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Holiday Climate Index in Kvemo Kartli (Georgia)

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Abstract

Weather and climate are two main factors that determine the bioclimatic resources of a territory and, accordingly, the degree of its suitability for the organization and development of the resort and tourism industry. Early studies used a variety of climate indices for tourism. In recent years, the so-called Holiday Climate Index (HCI), which is a combination of five climate elements (air temperature maximum, relative humidity, cloud cover, precipitation and wind), has been gaining popularity. Determination of HCI values for various locations in Georgia began in 2020 (Tbilisi, Kakheti region, 13 high-mountain points, etc.). In this work, an analysis of data on the long-term average values of the Holiday Climate Index (HCI) for 8 settlements in the Kvemo Kartli region of Georgia (Bolnisi, Gardabani, Dmanisi, Tetri Tskaro, Marneuli, Tsalka, Manglisi, Rustavi) is presented. The intra-annual distribution of HCI values was studied; correlations between individual stations were determined based on average monthly and seasonal HCI values; it was found that the regression equations for the intra-annual variation of average monthly HCI values for all points of Kvemo Kartli have the form of a ninth-order polynomial; categories of average monthly and seasonal HCI values in the specified settlements of Kvemo Kartli were determined; a comparison was made of the statistical characteristics of average monthly HCI values in 8 points of Kvemo Kartli with the indicated characteristics in Bolnisi, Gardabani, Marneuli, Rustavi (height of stations above sea level H < 1 km) and in Dmanisi, Tetri Tskaro, Tsalka, Manglisi (H > 1 km), and a corresponding analysis of the repeatability of HCI categories was conducted. It is shown that the bioclimatic conditions in Kvemo Kartli are favourable for the development of the resort and tourism industry for all months of the year. A visual map of the distribution of mean monthly HCI categories on the territory of Kvemo Kartli has been constructed.

Keywords: climate, bioclimate, resort and tourism industry, cartography

Introduction

The organization and development of the resort and tourism industry in the region directly depend on its geographical location, topography, vegetation, presence of natural disasters, weather and climate, etc. Weather and climate are two main factors that determine the bioclimatic resources of an area. Thus, the study of these resources, which are necessary for the organization and development of the resort and tourism industry, plays a major role and requires significant effort.

The study of the resort and recreational resources of Georgia was founded in the 20 s of the last century, when the “Research Institute of Balneology and Physiotherapy” was created. As a result of many years of field, stationary and practical studies of the institute, a trilingual atlas about the resorts and resort resources of Georgia was created and published (Vadachkoria et al., 1987). This atlas was awarded the State Prize of Georgia. It should be noted that this work (Vadachkoria et al., 1987) provided an impetus for the further development of multilateral research into the resort and tourism potential of Georgia.

Past studies have used many climate indices for tourism (Matzarakis, 2006; Matzarakis et al., 2021a, b; Amiranshvili et al., 2011, 2015a, 2018, 2022, 2019; Bolashvili et al., 2016; Amiranashvili & Kartvelishvili, 2008; Lanchava et al., 2021; Rutty et al., 2021; Kartvelishvili et al., 2023). The most

widely known index used both in the past and in the present is the Tourist Climate Index (TCI), proposed by Mieczkowski (1985).

In southern Caucasus countries, the monthly TCI was first calculated in Georgia for Tbilisi (Airanashvili et al., 2008) and then for many other locations in the Caucasus (Armenia, Azerbaijan, North Caucasus, etc.) (Amiranashvili et al., 2014, 2015b, 2017, 2018a, 2018b; Rybak & Rybak, 2016; Kartvelishvili et al., 2019).

The study by Mushawemhuka et al. (2020) presents the first TCI calculations for Zimbabwe. Tanana et al. (2021) evaluated the climate comfort of Argentina as an intangible resource for tourism.

Despite the wide application of the TCI, it has been subject to substantial critiques (Scott et al., 2016). The four key deficiencies of the TCI include the following: (1) the subjective rating and weighting system of climatic variables; (2) it neglects the possibility of the overriding influence of physical climatic parameters (e.g., rain, wind); (3) the low temporal resolution of climatic data (i.e., monthly data) has limited relevance for tourist decision-making; and (4) it neglects the varying climatic requirements of major tourism segments and destination types (i.e., beach, urban, winter sports tourism).

