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Comparative Characteristics of the Tourism Climate Index in the South Caucasus Countries Capitals (Baku, Tbilisi, Yerevan)

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Abstract

Comparative analysis of the monthly values of Tourism Climate Index (TCI) in the South Caucasus countries capitals (Baku, Tbilisi, Yerevan) are presented. The statistical structure of TCI is studied. In the indicated cities between the TCI values are the high linear correlation, which reaches 1. The intra-annual distribution of the TCI values for all cities has bimodal nature with the extremum during June and September and by the polynomial of the ninth power are described. In Tbilisi, in comparison with Baku and Yerevan, from May through September somewhat decreased values of TCI are observed, which is caused by heavier precipitation and smaller sunshine duration in the capital of Georgia. As a whole, the climate of all three capitals is suitable for the year-round mass tourism (TCI categories changes from "Marginal" to "Excellent" in Tbilisi and from "Marginal" to "Ideal" in Baku and Yerevan, with the average annual category for all cities – "Good").

Key words: tourism climate index, bioclimate.

INTRODUCTION

Tourism as an important sector of the global economy is influenced by geographical location, topography, landscape, vegetation, fauna, ecological situation, weather, climate, etc. Weather and climate are two factors that in many respects influence decisions regarding areas to be visited [1]. Many climate indices for tourism have been applied in past research. Survey information about them can be found for example in the works [1, 2].

A climate index approach is one way and researchers have attempted to represent the multifaceted nature of the climate potential for tourism. Several indices have been developed over the last 45 years to assess the suitability of climate for tourism activities [3-6].

The most widely known and applied index is the tourism climate index proposed by Mieczkowski [3]. 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.

TCI is used in many countries of world [2,4,5,7,8], including such countries of Black Sea-Caspian region as Turkey [9] and Iran [10-14]. In south Caucasus countries, monthly value of TCI be calculated in Georgia, first for Tbilisi [15], then for Batumi and Anaklia [16-18].

For the tourism climatology recently is used also this bioclimatic parameter, as Physiologically Equivalent Temperature (PET) - combination of daily air temperature, relative humidity, wind velocity

and mean cloud cover, etc. PET is one of the most popular physiological thermal indices derived from the human energy balance, is used in the analysis in order to describe the effect of climate [19-21].

For evaluating the bioclimatic potential of locality in Georgia from the human thermal comfort the complex thermal indices, as Air Equivalent-Effective Temperature (EET- combination of air temperature, relative humidity and wind velocity) and Air Radiationally Equivalent-Effective Temperature (REET- combination of air temperature, relative humidity, wind velocity and solar radiation intensity) was used [22,23]. In particular: the long–term variations of EET in Tbilisi and Kutaisi was study [24,25]; the connection of EET with the health of the population of Tbilisi city is studied [26]; it is shown, that as a whole in the days with the smog situation together with air pollution by ozone, the ozone forming gases and the aerosols under the conditions Tbilisi (especially suffering cardiovascular diseases) an essential effect on the health of people have the thermal regime of air [27]; it is shown that the values of EET and REET in the different places of Tbilisi city essentially differ from each other [28]; comparative analysis of EET in some cities of Georgia and Brazil was carried out [29]; is examined a question about the use of data about air thermal regime (as and TCI), with certification of the health resort and tourist resources of Georgia [18, 30].

At present the sensation of man to the thermal action of air, the climatic indices of tourism, etc. usually are described not by physical quantities, but by terms (“coldly”, “comfortably”, “warmly”, etc.). A similar terminology is more intelligible for the wide circle of population, than physical quantities. One cannot fail to note that about three centuries ago for describing the climate of Georgia similar terms used the famous Georgian historian and geographer Vakhushti Bagrationi [31].

As it follows of the aforesaid above, to the studies of the complex bioclimatic characteristics of health resort and tourist zones (including TCI) to be of great importance. The significant studies on these questions in Turkey and Iran are carried out [9-14]. At the same time, an explicit deficiency in the studies of the tourism climate index in the countries of South Caucasus (adjacent with Turkey and Iran) is observed (especially in Armenia and Azerbaijan).

The purpose of this paper is to determine tourism climate conditions (TCI) in Baku and Yerevan in comparison with Tbilisi and the most suitable months for tourism and tourist activities in these cities. This work is the beginning of a more detailed study of the indicated index of tourism in these countries, which will make it possible to reveal the common picture of the distribution of this bioclimatic factor for entire Black Sea-Caspian region.

