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Statistical Characteristics of the Monthly Mean Values of Tourism Climate Index in Mestia (Georgia) in 1961-2010

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ABSTRACT

The statistical characteristics of the monthly mean values of the Tourism Climate Index (TCI) and its components for Mestia in the period from 1961 through 2010 are represented. In particular, the changeability of the indicated bioclimatic parameters into 1986÷2010 in comparison with 1961÷1985 is studied.

Key Words: Bioclimate, Tourism Climate Index.

Introduction

Health resort - tourist industry is one of the most important sectors of the world economy. This sector in many respects depends on geographical position, topography, landscape, vegetation, fauna, ecological situation, weather, climate and so forth weather and climate - this two factors, in many respects of the determining bioclimatic resources localities/terrains, which should be visited for the treatment, leisure or tourism. Therefore, to a study of these resources, which can be useful for organization or development of the health resort- tourist of branch, in many countries, including in Georgia, is paid special attention [1-9].

There are more than 200 biometeorological and bioclimatic indices, which determine the influence of meteorological and climatic factors on the health of people (Air Equivalent-Effective Temperature – EET, Air Effective Temperature - ET, Wet-Bulb-Globe Temperature - WBGT, Wind Chill – WCI, Cooling Power – CP, Subjective temperature index –STI, Perceived temperature - PMV, Physiologically Equivalent Temperature - PET, Standard Effective Temperature - SET, Physiological Subjective Temperature and Subjective Temperature - MENEX, Universal Thermal Climate Index – UTCI, etc.) [11-14, http://www.igipz.pan.pl/Bioklima-zgik.html]. With the use of different indices in the last century a study of bioclimate in many countries of world [13-22], including Georgia [6, 7, 10, 23-27] is carried out.

Several indices have been developed to assess the suitability of climate for tourism activities [2, 17, 28, 29]. The most widely known and applied index is the tourism climate index proposed by Mieczkowski [28]. This index is combination of seven factors and parameters. Mieczkowski's "Tourism Climate Index" (TCI) was designed to use climate data, being widely available for tourist destinations worldwide. Data about TCI are using for the information of "Average Tourist" and can be useful for the planning developments of mass tourism.

In some work the criticism of TCI is noted. Thus, in the paper [30] the Holiday Climate Index (HCI) was developed and discuss the design of the HCI and how the limitations of the TCI were overcome. It then presents an inter-comparison of the results from HCI:Urban and TCI for geographically diverse urban destinations across Europe. The results illustrate how the HCI:Urban rates the climate of many cities higher

than the TCI, particularly in shoulder seasons and the winter months, which is more consistent with observed visitation patterns. The authors note, that the results empirically demonstrate that use of the TCI should be discontinued.

However, in our opinion, until is revealed united bioclimatic index for the tourism, use of TCI, in spite of its deficiencies, it is nevertheless useful (at least, is a possibility of the comparison of the level of bioclimatic comfort for the "Average Tourist" in the different countries).

TCI (frequently together with other bioclimatic indices) sufficiently long ago is used in many countries of the world [2, 3, 29, 31- 47], including the South and Nord Caucasus regions [10, 41, 48-56].

The number of works is dedicated to the study of the influence of climate change to the TCI changeability [10, 22, 29, 35, 37, 41, 52, 56, etc.].

In Georgia the changeability of TCI in the period from 1961 through 2010 was studied for four points of Adjarian Autonomous Republic [10, 52] and four points of Kakheti region [56]. For the indicated localities the monthly average values of TCI with the use data of Georgian National Environmental Agency [57] are calculated.

In particular in 1986-2010 in comparison with 1961-1985 the average number of days per annum with the categories of TCI "Marginal" and higher, with those causing for the "Average Tourist" favorable bioclimatic situation, in the separate points of Adjarian Autonomous Republic it changed as follows: Batumi - insignificant decrease - 293 and 286 days, respectively; Kobuleti - invariability (on 278 days for both periods of time); Khulo - significant decrease (281 and 264 days, respectively); Goderzi - significant increase (178 and 200 days, respectively) [10, 52]. In Kakheti these changes are the following: Telavi - practically invariability (357 and 359 days, respectively); Dedoplistskaro - insignificant decrease (348 and 341 days, respectively); Kvareli - practically invariability (341 and 345 days, respectively); Sagarejo - small increase (346 and 353 days, respectively) [56].