To overcome the above limitations of the TCI, the Holiday Climate Index (HCI) was developed to more precisely assess the climatic suitability of tourism destinations. The word "holiday" was chosen to better reflect what the index was designed for (i.e., leisure tourism), as tourism is much broader by definition ("Tourism is a social, cultural and economic phenomenon which entails the movement of people to countries or places outside their usual environment for personal or business/professional purposes") (Javan, 2017; Rutty et al., 220; Hejazizadeh et al., 2019). In the same works, comparisons between the HCI and TCI were made.

A comparison of the Holiday Climate Index and Tourism Climate Index at several locations in Georgia and the North Caucasus (Amiranashvili et al., 2020; Amiranashvili & Kartvelishvili, 2021; Amiranashvili et al., 2021) is presented. The article by Amiranashvili et al. (2018b) compares the values and categories of the TCI and HCI in Tbilisi. The long-term average HCIs for 12 Kakheti locations (Akhmeta, Dedoplistskaro, Gombori, Gurjaani, Kvareli, Lagodekhi, Omalo, Sagarejo, Shiraki, Telavi, Tsnori and Udabno) are presented in Amiranashvili & Kartvelishvili (2021). For 6 stations in this region (Dedoplistskaro, Gurjaani, Kvareli, Lagodekhi, Sagarejo and Telavi), detailed analyses of the monthly, seasonal and annual HCIs over the 60-year period (1956-2015) were carried out. Comparisons of monthly HCIs and tourism climate indices (TCIs) for four points in the Kakheti region (Dedoplistskaro, Kvareli, Sagarejo and Telavi) based on data from 1961 to 2010 were carried out. The results of the comparative analysis of the Tourism Climate Index and the Holiday Climate Index, as well as the ratings of the components of these indices for six points in the North Caucasus (Kislovodsk, Pyatigorsk, Essentuki, Zheleznovodsk, Teberda and Nalchik), are presented in (Amiranashvili et al. 2021).

It was found that there is a high degree of correlation between the HCI and TCI. However, considering that the TCI is calculated for the so-called "average tourist" (regardless of gender, age, physical condition), the value and category of this index are lower than the HCI values and categories. In general, based on our estimation, the HCI more adequately determines the bioclimatic state of the environment for the development of various types of tourism than does the TCI (Amiranashvili et al. 2020, 2021; Amiranashvili & Kartvelishvili, 2021).

Using the Holiday Climate Index (HCI: Urban), this research (Williams, 2021) examines long-term tourism climate records in Tokyo between 1964 and 2019. The findings suggest greater climatic variability and a decrease in the favourability of Tokyo's tourism climatic resources in all three summer months. According to these findings, adaptation and mitigation strategies are recommended, and a Japanocentric tourism climate index is proposed.

Carrillo et al. (2021) noted that the TCI and HCI are good indicators of the environmental conditions for leisure activities in the Canary Islands. Using the Regional Climate Model, it is shown that by 2030-2059 and 2070-2099, tourism performance is expected to improve significantly in the winter and off-season but deteriorate in the summer months, including October, in the southeast, which is where hotels are currently located.

The aim of this study (Araci et al., 2021) is to assess the future HCI performances of urban and beach destinations in the greater Mediterranean region. For this purpose, HCI scores for the reference (1971-2000) and future (2021-2050, 2070-2099) periods were computed. HCI: The urban results showed that the Canary Islands have suitable conditions for tourism during almost all four seasons and all periods, which will have certain implications when other core Mediterranean competitors lose their relative climatic attractiveness. The HCI:Beach results for the summer season showed that Las Canteras,

Alicate, Pampelonne, Myrtos, Golden Sands and Edremit all pose very good to excellent conditions without any Humidex risks for the extreme future scenario (2070-2099).

Detailed information on the variability of the monthly values of the Holiday Climate Index in Tbilisi in 1956-2015 is presented in Amiranashvili et al. (2020). It also presents data on the interval forecasts of HCI variability in Tbilisi for the next few decades.