STUDY AREA, METHOD AND DATA DESCRIPTION

The study area the capitals of Azerbaijan, Georgia and Armenia (Baku, Tbilisi and Yerevan) are. The location of these cities in fig. 1 is presented.

Fig. 1 Location of Baku, Tbilisi and Yerevan

Brief geographical and climatic description of these cities is represented below.

Baku (40.42° N, 49.77° E, H – 61 m a.s.l.) is situated on the western coast of Caspian Sea. In the vicinity of the city there are a number of mud volcanoes and salt lakes. Baku has a subtropical semi-arid climate with warm and dry summers, cool and occasionally wet winters, and strong winds all year long. However, unlike many other cities with this climate, Baku does not see extremely hot summers. This is largely because of its northerly latitude and the fact that it is located on a peninsula on the shore of the Caspian Sea. Baku and the Absheron Peninsula on which it is situated, is the most arid part of Azerbaijan (precipitation here is around or less than 250 mm a year). The majority of the light annual precipitation occurs in seasons other than summer, but none of these months are particularly wet.

At the same time Baku is noted as a very windy city throughout the year, hence the city's nickname the "City of Winds", and gale-force winds, the cold northern wind khazri and the warm southern wind gilavar are typical here in all seasons. The daily mean temperature in July and August averages 26.2 °C, and there is very little rainfall during that season. During summer the khazri sweeps through, bringing desired coolness. Winter is cool and occasionally wet, with the daily mean temperature in January and February averaging 4.6 °C. During winter the khazri sweeps through, driven by polar air masses; temperatures on the coast frequently drop below freezing and make it feel bitterly cold. Winter snow storms are occasional; snow usually melts within a few days after each snowfall [32, 33].

Tbilisi (41.68° N, 44.95° E, H – 490 m a.s.l.) lies in Eastern Georgia on both banks of the Mtkvari (Kura) River. The elevation of the city ranges from 380–770 meters above sea level and has the shape of an amphitheatre surrounded by mountains on three sides. To the north, Tbilisi is bounded by the Saguramo Range, to the east and south-east by the Iori Plain, to the south and west by various endings

(sub-ranges) of the Trialeti Range. The relief of Tbilisi is complex. The part of the city which lies on the left bank of the Mtkvari (Kura) River extends for more than 30 km from the Avchala District to River Lochini. The part of the city which lies on the right side of the Mtkvari River on the other hand is built along the foothills of the Trialeti Range, the slopes of which in many cases descend all the way to the edges of the river Mtkvari. The mountains, therefore, are a significant barrier to urban development on the right bank of the Mtkvari River. This type of a geographic environment creates pockets of very densely developed areas while other parts of the city are left undeveloped due to the complex topographic relief.

The average annual temperature in Tbilisi is 12.8 °C. January is the coldest month with an average temperature of 0.9 °C. July is the hottest month with an average temperature of 24.4 °C. Average annual precipitation is 538 mm. May and June are the wettest months (averaging 84 mm of precipitation each) while January is the driest (averaging 20 mm of precipitation). Snow falls on average 15–25 days per year. The surrounding mountains often trap the clouds within and around the city, mainly during the Spring and Autumn months, resulting in prolonged rainy and cloudy weather. Northwesterly winds dominate in most parts of Tbilisi throughout the year. Southeasterly winds are common as well [23,32,34].

Yerevan (40.13° N, 44.47° E, H – 890 m a.s.l.) has an average height of 990 m, with a minimum of 865 m and a maximum of 1390 m above sea level. It is located on to the edge of the Hrazdan River, northeast of the Ararat plain (Ararat Valley), to the center-west of the country. The upper part of the city is surrounded with mountains on three sides while it descends to the banks of the river Hrazdan at the south. Hrazdan divides Yerevan into two parts through a picturesque canyon.

The climate of Yerevan is continental semi-arid, with the influence of mountain climate, with hot dry summers and cold snowy winters. This is attributed to Yerevan being on a plain surrounded by mountains and to its distance from the sea and its effects. The summers are usually very hot with the temperature in August reaching up to 40 °C (average temperature in July-August is 25.3 °C) , and winters generally carry snowfall and freezing temperatures with January often being as cold as –15 °C (average temperature in January-February is -3.1 °C). The amount of precipitation is small, amounting annually to about 340 mm (in July-September mean monthly value of precipitation is 12 mm). Yerevan experiences an average of 2470 sunlight hours per year (in July-August mean monthly sunlight hours is 338) [32, 35].

