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ASSESSMENT OF THE CURRENT STATE OF THE TOURISM CLIMATE INDEX (TCI) IN THE AZERBAIJANI PART OF THE LESSER CAUCASUS REGION

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Abstract: The objective of the research is to conduct a comprehensive assessment of the tourist attractiveness of two parts of the Lesser Caucasus region of Azerbaijan, using the TCI (Tourism Climate Index) calculation methodology. This study uses meteorological data from stations on the northeastern and southern slopes of the Lesser Caucasus, obtained from the National Meteorological Database. The analysis is based on 3-hourly observations of air temperature, humidity, wind speed, cloud cover, and precipitation, covering 1966–2009 (northeastern slopes) and 1966–1990 (southern slopes), supplemented by monthly observations and reanalysis-based reconstructed data for later periods. The methodological framework relies on Mieczkowski's Tourism Climate Index (TCI). The results indicate that ideal tourism conditions are generally absent on the northeastern slopes of the Lesser Caucasus, where tourism favorability is mainly limited to summer and early autumn. Lowland stations show a longer period of high TCI values, whereas mountainous areas are favorable almost exclusively in summer. On the southern slopes, ideal conditions occur only in lowland areas during summer and are absent in middle- and high-altitude zones. Across all stations, TCI follows a clear seasonal (sinusoidal) pattern with warm-season maxima, while unfavorable conditions dominate at higher elevations. Overall, ideal and excellent tourism conditions are concentrated in summer, whereas acceptable and marginal conditions prevail during transitional seasons and winter. In the northeastern slopes of the Lesser Caucasus, ideal tourism conditions are absent. In lowland areas, excellent tourism conditions exist from June to September, very good and good conditions prevail from May to September, while acceptable tourism conditions are present from January to December. Excellent tourism conditions are characteristic of May-September, very good conditions in April and October, and good conditions in October. Acceptable conditions are observed during January-March and November-December. The methodology used in this research can be applied for analyzing intra-regional differentiation of climate attractiveness for tourism within the framework of assessing tourism-recreation potential in other regions of Azerbaijan.

Keywords: Climatic conditions, climate change, Tourism Climate Index (TCI), tourism, equivalent-effective temperature, Lesser Caucasus region, climatic suitability for tourism

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INTRODUCTION

The quantitative calculation of integral parameters dependent on the climate of a specific territory plays a crucial role in objectively determining the attractiveness of regions for tourism and recreation development (Dubois et al., 2016). Although climate indicator calculations are rarely used in local research practice concerning the influence of climatic factors on the development of the recreation and tourism industry, the conceptual framework for indexing climatic conditions in terms of living environment comfort has been developing since the mid-1980s (Rybak & Rybak, 2016).

The multicomponent climate concept, as a tourism resource, has driven the development of climate indices to characterize the climatic conditions of specific regions. These indices are designed to facilitate an objective interpretation of the integrated effects of various climatic factors. They enable the comparison of different territories in terms of climatic comfort, which is crucial for the comprehensive development of the tourism sector (De Freitas, 2003).

For an extended period, the improper utilization and inadequate validation of climatic factors in theoretical research have led to difficulties in applying the results of such studies in practical work (Rybak & Rybak, 2016). However, over the past decade, numerous researchers have begun paying greater attention to investigating the impact of climatic conditions on tourism requirements. Currently, research efforts focusing on the study and analysis of environmental factors affecting the tourism sector have intensified significantly. For instance, certain studies conducted in this direction have been reflected in literature reviews (Amiranashvili et al., 2018; Jong et al., 2023). From the perspective of tourism development, one of the most widely used methods for assessing the climatic potential or index of various regions is the Mieczkowski index. The theoretical foundations and principles of this index were presented in (Mieczkowski, 1985) under the name *Tourism Climate Index (TCI)*. The fact that it remains extensively used today demonstrates the ongoing need for a unified approach to quantitatively evaluating climatic comfort. As discussed in (Kovacs & Unger, 2001), a modified version of Mieczkowski's

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TCI was applied in research to assess the impact of projected climate changes on the tourism sector when selecting destinations in North America. Perch-Nielsen et al., 2010 analyzed Europe's current climatic resources for tourism and projected future climate changes using the TCI. The study demonstrated that Southern Europe currently offers the most favorable conditions for the tourism sector. This indicator deteriorates toward northern regions and with increasing altitude. According to prognostic estimates, more favorable conditions will shift northward, leading to improved climatic resources in Northern and Central Europe during most seasons. Southern Europe will experience a sharp decline in tourism conditions during summer, though this will be compensated by improvements from October through April.

Yan & Yin, 2015 assessed the spatiotemporal characteristics of climate's impact on seasonal tourism activity in China using data from 1981-2010, and developed corresponding recommendations for the tourism sector.

Toy & Yilmaz, 2016 evaluated the tourism and recreation potential of the northeastern Anatolia region of Turkey from the perspective of climatic factors' impact, using the case study of Erzincan city and employing data from 1975-2011.

Jong et al., 2023 conducted empirical research supporting the long-term sustainable development of Malaysia's tourism industry based on the TCI index, utilizing monthly values of climatic factors including air temperature and humidity, atmospheric precipitation, sunshine duration, cloud cover, and wind speed for the period 2010-2020.

The relationship between tourism development and climate change has also been examined in other regions, including South Africa (Pandy & Rogerson, 2021). Amiranashvili et al., 2018 utilized monthly climatic data from 1961-2010 from four hydrometeorological stations in Georgia's Kakheti region to assess the spatiotemporal distribution characteristics of the TCI index. A comparable approach was applied by Pashkov et al., 2023, who assessed the tourism and climatic potential of Northern Kazakhstan using the Tourism Climate Index and demonstrated the suitability of the TCI methodology for evaluating regional tourism resources under different climatic conditions.

Badalova et al., 2014a present the results of the first comprehensive study conducted in this field within the Republic of Azerbaijan during the past decade. The research calculated the equivalent-effective temperature (dependent on air temperature, relative humidity, and wind speed) for mountainous areas of the Greater Caucasus using 1971-2010 data, subsequently evaluating the climatic comfort level of the studied region (Badalova et al., 2014b; Ramazanov, 2015; Suleymanov et al., 2016). It should be noted that the calculation and analysis of tourism potential parameters based on meteorological dependencies using the TCI methodology have not yet been applied in climate studies across various regions of Azerbaijan. It is well known that in such studies, the collection of meteorological data, the performance of calculations, and the corresponding evaluations require a long period of time. In Azerbaijan, obtaining complete datasets is highly resource-intensive due to both objective and subjective factors. Moreover, work on this article began in 2024, and it was only possible to obtain data up to 2022. Therefore, the calculation period was limited to 2022.