In this work the changeability of TCI and its components for Mestia from 1961 to 2010 is studied.

Study Area, material and methods

Study area – Mestia. Mestia (population - 2700 people) is a small town and the capital of the Svaneti Region and has been named a World Heritage by UNESCO.

Mestia is situated 425 km (distance by car) from Georgia's capital city, Tbilisi, and located at 1500 meters above sea level.Mestia is a paradise for mountain lovers and home to the country's highest mountain Shara (5201 metres above sea level).

This young mountain resort of Georgia with well-developed tourism facilities gives huge opportunities for free riding, backcountry skiing, glade skiing, and cross country skiing. Mestia and the surrounding villages with their medieval towers are unique and very beautiful. There are two ski resorts in this area, Hatsvali, and Tetlundi. These resorts are covered by stunning pine forests and are perfect for enjoying glade skiing. Hatsvali is for beginners and intermediate skiers with short and well-groomed slopes that are easy to ride. Tetnuldi ski area is for skiers of any level with slopes ranging from easy to extremely hard. It is surrounded by tall mountains and the Alpine zone with great snow conditions.

Tourists interested in religious history will find plenty of examples of wall paintings, frescoes and icons from the Middle Ages in the churches around Mestia. Within Mestia, the Church of Saint George contains well-preserved crosses and icons from the XII century. Additionally, Pusdi Church still contains fragments of XIII century wall paintings [https://www.houseoftours.com/travel-tips/amazing-ski-resorts-perfect-skiing-in-georgia; https://www.georgia.travel/destinations/mestia].

Coordinates and heights of the meteorological stations in Mestia: Latitude – 43.05° N, Longitude – 42.75 E°, Height - 1441 m, a.s.l., straight distance from Tbilisi – 225 km (Fig. 1).

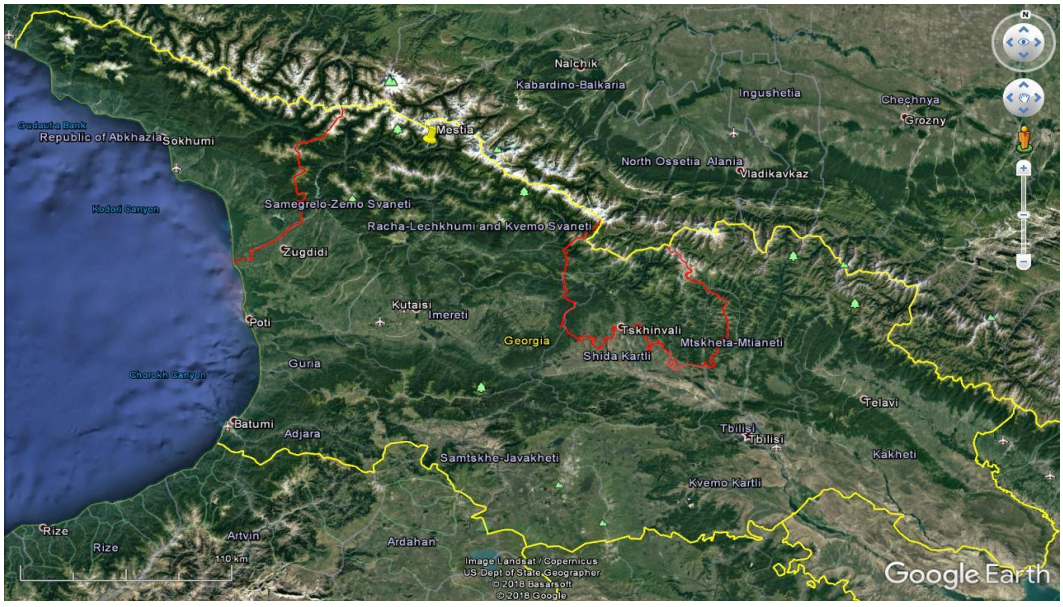


Fig.1. Locations of meteorological stations in Mestia

In the work the Tourism Climate Index (TCI) developed by Mieczkowski [28] is used. TCI is a combination of seven parameters, three of which are independent and two in a bioclimatic combination:

