

## **Holiday Climate Index in Kakheti (Georgia)**

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### **ABSTRACT**

*Data about long-term monthly average values of Holiday Climate Index (HCI) for 12 locations of Kakheti (Akhmeta, Dedoplistskaro, Gombori, Gurjaani, Kvareli, Lagodekhi, Omalo, Sagarejo, Shiraki, Telavi, Tsnori and Udabno) are presented. For 6 stations of this region (Dedoplistskaro, Gurjaani, Kvareli, Lagodekhi, Sagarejo and Telavi) detailed analysis of the monthly, seasonally and annually HCIs values over a 60-year period (1956-2015) are carried out. Comparison of monthly values of HCI and Tourism Climate Index (TCI) for four points of Kakheti (Dedoplistskaro, Kvareli, Sagarejo and Telavi) based on data from 1961 to 2010 are carried out.*

**Key Words:** *Bioclimate, Tourism Climate Index, Holiday Climate Index.*

### **Introduction**

Weather and climate are two factors that in many respects influence on tourism development. Many climate indices for tourism have been applied in past research [1-6]. The most widely known and applied index is the Tourism Climate Index (TCI) proposed by Mieczkowski [7]. In south Caucasus countries, monthly value of TCI be calculated in Georgia, first for Tbilisi [8], then for many other locations of Caucasus (Armenia, Azerbaijan, North Caucasus etc.) [9-16]. For example, the statistical characteristics of the monthly mean, annual and half year values of tourism TCI and its components for four points of Kakheti (Telavi, Dedoplistskaro, Kvareli and Sagarejo) in the period from 1961 through 2010 in [14, 16] are represented. In particular, the changeability of the indicated bioclimatic parameters into 1986÷2010 in comparison with 1961÷1985 is studied, and also the trends of values of TCI for higher enumerated points are investigated.

Despite the TCI's wide application, it has been subject to substantial critiques [17]. The four key deficiencies of the TCI include: (1) the subjective rating and weighting system of climatic variables; (2) it neglects the possibility of an overriding influence of physical climatic parameters (e.g., rain, wind); (3) the low temporal resolution of climate 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 noted limitations of the TCI, a Holiday Climate Index (HCI) was developed to more accurately assess the climatic suitability of destinations for tourism. The word "holiday" was chosen to better reflect what the index was designed for (i.e., leisure tourism), since 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" [18-23]).

Results of comparison of the holiday climate index and the tourism climate index in Tbilisi are presented in [24]. Comparison of the values and categories of the Tourism Climate Index and Holiday

Climate Index in Tbilisi shows that the intra-annual variation of both indices is similar and has a bimodal form. However, given that the TCI is calculated for the so-called “average tourist” (regardless of gender, age, physical condition), the value and category of this index is lower than the HCI values and categories. In general, HCI more adequately determines the bioclimatic state of the environment for the development of various types of tourism than TCI [24]. The detailed information on the variability of the monthly values of the Holiday Climate Index (HCI) in Tbilisi in 1956-2015 in [25] are presented. It also presents data on the interval forecast of variability of HCI values in Tbilisi for the next few decades.

This study develops a long-term average of HCI for 12 stations of Kakheti region of Georgia (Akhmeta, Dedoplistskaro, Gombori, Gurjaani, Kvareli, Lagodekhi, Omalo, Sagarejo, Shiraki, Telavi, Tsnori and Udabno), detailed analysis of the monthly, seasonally and annually HCIs values over a 60-year period (1956-2015) for 6 stations of this region (Dedoplistskaro, Gurjaani, Kvareli, Lagodekhi, Sagarejo and Telavi) and comparison of monthly values of HCI and TCI for four points of Kakheti (Dedoplistskaro, Kvareli, Sagarejo and Telavi) based on data from 1961 to 2010.

## Study Area, Material and Methods

Study area - Kakheti region of Georgia (below - Kakheti). Kakheti is located in the eastern part of Georgia. Area - 11375 km<sup>2</sup>, population - 314.7 thous. pers., (including of urban - 71.4 thous. pers.), the capital of region - Telavi (population - 19.8 thous. pers.) [www.geostat.ge].

A visit to Kakheti can be a fascinating experience because of its beautiful mountain landscapes, stunning regions, ancient world temples and monasteries, picturesque valleys and rivers and home to amber grapes that grows under the warmth of the sun. Kakheti is not only famous as a tourism destination, but it is also locally recognized as Georgia’s center for winemaking.

Studies for 12 locations of Kakheti (Akhmeta, Dedoplistskaro, Gombori, Gurjaani, Kvareli, Lagodekhi, Omalo, Sagarejo, Shiraki, Telavi, Tsnori and Udabno) are carried out.

Fig. 1 depicts the map of the arrangement of the indicated meteorological stations. Table 1 presents information about coordinates and heights of these 12 meteorological stations, whose data were used in the work. These stations that are located from 223 to 1880 meters above sea level and are open to fresh and pure air because of this.

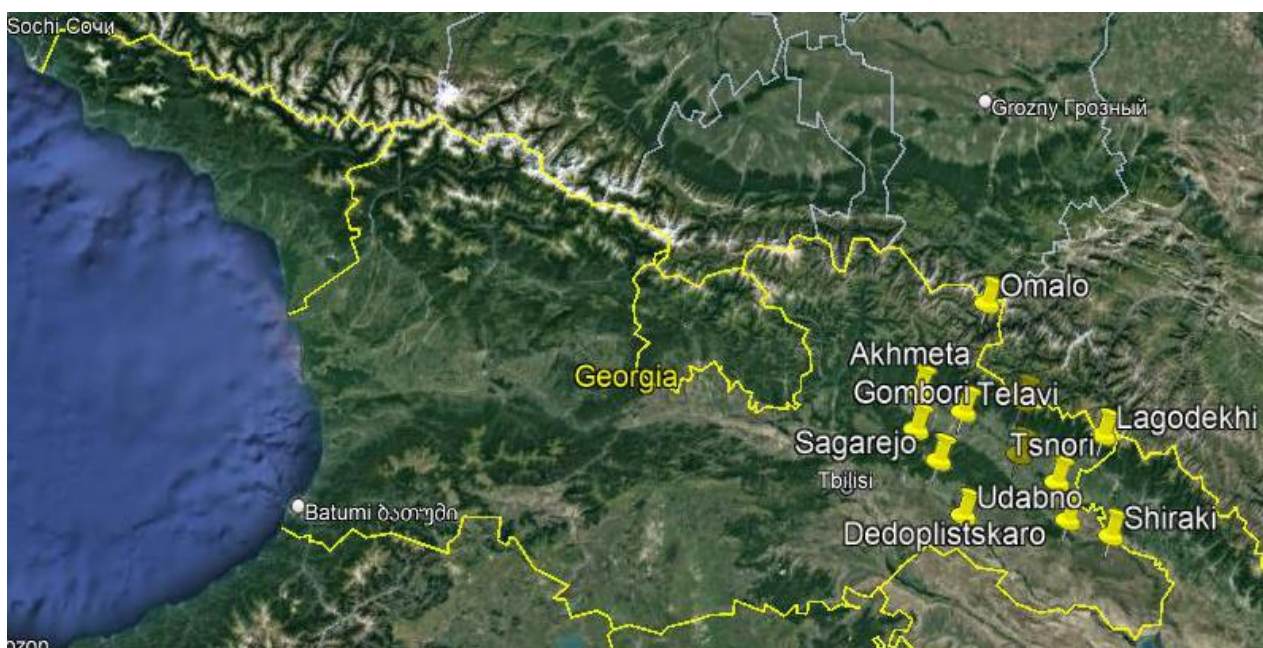


Fig.1. Locations of 12 meteorological stations in Kakheti.

Table 1. Coordinates and heights of the 12 meteorological stations in Kakheti.

Location (Abbreviation)	Latitude, N°	Longitude, E°	Height, m, a.s.l.
Akhmeta (Akhm)	42.02	45.22	567
Dedoplistskaro (Ded)	41.47	46.08	800
Gombori (Gom)	41.86	45.20	1085
Gurjaani (Gur)	41.75	45.80	410
Kvareli (Kvar)	41.97	45.83	449
Lagodekhi (Lagod)	41.82	46.30	362
Omalo	42.38	45.63	1880
Sagarejo (Sag)	41.73	45.33	802
Shiraki (Shir)	41.40	46.33	555
Telavi (Tel)	41.93	45.48	568
Tsnori	41.63	46.02	223
Udabno (Udab)	41.50	45.47	750

In this work the Holiday Climate Index (HCI) is used. The HCI uses five climatic variables related to the three facets essential to tourism (table 2): thermal comfort (TC), aesthetic (A), and physical (P) facet. The five climatic variables used for the HCI input are maximum air temperature and relative humidity (TC), cloud cover (A), precipitation and wind (P) [12].

The HCI score is calculated according to the following formula:  $HCI = 4 \cdot T + 2 \cdot A + 3 \cdot R_d + 1 \cdot W$ . In tables 2-4 components of Holiday Climate Index, HCI's rating scheme and HCI's category are presented.

Table 2. Components of Holiday Climate Index (HCI).

Facet	Climatic Variable	Index Weighting (%)
Thermal Comfort (TC)	Dry-bulb Temperature (°C): Maximum Temperature (°C)	40%
	Relative Humidity (%): Mean RH	
Aesthetic (A)	Cloud Cover (%)	20%
Physical (P)	Amount of Rain (mm)	30%
	Wind Speed (km/h)	10%

Table 3. HCI's Rating Scheme.