Amiranashvili et al. (2021) performed a detailed analysis of monthly, seasonal and annual HCI values during a 60-year period (1956-2015) for 13 mountainous locations in Georgia (Bakhmaro, Bakuriani, Borjomi, Goderdzi, Gudauri, Khaishi, Khulo, Lentekhi, Mestia, Pasanauri, Shovi, Stepantsminda, and Tianeti) and compared HCIs and TCIs of monthly values for three points in Georgia (Goderdzi, Khulo and Mestia) based on data from 1961 to 2010. The variability data of the HCI in 1986-2015 compared to those in 1956-1985 and the trends of the HCI in 1956-2015 are also presented. Using Mestia as an example, the expected changes in the monthly, seasonal and annual HCIs of 2041-2070 and 2071-2100 were assessed. Some results of this work were used in (Kartvelishvili et al., 2023; Fourth National Communication of Georgia, 2021).

It should be noted that the scale of various bioclimatic indices (including TCI and HCI) is quite consistent with data on public health in various regions of Georgia (Amiranashvili et al., 2012, 2018, 2021), as well as on the spread of the COVID-19 virus in Tbilisi (Amiranashvili et al 2022).

This work is a continuation of previous studies. This study develops a long-term average HCI for 8 stations in the Kvemo Kartli region of Georgia (Bolnisi, Gardabani, Dmanisi, Tetri Tskaro, Marneuli, Tsalka, Manglisi, Rustavi), which is known for its historical attractions and resort and tourism resources.

Figure 1. Locations of the 8 meteorological stations in Kvemo Kartli

Methods and Materials

Study Area

Kvemo Kartli region of Georgia (below - Kvemo Kartli). Kvemo Kartli is in the southeastern part of Georgia. The area is 6 436.2 km^2, the population is 442.8 thousand. pers., (including of urban - 197.5 thous. pers.), the capital of the region, Rustavi (population - 132.3 thous. pers.).

The natural-geographic conditions of Kvemo Kartli, as well as natural, cultural and historical monuments, create an opportunity for the development of tourism in the region. The prospective directions of tourism are horse-riding, hunting tourism, eco-tourism, cognitive tourism, family tourism, ethnographic tourism, agro-tourism, medical-rehabilitation tourism, etc. In Kvemo Kartli, tourists can see settlements dating back to the first millennium BC. The discovery of a prehistoric settlement and human remains in Dmanisi is considered a major archaeological discovery. According to experts, a hominid lived in Dmanisi 1.8 million years ago. Therefore, Dmanisi can be considered the earliest settlement in Europe and Asia. Kvemo Kartli has more than 650 historical monuments, 300 of which are included in various tourist routes.

Methodology

Studies of 8 locations in Kvemo Kartli (Bolnisi, Gardabani, Dmanisi, Tetri Tskaro, Marneuli, Tsalka, Manglisi, and Rustavi) were carried out. Fig. 1 shows a map of the arrangement of the indicated meteorological stations.

Table 1 presents information about the coordinates and heights of these 8 meteorological stations, whose data were used in this work. These stations are located 300 to 1458 meters above sea level.

Table 1. Coordinates and heights of the 8 meteorological stations in Kvemo Kartli

Location (Abbreviation)	Latitude, N°	Longitude, E°	Elevation (H), m, a.s.l.	Period of observation
Bolnisi (Boln)	41.45	44.55	534	1956-2015
Gardabani (Gard)	41.45	45.10	300	1956-2015
Dmanisi (Dman)	41.33	44.20	1309	1961-1990
Tetri Tskaro (T-Tsk)	41.55	44.47	1151	1961-1990
Marneuli (Marn)	41.48	44.80	432	1938-1960
Tsalka (Tsal)	41.60	44.08	1458	1956-2015
Manglisi (Mang)	41.70	44.38	1194	1961-1990
Rustavi (Rust)	41.55	45.02	332	1949-1960

