

ASSESSMENT OF TOURISM AND CLIMATE POTENTIAL OF TERRITORIES OF NORTHERN KAZAKHSTAN

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Abstract: The purpose of the research was to assess the degree of favorableness of the bioclimatic conditions of the territory of Northern Kazakhstan by calculating the tourist climate index (TCI) and analyzing its spatial and temporal variability. Archival, stock materials and data on the main meteorological and climatic indicators for 63 weather stations for the period 1966–2020 were used. The study used methods of mathematical and statistical analysis, GIS technologies. The level of climatic attractiveness varies from "very unfavorable" in the winter months to "comfortable" in the summer. It was determined that the territory of Northern Kazakhstan as a whole is relatively homogeneous in terms of the average annual TCI index (28-38). Depending on the values of the index, 5 categories of climatic attractiveness of the territory of Northern Kazakhstan were identified (comfortable, moderate, neutral, unfavorable, extremely unfavorable). The most favorable conditions for tourist and recreational activities are formed in the summer months in the northeastern and southwestern sectors of the region. Recommendations are given on the spatial placement of tourist and recreational facilities and types of tourist activities in Northern Kazakhstan, taking into account the favorable weather and climatic conditions.

Key words: bioclimatic potential of the territory, tourist climate index, Northern Kazakhstan, meteorological data, tourist and recreational activities

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INTRODUCTION

Nowadays tourism is an important part of the tertiary sector of the global economy, providing up to 10% of GDP in pre-pandemic years and being the third (7%) most important export category in the world after fuel and chemicals, and the second (28%) in trade in services. According to the World Travel and Tourism Council, the contribution of the tourism industry to the GDP of different countries ranges from 0.5% (Algeria) to 79.4% (Maldives) (UNWTO, 2021). For a number of years now, the Transcaucasian states have been leading in the post-Soviet space, where Georgia is the undisputed leader – 27%, followed by Azerbaijan and Armenia by a wide margin – 15% and 14% of GDP, respectively. Unfortunately, the Republic of Kazakhstan, with its vast territory and the richest natural, historical and cultural attractions, is ranked 129th in the world ranking with a modest share of 6% of GDP. In the recently published (U.S. News Best Countries ranking, 2022), where foreign direct investment and international tourism income were the most important predictors, the country ranked second to last, 84th, ahead of only Iran. Based on the current Concept for the Development of the Tourism Industry of Kazakhstan (The concept of development of the tourism industry..., 2017), as well as in connection with the recovery of the industry from the consequences of COVID-19, modern studies of the tourism and recreational potential of the regions have particular importance. The development of tourism in any territory is based on the attractiveness of the health-improving potential of natural objects of the locality under consideration. One of the most important recreational forming

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natural components is the climatic factor and, as a rule, weather and climatic conditions are the main limiting factor. The synergistic effect of meteorological (weather) characteristics determines the recreational potential of the climate.

Meteorological parameters (air temperature, atmospheric pressure, wind speed, air humidity, solar radiation intensity, etc.) can have values that both contribute to and hinder the preservation and promotion of health. It is known that the healing effect of the meteorological factor is characteristic only for a certain range of values of its parameters (range of physiological comfort). The action of the factor in other ranges only impairs health. The combination of meteorological parameters determines the climatic potential of the territory for the development of tourist and recreational activities.

The choice of the object of study is not accidental: Northern Kazakhstan is a large natural and economic region - its area is 601 thousand km² and population is 4.2 million people (data on 01.01.2023). The social and economic significance of the region has increased many times since the transfer of the capital to the city of Akmola (the current city of Astana) in 1997. Northern Kazakhstan, being an integral part of the Kazakhstan tourism space (Azhayev et al., 2020; Makhanova et al., 2022; Mazhitova et al., 2018; Ozgeldinova et al., 2020; Sagatbayev et al., 2019; Yegemberdiyeva et al., 2020; Kitaibekova et al., 2023) despite increased domestic demand on the tourism product, stands out among other regions with unjustifiably low indicators of the development of the industry. Located in the far north of the country in the junction zone of the West Siberian lowland and Saryarka (Kazakh low hills), stretching from north to south for almost 900 km (from 49 ° N to 55 ° N) and from west to east - more than 1300 km within the forest and steppe, steppe and desert and steppe natural zones, the area is characterized by a heterogeneous landscape space, which has led to a variety of territories favorable for the development of tourism. However, at present, over 95% of tourist visits are only in three districts - Burabay (with Zerenda), Bayanaul and Shalkar-Imantau (Figure 1). The aim of the study was an integrative assessment of the favorableness of the bioclimatic conditions of the territory of Northern Kazakhstan by calculating the tourism climate index (TCI) to improve management decisions on the scale of both individual destinations and the region as a whole. A review of the publication of recent years shows that in the countries of the post-Soviet space there is no or extremely poorly studied climate impact on tourism, not to mention the impact of climate policy on tourism demand, as well as integrated climate and carbon risks in tourism (Dogru et al., 2019; Steiger et al., 2023), which should be the subject of further research.