Rating	T - Effective Temperature (°C)	A - Daily Cloud Cover (%)	R <sub>d</sub> - Daily Precipitation (mm)	W - Wind Speed (km/h)
10	23÷25	11÷20	0	1÷9
9	20÷22; 26	1÷10; 21÷30	<3	10÷19
8	27÷28	0; 31÷40	3÷5.99	0; 20÷29
7	18÷19; 29÷30	41÷50		
6	15÷17; 31÷32	51÷60		30÷39
5	11÷14; 33÷34	61÷70	6÷8.99	
4	7÷10; 35÷36	71÷80		
3	0÷6	81÷90		40÷49
2	-5÷-1; 37÷39	90÷99	9÷12	
1	<-5	100		
0	>39		>12	50÷70
-1			>25	
-10				>70

Table 4. HCI's Category.

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

For the 12 indicated localities the long-term monthly average values of HCI with the use data of Georgian National Environmental Agency are calculated. For 6 stations of this region (Dedoplistskaro, Gurjaani, Kvareli, Lagodekhi, Sagarejo and Telavi) detailed analysis of the monthly, seasonally and annually HCIs values over a 60-year period (1956-2015) are carried out. Comparison of monthly HCI and TCI values for four points of Kakheti (Dedoplistskaro, Kvareli, Sagarejo and Telavi) based on data from 1961-2010 are carried out [14,16].

In the work analysis of data is carried out with the use of the standard statistical analysis methods. The following designations will be used below: Mean – average values; Min – minimal values; Max - maximal values; 99%\_Low and 99%\_Upp - Low and Upper levels of 99% confidence interval of mean values; R<sup>2</sup> - coefficient of determination; R - coefficient of linear correlation.

## Results and discussion

Results in the Table 4-18 and Fig. 2-17 are presented.

### 1. Basic information about HCI for 12 points of Kakheti.

Data about long-term mean of HCI real values at 12 locations of Kakheti in Fig. 2 are presented.

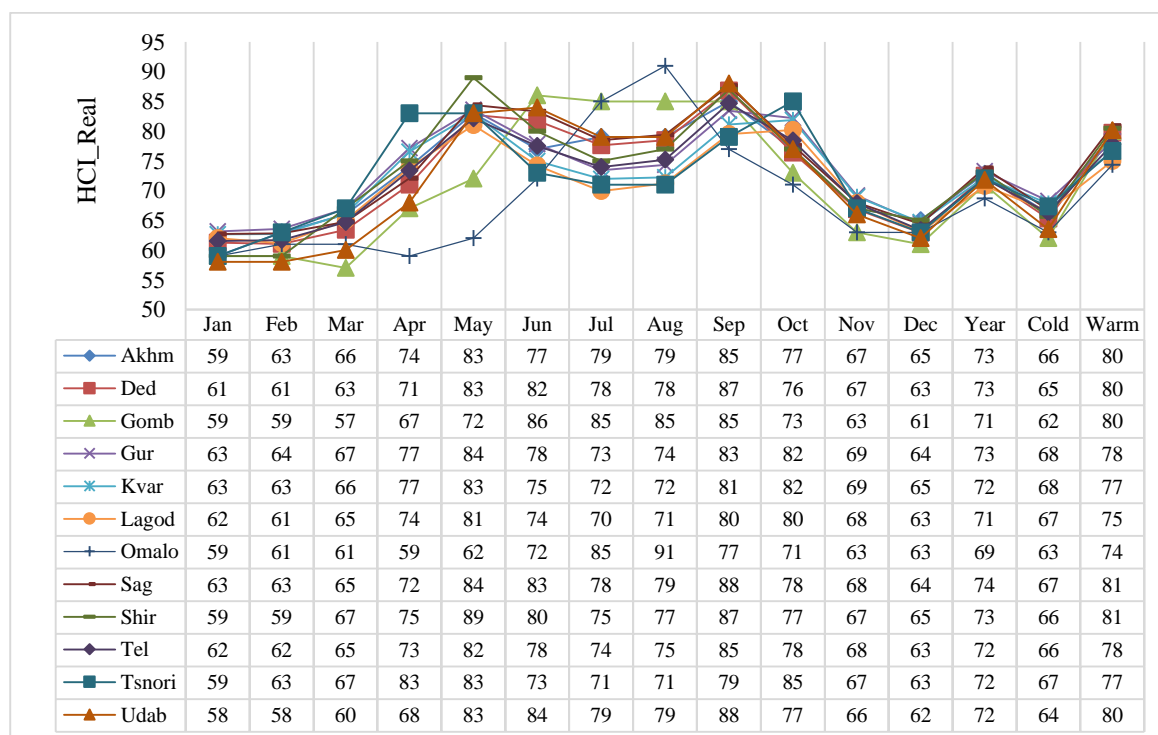


Fig. 2. Mean of HCI real values at 12 locations of Kakheti.

As follows from Fig. 2 mean monthly values of HCI change from 57 (Gombori, March, Acceptable) to 91 (Omalo, August, Ideal). The variability of HCI values for individual items is as follows:

Akhmeta (59, January – 85, September), Dedoplistskaro (61, January, February – 87, September), Gombori (57, March – 86, June), Gurjaani (63, January – 84, May), Kvareli (63, January, February – 83, May), Lagodekhi (61, February – 81, May), Omalo (59, January, April – 91, August), Sagarejo (63, January, February – 88, September), Shiraki (59, January, February – 89, May), Telavi (62, January, February – 85, September), Tsnori (59, January – 85, October, Udabno (58, January, February – 88, September).

Table 5. Linear correlation coefficient between separated stations on the mean monthly values of HCI (R min = 0.60,  $\alpha = 0.05$ ; R min = 0.56,  $\alpha = 0.075$ ; R min = 0.52,  $\alpha = 0.10$ ; R min = 0.47,  $\alpha = 0.15$ ).

Location	Akhm	Ded	Gomb	Gur	Kvar	Lagod	Omalo	Sag	Shir	Tel	Tsnori	Udab
<b>Akhm</b>	1	0.97	0.87	0.92	0.89	0.90	0.64	0.97	0.97	0.97	0.82	0.96
<b>Ded</b>	0.97	1	0.91	0.91	0.87	0.89	0.64	1.00	0.96	0.98	0.75	1.00
<b>Gomb</b>	0.87	0.91	1	0.71	0.64	0.66	0.85	0.90	0.78	0.82	0.52	0.93
<b>Gur</b>	0.92	0.91	0.71	1	0.99	0.99	0.38	0.92	0.95	0.97	0.94	0.89
<b>Kvar</b>	0.89	0.87	0.64	0.99	1	1.00	0.32	0.88	0.93	0.95	0.96	0.85
<b>Lagod</b>	0.90	0.89	0.66	0.99	1.00	1	0.35	0.90	0.94	0.96	0.94	0.87
<b>Omalo</b>	0.64	0.64	0.85	0.38	0.32	0.35	1	0.62	0.48	0.53	0.22	0.67
<b>Sag</b>	0.97	1.00	0.90	0.92	0.88	0.90	0.62	1	0.96	0.98	0.76	0.99
<b>Shir</b>	0.97	0.96	0.78	0.95	0.93	0.94	0.48	0.96	1	0.98	0.84	0.94
<b>Tel</b>	0.97	0.98	0.82	0.97	0.95	0.96	0.53	0.98	0.98	1	0.85	0.97
<b>Tsnori</b>	0.82	0.75	0.52	0.94	0.96	0.94	0.22	0.76	0.84	0.85	1	0.72
<b>Udab</b>	0.96	1.00	0.93	0.89	0.85	0.87	0.67	0.99	0.94	0.97	0.72	1

Linear correlation coefficient between separated station on the mean monthly values of HCI changes as follows (Table 5). Akhmeta: 0.64 (Omalo) - 0.97 (Dedoplistskaro, Sagarejo, Shiraki, Telavi); Dedoplistskaro: 0.64 (Omalo) – 1.00 (Sagarejo, Udabno); Gombori: 0.52 (Tsnori) – 0.93 (Udabno); Gurjaani: 0.38 (non sign, Omalo) – 0.99 (Kvareli, Lagodekhi); Kvareli: 0.32 (non sign, Omalo) – 1.00 (Lagodekhi); Lagodekhi: 0.35 (non sign, Omalo) – 1.00 (Kvareli); Omalo: 0.22 (non sign, Tsnori) – 0.85 (Gombori); Sagarejo: 0.62 (Omalo) – 1.00 (Dedoplistskaro); Shiraki: 0.48 (Omalo) – 0.98 (Telavi); Telavi: 0.53 (Omalo) – 0.98 (Dedoplistskaro, Sagarejo, Shiraki); Tsnori: 0.22 (non sign, Omalo) – 0.96 (Kvareli); Udabno: 0.67 (Omalo) – 1.00 (Dedoplistskaro).

Distribution of mean monthly values of TCI for 12 locations of Kakhети by a ninth power of polynomial ( $R^2 \geq 0.978$ ) are described. Coefficients of the equation of the regression of the intra-annual motion of mean monthly values of HCI for these points in Table 6 are presented.

Table 6. Coefficients of the equation of the regression of the intra-annual motion of mean monthly values of HCI for 12 points of Kakhети.