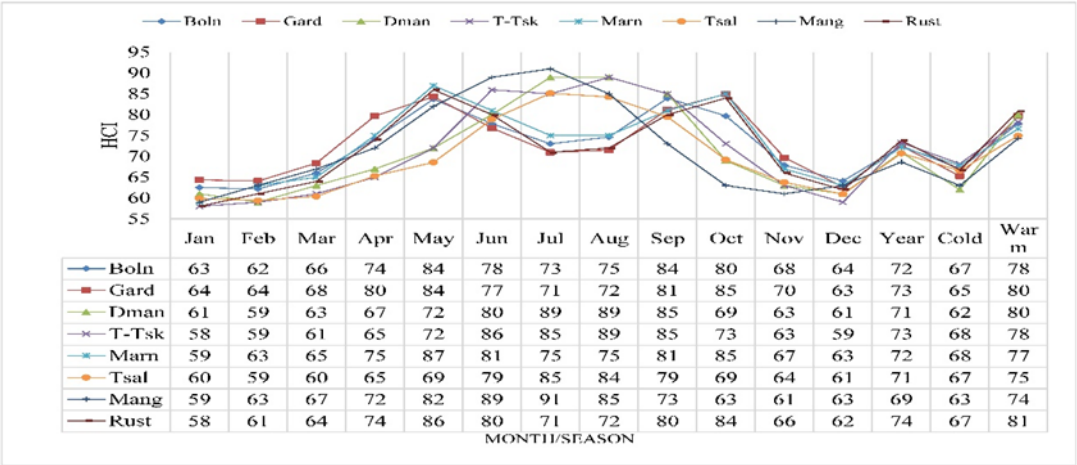
In this work, the Holiday Climate Index (HCI) is used. The following five climatic variables are used for HCI identification: air temperature maximum, relative humidity, cloud cover, precipitation and wind (Scott et al., 2016; Amiranashvili et al., 2020a; Amiranashvili & Kartvelishvili, 2021; Amiranashvili et al., 2021a).

The rating scheme and HCI categories (Scott et al., 2016; Amiranashvili et al., 2020a) are presented in Table 2.

Table 2. HCI's Category

HCI Score	Category (Abbreviation)	HCI Score	Category (Abbreviation)
90÷100	Ideal	40÷49	Marginal (Marg.)
80÷89	Excellent (Excellent)	30÷39	Unfavourable (Unf.)
70÷79	Very Good (Very Good)	20÷29	Very Unfavourable (V_Unf.)
60÷69	Good	10÷19	Extremely Unfavourable (Ext_Unf.)
50÷59	Acceptable (Acceptable)	9÷-9; -10÷-20	Impossible (Impos.)

In this work, the monthly mean data of the indicated meteorological parameters from the Georgian National Environmental Agency (Bolnisi, Gardabani, Tsalka), famous reference books on the climate of the USSR (issue 14; Marneuli, Rustavi) and the Scientific and Applied of Georgia Climate Reference (2020) (Dmanisi, Tetri Tskaro, Manglisi) were used. Based on these data, the HCI monthly average values were calculated. Analysis of the HCI data using standard statistical analysis methods was carried out (Kobisheva & Narovlianski, 1978). The following designations are used: Mean – average values; Min – minimal values; Max – maximal values; St Dev – standard deviation; C_v – coefficient of variation, % (C_v = 100· St Dev/Mean); R^2 – coefficient of determination; R – coefficient of linear correlation; α – level of significance; H – altitude of the weather station at sea level, meter or km.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Cold	Warm
Boln	63	62	66	74	84	78	73	75	84	80	68	64	72	67	78
Gard	64	64	68	80	84	77	71	72	81	85	70	63	73	65	80
Dman	61	59	63	67	72	80	89	89	85	69	63	61	71	62	80
T-Tsk	58	59	61	65	72	86	85	89	85	73	63	59	73	68	78
Marn	59	63	65	75	87	81	75	75	81	85	67	63	72	68	77
Tsal	60	59	60	65	69	79	85	84	79	69	64	61	71	67	75
Mang	59	63	67	72	82	89	91	85	73	63	61	63	69	63	74
Rust	58	61	64	74	86	80	71	72	80	84	66	62	74	67	81

Figure 2. Mean HCI values at 8 locations of Kvemo Kartli

Results

The results are presented in figures 2-3 and tables 3-8. The long-term mean HCI real values at 8 locations in Kvemo Kartli are presented in Fig. 2.

As shown in Fig. 2, the mean monthly HCI changed from 58 (Tetri Tskaro, Rustavi, January, Acceptable) to 91 (Manglisi, July, Ideal). The variability of HCI values for individual items is as follows:

Bolnisi (62, February–84, May, September), Gardabani (63, December–85, October), Dmanisi (59, February–89, July, August), Tetri Tskaro (58, January–89, August), Marneuli (59, January–87, May), Tsalka (59, February–85, July), Manglisi (59, January–91, July), and Rustavi (58, January–86, May).