In the indicated cities is paid special attention for the development of local and international tourism. Here are many historical and cultural objects, developed contemporary tourist infrastructure. Information about the climatic indices of tourism will be useful for planning the most optimum forms of tourist service depending on the seasons of year.

In the work the Tourism Climate Index (TCI) developed by Mieczkowski [3] 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 [3]. Information about TCI category in table 1 is presented.

Table 1 TCI category

TCI	Category	კატეგორია	Категория
90 ÷ 100	Ideal	იდეალური	Идеальный
80 ÷ 89	Excellent	შესანიშნავი	Отличный
70 ÷ 79	Very Good	ძალიან კარგი	Очень хороший
60 ÷ 69	Good	კარგი	Хороший
50 ÷ 59	Acceptable	სასიამოვნო	Приятный
40 ÷ 49	Marginal	მისაღები	Приемлемый
30 ÷ 39	Unfavorable	არახელსაყრელი	Неблагоприятный
20 ÷ 29	Very Unfavorable	ძალიან არახელსაყრელი	Очень неблагоприятный
10 ÷ 19	Extremely Unfavorable	უკიდურესად არახელსაყრელი	Крайне неблагоприятный
- 30 ÷ 9	Impossible	მიუღებელი	Неприемлемый

For the TCI calculation data of reference books according to the climate USSR, and also the information [23, 32] was used.

RESULTS AND DISCUSSION

The results of TCI calculations in table 2- 3 and fig. 2-7 are presented.

The statistical characteristics of TCI in Baku, Tbilisi and Yerevan in table 2 are presented. As follows from this table the average annual values of TCI for these cities approximately identical and corresponds to category “Good” (table 1). The values of TCI in Baku and Yerevan respectively change from 42 to 96 and from 40 to 90 (TCI categories from “Marginal” to “Ideal”), and in Tbilisi - from 47 to 83 (TCI categories from “Marginal” to “Excellent”). The changeability of TCI values in Tbilisi is lower than in Baku and Yerevan (the coefficients of variation Cv are respectively equal 22.2 % and 28.5 %). In the indicated cities between the TCI values are the high linear correlation, which reaches 1 (0.95-0.99).

The intra-annual distribution of the TCI values for all cities by the polynomial of the ninth power are described (the values of the coefficients of the equation of regression in table 2 are presented).

Table 2 The statistical characteristics of TCI in Baku, Tbilisi and Yerevan

Parameter	Baku	Tbilisi	Yerevan
Mean	68	65	67
Min	42	47	40
Max	96	83	90
Range	54	36	50
St Dev	19.4	14.4	19.2

Cv,%	28.5	22.2	28.6
	Correlation Matrix		
Baku	1	0.97	0.95
Tbilisi	0.97	1	0.99
Yerevan	0.95	0.99	1
	Equation of regression (X-Month): $TCI = a \cdot X^9 + b \cdot X^8 + c \cdot X^7 + d \cdot X^6 + e \cdot X^5 + f \cdot X^4 + g \cdot X^3 + h \cdot X^2 + i \cdot X + j$		
a	-0.00046	-0.000158	-0.0002
b	0.027202	0.009211	0.012164
c	-0.6768	-0.22664	-0.30811
d	9.313112	3.06806	4.308201
e	-77.4712	-24.9827	-36.3832
f	400.1821	125.8938	190.9943
g	-1270.38	-390.183	-618.776
h	2364.626	715.2294	1184.654
i	-2305.93	-695.292	-1193.99
j	922.3333	313.5	510.5
R^2	0.997	0.995	0.997

The data about the monthly values of TCI in fig. 2 are presented. Taking into account the high values of the coefficients of determination R^2 in this figure they are given only calculated values of TCI (real and calculated values of TCI practically are identical).