Equation of regress., coefficients	$HCI = a \cdot X^9 + b \cdot X^8 + c \cdot X^7 + d \cdot X^6 + e \cdot X^5 + f \cdot X^4 + g \cdot X^3 + h \cdot X^2 + i \cdot X + j, (X\text{-Month})$										
	a	b	c	d	e	f	g	h	i	j	R <sup>2</sup>
<b>Akhm</b>	-7.05E-05	3.81E-03	-8.54E-02	1.02E+00	-7.08E+00	2.82E+01	-6.12E+01	6.11E+01	-9.50E+00	4.65E+01	0.978
<b>Ded</b>	-2.35E-04	1.35E-02	-3.26E-01	4.37E+00	-3.52E+01	1.76E+02	-5.40E+02	9.72E+02	-9.25E+02	4.08E+02	0.996
<b>Gom</b>	-6.56E-05	3.78E-03	-9.19E-02	1.23E+00	-9.81E+00	4.79E+01	-1.41E+02	2.38E+02	-2.10E+02	1.33E+02	0.979
<b>Gur</b>	4.62E-05	2.70E-03	6.75E-02	9.38E-01	7.94E+00	4.22E+01	1.39E+02	2.69E+02	2.74E+02	1.09E+02	0.996
<b>Kvar</b>	2.38E-06	-2.91E-04	1.31E-02	-2.93E-01	3.67E+00	-2.67E+01	1.12E+02	-2.56E+02	2.88E+02	-5.82E+01	0.990
<b>Lagod</b>	-4.37E-05	2.44E-03	-5.61E-02	6.80E-01	-4.68E+00	1.81E+01	-3.67E+01	3.36E+01	-7.02E+00	5.81E+01	0.993
<b>Omalo</b>	1.57E-04	-9.07E-03	2.22E-01	-3.00E+00	2.44E+01	-1.23E+02	3.82E+02	-6.99E+02	6.78E+02	-2.00E+02	0.990
<b>Sag</b>	4.92E-05	2.88E-03	7.19E-02	9.99E-01	8.46E+00	4.49E+01	1.48E+02	2.87E+02	2.92E+02	1.16E+02	0.997
<b>Shir</b>	1.22E-04	7.16E-03	1.79E-01	2.49E+00	2.11E+01	1.12E+02	3.68E+02	7.14E+02	7.27E+02	2.89E+02	0.984
<b>Tel</b>	-1.46E-04	8.30E-03	-1.98E-01	2.59E+00	-2.02E+01	9.72E+01	-2.85E+02	4.89E+02	-4.45E+02	2.23E+02	0.993
<b>Tsnori</b>	2.22E-04	-1.31E-02	3.31E-01	-4.69E+00	4.06E+01	-2.20E+02	7.40E+02	-1.45E+03	1.49E+03	-5.31E+02	0.996
<b>Udab</b>	-2.79E-04	1.61E-02	-3.93E-01	5.30E+00	-4.31E+01	2.17E+02	-6.71E+02	1.22E+03	-1.16E+03	4.95E+02	0.997

In Table 7 information about distribution types of mean monthly values of HCI at 12 locations of Kakheti are provided.

As follows from this Table in general bimodal distribution type of HCI is observed (10 locations from 12). For stations Akhmeta, Dedoplistskaro, Sagarejo, Shiraki and Telavi the first and second extremum in HCI distribution fall on May and September respectively; for stations Gurjaani, Kvareli and Lagodekhi - on May and September-October; for Tsnori - on April-May and October and for Udabno - on May-June and September.

For Gombori unimodal distribution type of HCI with plateau in June-September is observed; for Omalo - unimodal distribution type with maximum in August.

Table 7. Distribution types of mean monthly values of HCI at 12 locations of Kakheti.

Location	Distribution type	First extremum	Second extremum	Location	Distribution type	First extremum	Second extremum
Akhmeta	Bimodal	May	Sep	Omalo	Unimodal	Aug	
Dedoplistskaro				Sagarejo	Bimodal	May	Sep
Gombori	Unimodal, plateau	June-Sept		Shiraki			
Gurjaani	Bimodal	May	Sep-Oct	Telavi			
Kvareli				Tsnori			
Lagodekhi				Udabno	May-Jun	Sep	

In Table 8 and 9 data about categories of mean monthly and seasonal values of HCI at 12 locations of Kakheti in cold and warm period are presented.

Table 8. Categories of mean monthly and seasonal values of HCI at 12 locations of Kakheti in cold period.

Location	Jan	Feb	Mar	Oct	Nov	Dec	Cold	Year
Akhmeta	Accept.	Good	Good	Very Good	Good	Good	Good	Very Good
Dedoplistskaro	Good							
Gombori	Accept.	Accept.	Accept.					
Gurjaani	Good	Good	Good	Excell.				
Kvareli								
Lagodekhi								
Omalo	Accept.	Good	Good	Very Good				
Sagarejo	Good							
Shiraki	Accept.			Accept.				
Telavi	Good	Good	Excell.					
Tsnori	Accept.	Accept.	Very Good					
Udabno								

Table 9. Categories of mean monthly and seasonal values of HCI at 12 locations of Kakheti in warm period.

Location	Apr	May	Jun	Jul	Aug	Sep	Warm
Akhmeta	Very Good	Excell.	Very Good	Very Good	Very Good	Excell.	Excell.
Dedoplistskaro			Excell.				
Gombori	Good	Very Good	Very Good	Excell.	Excell.		
Gurjaani	Very Good	Excell.		Very Good	Very Good	Very Good	
Kvareli							
Lagodekhi	Accept.	Good	Very Good	Excell.	Ideal	Very Good	
Omalo							
Sagarejo							
Shiraki	Very Good	Excell.	Excell.	Very Good	Very Good	Excell.	
Telavi			Very Good				
Tsnori	Excell.	Excell.	Excell.	Excell.	Excell.	Excell.	
Udabno	Good						

As follows from these Tables, categories of mean monthly and seasonal values of HCI at 12 locations of Kakheti changes from Acceptable to Ideal.

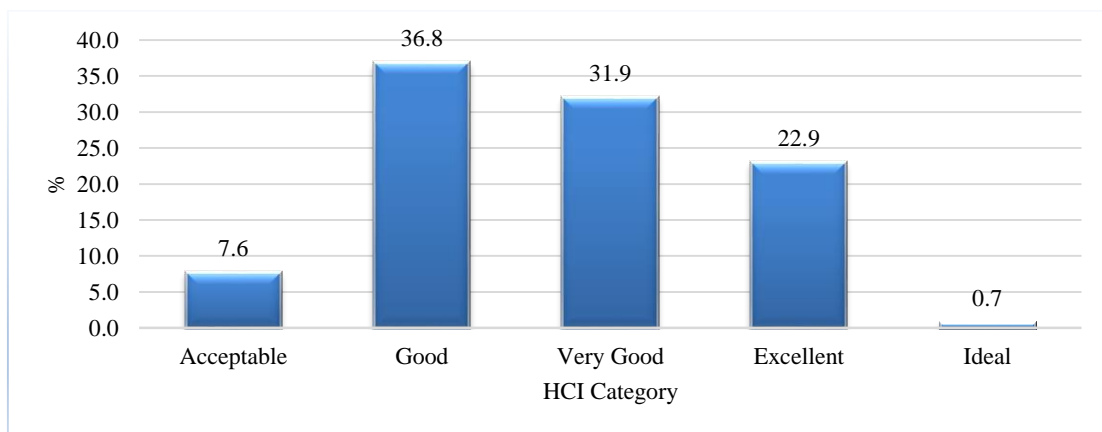


Fig. 3. Repetition of mean monthly HCI category at 12 locations of Kakheti.

In Fig. 3 information about repetition of mean monthly HCI category at 12 locations of Kakheti is presented. So, as follows from Tables 8, 9 and Fig. 3 in Kakheti there are favorable conditions for the development of tourism and resorts throughout the year.

## 2. Analysis of HCI and HCI components at 6 points of Kakheti in 1956-2015.

Detailed analysis of HCI and HCI components at 6 points of Kakheti from 1956 to 2015 in Fig. 4-15 and Tables 10-15 are presented.

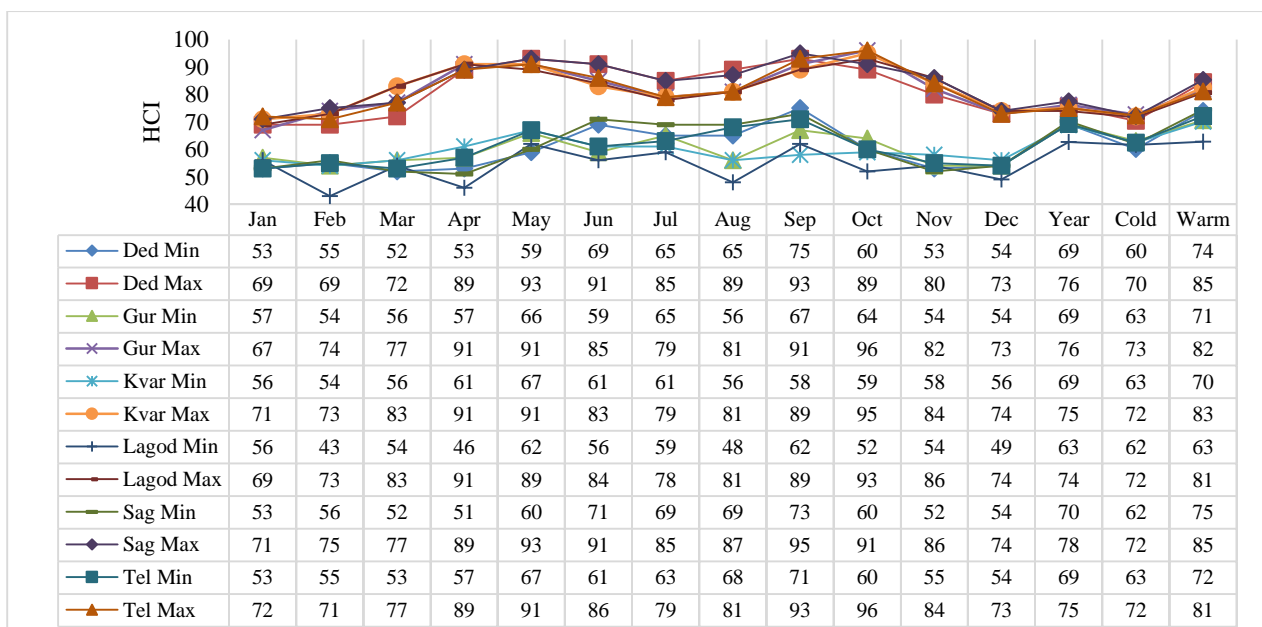


Fig. 4. Min and Max values of HCI at 6 locations of Kakheti in different months and season in 1956-2015.