Table 3. Linear correlation coefficients between the monthly means and seasonal values of the HCI at the separate stations (R min = 0.41, α = 0.15; R max = 0.98, α = <0.001)

Location	Boln	Gard	Dman	T-Tsk	Marn	Tsal	Mang	Rust
Boln	1	0.94	0.68	0.73	0.97	0.65	0.58	0.96
Gard	0.94	1	0.49	0.53	0.93	0.44	0.41	0.95
Dman	0.68	0.49	1	0.96	0.62	0.97	0.84	0.58
T-Tsk	0.73	0.53	0.96	1	0.70	0.98	0.82	0.66
Marn	0.97	0.93	0.62	0.70	1	0.62	0.60	0.98
Tsal	0.65	0.44	0.97	0.98	0.62	1	0.83	0.57
Mang	0.58	0.41	0.84	0.82	0.60	0.83	1	0.53
Rust	0.96	0.95	0.58	0.66	0.98	0.57	0.53	1

The data analysis in Fig. 2 (Table at the bottom of the figure) shows that the linear correlation coefficients between the mean monthly and seasonal HCI values at the separate stations change as follows (Table 3). Bolnisi: 0.58 (Manglisi) - 0.97 (Marneuli); Gardabani: 0.41 (Manglisi) – 0.95 (Rustavi); Dmanisi: 0.49 (Gardabani) – 0.97 (Tsalka); Tetri Tskaro: 0.53 (Gardabani) – 0.98 (Tsalka); Marneuli: 0.60 (Manglisi) – 0.98 (Rustavi); Tsalka: 0.44 (Gardabani) – 0.98 (Tetri Tskaro); Manglisi: 0.41 (Gardabani) – 0.84 (Dmanisi); Rustavi: 0.53 (Manglisi) – 0.98 (Marneuli).

Table 4. Coefficients of regression equation of the intra-annual motion of HCI monthly mean values for 8 points of Kvemo Kartli

Equation of regress., coefficients	HCI = a·X9+b·X8+c·X7+d·X6+e·X5+f·X4+g·X3+h·X2+i·X+j, (X-Month)										
	a	b	c	d	e	f	g	h	i	j	R^2
Boln	-1.50E-04	8.56E-03	-2.06E-01	2.72E+00	-2.15E+01	1.05E+02	-3.12E+02	5.48E+02	-5.12E+02	2.53E+02	0.993
Gard	3.85E-05	-2.32E-03	6.18E-02	-9.41E-01	8.91E+00	-5.31E+01	1.94E+02	-4.05E+02	4.31E+02	-1.10E+02	0.999
Dman	-5.14E-05	2.89E-03	-6.97E-02	9.45E-01	-7.91E+00	4.21E+01	-1.41E+02	2.84E+02	-3.03E+02	1.87E+02	0.996
T-Tsk	-1.39E-04	8.16E-03	-2.04E-01	2.83E+00	-2.39E+01	1.26E+02	-4.06E+02	7.71E+02	-7.65E+02	3.54E+02	0.989
Marn	-2.23E-06	1.48E-04	-1.67E-03	-4.61E-02	1.36E+00	-1.43E+01	7.49E+01	-2.01E+02	2.57E+02	-5.93E+01	0.990
Tsal	1.36E-05	-8.02E-04	1.97E-02	-2.62E-01	2.05E+00	-9.78E+00	2.82E+01	-4.60E+01	3.68E+01	4.90E+01	0.996
Mang	-4.59E-06	2.98E-04	-8.73E-03	1.49E-01	-1.59E+00	1.07E+01	-4.35E+01	1.02E+02	-1.22E+02	1.13E+02	0.999
Rust	-6.21E-05	3.65E-03	-8.88E-02	1.15E+00	-8.69E+00	3.82E+01	-9.50E+01	1.24E+02	-7.08E+01	6.88E+01	0.993

The distributions of the mean monthly values of the TCI for 8 locations in Kvemo Kartli according to the ninth power of the polynomial ($R^2 \geq 0.989$) are described. The coefficients of the equation of the regression of the intra-annual motion of the mean monthly HCIs for these points are presented in Table 4.

Table 5 shows the distribution types of the mean monthly HCIs at 8 locations in Kvemo Kartli.