$$TCI = 8 \cdot Cld + 2 \cdot Cla + 4 \cdot R + 4 \cdot S + 2 \cdot W$$

Where Cld is a daytime comfort index, consisting of the mean maximum air temperature Ta, max (°C) and the mean minimum relative humidity RH (%), Cla is the daily comfort index, consisting of the mean air temperature (°C) and the mean relative humidity (%), R is the precipitation (mm), S is the daily sunshine duration (h), and W is the mean wind speed (m/s).

In contrast to other climate indices, every contributing parameter is assessed. Because of a weighting factor (a value for TCI of 100), every factor can reach 5 points. TCI values >= 80 are excellent, while values between 60 and 79 are regarded as good to very good. Lower values (40 – 59) are acceptable, but values < 40 indicate bad or difficult conditions for understandable to all tourism.

Table 1 presents information about the categories of TCI depending on its values. In the right column of table are given frequently used below the shortened versions of these categories.

Table 1

Categories of TCI

TCI	Category	Categ.	TCI	Category	Categ.
90 ÷ 100	Ideal	Ideal	40 ÷ 49	Marginal	Marg.
80 ÷ 89	Excellent	Excell.	30 ÷ 39	Unfavorable	Unf.
70 ÷ 79	Very Good	V_Good	20 ÷ 29	Very Unfavorable	V_Unf.
60 ÷ 69	Good	Good	10 ÷ 19	Extremely Unfavorable	Extr. Unf.
50 ÷ 59	Acceptable	Accept.	- 30 ÷ 9	Impossible	Imp.

For the indicated localitie the monthly average values of TCI in the period from 1961 through 2010 with the use data of Georgian National Environmental Agency are calculated.

For the data analysis the standard statistical methods of the studies were used [58]. The following designations will be used below: Mean – average values; Min – minimal values; Max - maximal values; Range = Max-Min; St Dev – standard deviation; σ_m - standard error; Cv = 100·St Dev/Mean, coefficient of variation (%); Skew - coefficient of skewness; Kurt - coefficient of kurtosis; R^2 – coefficient of determination; 99% Low and 99% Upp – 99% confidence interval of lower and upper calculated level accordingly. The difference between the mean values of TCI into 1986-2010 and 1961-1985 with the use of Student's criterion was determined (level of significance not worse than 0.15).

Results and discussion

Results in the Table 2-5 and Fig. 2-6 are presented.

Table 2-4 and in Fig. 2,3 presents the generalized statistical data about the values of TCI for Mestia. The results of the analysis of these data are given below.

Mean monthly values of TCI varied from 30.5 (Dec, Unf.) to 76.1 (Jul, V_Good). Range of a change of the values of TCI in 1961÷2010 - from 13.0 (Jan, Extr. Unf.) to 88.0 (Aug, Excell.).

99% Low and Upp level of confidence interval of mean values of TCI change from 28.1 (Dec, V_Unf.) to 78.0 (Jul, V_Good).

The largest variations in TCI values are observed in October and December (Cv = 23.1%), the smallest - in July (Cv = 7.0%).

The distribution of TCI values in individual months is close to normal (corresponding values of the Skew and Kurt coefficients).

The intra-annual distribution of mean monthly values of TCI in Mestia is unimodal with the plateau from June through September and take the form of eight power polynomial.

For comparison, we note that this distribution for the previously studied points of Kakheti is the following: Telavi - bimodal with the extrema in May-June and September; Dedoplistskaro - bimodal with the extrema during June and September; Kvareli - bimodal with the extrema during May and September; Sagarejo - unimodal with the plateau from June through September [56]. But all four distributions, as in Tbilisi, Baku and Yerevan [51], take the form of ninth power polynomial.