In Fig. 4 and Tables 10,11 data about Min and Max values of HCI and these categories at 6 locations of Kakheti in different months and season in 1956-2015 are presented. As follows from these Fig. and Tables values of HCI in 6 locations of Kakheti changes from 43 (Lagodekhi, February, Marginal) to 96 (Telavi, October, Ideal).

Table 10. Categories of Min and Max values of HCI at 6 locations of Kakheti in cold period in 1956-2015.

Location	Parameter	Jan	Feb	Mar	Oct	Nov	Dec	Cold	Year	
Ded	Min	Accept. Good	Accept.	Accept. Very Good	Good	Accept. Excell.	Accept. Very Good	Good Very Good	Good Very Good	
Ded	Max		Good		Excell.					
Gur	Min		Accept. Very Good		Marg.					Good
Gur	Max									Ideal
Kvar	Min	Accept.	Marg.	Accept. Excell.	Accept. Ideal	Accept. Excell.	Marg.	Good Very Good		
Kvar	Max	Very Good								
Lagod	Min	Accept.	Very Good	Accept. Excell.	Accept. Ideal	Accept. Excell.	Marg. Very Good	Good Very Good		
Lagod	Max	Good								
Sag	Min	Accept. Very Good	Accept. Very Good	Accept. Very Good	Good Ideal	Accept. Excell.	Accept. Very Good	Good Very Good	Very Good	
Sag	Max								Good	
Tel	Min								Good	
Tel	Max								Very Good	

Table 11. Category of Min and Max values of HCI at 6 locations of Kakheti in warm period in 1956-2015.

Location	Parameter	Apr	May	Jun	Jul	Aug	Sep	Warm
Ded	Min	Accept.	Accept.	Good	Good	Good	Very Good	Very Good Excell.
Ded	Max	Excell.	Ideal	Ideal	Excell.	Excell.	Ideal	
Gur	Min	Accept.	Good Ideal	Accept.	Good Very Good	Accept. Excell.	Good	
Gur	Max	Ideal		Excell.			Ideal	
Kvar	Min	Good		Good			Accept.	
Kvar	Max	Ideal		Excell.			Excell.	
Lagod	Min	Marg.	Good	Accept.	Accept.	Marg.	Good	Good
Lagod	Max	Ideal	Excell.	Excell.	Very Good	Excell.	Excell.	Excell.
Sag	Min	Accept. Excell.	Good Ideal	Very Good	Good	Good Excell.	Very Good Ideal	Very Good Excell.
Sag	Max			Ideal	Excell.			
Tel	Min			Good	Good			
Tel	Max			Excell.	Very Good			

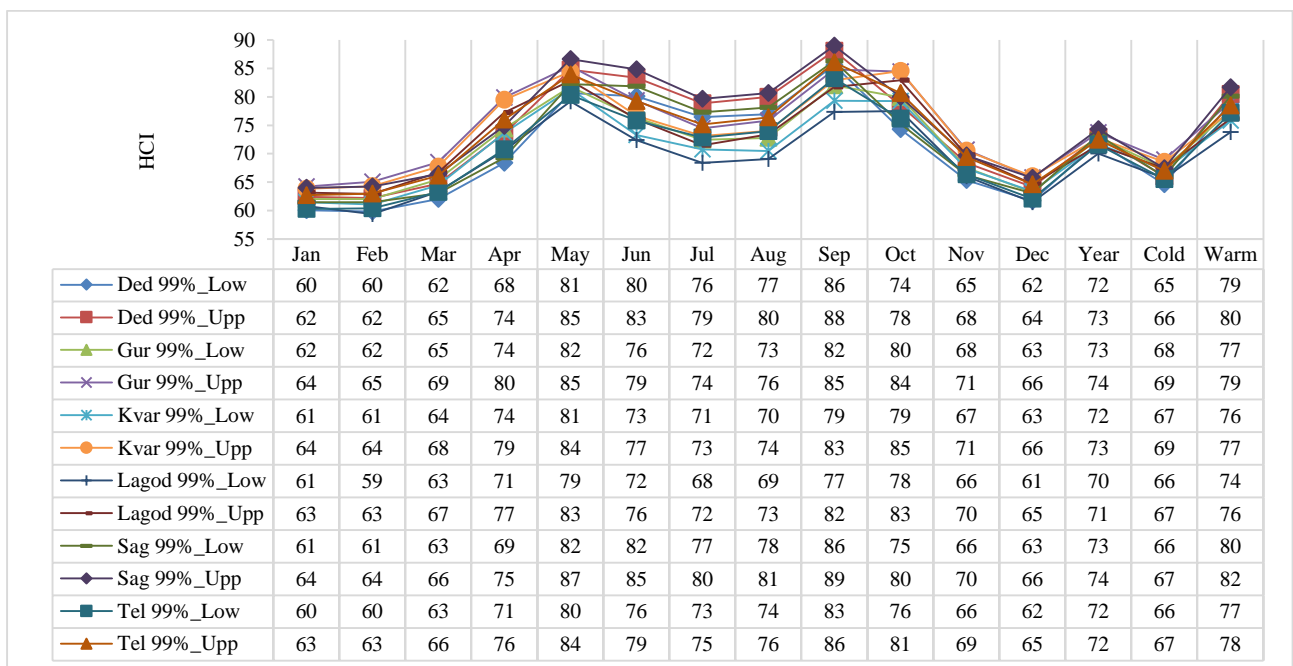


Fig. 5. Low and Upper levels of 99% confidence interval of mean values of HCI at six locations of Kakheti in 1956-2015.



Table 12. Category of Low and Upper levels of 99% confidence interval of mean values of HCI at 6 locations of Kakheti in cold period in 1956-2015.

Location	Parameter	Jan	Feb	Mar	Oct	Nov	Dec	Cold	Year		
Ded	99%_Low	Good	Good	Good	Very Good	Good	Good	Good	Very Good		
Ded	99%_Upp					Good					
Gur	99%_Low				Excell.	Very Good					
Gur	99%_Upp									Very Good	
Kvar	99%_Low				Very Good	Excell.				Good	Very Good
Kvar	99%_Upp										
Lagod	99%_Low				Accept.	Very Good				Excell.	
Lagod	99%_Upp				Good						
Sag	99%_Low				Good	Very Good				Excell.	
Sag	99%_Upp										
Tel	99%_Low				Very Good	Excell.				Good	
Tel	99%_Upp										

Table 13. Category of Low and Upper levels of 99% confidence interval of mean values of HCI at 6 locations of Kakheti in warm period in 1956-2015.

Location	Parameter	Apr	May	Jun	Jul	Aug	Sep	Warm
Ded	99%_Low	Good	Excell.	Excell.	Very Good	Very Good	Excell.	Very Good
Ded	99%_Upp	Very Good				Excell.		
Gur	99%_Low	Very Good	Excell.	Very Good	Very Good	Very Good	Excell.	Very Good
Gur	99%_Upp	Excell.						
Kvar	99%_Low	Very Good	Very Good	Good	Good	Very Good		
Kvar	99%_Upp					Excell.		
Lagod	99%_Low		Very Good	Very Good	Very Good	Very Good		
Lagod	99%_Upp		Excell.					
Sag	99%_Low	Good	Excell.	Excell.	Very Good	Very Good	Excell.	Excell.
Sag	99%_Upp	Very Good						
Tel	99%_Low	Very Good	Excell.	Very Good	Very Good	Very Good	Excell.	Very Good
Tel	99%_Upp							

In Fig. 5 and Tables 12,13 information about 99%\_Low and 99%\_Upp levels of mean values of HCI and these categories at 6 locations of Kakheti in different months and season in 1956-2015 are presented. As follows from these Fig. and Tables values of HCI in 6 locations of Kakheti changes from 43 (Lagodekhi, February, Marginal) to 96 (Telavi, October, Ideal). As follows from these Fig. and Tables values of HCI in 6 locations of Kakheti changes from 59 (Acceptable) to 89 (Excellent).



Fig. 6. Repetition of monthly values of TCI categories at six locations of Kakheti in 1956-2015.

In Fig. 6 data about repetition of monthly values of TCI category at six locations of Kakheti in 1956-2015 are presented. The variability of this repetition for separate locations of Kakheti is as follows: Dedoplistskaro (2,6%, Ideal – 34.2%, Good), Gurjaani (1,5%, Ideal – 33,8% Good), Kvareli (1,4%, Ideal – 36.3%, Good), Lagodekhi (0,6%, Marginal, Ideal – 35.4%, Good), Sagarejo (5,0%, Ideal – 34.2%, Good), Telavi (0,6%, Ideal – 36.7%, Good).