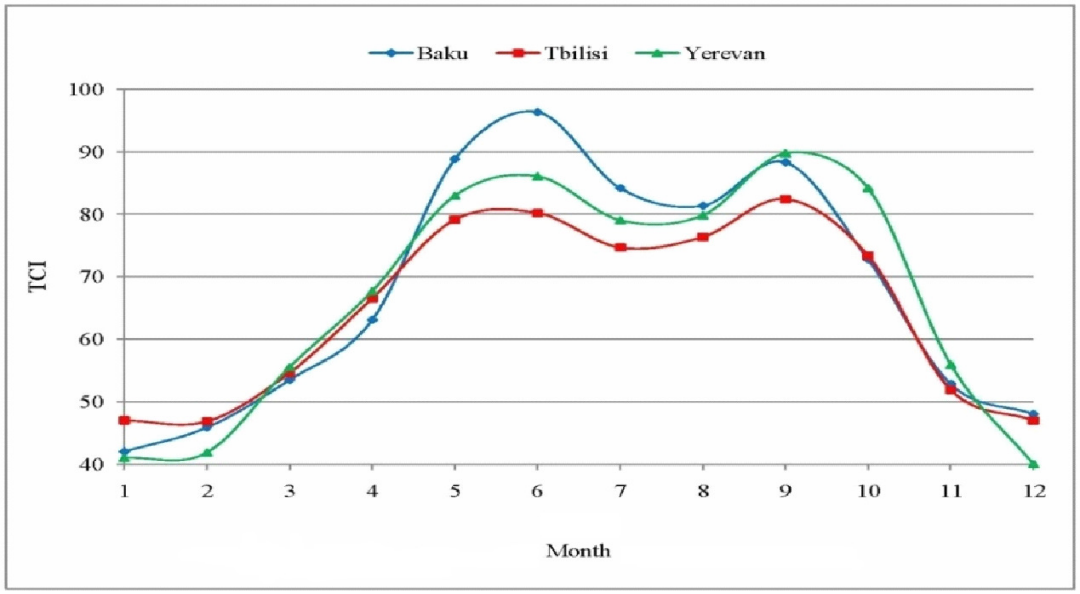

Fig. 2 Calculated values of TCI in Baku, Tbilisi and Yerevan

As follows from fig.2 the intra-annual distribution of the TCI values for all cities has bimodal nature with the extremum during June and September. Let us note that the bimodal type of distribution of TCI values in many other places is observed. For example the cities of Mahabad, Jolfa, Marageh, Sagez, and Parsabad (Iran) had a bimodal-shoulder peak distribution The TCI maximum values were found in May, June and October. In these cities the spring and autumn weather are climatically comfortable for tourism [10]. New Orleans, Charleston, New York, St. Louis, Batumi also relate to the cities with bimodal-shoulder peak TCI distribution [5, 16], etc.

For determining the reasons for the bimodality TCI values distribution, and also decreased of their values in Tbilisi, let us examine the statistical characteristics of separate components of TCI (table 3, fig. 3-6).

Table 3 The statistical characteristics of TCI components in Baku, Tbilisi and Yerevan (in the brackets - share of the average annual TCI values, %)

TCI components	Parameter	Baku	Tbilisi	Yerevan
8·Cld	Mean	27 (*39.7*)	28 (*43.1*)	25 (*37.3*)
	Min	16	16	12
	Max	40	40	40
2·Cla	Mean	6 (*8.8*)	6 (*9.2*)	6 (*9.0*)
	Min	3	3	2
	Max	10	10	10
4·R	Mean	18 (*26.5*)	15 (*23.1*)	18 (*26.9*)
	Min	16	10	14
	Max	20	18	20
4·S	Mean	11 (*16.2*)	10 (*15.3*)	12 (*17.9*)
	Min	4	6	4
	Max	20	16	20
2·W	Mean	6 (*8.8*)	6 (*9.2*)	6 (*9.0*)
	Min	3	4	3
	Max	8	8	9