Table 5. Intra-annual distribution types of HCI monthly mean values at 8 locations in Kvemo Kartli

Location	Distribution type	First extremum (Max)	Second extremum

Bolnisi	Bimodal	May	Sep
Gardabani	Bimodal	May	Oct
Dmanisi	Unimodal, flat	Jul, Aug	
Tetri Tskaro	Bimodal	Jun	Aug
Marneuli	Bimodal	May	Oct
Tsalka	Unimodal	Jul	
Manglisi	Unimodal	Aug	
Rustavi	Bimodal	May	Oct

According to this table, a generally bimodal distribution of HCIs is observed (5 locations from 8 locations). For the Gardabani, Marneuli, and Rustavi stations, the first and second extrema of the HCI distribution occur in May and October, respectively; for the Bolnisi station, they occur in May and September; and for the Tetri Tskaro station, they occur in June and August.

Table 6. Categories of HCI monthly means and seasonal values at 8 locations in Kvemo Kartli during the cold period

Location	Jan	Feb	Mar	Oct	Nov	Dec	Cold	Year
Bolnisi	Good	Good	Good	Excellent	Good	Good	Good	Very Good
Gardabani					Very Good			
Dmanisi		Acceptable		Good	Good			
Tetri Tskaro	Acceptable			Very Good		Acceptable		
Marneuli		Good		Excellent		Good		
Tsalka	Good	Acceptable		Good				
Manglisi	Acceptable			Very Good				Good
Rustavi		Good		Excellent				Very Good

For Dmanisi, a unimodal distribution of HCIs with plateaus from July–August was observed; for Tsalka and Manglisi, unimodal distributions with maxima occurred in July and August, respectively.

Table 7. Categories of HCI monthly means and seasonal values at 8 locations in Kvemo Kartli during the warm period

Location	Apr	May	Jun	Jul	Aug	Sep	Warm	Year
Bolnisi	Very Good	Excellent	Very Good	Very Good	Very Good	Excellent	Very Good	Very Good
Gardabani	Excellent						Excellent	
Dmanisi	Good	Very Good	Excellent	Excellent	Excellent		Very Good	
Tetri Tskaro								
Marneuli	Very Good	Excellent		Very Good	Very Good			
Tsalka	Good	Good	Very Good	Excellent	Excellent	Very Good		
Manglisi		Very Good	Excellent		Ideal	Excellent		Good
Rustavi	Very Good	Excellent		Very Good	Very Good		Excellent	Very Good

In Tables 6 and 7, the mean monthly and seasonal HCI values at 8 locations in Kvemo Kartli during cold and warm periods are presented.

As shown in these tables, the categories of the mean monthly and seasonal HCIs at 8 locations in Kvemo Kartli change from acceptable to ideal.

Table 8 shows the statistical characteristics of the monthly mean HCIs at 8 locations in Kvemo Kartli (all stations); at Bolnisi, Gardabani, Marneuli, and Rustavi (H < 1 km); and at Dmanisi, Tetri Tskaro, Tsalka, and Manglisi (H > 1 km).

Table 8. Statistical characteristics of the monthly mean HCIs at 8 locations in Kvemo Kartli (all stations); at Bolnisi, Gardabani, Marneuli, and Rustavi (H < 1 km); and at Dmanisi, Tetri Tskaro, Tsalka, and Manglisi (H > 1 km).

Location	All station		H < 1 km		H > 1 km	
Variable	HCI	Category	HCI	Category	HCI	Category
Min	58	Acceptable	58	Acceptable	58	Acceptable
Max	91	Ideal	87	Excellent	91	Ideal

Mean	72	Very Good	73	Very Good	71	Very Good
St Dev	9.8		8.5		11.0	
Cv,%	13.6		11.7		15.5	

As follows from this table, the HCIs for stations with H < 1 km change from 58 (Acceptable) to 87 (Excellent), and for stations with H > 1 km from 58 (Acceptable) to 91 (Ideal). For both groups of stations, the average HCIs are in the "Very Good" category (73 and 71, respectively).

Fig. 3 shows the repetition of the monthly mean HCI category at 8 locations in Kvemo Kartli (all stations); at Bolnisi, Gardabani, Marneuli, and Rustavi (H < 1 km); and at Dmanisi, Tetri Tskaro, Tsalka, and Manglisi (H > 1 km).

Therefore, as shown in Tables 6 and 7 and Fig. 3, in Kvemo Kartli, there are favourable conditions for the development of tourism and resorts throughout the year.