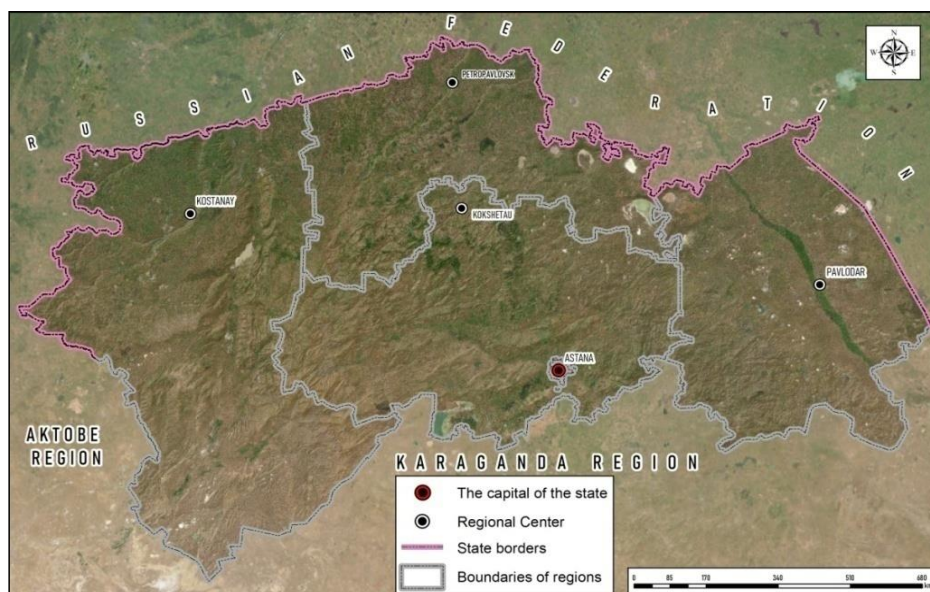


Figure 1. Northern Kazakhstan (open satellite image from Google)

METHODOLOGY

The methodological base of the study is leaned on theoretical and applied publications on bioclimatology, human ecology, medical geography, recreational geography, and balneology. Global climate change has not only caused a shift in seasonality, but has also led to severe weather fluctuations and an increase in extreme weather (Reidmiller et al., 2018). Nowadays more and more researches are focusing on the climatogenic determinism of destination choice and the climatic attractiveness of major tourist areas (Hamilton and Lau, 2005; Maddison, 2001; Lise and Tol, 2002; Scott and Lemieux, 2010). An important place is occupied by works on studying the experience and results of research on the meteorological factor and its parameters from the standpoint of assessing the tourist and recreational potential of various territories, the comfort of the natural landscape environment (Steadman, 1979a, 1979b, 1994).

At the moment, in medical climatology, many bioclimatic indices are known. They are used to assess the comfort of the climate and its potential. Among them, the most famous and actively used in studies conducted at various territorial levels are: equivalent effective temperature (Aizenshtadt, 1964), radiation equivalent – effective temperature (Golovina and Trubina, 1997), weather severity index (Kobysheva et al., 2008), universal thermal comfort index (Universal Thermal Climate Index – UTCI) (Błażejczyk et al., 2010, 2012, 2013). To determine the favorable bioclimatic conditions of the territory of Northern Kazakhstan, we took the Tourist Climate Index (TCI) (Mieczkowski, 1985). Let us make a reservation right away that this index, despite its wide distribution Li et al., 2023; Lukić et al., 2021; Parubova and Perevedencev, 2022,