Table 2

Statistical characteristics of TCI in Mestia

Param.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TCI												
Mean	32.1	36.6	43.2	50.3	66.7	74.5	76.1	75.7	74.7	56.2	41.1	30.5
Min	13.0	23.0	25.0	35.0	47.0	61.0	65.0	62.0	56.0	38.0	22.0	21.0
Max	52.0	50.0	55.0	72.0	84.0	86.0	87.0	88.0	85.0	87.0	64.0	49.0
Range	39.0	27.0	30.0	37.0	37.0	25.0	22.0	26.0	29.0	49.0	42.0	28.0
Median	33.0	35.5	43.5	50.0	67.0	75.5	77.0	76.5	75.0	53.5	42.5	32.0
Mode	35.0	35.0	41.0	37.0	77.0	81.0	77.0	72.0	77.0	46.0	43.0	32.0
St Dev	7.37	6.20	6.83	9.09	9.31	6.15	5.34	6.14	6.37	13.01	8.97	6.50
σ_m	1.05	0.89	0.98	1.30	1.33	0.88	0.76	0.88	0.91	1.86	1.28	0.93
Cv (%)	23.0	16.9	15.8	18.1	14.0	8.3	7.0	8.1	8.5	23.1	21.8	21.3
Skew	-0.1	0.2	-0.6	0.3	-0.1	-0.4	-0.3	-0.2	-0.7	0.7	0.1	0.3
Kurt	0.7	-0.5	0.3	-0.5	-0.5	-0.5	-0.7	-0.3	0.6	-0.5	-0.3	-0.2
99% Low	29.4	34.4	40.7	47.0	63.3	72.3	74.1	73.4	72.3	51.4	37.8	28.1
99% Upp	34.8	38.9	45.7	53.6	70.1	76.7	78.0	77.9	77.0	61.0	44.4	32.9

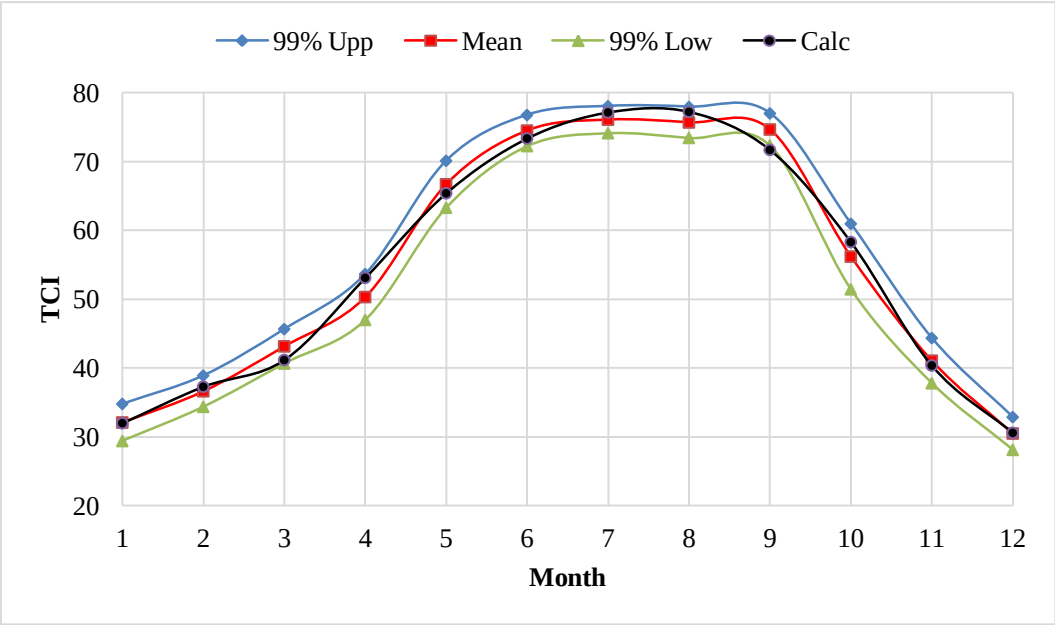


Fig.2. Mean real and calculated values of TCI and their 99% confidence interval in Mestia