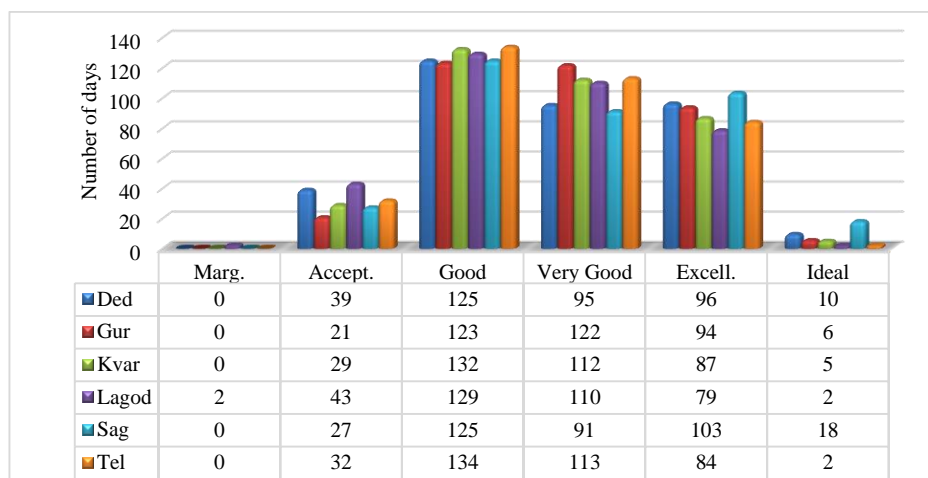


Fig. 7. Number of days in year of various categories of HCI at six locations of Kakheti in 1956-2015.

Respectively the variability of number of days in year of various categories of HCI for separate locations of Kakheti is as follows (Fig. 7): Dedoplistskaro (10, Ideal – 125, Good), Gurjaani (6, Ideal – 123, Good), Kvareli (5, Ideal – 132, Good), Lagodekhi 2, Marginal, Ideal – 129, Good), Sagarejo (18, Ideal – 125, Good), Telavi (2, Ideal – 134, Good).

In Table 14 and Fig. 8-11 data about Min, Max and mean values of HCI components at six locations of Kakheti are presented. As follows from these Table and Fig. the monthly values of HCI components changes from 0 (Rd, Lagodekhi) to 10 (all components, all locations). The monthly mean values of HCI components changes from 3.3 (T, Lagodekhi) to 10 (W, all locations besides Lagodekhi).

Table 14. Data of Min and Max values of HCI components at six locations of Kakheti.

Parameter	All data		Mean monthly 1956-2015		All data		Mean monthly 1956-2015	
	Min	Max	Min	Max	Min	Max	Min	Max
	<b>Dedoplistskaro</b>				<b>Lagodekhi</b>			
<b>T</b>	2	10	3.3	9.2	2	10	3.6	9.3
<b>A</b>	2	10	4.8	7.0	2	10	4.6	7.0
<b>Rd</b>	5	10	8.4	9.0	0	10	7.7	9.0
<b>W</b>	9	10	9.8	10	8	10	9.6	9.9
	<b>Gurjaani</b>				<b>Sagarejo</b>			
<b>T</b>	2	10	3.6	9.4	2	10	3.4	9.5
<b>A</b>	3	10	5.2	7.4	3	10	5.1	7.4
<b>Rd</b>	2	10	8.1	9.0	2	10	8.3	9.0
<b>W</b>	10	10	10	10	9	10	9.9	10
	<b>Kvareli</b>				<b>Telavi</b>			
<b>T</b>	2	10	3.6	9.6	2	10	3.4	9.6
<b>A</b>	3	10	4.8	7.2	1	10	4.5	6.5
<b>Rd</b>	2	10	7.9	9.0	5	10	8.0	9.0
<b>W</b>	10	10	10	10	9	10	9.9	10

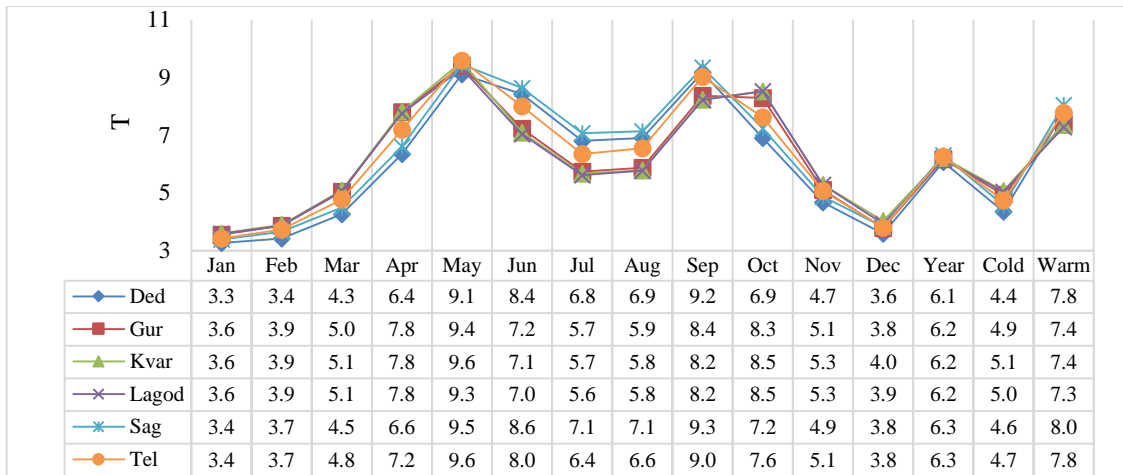


Fig. 8. Mean monthly and seasonal values of T component of HCI at six locations of Kakheti in 1956-2015.

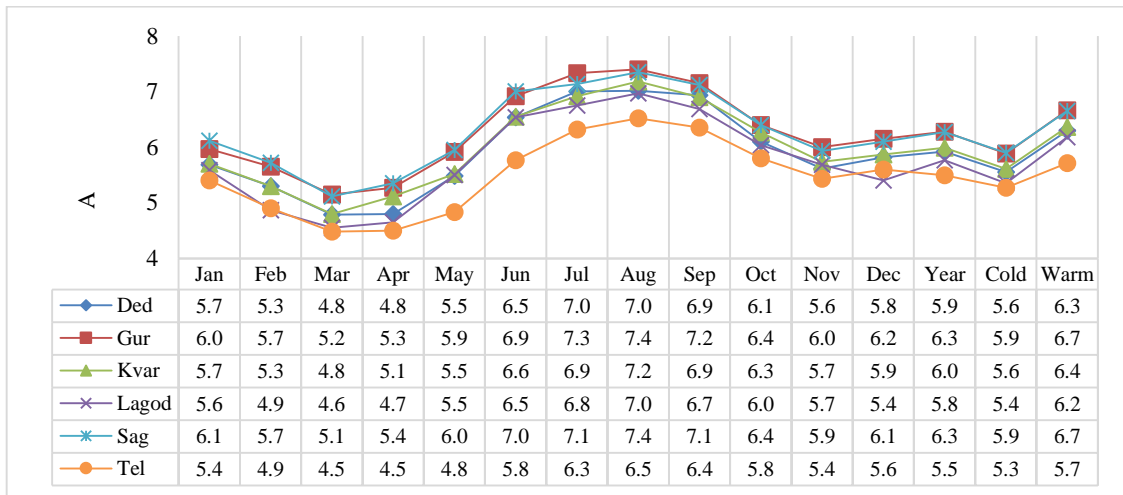


Fig. 9. Mean monthly and seasonal values of A component of HCI at six locations of Kakheti in 1956-2015.

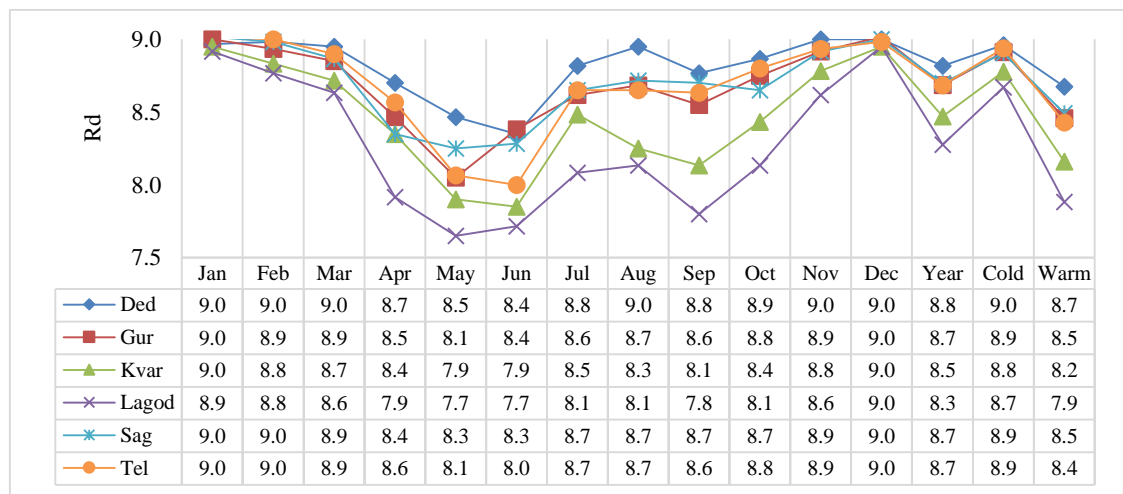


Fig. 10. Mean monthly and seasonal values of Rd component of HCI at six locations of Kakheti in 1956-2015.