On the other hand, since the analysis of the daily dynamics of the TCI index is of considerable importance, the corresponding graphs were constructed (Figures 4 and 5). As the daily and 3-hourly data for the stations located on the northeastern slopes of the Lesser Caucasus cover the period 1966–2009, while the data for the stations on the southern slopes cover the period 1966–1990, the averaged daily dynamics of the TCI were also presented for the respective periods under consideration. The reconstruction of daily data for the subsequent period using analogous methods is not feasible.

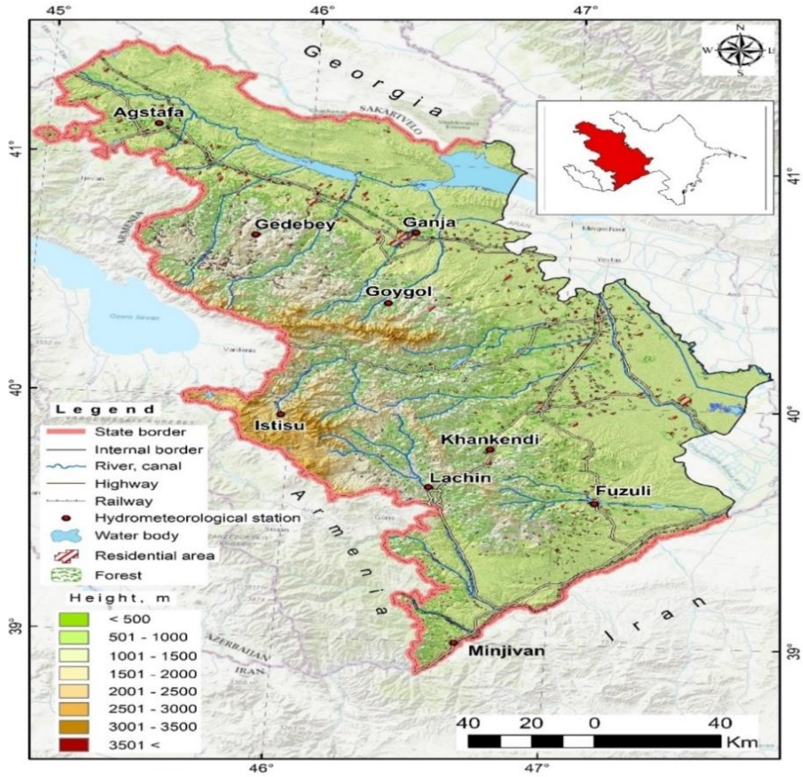

Figure 1. Geographic location of the study area and map of meteorological stations (Source: The author)

MATERIALS AND METHODS

As shown in Figure 1, the distribution of meteorological stations across Azerbaijan's Lesser Caucasus is non-uniform due to varying climatic conditions, a consequence of the complex topography of the Lesser Caucasus mountains.

For instance, the mountains occasionally act as barriers, blocking incoming subtropical/tropical warm air masses or cold continental/arctic air. The study focuses on the northeastern and southern slopes of Azerbaijan's Lesser Caucasus, utilizing data from 9 hydrometeorological stations in the region. Table 1 provides geographic details of these stations' locations.

The data used in the research were obtained from the database of the National Hydrometeorological Service (Safarov, 2002a) From the database meteorological elements such as air temperature maximum temperature relative humidity minimum relative humidity (%) wind speed (m/s) total cloud cover (points) and amount of atmospheric precipitation (mm) were selected for a 3-hour observation period per day. Based on the above-mentioned data multi-year series were compiled for each station and they were used in this research The meteorological data used in our study differ from those used in calculating TCI (Scott & McBoyle, 2001) Specifically instead of daily average data observation data collected every three hours were used Instead of daily maximum temperature values of 3-hour maximum temperature were used.

It should be noted that due to various subjective reasons it was not possible to obtain not only 3-hourly but even daily data from meteorological stations located on the northeastern slopes of the Lesser Caucasus for 2010-2022. However monthly average air temperature values and monthly cumulative atmospheric precipitation amounts were obtained for these years. The hydrometeorological stations located in the southern region of the Lesser Caucasus were in a military conflict zone during 1990-2020 and no hydrometeorological measurements were conducted (Huseynov & Shirinov, 2023). Nevertheless reconstructed data series for 1991-2015 from these stations were used (www.stat.gov.az). Data for 2016-2022 were restored through reanalysis In this process reference was also made to NASA's Merra-2 meteorological satellite database (https://power.larc.nasa.gov). Based on these data the methodology for evaluating all indicators included in the TCI will be presented during the analysis of each indicator below (Safarov, 2019).

Table 1. Geographical characteristics of hydrometeorological stations' locations in the Lesser Caucasus region (Source: National Hydrometeorological Service)

Station	Latitude	Longitude	Altitude (m)	The length of the 3-hourly data series	The length of the monthly data series	The length of the monthly reanalyzing data series
Northeastern slope of the Lesser Caucasus region						
Aghstafa	41.1	45.4	311	1966-2009	2010-2022	-
Gadabay	40.7	45.8	1480	1966-2009	2010-2022	-
Goygol	40.4	46.3	1607	1966-2009	2010-2022	-
Ganja	40.7	46.4	309	1966-2009	2010-2022	-
Southern slope of the Lesser Caucasus region						
Istisu	39.9	46.0	2294	1966-1990	1991-2015	2016-2022
Khankandi	39.8	46.8	827	1966-1990	1991-2015	2016-2022
Lachin	39.7	46.5	1168	1966-1990	1991-2015	2016-2022
Fuzuli	39.6	47.2	439	1966-1990	1991-2015	2016-2022
Minjivan	39.0	46.7	313	1966-1990	1991-2015	2016-2022

Huseynov & Shirinov, 2023 utilized both observed monthly mean air temperature and monthly precipitation amounts along with reanalysis-derived values for 1981-2015 to implement data correction for 2016-2022 at meteorological stations in the southern Lesser Caucasus region following the methodology presented in Stefanovich et al., 2020.

$$Y_i' = r \cdot \frac{\sigma_x}{\sigma_y} \cdot \left(Y_i - \overline{Y}\right) + \overline{X} \qquad (1)$$

Here, Y_i'-represents the corrected series, Y_i-denotes the reanalysis data series, $\bar{X}$ and $\bar{Y}$ are the mean values of station observations and reanalysis data respectively, r is the correlation coefficient, and σ_x and σ_y are the variances of the station observations and reanalysis series respectively. The correction using formula (1) was performed separately for each month's data. For calculating daily mean and monthly mean TCI values from 3-hourly meteorological observations, a Fortran-based computer algorithm was developed. All subsequent analytical indicators were also computed using this program. The duration of sunshine during the day is one of the input parameters for calculating the TCI index Since almost none of the studied stations had data for this parameter its values (S) were calculated based on their dependence on total cloud cover (Badescu, 2002).