Table 3

Coefficients of the equation of the regression of the intra-annual motion of mean monthly values of TCI for Mestia

Equation of regression	$TCI = a \cdot X^8 + b \cdot X^7 + c \cdot X^6 + d \cdot X^5 + e \cdot X^4 + f \cdot X^3 + g \cdot X^2 + h \cdot X + i$, (X-Month)		
Coefficients	Value	Coefficients	Value
a	-0.00011	f	66.03142
b	0.006476	g	-160.213
c	-0.15528	h	196.2885
d	2.003176	i	-56.9114
e	-15.0458	R^2	0.99085

Table 4

Statistical characteristics of TCI category in Mestia in 1961-2010

Parameter	**TCI category**					
Month	Jan	Feb	Mar	Apr	May	Jun
Mean	Unf.	Unf.	Marg.	Accept.	Good	V_Good
Min	Extr. Unf.	V_Unf.	V_Unf.	Unf.	Marg.	Good
Max	Accept.	Accept.	Accept.	V_Good	84	86
Month	Jul	Aug	Sep	Oct	Nov	Dec
Mean	V_Good	V_Good	V_Good	Accept.	Marg.	Unf.
Min	Good	Good	Accept.	Unf.	V_Unf.	V_Unf.
Max	Excell.	Excell.	Excell.	Excell.	Good	Marg.

Fig.3. Category of TCI in Mestia and their 99% confidence intervals in different months of year (Photo from [https://georgia.travel/en_US/svaneti/mestia])

Table 5

Monthly variations of TCI and TCI components in Mestia in 1961-2010

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Param.	**TCI**											
Mean 1961-2010	32.1	36.6	43.2	50.3	66.7	74.5	76.1	75.7	74.7	56.2	41.1	30.5
I - Mean 1986-2010	31.0	34.8	42.7	50.8	66.9	73.8	75.8	75.5	74.4	55.9	40.6	29.6
II - Mean 1961-1985	33.2	38.4	43.6	49.8	66.5	75.2	76.4	75.9	74.9	56.5	41.6	31.4
Differ. I-II, $\alpha \leq 0.15$	No	-3.6	No	No	No	No	No	No	No	No	No	No
Param.	**Cld**											
Mean 1961-2010	1.3	1.5	2.0	2.7	4.1	4.9	4.9	4.9	4.8	3.1	2.0	1.4
I - Mean 1986-2010	1.2	1.5	2.0	2.8	4.1	4.9	4.9	4.8	4.8	3.2	2.0	1.4
II - Mean 1961-1985	1.3	1.5	2.0	2.5	4.1	4.9	5.0	5.0	4.9	3.1	2.0	1.4
Differ. I-II, $\alpha \leq 0.15$	-0.14	No	No	0.3	No	No	No	-0.2	No	No	No	No
Param.	**Cla**											
Mean 1961-2010	0.4	0.8	1.3	1.8	2.3	2.7	3.4	3.3	2.5	2.0	1.4	0.7
I - Mean 1986-2010	0.4	0.7	1.3	1.8	2.3	2.7	3.6	3.6	2.5	2.0	1.4	0.8
II - Mean 1961-1985	0.3	0.8	1.3	1.8	2.4	2.6	3.3	3.0	2.5	2.0	1.4	0.6
Differ. I-II, $\alpha \leq 0.15$	No	No	No	No	-0.1	0.14	0.28	0.54	No	0.08	No	No
Param.	**R**											
Mean 1961-2010	3.1	3.2	2.8	2.3	2.3	2.0	2.3	2.3	2.5	2.2	2.6	2.5
I - Mean 1986-2010	2.9	2.8	2.5	2.1	2.1	2.0	2.4	2.5	2.5	2.0	2.4	2.2
II - Mean 1961-1985	3.3	3.7	3.0	2.4	2.4	2.0	2.2	2.0	2.4	2.4	2.7	2.7
Differ. I-II, $\alpha \leq 0.15$	No	-0.88	-0.52	No	No	No	No	No	No	No	No	No
Param.	**S**											
Mean 1961-2010	1.4	1.6	2.2	2.1	2.7	3.2	3.7	3.7	2.9	2.4	1.6	1.1
I - Mean 1986-2010	1.4	1.6	2.3	1.9	2.8	3.0	3.7	3.7	2.9	2.3	1.7	1.1
II - Mean 1961-1985	1.3	1.6	2.0	2.2	2.7	3.4	3.7	3.7	2.9	2.4	1.5	1.1
Differ. I-II, $\alpha \leq 0.15$	No	No	0.3	-0.24	No	-0.3	No	No	No	No	0.18	No
Param.	**W**											
Mean 1961-2010	1.6	1.8	2.5	3.9	4.7	4.5	2.9	3.0	4.7	4.4	2.7	1.7
I - Mean 1986-2010	1.5	1.8	2.5	4.1	4.9	4.4	2.6	2.5	4.6	4.4	2.7	1.7
II - Mean 1961-1985	1.6	1.8	2.5	3.7	4.5	4.6	3.2	3.5	4.8	4.4	2.8	1.7
Differ. I-II, $\alpha \leq 0.15$	No	No	No	0.4	0.44	No	-0.6	-1.02	No	No	No	No