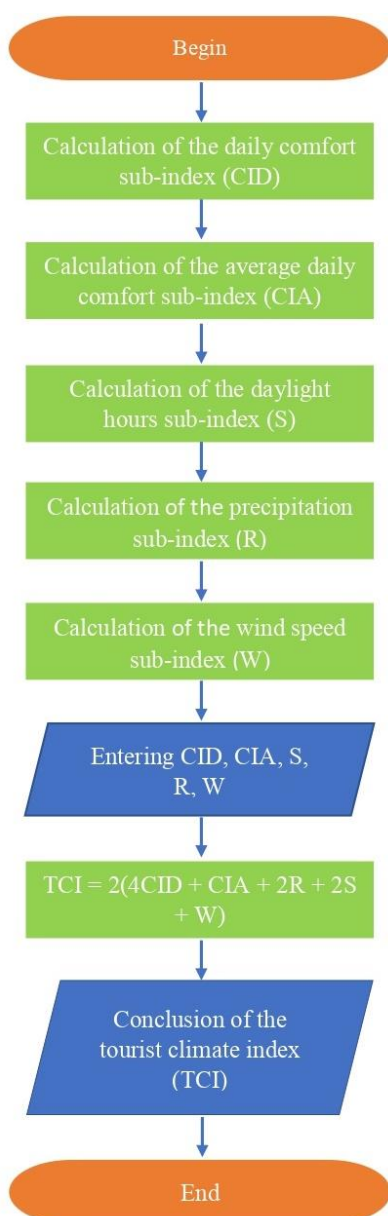


Figure 2. Algorithm for determining the TCI

The solar or daylight sub-index (S) reflects the duration of the sunshine period per day. This sub-index is calculated as the difference between the time of sunset and sunrise for each day of the year, taking into account the latitude of the area and the declination of the sun:

$$T_s = 12 + \frac{12}{\pi} \arccos \left(\frac{-\sin \varphi \sin \delta}{\cos \varphi \cos \delta} \right), \quad T_r = 12 - \frac{12}{\pi} \arccos \left(\frac{-\sin \varphi \sin \delta}{\cos \varphi \cos \delta} \right) \quad (3)$$

where T_s is the time of sunset, T_r is the time of sunrise, φ is the latitude of the area, δ is the declination of the sun.

When calculating the precipitation sub-index (R), daily precipitation figures were multiplied by the number of days in the month. The wind sub-index (W) was determined on the basis of data on wind speed and air temperature using the formula below (Mieczkowski, 1985, 225–228):

$$W = \sqrt{(100v + 10.45 - v) \cdot (33 - T_a)} \cdot 1.162 \quad (4)$$

where: T_a – atmospheric air temperature, °C; v is the wind speed, m/s. When calculating the TCI index, each sub-index was assigned a climatic attractiveness score, which varies from 5 (optimal) to -3 (very unfavorable). For all sub-indices, the maximum value of the assessment is taken equal to 5 points, the minimum - (-3).

Sub-index estimates of meteorological climate parameters in points are formed on the basis of empirical data from physiological studies, as well as a study of people's tourist preferences. According to these studies, the sub-indices of temperature (thermal) comfort CID and CIA are considered the most significant in terms of the total contribution to the TCI index. At the same time, the share of the daily comfort sub-index (CID) in the formation of TCI is 40%, and the daily comfort index (CIA) is 10. The solar sub-index (S) is 20%, the precipitation sub-index has the same importance, the remaining 10% of the TCI value falls on the wind subindex. The information and factual base of our study was the daily meteorological data of 63 representative meteorological stations in the region with a continuous long-term series of

is subject to active criticism (De Freitas et al., 2008; Rutty and Scott, 2014; Scott et al., 2012). As the main shortcomings, opponents point to the subjective assessment system and the distorted share of climate variables, suggesting abandoning it in favor of the Holiday Climate Index (HCI) developed in opposition to it, later differentiated into urban and beach (Scott et al., 2016), or created based on the TCI Camping Climate Index (CCI) (Rutty et al., 2020; Ma et al., 2020; Fichett and Meyer, 2023). However, despite these shortcomings, TCI is optimal for Northern Kazakhstan, because, due to the sharply continental climate, the tourist potential of the region is determined by temperature variables.