$$S = S_0 \cdot (1 - N) \qquad (2)$$

Here S_0 represents maximum possible sunshine duration during the day N denotes total cloud cover. The maximum possible sunshine duration was determined depending on the geographical location of meteorological stations as will be explained below. Our research is based on Mieczkowski's Tourism Climate Index (TCI) (Mieczkowski, 1985), which consists of a weighted sum of sub-indices including the daytime comfort sub-index (CID), daily comfort sub-index (CIA), precipitation (R), sunlight duration (S), and wind speed (W), each with their respective weighting coefficients.

$$TCI = 2 \cdot (4 \cdot CID + CIA + 2 \cdot R + 2 \cdot S + W) \qquad (3)$$

The qualitative description of sub-indices and their relative influence on TCI values are presented in Table 2. Table 3 presents all sub-indices evaluated on a 0 to 5 scale according to the methodology established in (Blazejczyk et al., 2012). The optimal values for CID and CIA fall within the 20-25°C range, which is slightly lower than the 20-27°C range recommended by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) (Blazejczyk et al., 2012).

Table 2. Components of the Tourism Climate Index (TCI) (Source: Mieczkowski,1985; Rybak & Rybak, 2016)

Sub-index	Meteorological information	İnfulence on TCI	Weightage, %
SID	T_{max}- maximum daily air temperature (^{0}C) RH_{min} – minimum daily relative humidity (%)	Thermal comfort when maximum tourist activity occurs	40
SIA	T_{mean}- mean daily air temperature (^{0}C) RH_{min} – meandaily relative humidity (%)	Thermal comfort over 24 hours period including night time	10
R	Total precipitation (mm)	A negative factor on ocerall experience	20
S	Total hours of sunshine (hours)	A positive factor on ocerall experience	20
W	W – average wind speed (km/h or km/s)	Highly dependens on air temperature (evaporativ cooling effect in hot climates rated positivily, while ‘wind chill’ in cold climates rated negatively	10

Table 3. Classification scheme for TCI Source: Mieczkowski,1985; Rybak & Rybak, 2016

Score	**Descriptive Catefory**
90≤TCI≤100	Ideal
80≤TCI≤89	Execellent
70≤TCI≤79	Very good
60≤TCI≤69	Good
50≤TCI≤59	Acceptable
40≤TCI≤49	Marginal
30≤TCI≤39	Unfavorable
20≤TCI≤29	Veru unfavorable
10≤TCI≤19	Extremely unfavorable
-30≤TCI≤9	İmpossible

Table 4. TCI’s Rating Scheme (Source: Mieczkowski,1985)

Rating	Effective tempera-ture (^{0}C)	Precipi-tation (mm)	Sunshine hours/day	Wind Speed (km/hours)			
				With maximum daytime air tem-peratures ranging from 15 to 24^{0}C	With maximum daytime air temperatures ranging above 24^{0}C	In hot weather	Wind Chill Cooling (watts/(m^2·hour)
5.0	20-26	0.0-14.9	≥10	<2.88	12.24-199.97		
4.5	19-27	15.0-29.9	9	2.88-5.75			
4.0	18-28	30.0-44.9	8	5.76-9.03			<500
3.5	17-29	45.0-59.9	7	9.04-12.23			
3.0	16-30	60.0-749	6	12.24-19.79	5.76-9.03 - 24.30-28.79		500-625
2.5	10-15, 31	75.0-89.9	5	19.80-24.29	2.88-5.75		
2.0	5-9, 32	105.0-119.9	4	24.30-28.79	< 2.88 - 28.80-38.52	<2.88	635-750
1.5	0-4, 33	105.0-119.9	3	28.80-38.52		2.88-5.75	750-875
1.0	-5 - -1, 34	120.0-134.9	2			5.76-9.03	875-1000
0.5	35	135.0-149.9	1			9.04-12.23	1000-1125
0.25							1125-1250
0.0	-10 - -6, >36	>150	<1	>38.2	>38.2	>12.24	>1250
-1.0	-15 - -11						
-2.0	-20 - -16						
-3.0	<-20						

The maximum value of TCI is set at 100, while the minimum value is -30. Climate attractiveness is considered impossible under conditions of -30 ≤ TCI ≤ 9. The rating values of "climate attractiveness" based on TCI values are presented in Table 4. The calculation of CID and CIA sub-indices utilizes the equivalent-effective temperature formula proposed by F.A. Missenard and implemented in (Blazejczyk et al., 2012). For CID computation, the observed maximum air temperature during daytime hours along with corresponding relative humidity and wind speed values are used, while the CIA sub-index employs daily mean values of these meteorological parameters (Badescu, 2002; Jong et al., 2023):

$$EET = 37 - \frac{37-t}{0,68-0,0014\cdot RH+\frac{1}{1,76+1,4\cdot v^{0,75}}} - 0,29\cdot t\cdot\left(1-\frac{RH}{100}\right) \qquad (4)$$

Here, ***v*** represents wind speed (m/s). The wind speed was adjusted to a standard height of 1.5 m by multiplying it by 2/3.

As mentioned above, the 3-hourly meteorological data cover the period 1966-2009 for stations on the northeastern slopes of the Lesser Caucasus and 1966-1990 for stations in the southern region. For subsequent years, only monthly mean air temperature values were used in an attempt to calculate the CIA index. As seen from formula (4), the parameter that significantly influences this index's value is mean air temperature. Based on this, a statistical analysis of the dependence of the CIA index's monthly values on the monthly mean air temperature ($T_{month\ ave.}$) was performed. This dependence was determined to have a simple linear relationship.

That is,

$$CIA = a\cdot T_{month\ ave.} + b \qquad (5)$$

Here, a and b are coefficients.

The values of correlation coefficients for equation (5) are given in Table 5.

Table 5. Correlation coefficients of the relationships in equation (5) (Source: The author's conclusions)

Station	Months											
	01	02	03	04	05	06	07	08	09	10	11	12
Northeastern slope of the Lesser Caucasus region												
Aghstafa	0.81	0.92	0.95	0.96	0.92	0.97	0.97	0.98	0.93	0.96	0.93	0.82
Ganja	0.84	0.90	0.91	0.93	0.90	0.95	0.95	0.96	0.93	0.90	0.86	0.81
Gadabay	0.76	0.73	0.74	0.79	0.78	0.81	0.88	0.82	0.76	0.77	0.89	0.90
Goygol	0.88	0.81	0.82	0.86	0.79	0.90	0.88	0.90	0.79	0.80	0.82	0.75
Southern slope of the Lesser Caucasus region												
Istisu	0.75	0.76	0.74	0.75	0.75	0.86	0.76	0.78	0.77	0.87	0.83	0.78
Lachin	0.94	0.92	0.91	0.95	0.91	0.95	0.97	0.93	0.96	0.90	0.85	0.87
Khankendi	0.92	0.92	0.86	0.92	0.92	0.95	0.98	0.95	0.92	0.88	0.84	0.85
Fuzuli	0.90	0.87	0.85	0.91	0.89	0.93	0.95	0.90	0.91	0.91	0.79	0.79
Minjivan	0.79	0.92	0.82	0.88	0.83	0.84	0.90	0.88	0.80	0.79	0.78	0.75

As evident from Table 5, the derived relationships exhibit a very high level of reliability and have been successfully utilized in this study. One of the challenges in the research was calculating the monthly values of the CID index. As mentioned earlier, both CIA and CID are computed using formula (4), with the difference between them depending on which temperature and relative humidity indicators are used during the day. Naturally, the CID index should be higher than the CIA index, and the calculation results confirm this. Therefore, the difference between these two indices-calculated based on historical data-was determined, and then this difference was added to CIA to compute the monthly values of CID.