Notably, the research results of this work, in addition to scientific interest, also have practical applications for planning the development of the resort and tourism industry in the Kvemo Kartli region.

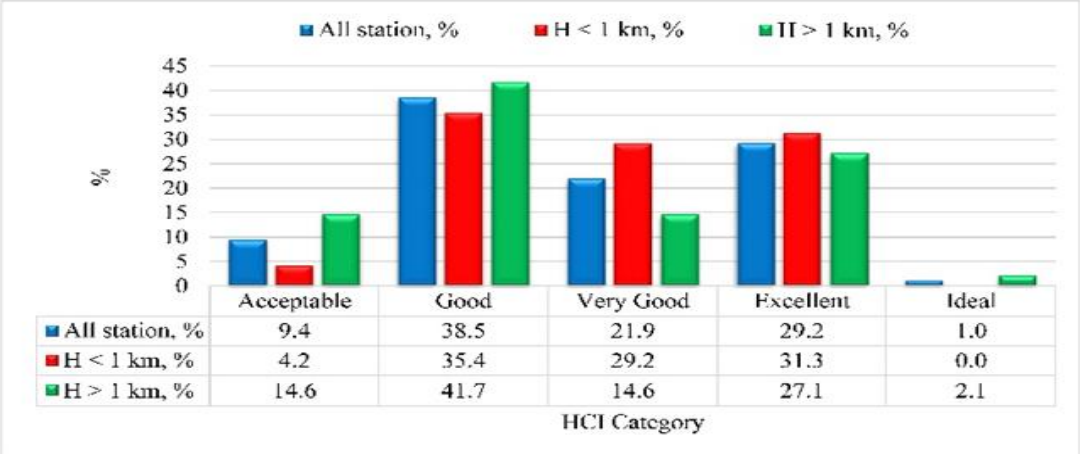


Figure 3. Repetition of monthly mean HCI category at 8 locations of Kvemo Kartli (All station) and at Bolnisi, Gardabani, Marneuli, Rustavi (H < 1 km) and at Dmanisi, Tetri Tskaro, Tsalka, Manglisi (H > 1 km)

Finally, in Fig. 4, a map of the distribution of mean monthly HCI categories in the territory of Kvemo Kartli (in Georgian) is presented.

This map was constructed in accordance with previously reported methods (Rekacewicz, 2005; Rekacewixz &Stienne, 2013). Such maps are very visual and are intended for a wide range of people who want to receive information about various data, phenomena, events, etc., presented in an easy-to-understand form. The bioclimatic conditions of Kvemo Karli are related to the resort and tourism potential of this region.

Note that a similar map has been prepared for the Atlas of the Kakheti region (ready for publication) from the series Geographical Atlases of Georgia.

The indicated map (Fig. 4) will be included in the Atlas of the Kvemo Kartli region (forthcoming) from the same series of geographical atlases of Georgia.

In both cases, the methodology for constructing maps (Rekacewicz, 2005; Rekacewicz & Stienne, 2013) under Georgian conditions was used for the first time.

Discussions

In recent decades, due to the unprecedented rate of increase in air temperature, climate change on our planet has become a particularly urgent problem. At the same time, changes in air temperature and other climate elements have significant spatial and temporal heterogeneity on both global and regional (even the territory of small countries with complex terrain) scales.

This problem of climate change is also very relevant in Georgia due to the diversity of climatic regions in its territory. Moreover, changes in the thermal regime of the atmosphere increase people's vulnerability to external factors.

The negative impact of the environment on human health can be mitigated by the development of resorts and the tourism industry, which allows people to undergo treatment, health and rehabilitation activities and to actively relax. Therefore, in recent years, special attention has been given to the development of this sector of the economy and, accordingly, to the identification of new bioclimatic resources in existing and promising resort and tourist areas.

Therefore, studying the impact of climate change on the variability of various thermal indices, including the TCI and HCI, is important.

The conducted studies once again confirmed the presence of a variety of climatic and bioclimatic conditions in Georgia, as well as the characteristics of their temporal variability. It is concluded that it is necessary to conduct a detailed study of climate change (as well as bioclimate) not only on a regional but also on a local scale.