This study included the following stages: collection, systematization and analysis of initial data (basic meteorological indicators); calculation of the TCI index, interpretation of the results obtained; creation of cartographic models and conducting spatio-temporal analysis of the distribution of TCI across the territory of the region; zoning of the territory of the region according to the size of the TCI; development of proposals for the improvement of management decisions and the development of appropriate types of recreation, tourism in the region, taking into account the degree of bioclimatic comfort of the territory.

The flowchart of TCI calculation is shown in Figure 2. The index is calculated using the following formula (Mieczkowski, 1985, 225–228):

$$TCI = 2(4CID + CIA + 2R + 2S + W) \quad (1)$$

where TCI is the tourist climate index, in points; CID – daily comfort sub-index, CIA – average daily comfort sub-index, S – daylight hours sub-index, R – precipitation sub-index, W – wind speed sub-index. The calculations were carried out by months, which made it possible to assess the bioclimatic conditions of the region for the integrative development of tourist and recreational activities throughout the year. The TCI includes five sub-indices that assess daily thermal comfort, daily thermal comfort, precipitation, sunshine duration and wind speed.

Temperature daily sub-index or daily comfort sub-index (CID) characterizes the conditions of thermal comfort in the season with maximum tourist activity.

Temperature average daily sub-index or average daily comfort index (CIA) shows the temperature comfort during the day. The temperature (thermal) comfort sub-index is calculated from the effective temperature (ET) or the equivalent effective temperature (EET). The latter indicator is a derivative of temperature, relative humidity and wind speed. Effective air temperature (EAT) or equivalent effective temperature (EET), in °C, was determined using the formula given in:

$$ET (EET) = 37 - \frac{(37 - T_a) / (0.68 - 0.0014 \cdot R_a + 1 / (1.76 + 1.4 \cdot v \cdot 0.75))}{1 - 0.01 R_a} - 0.29 T_a \cdot (1 - 0.01 R_a) \quad (2)$$

where: T_a – atmospheric air temperature, °C; R_a – relative air humidity, %; v is the wind speed, m/s. To calculate the sub-index SID, data on the maximum temperature per day and the corresponding indicators of relative humidity and wind speed were used, for the sub-index CIA we used average daily data.

observations for the period 1966–2020. The main meteorological parameters (air temperature, atmospheric pressure, wind speed, relative air humidity, solar radiation intensity) were selected and summarized, which determine the bioclimatic potential of the territory for the development of tourist and recreational activities.

In addition, some meteorological parameters were taken from reference data (Agroclimatic resources of the Akmola region, 2017; Agroclimatic resources of the Kostanay region, 2017; Agroclimatic resources of the North Kazakhstan region, 2017; Agroclimatic resources of the Pavlodar region, 2017). The obtained values of the tourism climate index for the period under review were grouped according to the classification developed on the basis of empirical data (Scott and McBoyle, 2001). The TCI index is calculated for the "average person", not taking into account the individual characteristics of adaptive mechanisms. According to this classification, the maximum TCI score of 100 points characterizes the "ideal climatic attractiveness" of the territory for recreational activities.

RESEARCH RESULTS AND DISCUSSION

Due to the continental position and the associated features of the circulation of air masses, the nature of the underlying surface and the predominance of flat relief, the climate of Northern Kazakhstan belongs to the West Siberian climatic zone of the temperate belt and is distinguished by a number of features: sharply continental, the Palmer index ranges from -0.81 to -1.23, quite sharp intra-day temperature changes are typical, especially in the off-season, uneven distribution of precipitation throughout the year (with a summer maximum and a winter minimum) and from year to year. The region is characterized by abnormally cold climate for this latitude, the absolute minimum (-57 °C, Atbasar) in Kazakhstan is recorded here, the average long-term amplitude of temperature extremes is 85–88 °C.

In the north of the region, throughout the year, the midday height of the Sun varies from 11°36' to 58°24', and in the south - from 17°54' to 64°38'. The length of the day varies in the north from 7 hours 5 minutes to 17 hours 17 minutes, in the south - from 8 hours 04 minutes to 16 hours 23 minutes per day.