The precipitation sub-index (R) was derived by calculating the monthly cumulative atmospheric precipitation amounts.

The duration of daylight sub-index (S) for each day is determined by the difference between sunset and sunrise times:

$$S = 24 - T_r \quad (6) \qquad T_r = 12 - \frac{12}{\pi} arccos\left(-\frac{A^t}{B^t}\right) \quad (7)$$

$$A^t = sin\,\phi \bullet sin\,\delta^j \quad (8) \qquad B^t = cos\,\phi \bullet cos\,\delta^j \quad (9)$$

$$\delta^j = \delta_0 \cdot sin\left(360^0 \cdot \frac{284+n}{365}\right) \quad (10)$$

Here, φ represents the geographic latitude of the meteorological station, n is the day number starting from January 1, and δ_o = 23.45° is the astronomical coefficient for the Northern Hemisphere.

Table 6. Long-term monthly mean values and variances (σ) of the S sub-index at meteorological stations in the northeastern region of the Lesser Caucasus (Source: The author's conclusions)

Station	01		02		03		04		05		06	
	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ
Aghstafa	1.83	0.67	1.85	0.78	2.01	0.96	2.98	0.92	2.60	0.94	3.26	0.70
Ganja	1.93	0.70	1.85	0.82	2.07	0.97	2.44	0.90	2.77	0.87	3.34	0.53
Gadabay	2.26	0.49	2.32	0.62	2.44	0.92	2.73	1.01	2.92	1.12	3.22	0.94
Goygol	2.55	0.41	2.48	0.58	2.71	0.86	3.09	0.93	3.21	1.21	3.48	0.87

Station	07		08		09		10		11		12	
	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ
Aghstafa	3.36	0.72	3.16	0.73	3.02	0.59	2.35	0.60	1.84	0.71	1.75	0.58
Ganja	3.57	0.65	3.15	0.74	3.03	0.72	2.36	0.63	1.89	0.68	1.83	0.59
Gadabay	2.97	1.14	2.89	1.28	2.97	0.73	2.49	0.74	2.20	0.59	2.16	0.49
Goygol	3.44	0.91	3.15	0.84	3.23	0.62	2.70	0.66	2.33	0.53	2.41	0.45

Table 7. Long-term monthly mean values and variances (σ) of the S sub-index at meteorological stations in the southern region of the Lesser Caucasus (Source: The author's conclusions)

Station	01		02		03		04		05		06	
	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ
Istisu	2.13	0.52	2.19	0.54	2.00	0.50	1.69	0.56	1.77	0.75	2.15	0.66
Lachin	1.97	0.85	1.84	0.99	1.68	1.14	1.92	1.30	2.13	1.35	3.03	1.25
Khankendi	1.95	0.78	1.95	0.78	1.80	1.01	2.13	1.17	2.32	1.17	3.10	0.90
Fuzuli	1.88	0.65	1.62	0.70	1.60	0.69	2.21	0.57	2.77	0.77	4.06	0.61
Minjivan	2.23	0.61	2.10	0.75	1.83	0.66	2.48	0.67	3.04	0.82	4.12	0.85

Station	07		08		09		10		11		12	
	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ	S_{ave}	σ
Istisu	2.12	0.95	2.23	0.86	2.69	0.75	2.23	0.55	2.23	0.58	2.08	0.42
Lachin	3.40	1.29	3.18	1.27	2.77	1.05	2.13	1.01	1.81	0.95	1.89	0.69
Khankendi	3.48	1.16	3.17	1.13	2.75	1.11	2.08	0.97	1.87	0.83	2.00	0.70
Fuzuli	4.33	0.72	3.90	0.88	3.12	0.81	2.06	0.63	1.65	0.62	1.79	0.50
Minjivan	4.17	0.86	3.88	1.05	3.17	1.00	2.33	0.65	2.00	0.62	2.19	0.55

For calculating the monthly values of the S sub-index during 1991-2022 and 2010-2022, the same approach as the CID sub-index computation was applied. Assuming that the variances (σ) of the monthly mean values (S_{ave}) calculated during the actual observation period fall within acceptable limits (Tables 6, 7), their long-term monthly averages were utilized. The wind sub-index (W) was evaluated based on the criteria provided in Table 4.

Here, wind speed units were converted from m/s to km/h. For determining the W sub-index values during 1991–2022 and 2010-2022, the same methodology as applied to the monthly calculations of CID and S sub-indices was followed. Assuming the variances (σ) of the monthly mean W values during the actual observation period fell within acceptable limits (Tables 8, 9), their long-term monthly averages were utilized.

Table 8. Long-term monthly mean values and variances (σ) of the W sub-index at meteorological stations in the northeastern region of the Lesser Caucasus (Source: The author's conclusions)

Station	Months											
	01		**02**		**03**		**04**		**05**		**06**	
	W_{ave}	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**
Aghstafa	4.36	0.22	4.24	0.27	4.03	0.17	4.05	0.23	4.20	0.25	4.11	0.24
Ganja	4.42	0.18	4.36	0.22	4.28	0.29	4.27	0.27	4.31	0.26	4.25	0.29
Gadabay	4.15	0.33	4.18	0.37	4.22	0.42	4.23	0.31	4.28	0.34	4.31	0.31
Goygol	4.47	0.12	4.47	0.12	4.42	0.18	4.39	0.24	4.47	0.12	4.48	0.09
Station	Months											
	07		**08**		**09**		**10**		**11**		**12**	
	W_{ave}	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**
Aghstafa	4.12	0.26	4.13	0.26	4.22	0.25	4.35	0.23	4.36	0.22	4.42	0.18
Ganja	4.28	0.29	4.28	0.27	4.35	0.23	4.31	0.17	4.42	0.18	4.41	0.22
Gadabay	4.34	0.26	4.34	0.26	4.33	0.26	4.34	0.23	4.31	0.31	4.20	0.33
Goygol	4.50	0.00	4.48	0.09	4.47	0.12	4.45	0.14	4.70	0.12	4.45	0.14