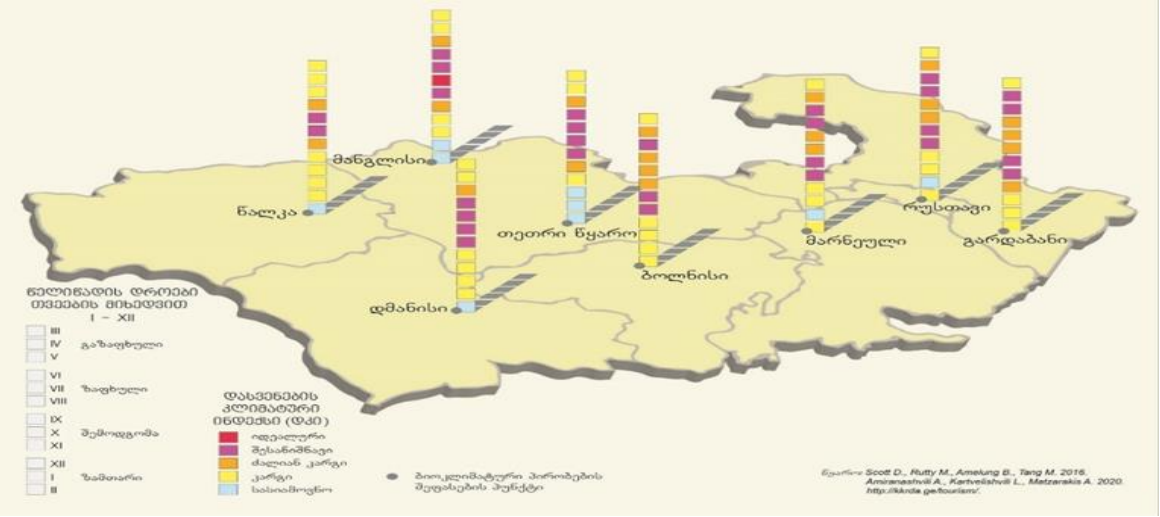


Figure 4. Map of the distribution of mean monthly HCI categories on the territory of Kvemo Kartli. Designations on the map. ბიოკლიმატური პირობების შეფასების პუნქტი - Point of assessment of bioclimatic conditions. Name of points: (წალკა - Tsalka, მანგლისი - Manglisi, დმანისი-Dmanisi, თეთრი წყარო - Tetri Tskaro, ბოლნისი-Bolnisi, მარნეული - Marneuli, რუსთავი - Rustavi, გარდაბანი-Gardabani). წელიადის დროები თვეების მიხედვით (I-XII) - Times of the year by month (I-XII): გაზაფხული (III-V), ზაფხული (VI-VIII), შემოდგომა (I-XI), ზამთაფი (XII-II) - Spring (III V), Summer (VI-VIII), Autumn (I-XI), Winter (XII-II). დასვენების კლიმატური ინდექსი (დკი): იდეალური, შესანიშნავი, ძალიან კარგი, კარგი, სასიამოვნო - Holiday Climate Index (HCI): Ideal, Excellent, Very Good, Good, Acceptable.

Conclusion

In recent decades, due to the unprecedented rate of increase in air temperature, climate change on our planet has become a particularly urgent problem. At the same time, changes in air temperature and other climate elements have significant spatial and temporal heterogeneity on both global and regional (even the territory of small countries with complex terrain) scales.

This problem of climate change is also very relevant in Georgia due to the diversity of climatic regions in its territory. Moreover, changes in the thermal regime of the atmosphere increase people's vulnerability to external factors.

The negative impact of the environment on human health can be mitigated by the development of resorts and the tourism industry, which allows people to undergo treatment, health and rehabilitation activities and to actively relax. Therefore, in recent years, special attention has been given to the development of this sector of the economy and, accordingly, to the identification of new bioclimatic resources in existing and promising resort and tourist areas.

Therefore, studying the impact of climate change on the variability of various thermal indices, including the TCI and HCI, is important.

The conducted studies once again confirmed the presence of a variety of climatic and bioclimatic conditions in Georgia, as well as the characteristics of their temporal variability. It is concluded that it is necessary to conduct a detailed study of climate change (as well as bioclimate) not only on a regional but also on a local scale.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

A.A. and N.B. conceived of the presented idea. L.K. and G.L. performed the analytic calculations. G.T. constructed the map and edited the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

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