The duration of sunshine increases from north to south from 2070 to 2562 hours/year. In the south of the region, the average duration of sunshine is 9.9–11.4 hours/day, in the north 9.3–10.1 hours/day. By winter, the duration of sunshine is reduced, reaching a minimum of 7.0–8.4 hours / day in December. The average long-term temperature of the summer period is +19.4 °C. At the same time, this indicator has a clear upward trend from +18.1 °C to +23.6 °C in the north from +18.1 °C in the south. In autumn, the average long-term temperature is +2.7–3.4 °C. In spring, the average long-term temperature is 4.5–6.0 °C. The average long-term temperature for the winter months is -16.8°C. The temperature difference from north to south in autumn is 1.3°C. The average annual air temperature is positive and amounts to 1.9–4.0 °C. Average January temperatures vary within -16–19 °C. The most severe weather and climatic conditions are in the north-eastern regions, the warmest and driest (located in the rain shadow) is the south-west of the region.

The average long-term annual precipitation in the south of the region is 207 mm (st. Ekidyln), increasing to the north to 420 mm (st. Saumalkol). The average annual wind speed in the north is 2.6 m / s, increasing to the south to 5.5 m / s, while in the annual course of wind speed throughout Northern Kazakhstan, 2 maximums are distinguished - in April and December (up to 34 m/s) and minimum in July. At all weather stations in the region, the prevailing wind directions on average for the year and especially in January are south and southwest. The values of the tourist climate index of the territory of Northern Kazakhstan obtained in the course of the calculations are presented in Table 1.

Table 1. TCI values of the territory of Northern Kazakhstan for the period 1966-2020 (Source: calculation is based on data: Kazhydromet, 2023)

Weather station	Months												Year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Astana	3	2	14	24	39	62	59	62	40	26	14	0	29
Bayanaul	6	5	18	44	52	63	61	65	56	47	16	3	36
Blagoveschenka	4	4	25	37	55	64	62	66	53	37	18	2	36
Bulaevo	5	4	23	43	58	67	69	68	49	30	12	2	36
Burabai	3	5	17	40	54	63	60	62	53	45	19	4	35
Vozvyshenka	9	12	24	41	53	63	66	67	51	37	21	9	38
Imantau	2	4	14	43	59	62	61	62	55	43	23	1	36
Kokshetau	3	3	10	27	36	61	58	61	44	26	9	0	28
Kostanai	4	3	13	22	41	61	60	63	43	20	12	1	29
Kishkenekol	8	7	23	46	64	63	61	61	58	41	21	5	38
Pavlodar	4	4	16	25	49	62	61	64	48	22	15	3	31
Petropavlovsk	6	6	23	44	60	61	63	66	55	38	21	2	37
Ruzaevka	1	4	14	28	39	62	60	63	36	22	13	-2	28
Saumalkol	1	2	18	31	44	62	61	62	42	24	16	-2	30
Sergeevka	6	3	14	28	39	66	65	63	36	22	14	2	30
Taiynsha	6	5	15	38	57	59	60	60	55	35	15	4	34
Timiryazovo	4	4	12	39	53	62	60	63	51	38	18	2	34
Chkalovo	6	6	13	36	55	60	58	61	53	37	15	4	34
Yavlenka	5	3	23	45	61	64	61	61	57	40	21	2	37

The annual TCI chart of representative weather stations is given below (Figure 3). Below we present the categories of climatic attractiveness of the territory of Northern Kazakhstan, depending on the values of the index (Table 2). The main

meteorological characteristics, summarized in the form of a tourist climate index, made it possible to determine the bioclimatic potential of the natural conditions of the region for the development of tourist and recreational activities.