Table 9. Long-term monthly mean values and variances (σ) of the W sub-index at meteorological stations in the southern region of the Lesser Caucasus (Source: The author's conclusions)

Station	Months											
	01		02		03		04		05		06	
	W_{ave}	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**
Istisu	3.77	0.48	3.83	0.46	3.92	0.36	3.96	0.44	4.17	0.28	4.29	0.25
Lachin	4.35	0.26	4.40	0.20	4.34	0.23	4.27	0.25	4.31	0.24	4.24	0.25
Khankandi	4.10	0.30	4.47	0.12	4.50	0.00	4.47	0.12	4.40	0.20	4.37	0.22
Fuzuli	4.48	0.10	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.44	0.16
Minjivan	4.08	0.49	4.19	0.42	4.33	0.31	4.37	0.30	4.44	0.21	4.44	0.21
Station	Months											
	07		08		09		10		11		12	
	W_{ave}	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**	**W_{ave}**	**σ**
Istisu	4.42	0.18	4.37	0.22	4.29	0.28	4.12	0.32	3.90	0.37	4.13	0.44
Lachin	4.31	0.24	4.29	0.25	4.44	0.17	4.47	0.12	4.47	0.12	4.45	0.15
Khankandi	4.28	0.25	4.33	0.24	4.43	0.17	4.43	0.17	4.48	0.09	4.4	0.12
Fuzuli	4.48	0.10	4.46	0.13	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00
Minjivan	4.44	0.21	4.40	0.24	4.45	0.20	4.44	0.21	4.44	0.21	4.19	0.49

DISCUSSION

The research results are presented below. The annual progression of monthly TCI values in the Azerbaijani part of the Lesser Caucasus region is shown in Figures 2 and 3. As seen in Figure 2, ideal tourism conditions do not exist on the northeastern slopes of the Lesser Caucasus. In Aghstafa, excellent tourism conditions prevail from June to September, very good and good conditions from May to September, and acceptable conditions are observed year-round (January-December). In this area, monthly TCI scores range between 62-96 (maximum) and 32-73 (minimum).

In Ganja, excellent tourism conditions occur from May to September, very good conditions from April to September, good conditions from April to October, and acceptable conditions persist year-round (January-December). Here, TCI values fluctuate between 63-98 (maximum) and 33-79 (minimum) across months.

In Gadabay, located at ~1100 m above sea level (approximately the same elevation as Ganja and Aghstafa), neither ideal nor excellent tourism conditions exist. Very good conditions occur from July to September, good conditions from June to September, and acceptable conditions are available from March to December. In this area, monthly TCI scores range between 60-89 (maximum) and 28-54 (minimum). At Goygol, situated at 1295 m elevation, ideal and excellent tourism conditions are also absent. Very good conditions prevail in July-August, good conditions in June-September, and acceptable conditions persist from February to December. Here, TCI values range from 59-93 (maximum) to 33-60 (minimum) across months. As seen in Figure 3, ideal tourism conditions exist in the lowland areas of the southern Lesser Caucasus region. However, this is only observed at the Minjivan and Fuzuli stations during June-August. At Minjivan, excellent tourism conditions occur from May to September, very good conditions in April and October, and good conditions are characteristic of October. Acceptable conditions are present from January-March and November-December. In this area, monthly TCI values range between 64-99 (maximum) and 39-84 (minimum).

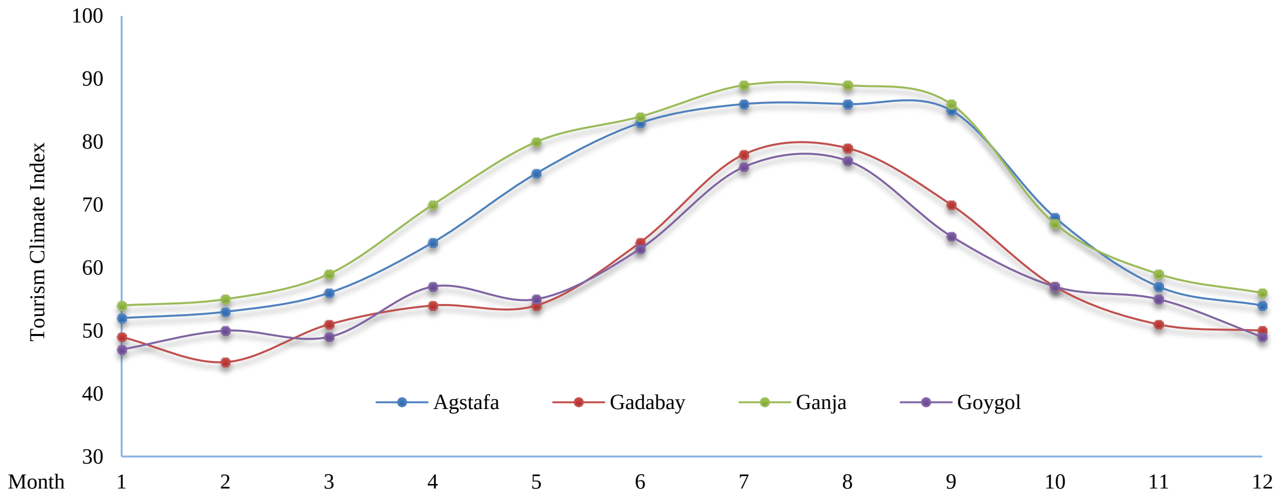

Figure 2. Intra-annual variation of calculated TCI values at four locations in the northeastern region of the Lesser Caucasus (Source: The author's conclusions)

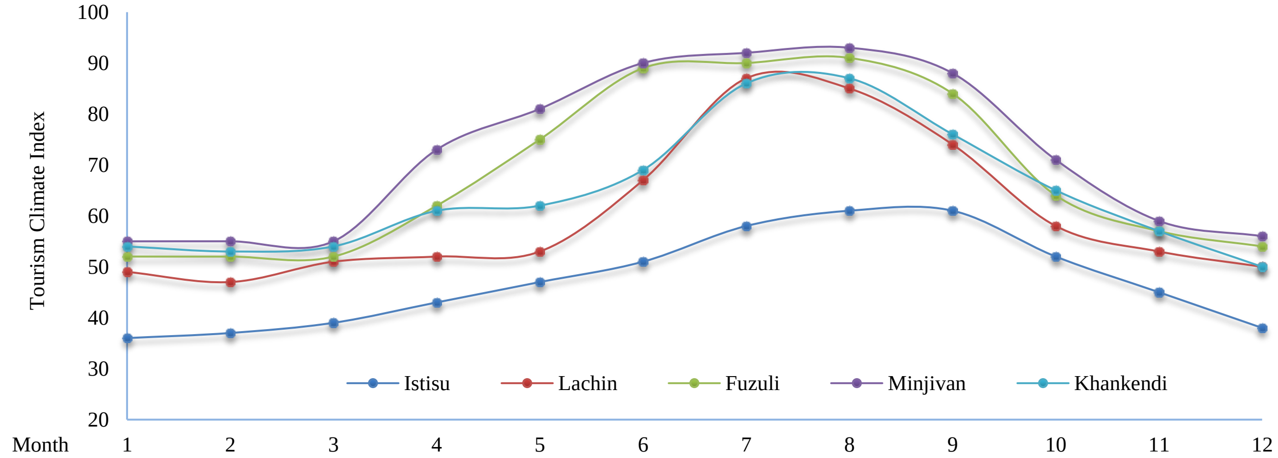

Figure 3. Intra-annual variation of calculated TCI values at five locations in the southern region of the Lesser Caucasus (Source: The author's conclusions)

