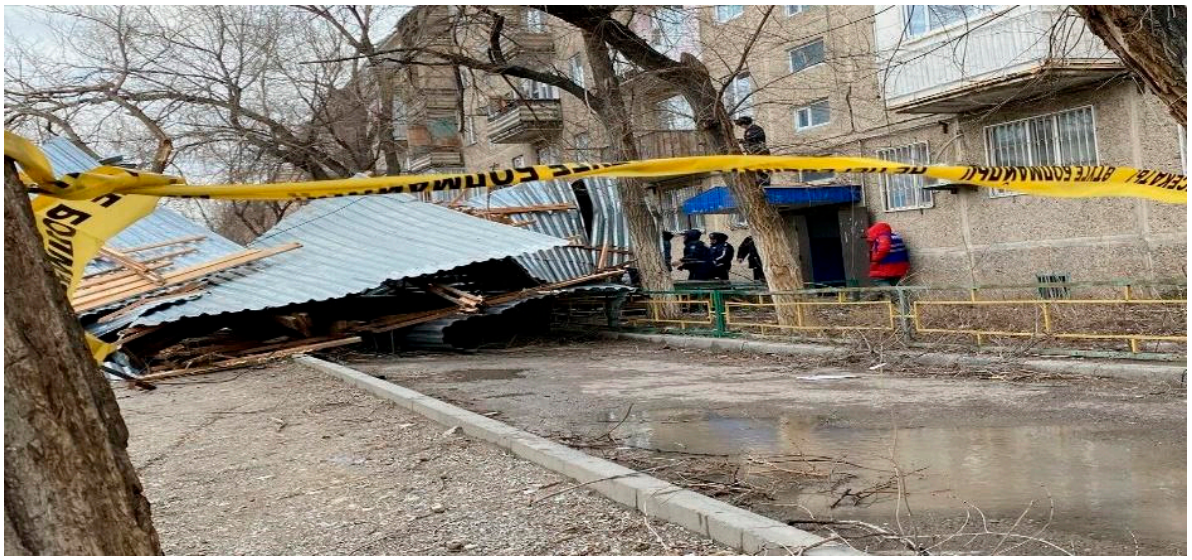

Figure 9. The consequences of the hurricane in Karatau, 2023 (photo from the public domain).

Table 6 presents data on the hazards associated with strong winds and their consequences for 2021–2023. When compiling the summary table, we used data from the Department of Emergency Situations of the Zhambyl Region [62].

Table 6. Dangerous hydrometeorological phenomena, 2021–2023. (Compiled by the authors, based on the Department of Emergency Situations of the Zhambyl Region data [62]).

	Dangerous Phenomenon	Date	Aftermath
Zhanatas	Strong wind (gusts up to 30 m/s)	23 January 2021	Power line breaks: 747 subscribers were left without power supply
	Strong wind (gusts up to 30 m/s)	3 January 2023	Emergency shutdown of electrical networks, central boiler room, cellular and telephone communications; 3500 subscribers were left without power supply
	Strong wind (gusts up to 26 m/s)	11 February 2023	Emergency shutdown of electrical networks: 2014 subscribers were left without power supply
Karatau	Strong wind (gusts up to 30 m/s)	3 January 2023	Emergency shutdown of electrical networks, partial breakdown of the metal roofs of eight multi-story buildings, including the administrative building of the city and the railway station; 3284 subscribers were left without power supply
	Strong wind (gusts up to 24 m/s)	11 February 2023	Emergency shutdown of electrical networks: 1785 subscribers were left without electricity supply; 3285 subscribers left without cold water supply; the roofs of five multi–story buildings were torn down

Hurricane winds pose a danger to people's lives and urban communications. The wind danger also threatens the food security of cities. In cases of very strong winds, combined with snowstorms in winter, and in the dry season with dust storms, transport to and from the city is closed for the safety of residents. Police block the roads leaving cities and turn potential travelers back to the city. Strong winds not only limit transport, but also cause a number of incidents of damage, which are episodic in other regions, but permanent in the studied region. In this regard, the development of urban agriculture in the small towns of the Zhambyl region is very relevant. This will also make it possible to reduce the cost of food, which is important in conditions of generally low income in the small towns. The cities of Zhanatas and Karatau have opportunities to create intensive agro-clusters. These measures should be implemented within the framework of specially developed strategies for adapting small towns to climate change.