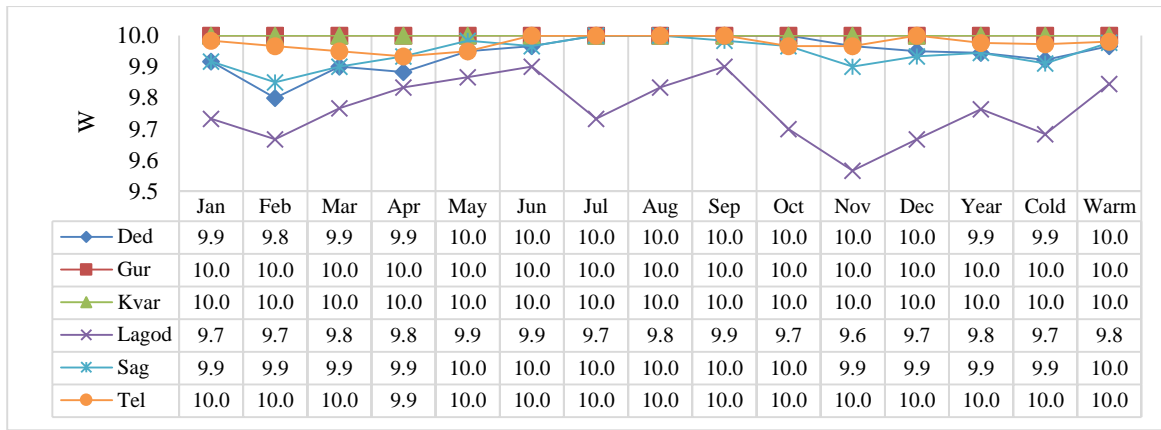


Fig. 11. Mean monthly and seasonal values of W component of HCI at six locations of Kakheti in 1956-2015.

Intra-annual distribution of mean monthly values of T component of HCI at six locations of Kakheti (Fig. 8), as well HCI (Fig. 2, Table 7), bimodal distribution type of this parameter is observed. The first extremum of T component for all locations in May is observed (range of change: 9.1, Dedoplistskaro – 9.6, Kvareli, Telavi). The second extremum of T component for Dedoplistskaro, Sagarejo and Telavi in September is observed, for Gurjaani, Kvareli and Lagodekhi – in September-October. Range of change for Dedoplistskaro, Sagarejo and Telavi is as follow: 9.0, Telavi – 9.3, Sagarejo. Range of change for Gurjaani, Kvareli and Lagodekhi is as follow: 8.2, Kvareli, Lagodekhi – 8.5, Kvareli, Lagodekhi.

Intra-annual distribution of mean monthly values of A component of HCI at six locations of Kakheti (Fig. 9) unimodal distribution type of this parameter is observed. The Max values of A component for all locations, besides Dedoplistskaro, in August is observed (range of change: 6.5, Telavi – 7.4, Gurjaani, Sagarejo). In Dedoplistskaro unimodal distribution type with plateau of A value is observed (7.0, July-August).

Intra-annual variation of mean monthly values of Rd component of HCI at six locations of Kakheti (Fig. 10) is not very significant. Range of change for separate locations is as follow. Dedoplistskaro: 8.4, June – 9.0, November-March, August; Gurjaani: 8.1, May – 9.0, December, January; Kvareli: 7.9, May, June – 9.0, December, January; Lagodekhi: 7.7, May, June – 9.0, December; Sagarejo: 8.3, May, June – 9.0, December – February; Telavi: 8.0, June – 9.0, December – February.

Intra-annual variation of mean monthly values of W component of HCI at six locations of Kakheti (Fig. 11) is not significant - range of change for all stations – from 9.6 to 10.0.

In Table 15 and Fig. 12-15 data about Min, Max and mean values of share of HCI components in HCI values at six locations of Kakheti are presented. As follows from these Table and Fig. the monthly values of share of HCI components changes from 0% (Share Rd, Lagodekhi) to 60.6% (Share T, Gurjaani, Lagodekhi). The monthly mean values of share of HCI components changes from 11.4% (Share W, Sagarejo) to 46.8% (Share T, Telavi).

Intra-annual distribution of mean monthly values of Share of T component of HCI value at six locations of Kakheti (Fig. 12), as well HCI and T (Fig. 2, 8, Table 7), bimodal distribution type of this parameter is observed. Range of change of Share of T component of HCI value for all stations (first extremum) is as follow: 44.0%, Dedoplistskaro – 46.8%, Telavi. Range of change of Share of T component of HCI value (second extremum) for Dedoplistskaro, Sagarejo and Telavi is as follow: 42.2%, Dedoplistskaro – 42.6%, Sagarejo. Range of change for Gurjaani, Kvareli and Lagodekhi is as follow: 40.1, Gurjaani – 42.5%, Lagodekhi.

Table 15. Data of Min and Max values of share of HCI components in HCI value at six locations of Kakheti, (%)

Parameter	All data		Mean monthly 1956-2015		All data		Mean monthly 1956-2015	
	Min	Max	Min	Max	Min	Max	Min	Max
	<b>Dedoplistskaro</b>				<b>Lagodekhi</b>			
Share T	12.3	53.3	21.2	44.0	13.1	60.6	23.1	46.1
Share A	7.5	30.8	13.2	18.5	7.4	29.2	12.5	19.7
Share Rd	19.0	50.9	30.3	44.3	0	50.9	28.1	43.3
Share W	10.0	19.2	11.5	16.2	9.0	23.3	12.2	15.9
	<b>Gurjaani</b>				<b>Sagarejo</b>			
Share T	13.1	60.6	22.4	45.1	15.1	60.0	21.5	44.9
Share A	8.5	27.4	13.6	20.0	9.4	26.9	14.1	19.4
Share Rd	9.1	47.4	28.7	42.9	10.0	50.9	29.2	43.3
Share W	10.4	18.5	12.0	15.9	10.0	19.6	11.4	15.9
	<b>Kvareli</b>				<b>Telavi</b>			
Share T	12.1	60.0	22.9	46.1	14.5	54.8	22.1	46.8
Share A	7.5	27.3	13.3	19.9	3.6	27.4	11.7	17.6
Share Rd	10.0	49.1	28.5	43.0	20.5	50.9	29.3	44.1
Share W	10.5	18.5	12.1	16.0	10.2	18.9	11.8	16.3

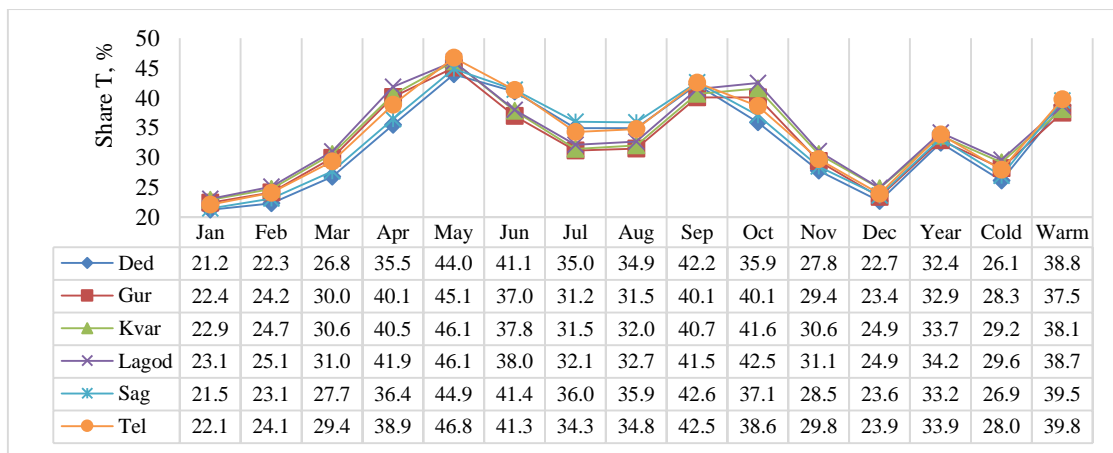


Fig. 12. Share of mean monthly and seasonal values of T component in HCI value at six locations of Kakheti in 1956-2015.

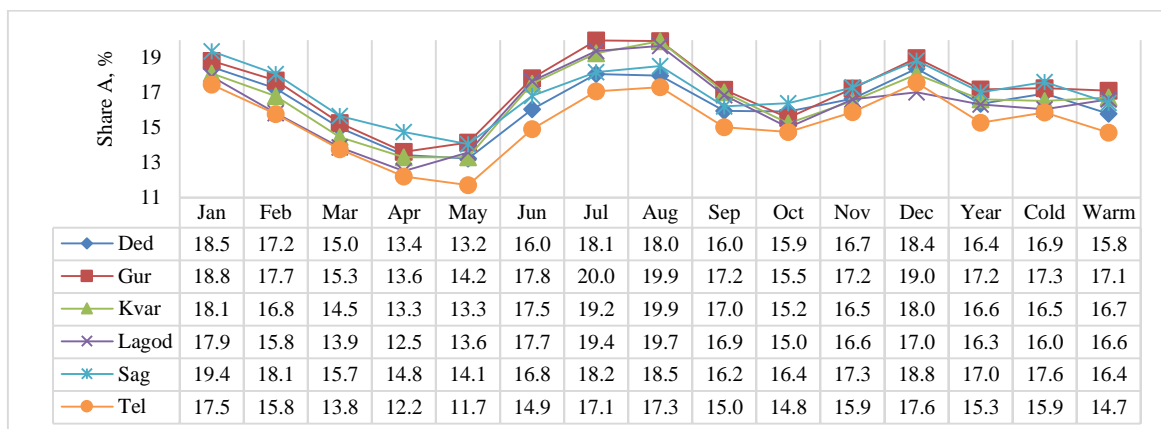


Fig. 13. Share mean monthly and seasonal values of A component in HCI value in six locations of Kakheti in 1956-2015.