At Fuzuli, excellent tourism conditions occur in September, very good conditions in May, good conditions in April and October, and acceptable conditions are characteristic of January-March and November-December. This station shows TCI values ranging from 61-99 (maximum) to 25-82 (minimum) across months.

In Khankendi (located at ~500 m elevation, similar to Minjivan and Fuzuli), ideal tourism conditions are absent. Excellent conditions occur only in September, very good conditions in September, good conditions from April-June and October, while acceptable conditions are characteristic for January-March and November-December. In this area, monthly TCI values range between 61-99 (maximum) and 37-70 (minimum).

In Lachin (situated at 855 m elevation), ideal tourism conditions are unavailable. Excellent conditions are limited to July-August, very good conditions to September, good conditions to June, and acceptable conditions are observed from March-May and October-November. Here, TCI scores fluctuate between 57-98 (maximum) and 30-69 (minimum) across months.

At Istisu, situated 2,257 meters above sea level, there are no ideal, excellent, or very good tourism conditions; good tourism conditions are only characteristic of August and September, while acceptable conditions are typical for June-July and October. In this area, TCI values range from 50-76 points (maximum) to 20-50 points (minimum) across different months.

As evident, the calculated TCI indices for all stations exhibit a sinusoidal distribution (Figures 2, 3) peaking during the warm season. This is entirely natural since the primary contributor to TCI is the daytime equivalent-effective temperature.

To more accurately assess the tourism suitability of TCI across different seasons, its diurnal variations throughout the year were graphed. The long-term mean daily TCI values utilized data from 1966-2009 for stations on the northeastern slopes of the Lesser Caucasus and 1966-1990 for stations in the southern region. The results are presented in Figures 4 and 5.

Analysis of monthly TCI dynamics and Figure 4 reveals no ideal tourism conditions on the northeastern slopes of the Lesser Caucasus. Excellent conditions begin on June 9 in Aghstafa and May 28 in Ganja, ending at both stations on September 23. This period lasts 106 and 118 days, respectively. Such conditions are atypical for Gadabay and Goygol. Very good tourism conditions are characteristic of all stations in the northeastern slopes.

The onset of this period occurs on May 6 in Aghstafa, April 19 in Ganja, June 30 in Gadabay, and July 3 in Goygol, with termination dates on October 9, October 7, September 10, and August 31, respectively. The longest tourism season occurs in Ganja, while the shortest is observed in Goygol. Good tourism conditions begin on April 8 in Aghstafa, March 25 in Ganja, June 11 in Gadabay, and June 13 in Göygöl, ending on October 26, October 3, and September 24, respectively.

Acceptable tourism conditions are not characteristic for Aghstafa and Ganja; in Gadabay, they begin on March 18 and end on November 9, while in Goygol they start on March 29 and conclude on December 4.

Analysis of the monthly TCI dynamics and Figure 5 reveals that ideal tourism conditions in the southern Lesser Caucasus region are only characteristic of the Minjivan station, beginning on June 23 and ending on September 4. Such conditions are not observed at the other four stations. Excellent conditions begin on May 19 in Minjivan, May 29 in Fuzuli, July 7 in Khankendi, and July 5 in Lachin, ending on September 28, September 23, September 1, and September 5, respectively. These conditions are not typical for Istisu, located in high mountainous terrain.

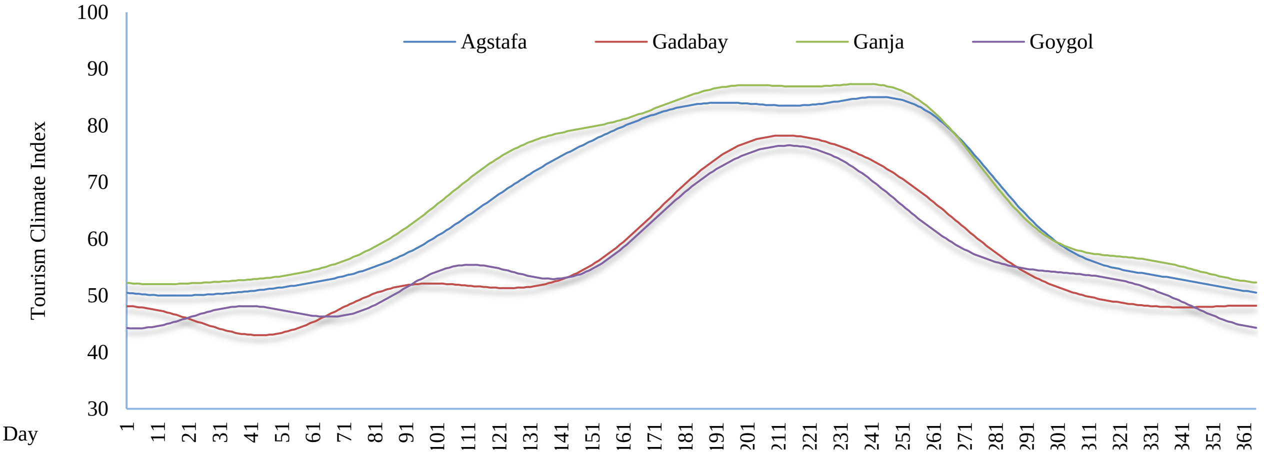

Figure 4. Diurnal variations of TCI (points) throughout the year for 1966-2009
in the northeastern region of the Lesser Caucasus (Source: The author's conclusions)