Although the presence of intercity highways improves the transport accessibility of cities, during the winter months during snowstorms, the roads connecting Zhanatas and Karatau with other settlements are closed for several days. All of this makes the cities of Zhanatas and Karatau vulnerable to natural elements, primarily climatic cataclysms. Poor development of public transport in cities also contributes to increased risk in winter.

3.3. State Policy to Support the Sustainable Development of Kazakhstan's Cities

Kazakhstan regained independence after the collapse of the Soviet Union. It is a country whose economy is based on the extraction and export of natural raw materials. Finally, it is a country in which the process of economic transformation is ongoing. Despite the obviousness of these three statements, they seem necessary because they suggest the current state policy in supporting sustainable development. State policy is focused on the development of the country's three largest cities, Almaty, Astana (Nur-Sultan), and Shymkent, in each of which the population increased by a factor of 3–5 times between 1989 and 2020 [63,64]. Contemporary economic challenges and global warming related to the anthropogenic increase in greenhouse gases have encouraged the country's authorities to take actions aimed at energy transformation. On the other hand, the energy sector and the entire economy of Kazakhstan are based on the burning of hard coal, crude oil, and natural gas. In 2018, 99.4% of electricity generation in the Zhambyl region was based on the use of natural gas and petroleum products (2018) [56]. This is the typical energy

production structure for all regions of the country. In such a case, it is difficult to talk about the actual implementation of programs supporting sustainable development based on the local importance of industrial monocities. However, based on the literature, it can be inferred that Kazakhstan intends to pursue a policy of supporting sustainable development in cities, an intent which is assumed in the Kazakhstan-2050 Development Strategy [64,65] and plans and documents presenting government policy [66,67].

However, as can be concluded from the literature on the subject, the current policy supporting the sustainable development of cities is not sufficient, even in the cases of the largest centers in the country. What is again obvious is that the largest investments in the promotion of sustainable development and smart cities take place in the new capital—Astana [33], which is relatively easy when developing a completely new city. However, the city of Almaty, as shown by the research results [34], has positive dynamics of development associated with the economic and social subsystems, but is characterized by negative development of the ecological subsystem. The analyzed work strongly emphasized the need to solve the city's environmental problems [34] (p. 6), while increasing the share of state support. This may result, on the one hand, from the lack of sustainable development programs, and, on the other hand, from the insufficient level of their actual implementation. This is also confirmed by other studies on the implementation of state programs; for example, a low level of state policy support is evident for the development of entrepreneurship ecosystems [35,68]. A Resolution of the Government of the Republic of Kazakhstan, dated 12 September 2023 (No. 781), approved the Comprehensive Plan for the Socio-Economic Development of the City of Zhanatas, Zhambyl Region for 2023–2027 [69]. This Plan is mainly aimed at creating new jobs and modernizing infrastructure. Environmental measures include such measures as planting at least two thousand trees and shrubs annually and constructing a waste-sorting complex. Consequently, this program does not address the issue of protecting the population from natural disasters, including strong winds.

Resolution of the Government of the Republic of Kazakhstan, dated 14 September 2023 (No. 796), approved the Comprehensive Plan for the Socio-Economic Development of the City of Karatau, Zhambyl Region for 2023–2027 [70]. The Plan is aimed at improving the socio-economic development of the city of Karatau. The main measures are aimed at diversifying the economy, updating infrastructure, and creating new jobs. The Program does not contain measures aimed at protecting the population from adverse natural phenomena, including strong winds.

The insufficient levels of support from government programs for the development of monocities such as the studied Zhanatas and Karatau are confirmed by field research. Insufficient infrastructure investments, the lack of protection against the wind's carrying of materials from the heaps created by mines, and the lack of activities aimed at the recultivation of post-industrial areas indicate the lack of a comprehensive policy to support the sustainable development of the studied cities.