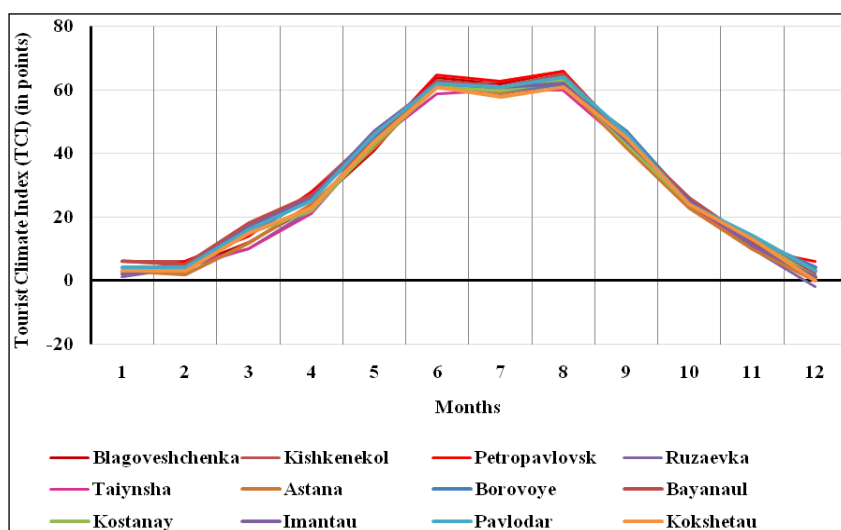


Figure 3. Annual course of TCI for a number of weather stations in Northern Kazakhstan (Source: compose is based on Table 1)

For the territory of Northern Kazakhstan, a correlation series of the dependence of the TCI value on the indicators of the main considered bioclimatic characteristics was revealed. TCI proportionally increases in summer with an increase in air temperature (in the range of +20–27 °C) and daylight hours. In winter, on the contrary, lowering the temperature below -20 °C reduces the value of the TCI index. The increase in wind speed above 5.0 m/s also contributes to the reduction of TCI. For all seasons, an increase in the number of days with precipitation causes a decrease in the value of the TCI index.

Table 2. Tourism climate comfort index scale (Source: Adapted from Anđelković et al., 2016)

Range TCI	Rate	Meteorological determinants	Purpose
56.1–70	Comfortable	High air temperature, few days with precipitation	Beach tourism (sunbathing, swimming)
42.1–56	Moderate	Warm weather and frequent rainfall	Excursions, sailing, agrotourism, ecotourism
28.1–42	Neutral	Sharp daily temperature and pressure fluctuations	Excursions, agrotourism
14.1–28	Unfavorable	Night frosts, frequent wind	Excursions
less than 0–14	very unfavorable	Prolonged frosts, blizzards, snowstorms	Snow activities in calm days