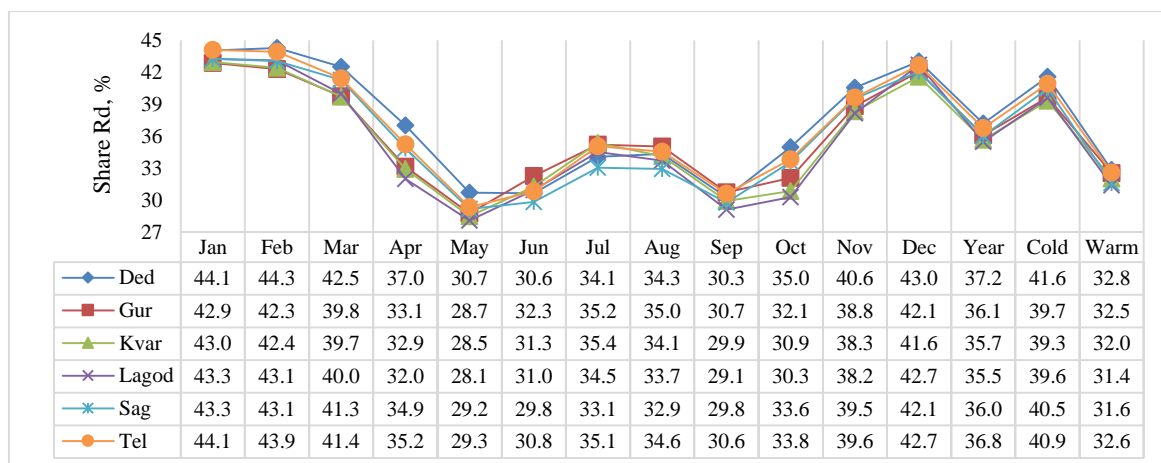


Fig. 14. Share mean monthly and seasonal values of Rd component in HCI value at six locations of Kakheti in 1956-2015.

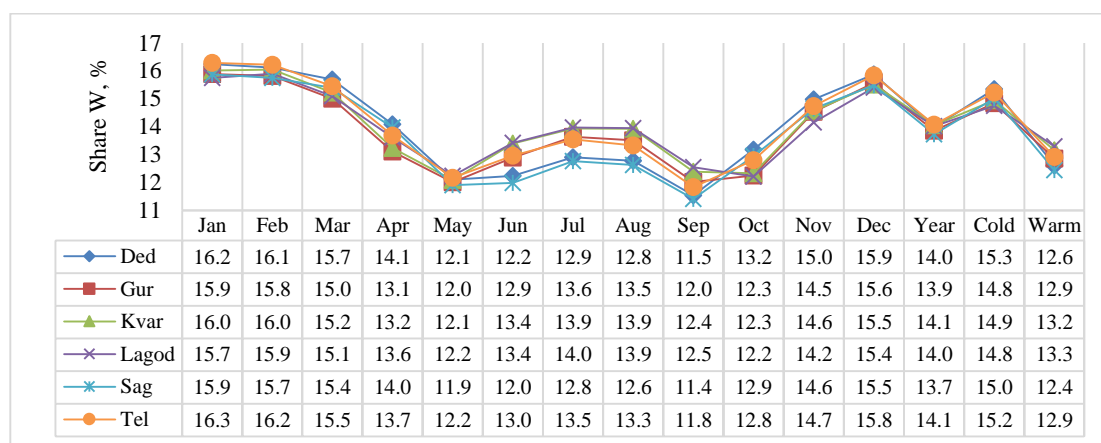


Fig. 15. Share of mean monthly and seasonal values of W component in HCI value at six locations of Kakheti in 1956-2015.

Intra-annual distribution of mean monthly values of Share of A components of HCI value at six locations of Kakheti (Fig. 13), as well HCI, T and Share T (Fig. 2, 8, 12, Table 7), have a bimodal type. For Dedoplistskaro, Gurjaani, Kvareli and Telavi first extremum of Share of A distribution in January and December is observed, for Lagodekhi and Sagarejo – in January. The second extremum of this distribution for all stations in July-August is observed.

Range of change of Share of A component of HCI value for all stations (first extremum) is as follow: 17.5%, Telavi – 19.0%, Gurjaani; Lagodekhi and Sagarejo – 17.9% and 19.4% respectively. Range of change of Share of A component of HCI value for all stations (second extremum) is as follow: 17.1%, Telavi – 20.0%, Gurjaani.

Intra-annual distribution of mean monthly values of Share of Rd and Share of W components of HCI value at all locations of Kakheti (Fig. 14, 15) have a bimodal type. Whereinto for both distributions, the first and second extremums coincide in time: December-February and July-August respectively. It should be noted that in both cases the summer extremum is significantly lower than the winter one.

Range of change of Share of Rd component of HCI value for all stations (first extremum) is as follow: 41.6%, Kvareli – 44.3%, Dedoplistskaro. Range of change of Share of Rd component of HCI value for all stations (second extremum) is as follow: 32.9%, Sagarejo – 35.4%, Kvareli.

Range of change of Share of W component of HCI value for all stations (first extremum) is as follow: 15.4%, Lagodekhi – 16.3%, Telavi. Range of change of Share of W component of HCI value for all stations (second extremum) is as follow: 12.6%, Sagarejo – 14.0%, Lagodekhi.

Range of change of different components of HCI for all station in year, cold and warm seasons is as follow respectively.

T component (Fig. 8). Year: 6.1, Dedoplistskaro – 6.3, Sagarejo, Telavi; cold season: 4.4, Dedoplistskaro – 5.1, Kvareli; warm season: 7.3, Lagodekhi – 8.0, Sagarejo.

A component (Fig. 9). Year: 5.5, Telavi – 6.3, Gurjaani, Sagarejo; cold season: 5.3, Telavi – 5.9, Gurjaani, Sagarejo; warm season: 5.7, Telavi – 6.7, Gurjaani, Sagarejo.

Rd component (Fig. 10). Year: 8.3, Lagodekhi – 8.8, Dedoplistskaro; cold season: 8.7, Lagodekhi – 9.0, Dedoplistskaro; warm season: 7.9, Lagodekhi – 8.7, Dedoplistskaro.

W component (Fig. 11). Year: 9.8, Lagodekhi – 10.0, Gurjaani, Kvareli, Telavi; cold season: 9.7, Lagodekhi – 10.0, Gurjaani, Kvareli, Telavi; warm season: 9.8, Lagodekhi – 10.0, all other locations.

Share of T component (Fig. 12, %). Year: 32.4, Dedoplistskaro – 34.2, Lagodekhi; cold season: 26.1, Dedoplistskaro – 29.6, Lagodekhi; warm season: 37.5, Gurjaani – 39.8, Telavi.

Share of A component (Fig. 13, %). Year: 15.3, Telavi – 17.2, Gurjaani; cold season: 15.9, Telavi – 17.6, Sagarejo; warm season: 14.7, Telavi – 17.1, Gurjaani.

Share of Rd component (Fig. 14, %). Year: 35.5, Lagodekhi – 37.2, Dedoplistskaro; cold season: 39.3, Kvareli – 41.6, Dedoplistskaro; warm season: 31.4, Lagodekhi – 32.8, Dedoplistskaro.

Share of W component (Fig. 15, %). Year: 13.7, Sagarejo – 14.1, Kvareli, Telavi; cold season: 14.8, Gurjaani, Lagodekhi – 15.3, Dedoplistskaro; warm season: 12.4, Sagarejo – 13.3, Lagodekhi.

### 3. Comparison of TCI and HCI at four location of Kakheti in 1961-2010.

Comparison of TCI and HCI values in many investigations are provided [17, 18, 20, 22, 23]. In Georgia, an analogous study conducted for Tbilisi [24].

Comparison of TCI and HCI at four location of Kakheti (Dedoplistskaro, Kvareli, Sagarejo and Telavi) in 1961-2010 is provided below (Fig. 16, 17, Table 16-18).

In Fig. 16 data about mean monthly and seasonal values of TCI and HCI at four locations of Kakheti in 1961-2010 are presented.

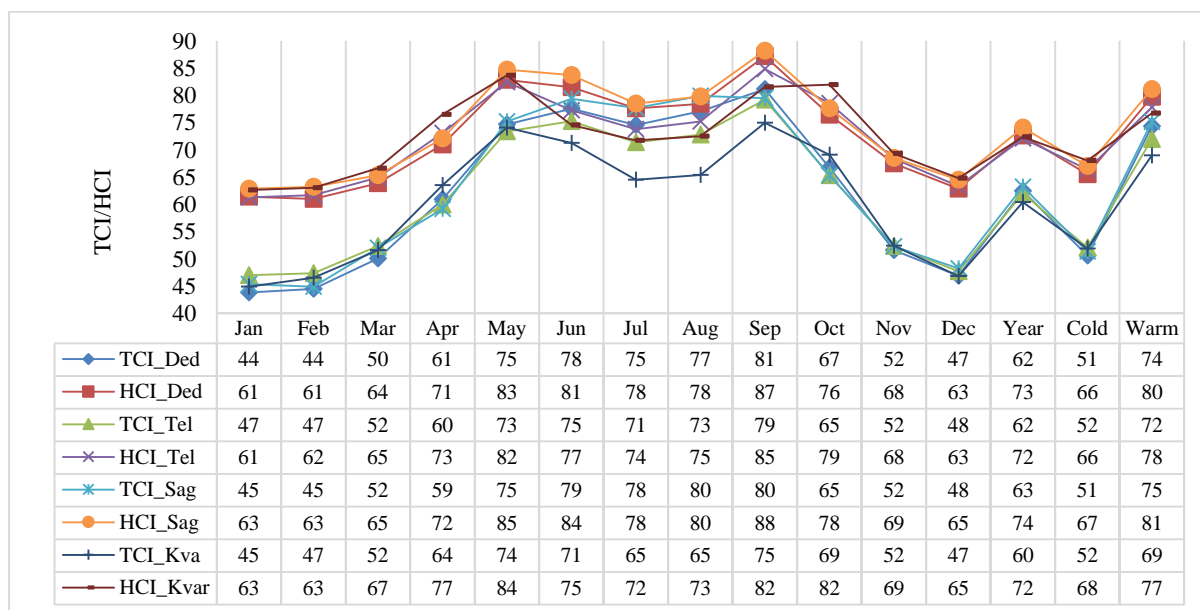


Fig. 16. Comparison of mean monthly and seasonal values of TCI and HCI at four location of Kakheti in 1961-2010.