4. Discussion

Climatic comfort in the city is one of the important indicators in assessing the sustainability of the city [71]. Stathopoulos notes that different countries and institutions use different criteria to set thresholds for acceptable and unacceptable wind conditions [72]. Research by Szűcs [73] shows that a windy urban environment can limit the utilization of urban space. Therefore, when assessing the climatic comfort in the city, the speeds and frequencies of winds are taken into account.

The American Society of Civil Engineers (ASCE) assessed the comfort of wind speed ranges depending on human activity; according to this assessment, wind speeds exceeding 5.4 m/s are uncomfortable during any human activity in urban conditions (Table 7).

Table 7. Comfortable wind speed, depending on the type of activity [74].

Activity	Comfortable Wind Speed Ranges (m/s)
Sitting	0–2.6
Standing	0–3.9
Walking	0–5.4
Uncomfortable for any activity	>5.4

In order to correlate the indicators of this study with the actual data for the studied cities, we analyzed the repeatability of wind speed. According to the above data in Table 6, if the wind speeds in cities exceed 5.4 m/s, climatic comfort decreases. From this point of view, inconveniences are caused by about 13% of all wind cases registered for 2010–2022 in the city of Zhanatas, and 5% of cases in the city of Karatau. According to our calculations based on Kazhydromet data for the period 2010–2022, wind speeds above 6 m/s are recorded, on average, 118 days per year in Zhanatas, and 40 days per year in Karatau. Among the small towns studied, Zhanatas has a more significant number of days with high wind speeds (above 6 m/s) which can negatively affect climatic comfort. With strong winds, the risk of dust and pollutants being carried into the city increases. According to Ameen, one of the dangers in the city is wind [58].

However, there is also a positive effect from the windy climate of the city. It should be noted that the prevailing winds with an average speed of 7–8 m/s and above also allowed the construction of the Zhanatas wind power plant [75], thereby contributing to the sustainable energy supply of the city. This power plant is the largest wind power plant, not only in Kazakhstan, but also in the whole of Central Asia; it has a capacity of 100 MW and has 40 wind turbines. The annual output of the Zhanatas WPP of 350 million kW/h will be able to meet the electricity needs of one million local households, which will improve the situation associated with the shortage of electricity in Southern Kazakhstan.

Contrasted with a coal power plant of equal capacity, the wind power facility can annually conserve 109,500 tons of coal and mitigate emissions, reducing sulfur dioxide by 1031 tons, nitrogen oxide by 934 tons, carbon dioxide by 289,000 tons, and dust by 322 tons, while also diminishing ash and slag emissions by 32,900 tons [75]. Thus, effective wind management is crucial for the city's sustainable development.

The positive aspects related to the construction of the wind power plant in Zhanatas cannot be disputed; however, they are individual in nature. Apart from the new investment, there are no visible investments in the city's infrastructure that support sustainable development. Additionally, it can be pointed out that, apart from the typical problems of sustainable development [76], in the cities studied, state policy, despite the official implementation of the development strategy, is simply not working. Similar state policies, development strategies, and other documents are presented in the conclusions of research by Alderman and Eggeling [77]. Our local observations are also confirmed by research on CO_2 emissions at the country level [78] which proves the existing opportunities to support sustainable development at the country level, and, at the same time, the slow pace of the implementation of the Kyoto Protocol agreements. The weakness of government policy in the case of monocities is even highlighted by official reports, which only emphasize improvements in electricity and water supply networks. At the same time, low effectiveness and a lack of impact and value for the end users of these programs and projects—the local community—were demonstrated [79]. Subsequent studies of monocities, which also include the centers we research, even recommend changing the current policy. The new policies should help these cities find their own ways of sustainable economic development [29].