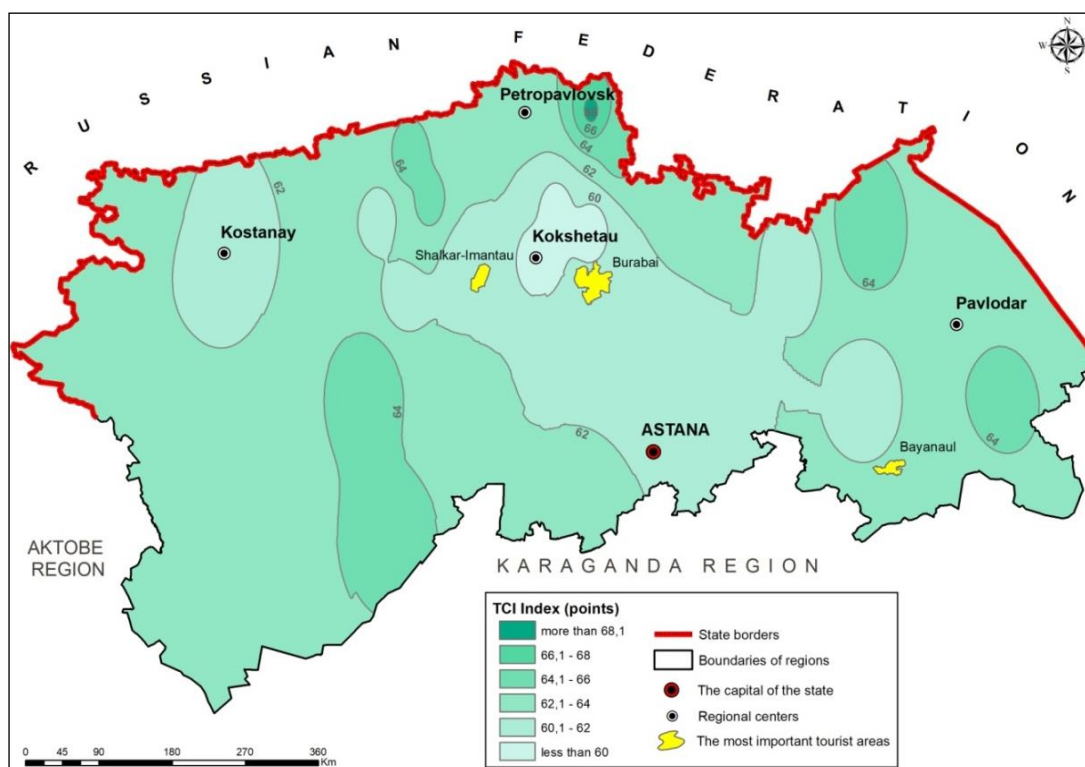


Figure 4. Zoning of the territory of Northern Kazakhstan according to summer TCI (Source: calculation is based on data: Kazhydromet, 2023)

Thus, the most favorable conditions for tourist and recreational activities in the territory of Northern Kazakhstan are formed in the summer months, when the most comfortable meteorological conditions are observed from the standpoint of human physiology. The formation of these conditions is facilitated by 3 most important predictor factors: high air temperatures and long daylight hours. Due to high solar insolation, elevated air temperature, the underlying surface, the water column of hydro facilities is warmed up. However, the adverse effect of such important climate component as wind is clearly pronounced. In summer, especially in June, there are wind gusts reaching ≥ 12 m/s. In the warm period of the year, the wind contributes not only to heating the surface of the body, but also to its cooling (due to the acceleration of moisture evaporation). The similar nature of the meteorological parameters of the natural environment makes it possible to develop a wide range of recreational activities in the summer season: swimming, fishing, picking berries, mushrooms and medicinal herbs (wild plants), horseback riding, hiking, etc. A spatial analysis of the summer TCI by extrapolation of meteorological indicators revealed that the most favorable combination of bioclimatic parameters is observed in the northeastern and southwestern sectors of the region, wedges azimuthally to the north, mostly repeating the orography of the northern outcrops of Saryarka rocks, which makes up 27% of the territory. TCI minima are noted near the years. Kostanay and Kokshetau, which is funded by cold June and frequent winds (Figure 4).

The least comfortable parameters of bioclimatic conditions in the region are characterized by the winter period. Among the unfavorable meteorological parameters, a stable negative thermal regime stands out (on some days the thermometer drops to -40 °C), which contributes to the shift of the optimal range of air temperature towards its decrease. Among the uncomfortable factors are also a short daylight hours (7–8 hours) and strong winds, frequent snowstorms – wind gusts of 24–34 m/s with a temperature drop to -30 °C and less. The relatively late sunrise and the rapid onset of dusk limit the duration of a person's stay in nature in winter and his recreational activity. Strong and prolonged wind, usually at the beginning and end of winter, along with low air temperature, affects the ratio of heat accumulation in the human body, increasing its loss to the environment. Although the winter TCI of the entire territory of Northern Kazakhstan corresponds to an extremely unfavorable level, a number of areas with index maxima stand out (Figure 5). These areas are located in the north and northeast of the region, which is explained by the prevailing anticyclonic air masses, which make some types of recreation possible on clear windless days at temperatures not lower than -15 – -17 °C. These are such types of recreation as skiing and sledding, horse teams, winter fishing on stocked reservoirs.