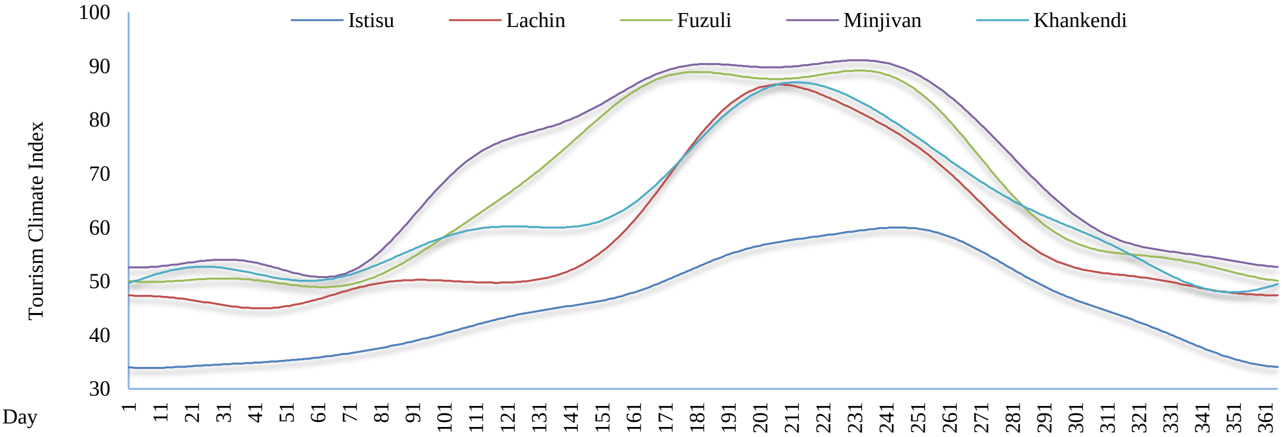

Figure 5. Diurnal variations of TCI (points) throughout the year for 1966-1990
in the southern region of the Lesser Caucasus (Source: The author's conclusions)

The period of very good tourism conditions begins on April 13 in Minjivan, May 9 in Fuzuli, June 20 in Khankendi, and June 21 in Lachin, ending on October 14, October 2, October 5, and August 20, respectively. Again, these conditions are not typical for Istisu. Good tourism conditions start on March 29 in Minjivan, April 22 in Fuzuli, April 19 in Khankendi, June 8 in Lachin, and August 21 in Istisu, concluding on November 4, October 20, October 29, October 8, and September 11, respectively. Acceptable tourism conditions persist year-round in Minjivan and Fuzuli. However, for other stations, this indicator begins on January 1 in Khankendi, March 20 in Lachin, and June 18 in Istisu, ending on December 3 in Khankendi, October 31 in Lachin, and October 16 in Istisu. In both examined regions of the Lesser Caucasus, unfavorable tourism conditions are characteristic only of mid- and high-altitude mountainous areas (Gadabay, Goygol, and Istisu), while other stations do not exhibit such conditions. Additionally, the altitudinal variation patterns of TCI across the Lesser Caucasus region were evaluated. For this purpose, linear regression equations were derived between the mean monthly TCI values (calculated for all 9 stations) and their respective elevations above sea level for each month. The coefficients of these relationships, along with the correlation coefficients between TCI values and elevation, are presented in Table 10. As seen in Table 10, the correlation coefficients for all monthly relationships were very high, ranging between 0.90-0.98. These values indicate a statistically significant strong relationship, confirming their utility for calculating TCI values across different elevations. Table 11 presents the distribution of TCI values across different elevations and months. As shown in Table 11, at 0 m elevation (sea level), TCI values exceed 57 points for all months, indicating characteristic acceptable tourism conditions. At this elevation: acceptable tourism conditions prevail during December-March, good tourism conditions occur in March, October and November, very good conditions in April, excellent conditions in May and September, while ideal conditions are characteristic of summer months.

At 500 m elevation, acceptable tourism conditions are characteristic for January-March and November-December, good tourism conditions occur in April and October, while very good conditions are observed in May. Excellent tourism conditions are characteristic for June-September, while no ideal tourism conditions exist at this elevation.

At 1000 m elevation, acceptable tourism conditions are characteristic for January-April, November, and December. Good tourism conditions occur in May and October, very good conditions in June and September, and excellent conditions in July and August. No ideal tourism conditions exist at this elevation.

At 1500 m elevation, acceptable tourism conditions occur in April-May and October, while very good conditions are observed from July to September. No ideal or excellent tourism conditions exist at this altitude.

At 2000 m elevation, acceptable tourism conditions occur in June and October, while good conditions prevail from July to September. No ideal, excellent, or very good tourism conditions exist at this altitude. At 2500 m and 3000 m elevations, acceptable tourism conditions occur only in July and August. No ideal, excellent, very good, or good tourism conditions exist at these altitudes. At 3500 m elevation, only August provides acceptable tourism conditions.

Table 10. Values of coefficients (a and b) and correlation coefficients (r) for the linear statistical equation between TCI values and elevation (Source: The author’s conclusions)

Month	Linear statistical equation (TCI = a·h + b) and correlation coefficients (r)			Month	Linear statistical equation (TCI = a·h + b) and correlation coefficients (r)		
	a	b	r		a	b	r
January	-0.0074	57	0.91	July	-0.0138	96	0.92
February	-0.0075	57	0.91	August	-0.0129	96	0.94
March	-0.0073	59	0.91	September	-0.0136	90	0.98
April	-0.0118	71	0.90	October	-0.0084	70	0.95
May	-0.0171	81	0.93	November	-0.0058	60	0.91
June	-0.0183	91	0.95	December	-0.0072	58	0.92

Table 11. Distribution of TCI values across different elevations and months (Source: The author’s conclusions)

Elevation, m	Month											
	01	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**
0	57	57	59	71	81	91	96	96	90	70	60	58
500	53	53	55	65	73	82	89	89	83	66	57	54
1000	50	50	52	59	64	73	82	83	76	62	55	51
1500	46	46	48	53	56	63	75	76	70	58	52	47
2000	42	42	44	47	47	54	68	70	63	54	49	43
2500	38	38	41	41	38	45	61	63	56	49	46	40
3000	35	35	37	36	30	36	54	57	49	45	43	36
3500	31	31	33	30	21	27	47	50	42	41	40	33

Table 12. Distribution of TCI by descriptive category *(1 - Ideal; 2 - Excellent; 3 - Very good; 4 - Good; 5 - Acceptable; 6 - Marginal; 7 - Unfavorable; 8 - Very unfavorable; 9 - Extremely unfavorable; 10 - Impossible)* (Source: The author’s conclusions)

Month	TCI category																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Ahgstafa										Ganja									
01	0	0	0	7	65	26	2	0	0	0	0	0	0	12	72	12	4	0	0	0
02	0	0	0	12	58	28	2	0	0	0	0	0	0	32	37	21	2	0	0	0
03	0	0	0	30	42	21	0	0	0	0	0	0	4	49	39	9	0	0	0	0
04	4	7	12	40	33	4	0	0	0	0	0	30	12	44	12	2	0	0	0	0
05	0	44	28	18	11	0	0	0	0	0	2	54	26	14	2	0	0	0	0	0
06	12	63	21	2	0	0	0	0	0	0	16	70	11	2	0	0	0	0	0	0
07	28	61	7	2	0	0	0	0	0	0	54	42	4	0	0	0	0	0	0	0
08	25	61	14	0	0	0	0	0	0	0	37	51	4	0	0	0	0	0	0	0
09	25	61	14	0	0	0	0	0	0	0	25	61	11	0	0	0	0	0	0	0
10	0	11	25	51	11	2	0	0	0	0	0	9	23	58	9	2	0	0	0	0
11	0	0	0	37	44	7	2	0	0	0	0	0	0	51	37	5	0	0	0	0
12	0	0	0	14	68	16	0	0	0	0	0	0	0	33	54	11	0	0	0	0

In the next phase of the research, the frequency of spatiotemporal distribution of TCI suitability categories was evaluated. For this purpose, the number of days observed for each category was determined per station and per month, then calculated as percentages relative to the total days in each month (Tables 12, 13, 14).