In general, the issue of urban sustainability is now being considered in connection with climate change [80]. The assessment of urban ecosystems should include the readiness of cities for the conditions associated with climate change and the ability to adapt to climate disasters. The level of adaptation of cities to climate-change disasters and the

reduction of the vulnerability of the urban environment [15,81,82] are of great importance for modern cities.

Bixler et al. [83] have proposed an approach to assessing the risks of multiple hazards, including social vulnerability, in the case of Austin, taking into account the likelihood that cities will be exposed to multiple catastrophic events. The cities we are considering are also subject to wind danger. This cannot but affect the socio-economic and psychological states of the populations of single-industry towns.

The United Nations Office for Disaster Risk Reduction (UNDRR) report "The Human Cost of Disasters 2000–2019" noted that extreme weather events have become dominant among natural disasters around the world over the past 20 years [84]. Climate changes are clearly visible in the territory we are considering. Taking into account this situation, the data obtained during field work in the studied cities were recorded and analyzed. In general, Kazakhstan has no experience in studying the resilience of small towns to climate change. And the problems associated with using foreign experience are obvious.

5. Conclusions

The conducted studies have shown that, in order to ensure the sustainable development of small towns in Zhambyl region, it is necessary to take into account favorable and unfavorable environmental factors. It has been determined that each small city has its own set of local natural and environmental conditions, and that these should be the guides when developing strategies for the development of these cities. The purpose of this article was to analyze the impact of wind conditions on the sustainable development of small towns in the Zhambyl region, and this has been achieved. Our hypothesis, that climate conditions in the absence of planning aggravate the problems of sustainable development of small cities, was tested, with positive results. Such dangerous hydrometeorological phenomena as frequent strong winds can be assessed as being one of the serious risks to the sustainable development of the cities of Zhanatas and Karatau, especially in winter.

Blocking factors that, along with the wind hazard, negatively affect the sustainable development of small towns in the Zhambyl region include the following:

- Altered anthropogenic landforms (landfills in an arid continental climate are not overgrown with vegetation; therefore, due to prevailing winds, they are sources of toxic dust);
- The locations of the industrial zones of the cities of Zhanatas and Karatau having been determined without taking into account the prevailing wind directions (winds blowing from the industrial zone to the city pollute the air);
- Sprawl of the territories of cities (the territories of cities are heterogeneously populated, and areas with uninhabitable houses remain; all of this does not contribute to the effective use of urban networks and impedes communications in the event of natural disasters);
- Lack of alternative life-support systems for cities during natural disasters. In this regard, in small towns of the Zhambyl region, it is proposed to introduce decentralized and autonomous heating systems for multi-apartment residential buildings, since these cities are provided with main gas pipelines.

The study showed that the current problems of small towns in the Zhambyl region relevant to their sustainable development are significant, but surmountable. Therefore, to solve these problems, concerted efforts by the authorities, scientists, and residents of cities are needed, primarily through the development of new science-based strategies, taking into account the main indicators of sustainable urban development, and increasing funding for the implementation of planned activities.

Each study has limitations related to the adopted research scheme and the selection of objects/factors/period for analysis. In the research undertaken, it should be noted that the results concern selected monocities, which are typical examples, but without additional research, the obtained results cannot be generalized. An attempt was made to determine the impact of wind on the sustainable development of monocities, but the impacts of rainfall

and water conditions also play important roles, the impacts of which may change the final conclusions. However, such an analysis requires additional research, which may constitute a direction for future analyses aiming to determine the natural conditions for sustainable development. It should also be stated that, in the literature on the subject, there are no classic works for other regions (e.g., the EU and the US) in the field of medical geography.

At the moment, we are dealing either with a lack of measurement of the negative impact of the mining industry on the city's inhabitants, or with difficulties in accessing data showing the actual degree of environmental degradation. This state of reality is indirectly evidenced by analyses of spatial differences in life expectancy in the cities of Kazakhstan, which is lower in mining mono-towns. This fact is confirmed by the strongly spatially diversified occurrence of diseases typical of mining, such as pneumoconiosis or diseases related to the extraction of heavy metals. However, confirmation of the above observations requires research in the field of medical geography.

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