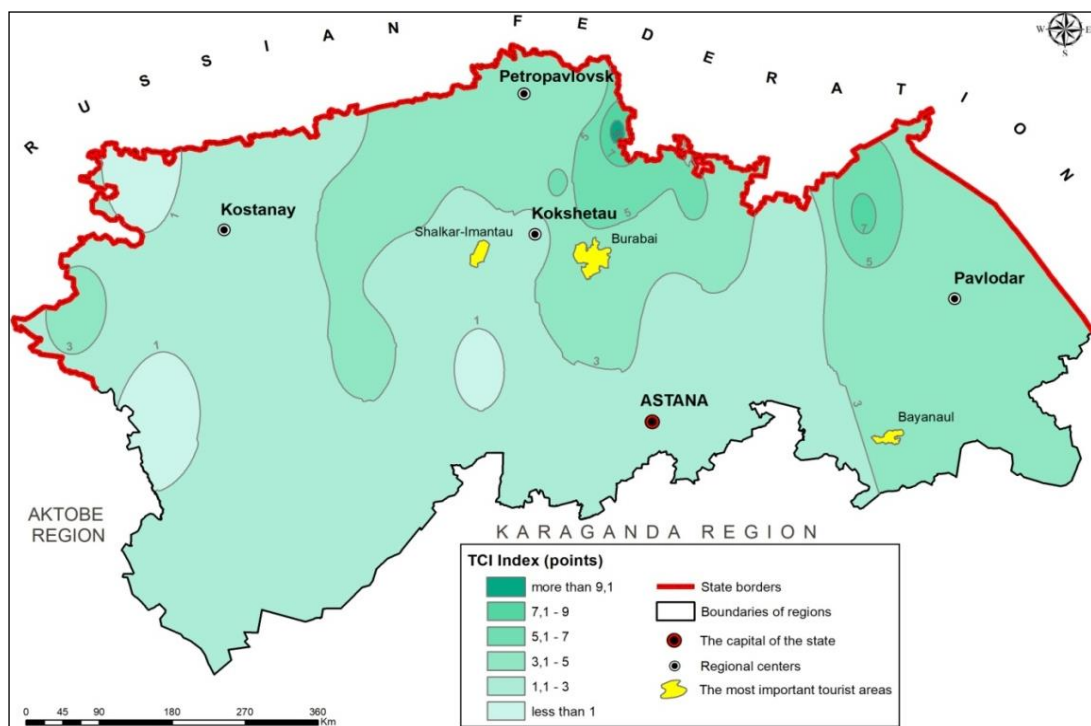


Figure 5. Zoning of the territory of Northern Kazakhstan according to winter TCI (Source: calculation is based on data: Kazhydromet, 2023)

The conjugated analysis of the zoning of the territory of Northern Kazakhstan according to TCI and the spatial distribution of the main objects of the tourism industry revealed a number of features. Thus, Burabai, which accounts for over 60% of regional tourist sites and 85% of visits (>1 million per year), is characterized by a “comfortable” climatic attractiveness in the summer, while in the autumn, winter and spring periods this territory is characterized by low indices of the index (due to low temperatures). The second most important tourist area, Bayanaul (10% and 5%, respectively), showed a similarly high correlation of TCI values and the temporal dynamics of tourist visits.

The performed studies indicate an excessive concentration of tourist facilities in limited areas, which creates prerequisites for the differentiation of tourist business objects by seasons (winter, summer), taking into account local features of meteorological conditions and the degree of their favorableness, in addition to the formed localization pattern.

CONCLUSIONS

The obtained TCI indicators made it possible to identify the potential of the climate of Northern Kazakhstan for the development of tourist and recreational activities, identify the seasons of the year with its maximum and minimum values, and analyze the spatial and temporal dynamics within the region. As a result of the study on the assessment of the bioclimatic potential of the region based on TCI, the following conclusions can be drawn:

1. Favorable bioclimatic conditions for tourism activities in the territory under consideration are observed only in the summer period, causing a limited development of beach tourism in the lakeside areas of the considered tourist areas.

2. The territory of Northern Kazakhstan is relatively homogeneous in terms of average annual TCI – the variability does not exceed 26% (from 28 to 38). However, the intra-annual distribution of TCI values varies from a "very unfavorable" level of comfort in the winter months to a "comfortable" level in the summer throughout the territory. Spatio-temporal analysis of the intra-annual movement of TCI showed that for 5-6 months a year it corresponds to "very unfavorable" and "unfavorable" levels of comfort, which makes it extremely difficult or impossible to organize any types of tourist and recreational activities on a constant basis.

3. Favorable meteorological parameters that contribute to the tourist attractiveness of the region in the summer include: high temperatures, good insolation, sufficient daylight hours. The unfavorable ones that reduce the TCI index in winter and, accordingly, the level of tourist attractiveness, include: low temperatures and physical climatic parameters - wind and snow.

The results of the research and the collected materials can be used by regional authorities (Department of Entrepreneurship and Tourism) for decentralization and effective planning of tourist and recreational activities in the territory of Northern Kazakhstan.

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