As seen in Table 12, the recurrence frequency of ideal conditions in Aghstafa was 4% in April, 12% in June, and 25-28% from July to September. In Ganja, it reached 2% in May, 16% in June, 54% in July, 37% in August, and 25% in September.

The recurrence frequency of excellent tourism climate conditions in Aghstafa and Ganja peaks in June (63-70%) and reaches its minimum in April (7%) for Aghstafa and October (9%) for Ganja, observed from April to October. Analogous recurrence results for the southern region of the Lesser Caucasus are presented in Tables 13 and 14. Istisu, located in a high mountainous area, exhibits its highest recurrence of good tourism conditions (51-53%) during August-September, with minimal values in May (4%) during spring and October-November (2%) in autumn. Acceptable conditions are most frequent from June-October, while marginal conditions peak during March-May and November-December. Unfavorable conditions dominate winter months (53-83%). Other unsuitable tourism conditions are not characteristic of this area.

Table 13. Distribution of TCI by descriptive category *(1 - Ideal; 2 - Excellent; 3 - Very good; 4 - Good; 5 - Acceptable; 6 - Marginal; 7 - Unfavorable; 8 - Very unfavorable; 9 - Extremely unfavorable; 10 - Impossible)* (Source: The author's conclusions)

Month	TCI category																			
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
	Minjivan										Fuzuli									
01	0	0	0	12	83	4	2	0	0	0	0	0	0	4	81	11	2	2	0	0
02	0	0	0	9	72	11	0	0	0	0	0	0	0	5	58	21	2	0	0	0
03	0	0	0	14	77	7	2	0	0	0	0	0	0	5	72	16	4	0	0	0
04	2	23	40	23	9	0	0	0	0	0	0	2	5	58	30	5	0	0	0	0
05	9	51	33	7	0	0	0	0	0	0	2	35	37	18	4	2	0	0	0	0
06	56	25	2	0	0	0	0	0	0	0	51	25	7	0	0	0	0	0	0	0
07	74	26	0	0	0	0	0	0	0	0	83	11	0	0	0	0	0	0	0	0
08	90	11	0	0	0	0	0	0	0	0	67	28	4	0	0	0	0	0	0	0
09	30	28	11	0	0	0	0	0	0	0	16	67	7	2	2	0	0	0	0	0
10	2	12	40	39	4	2	0	0	0	0	0	4	19	47	23	0	2	0	0	0
11	0	0	5	33	46	2	0	0	0	0	0	0	0	12	79	7	2	0	0	0
12	0	0	0	19	65	2	0	0	0	0	0	0	0	14	77	9	0	0	0	0

Table 14. Distribution of TCI by descriptive category*(1 - Ideal; 2 - Excellent; 3 - Very good; 4 - Good; 5 - Acceptable; 6 - Marginal; 7 - Unfavorable; 8 - Very unfavorable; 9 - Extremely unfavorable; 10 - Impossible)* (Source: The author's conclusions)

Month	TCI category																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Khankendi										Lachin									
01	0	0	0	9	68	11	4	0	0	0	0	0	0	2	35	44	5	0	0	0
02	0	0	0	11	51	19	5	0	0	0	0	0	0	2	26	56	7	0	0	0
03	0	0	0	11	61	19	5	0	0	0	0	0	0	0	26	65	4	0	0	0
04	0	12	11	25	32	16	0	0	0	0	0	0	0	7	53	39	0	0	0	0
05	0	7	21	33	21	14	0	0	0	0	0	0	2	12	47	32	5	0	0	0
06	0	14	30	33	12	0	0	0	0	0	0	18	23	26	19	12	0	0	0	0
07	35	53	11	0	0	0	0	0	0	0	35	53	11	2	0	0	0	0	0	0
08	18	40	37	5	0	0	0	0	0	0	19	53	12	4	0	0	0	0	0	0
09	2	26	39	23	4	0	0	0	0	0	5	26	44	16	9	0	0	0	0	0
10	0	0	5	61	26	2	0	0	0	0	0	0	2	37	53	7	2	0	0	0
11	0	0	0	19	56	7	0	0	0	0	0	0	0	5	77	18	0	0	0	0
12	0	0	0	25	61	7	0	0	0	0	0	0	0	0	49	28	0	0	0	0

CONCLUSION

The research conducted in the Azerbaijani part of the Lesser Caucasus region, utilizing observational and reanalysis data from hydrometeorological stations along with a modified version of Mieczkowski's TCI methodology, yielded the following results:

1. In the northeastern slopes of the Lesser Caucasus, ideal tourism conditions do not exist. In lowland areas, excellent tourism conditions prevail from June to September, very good and good conditions from May to September, and acceptable conditions are available year-round (January-December). In mountainous areas, neither ideal nor excellent conditions exist; very good conditions occur from July to September, good conditions from June to September, and acceptable conditions persist from March to December.

2. In the southern lowlands of this region, ideal tourism conditions exist from June to August. Excellent tourism conditions are characteristic of May-September, very good conditions for April and October, and good conditions for October. Acceptable conditions prevail from January-March and November-December. In the mid-mountainous areas of this territory, no ideal tourism conditions exist. Excellent conditions occur only in September, very good conditions in September, good conditions from April-June and October, while acceptable conditions are characteristic of January-March and November-December. In high mountainous areas, neither ideal, excellent, nor very good tourism conditions are available. Good conditions are limited to August and September, while acceptable conditions are typical for June-July and October.

3. The altitudinal variation patterns of TCI were evaluated. For all months, the correlation coefficients of the relationships were very high, ranging between 0.90-0.98. Subsequently, tourism suitability conditions were assessed across different elevations. This study represents the first comprehensive research conducted for this specific region of Azerbaijan, and its findings hold significant importance for tourism planning by relevant organizations and companies. The methodology employed in this research can be applied to analyze intra-regional differentiation of climate attractiveness for tourism within the framework of assessing tourism-recreation potential in other regions of Azerbaijan.

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