Table 5 presents information about the values of TCI and TCI components in Mestia in 1961-2010 and their changeability in 1986-2010 in comparison with 1961-1985 In particular, the range of mean for two

periods observations of the values of TCI and components of TCI and their changeability in the second period of time in comparison with the first are following:

TCI: 29.6÷ 76.4 (December and July respectively). Changeability is observed only during February (decrease in the limits of one and the same category);

Cld: 1.2÷5.0 (January, July and August respectively). Changeability is observed during January (decrease), April (increase) and August (decrease);

Cla: 0.3÷3.6 (January and July, August respectively); Changeability is observed during May (decrease), from June to August and October (increase);

R: 2.0÷3.7 (June, August October and February, respectively). Changeability is observed during February and March (decrease);

S: 1.1÷3.7 (December and July, August respectively). Changeability is observed during March (increase), April, June (decrease) and November (increase);

W: 1.5÷4.9 (January and May respectively). Changeability is observed in April, May (increase) and July, August (decrease).

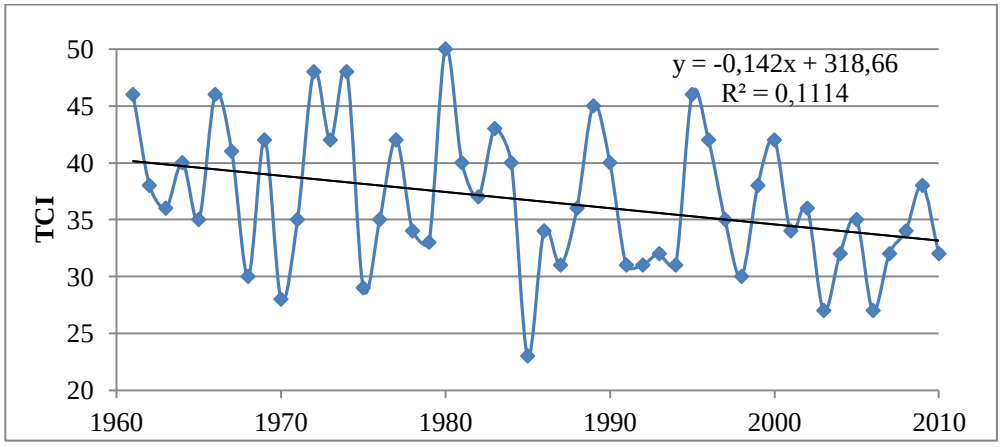
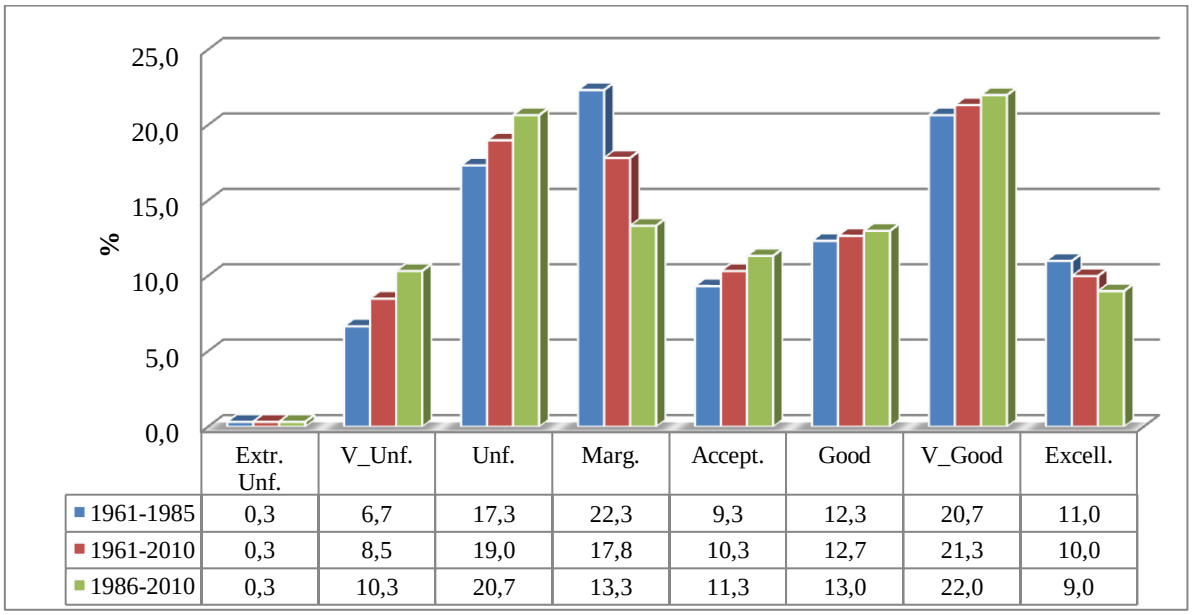


Fig.4. Trend of TCI in Mestia in 1961-2010 (Feb)

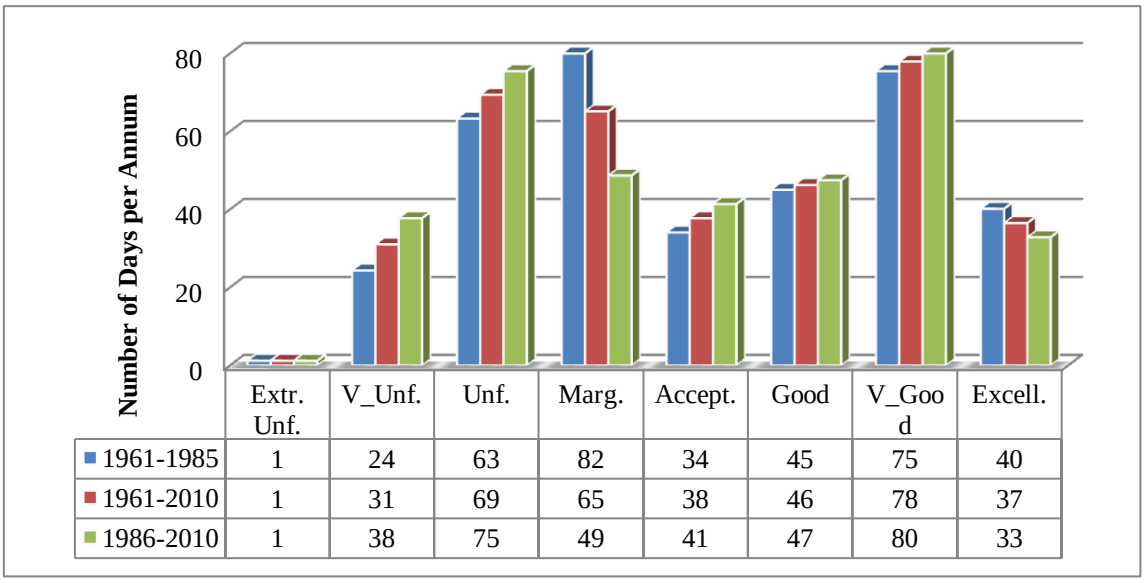
The graph of linear trend of TCI in the period from 1961 through 2010 for February in Fig. 4 is depicted.