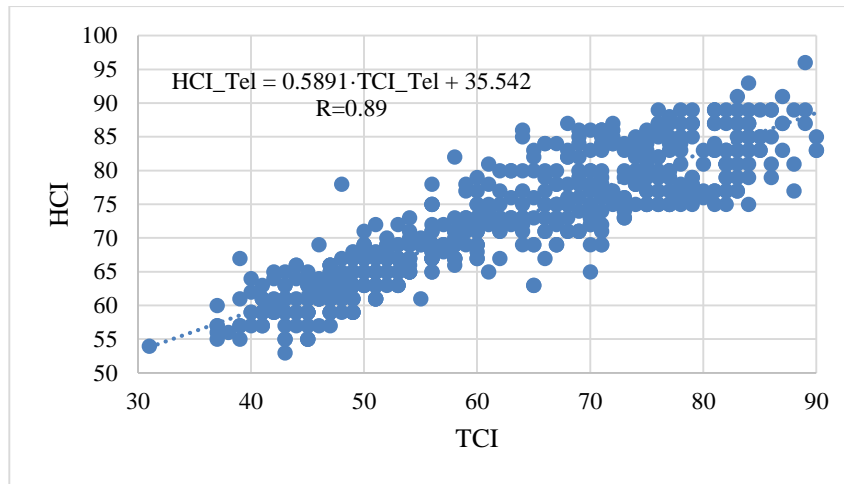


Fig. 17. Linear correlation and regression between monthly values of TCI and HCI in Telavi in 1961-2010.

$$\begin{aligned} \text{HCI\_Ded} &= 0.5886 \cdot \text{TCI\_Ded} + 35.869, (R=0.93); \text{HCI\_Kvar} = 0.584 \cdot \text{TCI\_Kvar} + 37.127, (R=0.88); \\ \text{HCI\_Sag} &= 0.587 \cdot \text{TCI\_Sag} + 36.969, (R=0.92); \text{For all values of } R, \alpha < 0.005. \end{aligned}$$

Comparison of the values and categories of the Tourism Climate Index [7] and Holiday Climate Index (Fig. 16, 17, Table 16-18) shows that the intra-annual variation of both indices is similar and has a bimodal form. Linear correlation between monthly values of TCI and HCI is high (Fig. 17, example for Telavi) and change from 0.88 (Kvareli) to 0.93 (Dedoplistskaro).

Table 16. Comparison of TCI and HCI categories at four location of Kakheti in cold period of year in 1961-2010.

Month	Jan	Feb	Mar	Oct	Nov	Dec	Cold	Year
<b>TCI_Ded</b>	Marg. Good	Marg. Good	Accept. Good	Good Very Good	Accept. Good	Marg. Good	Accept. Good	Good Very Good
<b>HCI_Ded</b>								
<b>TCI_Tel</b>								
<b>HCI_Tel</b>								
<b>TCI_Sag</b>				Good				
<b>HCI_Sag</b>								
<b>TCI_Kvar</b>								
<b>HCI_Kvar</b>				Excell.				

Table 17. Comparison of TCI and HCI categories at four location of Kakheti in warm period of year in 1961-2010.

Month	Apr	May	Jun	Jul	Aug	Sep	Warm		
<b>TCI_Ded</b>	Good	Very Good Excell.	Very Good	Very Good	Very Good	Excell.	Very Good		
<b>HCI_Ded</b>	Very Good		Excell.						
<b>TCI_Tel</b>	Accept. Very Good		Very Good						
<b>HCI_Tel</b>			Very Good						
<b>TCI_Sag</b>			Very Good						
<b>HCI_Sag</b>	Good		Excell.			Good	Good	Very Good Excell.	Good
<b>TCI_Kvar</b>			Very Good						
<b>HCI_Kvar</b>			Very Good						

Comparison of TCI and HCI categories shows, that in cold months, season and year HCI categories on 1-2 step higher than TCI categories (Table 16). Difference on 2 step in the following cases are observed: TCI\_Marginal → HCI\_Good, in January, February, December for all stations; TCI\_Good →



HCI\_Excellent, in October, for Kvareli. Difference on 1 step: TCI\_ Acceptable → HCI\_Good, in March, November, Cold season, for all stations; TCI\_Good → HCI\_Very Good in October for Dedoplistskaro, Telavi, Sagarejo and in year, for all stations.

Comparison of TCI and HCI categories in warm months and season shows, that HCI categories either the same than TCI categories, or 1-2 steps higher (Table 17).

Difference on 2 step in the following case is observed: TCI\_ Acceptable → HCI\_Very Good, in April for Telavi and Sagarejo.

Difference on 1 step: TCI\_ Good → HCI\_Very Good, in April, for Dedoplistskaro and Kvareli; in July, August and Warm season, for Kvareli; TCI\_Very Good → HCI\_ Excellent in May for all stations, in June for Dedoplistskaro and Sagarejo; in September, for Telavi, Sagarejo and Kvareli; in Warm season, for Sagarejo.

The same categories: Very Good, in June, for Telavi and Kvareli; in July and August, for Dedoplistskaro, Telavi and Sagarejo; in Warm season, for Dedoplistskaro and Telavi. Excellent, in September, for Dedoplistskaro.

Table 18. Comparison of Min and Max values of TCI and HCI and its category for four location of Kakheti in 1961-2010.

Parameter		Value	Location/Month/Category
TCI	Min	44	Dedoplistskaro, January, February, Marginal
	Max	81	Dedoplistskaro, September, Excellent
	Mean on Station	62	Good
HCI	Min	61	Good, Dedoplistskaro, January, February; Telavi, January
	Max	88	Sagarejo, September, Excellent
	Mean on Station	73	Very Good

In Table 18 comparison of Min and Max values of TCI and HCI and its category for four location of Kakheti is provided. As follows from this Table TCI value change from 44 (Dedoplistskaro, January, February, Marginal) to 81 (Dedoplistskaro, September, Excellent) and HCI value – from 61 (Good, Dedoplistskaro, January, February; Telavi, January) to 88 (Sagarejo, September, Excellent). Mean on the one station for TCI is 62 (Good) and for HCI - 73 (Very Good).

However, given that the TCI is calculated for the so-called “average tourist” (regardless of gender, age, physical condition), the value and category of this index is lower than the HCI values and categories. In general, HCI more adequately determines the bioclimatic state of the environment for the development of certain types of tourism (winter tourism, extreme tourism, etc.) than TCI.

## Conclusion

In the future, we are planning a more detailed study of the climatic resources of this and other regions of Georgia for tourism, recreation and treatment (mapping the territory on HCI and TCI, long-term forecasting of HCI and TCI, determining other modern climatic and bioclimatic indicators for tourism, recreation and treatment, assessing the adequacy of bioclimatic indicators scales to human health, etc.).

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## დასვენების კლიმატური ინდექსი კახეთში

ა.ამირანაშვილი, ლ.ქართველიშვილი

რეზიუმე

წარმოდგენილია მონაცემები დასვენების კლიმატური ინდექსის (დკი) მრავალწლიური საშუალო თვიური მნიშვნელობების შესახებ კახეთის 12 ადგილისთვის (ახმეტა, დედოფლისწყარო, გომბორი, გურჯაანი, ყვარელი, ლაგოდეხი, ომალო, საგარეჯო, შირაქი, თელავი, წნორი და უდაბნო). ამ რეგიონის 6 სადგურისთვის (დედოფლისწყარო, გურჯაანი, ყვარელი, ლაგოდეხი, საგარეჯო და თელავი) ჩატარებულია ყოველთვიური, სეზონური და წლიური დკი-ს მნიშვნელობების დეტალური ანალიზი 60 წლიანი პერიოდის განმავლობაში (1956-2015 წწ.). ჩატარებულია დკი-ს და ტურიზმის კლიმატური ინდექსის ყოველთვიური მნიშვნელობების შედარება კახეთის ოთხ პუნქტზე (დედოფლისწყარო, ყვარელი, საგარეჯო და თელავი) 1961-2010 წწ. მონაცემების საფუძველზე.

## Климатический Индекс Отдыха в Кахетии (Грузия)

А.Г. Амиранашвили, Л. Г. Картвелишвили

Резюме

Представлены данные о многолетних среднемесячных значениях Климата Индекса Отдыха (КИО) для 12 населенных пунктов Кахетии (Ахмета, Дедоплисцкаро, Гомбори, Гурджаани, Кварели, Лагодехи, Омало, Сагареджо, Шираки, Телави, Цнори и Удабно). Для 6 станций этого региона (Дедоплисцкаро, Гурджаани, Кварели, Лагодехи, Сагареджо и Телави) проведен детальный анализ месячных, сезонных и годовых значений КИО за 60-летний период времени (1956-2015 гг.). Проведено сравнение месячных значений КИО и Климатического Индекса Туризма для четырех пунктов Кахетии (Дедоплисцкаро, Кварели, Сагареджо и Телави) по данным с 1961 по 2010 гг.