	Extr. Unf.	V_Unf.	Unf.	Marg.	Accept.	Good	V_Good	Excell.
1961-1985	0,3	6,7	17,3	22,3	9,3	12,3	20,7	11,0
1961-2010	0,3	8,5	19,0	17,8	10,3	12,7	21,3	10,0
1986-2010	0,3	10,3	20,7	13,3	11,3	13,0	22,0	9,0

Fig.5. Repetition of category of monthly values of TCI in Mestia in three period of time

Fig.5 presents data about repetition of category of monthly values of TCI in Mestia in three period of time. As follows from this Fig. in different period of time repetition with TCI category “Magr.- Excell.” is following: 1961÷1985 – 75.7 %, 1961÷2010 – 72.2 %, 1986÷2010 – 68.7 %



	Extr. Unf.	V_Unf.	Unf.	Marg.	Accept.	Good	V_Good	Excell.
1961-1985	1	24	63	82	34	45	75	40
1961-2010	1	31	69	65	38	46	78	37
1986-2010	1	38	75	49	41	47	80	33

Fig.6. Number of days per annum with different category of TCI in Mestia in three period of time

Finally, Fig.6 presents data about number of days per annum with different category of TCI in Mestia in three period of time. As follows from Fig. 6 in different period of time number of days per annum with TCI category “Magr.- Excell.” is following: 1961÷1985 – 276 , 1961÷2010 – 264 , 1986÷2010 – 251.

Thus, in 1986-2010 in comparison with 1961-1985 the average number of days per annum with the categories of TCI "Marginal" and higher, with those causing for the "Average Tourist" favorable bioclimatic situation, decreased by 13 days.

Conclusion

Climate has a strong influence on the tourism and recreation sector and in some regions represents the natural resource on which the tourism industry is predicated. In this work the determination of the climatic potential of tourism for Mestia (Georgia) into the correspondence with that frequently utilized in other countries of the “Tourism Climate Index” (TCI) is carried out.

In the future we plan a more detailed study of the climatic resources of this and others regions of Georgia for the tourism (mapping the territory on TCI, long-term prognostication of TCI, determination of other contemporary climatic and bioclimatic indices for tourism – HCI etc.).

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მესტიაში (საქართველო) ტურიზმის კლიმატური ინდექსის საშუალო თვიური მნიშვნელობის სტატისტიკური მახასიათებლები 1961-2010 წწ.

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რეზიუმე

ნაშრომში წარმოდგენილია ტურიზმის კლიმატური ინდექსის (TCI) საშუალო თვიური საშუალო წლიური მნიშვნელობები მესტიაში 1961÷2010 წ.წ. პერიოდის მიხედვით. კერძოდ, შესწავლილია აღნიშნული ბიოკლიმატური პარამეტრების ცვლილება 1986÷2010 წლებში 1961÷1985 წლებთან შედარებით.

Статистические характеристики среднемесячных значений климатического индекса туризма в Местия (Грузия) в 1961-2010 гг.

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Резюме

Представлены статистические характеристики среднемесячных значений климатического индекса туризма (TCI) и его составляющих для Местия (Грузия) в период с 1961 по 2010 гг. В частности, изучена изменчивость указанных биоклиматических параметров в 1986÷2010 гг. по сравнению с 1961÷1985 гг.