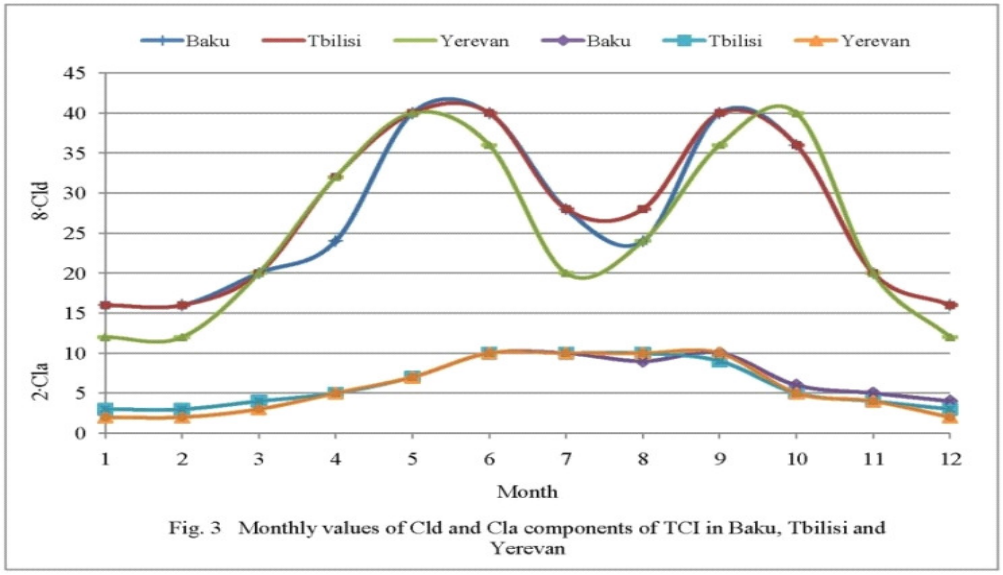

Fig. 3 Monthly values of Cld and Cla components of TCI in Baku, Tbilisi and Yerevan

As it follows from the table 3 the values of daytime comfort index (Cld varied from 37.3 % in Yerevan to 43.1 % in Tbilisi) and precipitation (R varied from 23.1 % in Tbilisi to 26.9 % in Yerevan) make the greatest share to the mean annual values of TCI in Baku, Tbilisi and Yerevan. The values of daily comfort index Cla and mean wind speed W make the smallest share to the mean annual values of TCI (approximately on 9 % for each city). The share of the mean annual daily sunshine duration S varied from 15.3 % in Tbilisi to 17.9 % in Yerevan.

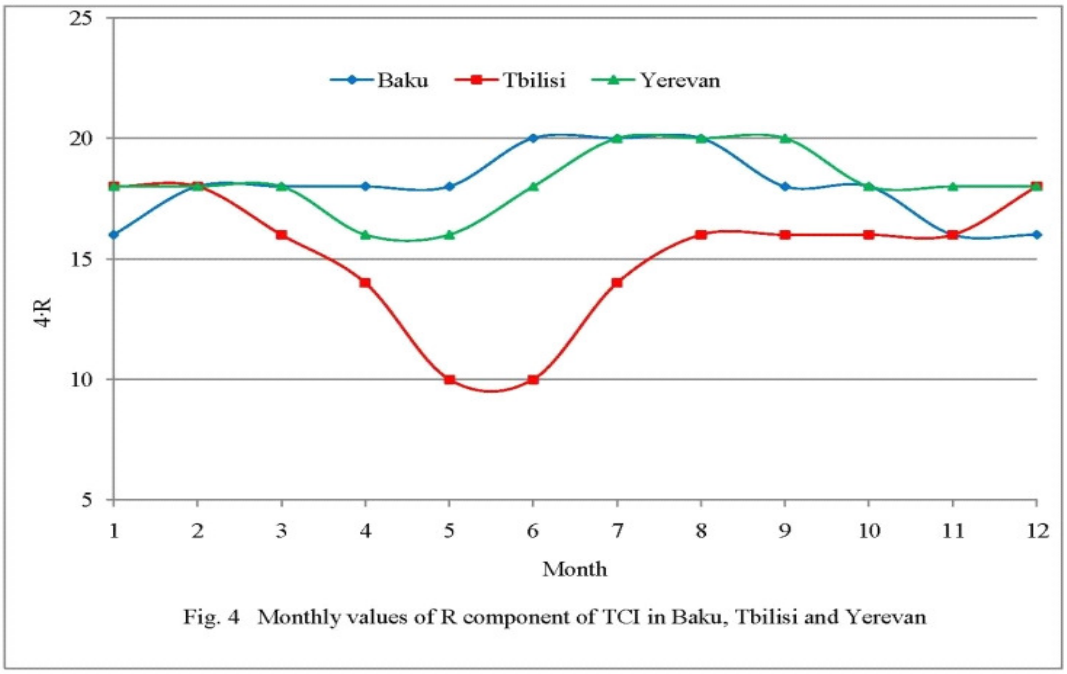

Fig. 4 Monthly values of R component of TCI in Baku, Tbilisi and Yerevan

As a whole, the lowered average annual values of TCI in Tbilisi (in comparison with Baku and Yerevan) are caused by more rainy climate and smaller sunshine duration, decreasing the contribution share R and S to the general value of TCI. Concerning the monthly values of TCI, in Tbilisi, in comparison with Baku and Yerevan, especially from May through September somewhat decreased values of TCI are observed (fig. 2), which also is caused by heavier precipitation and smaller sunshine duration in the capital of Georgia in these months, decreasing the contribution of R and S (fig. 4, 5).

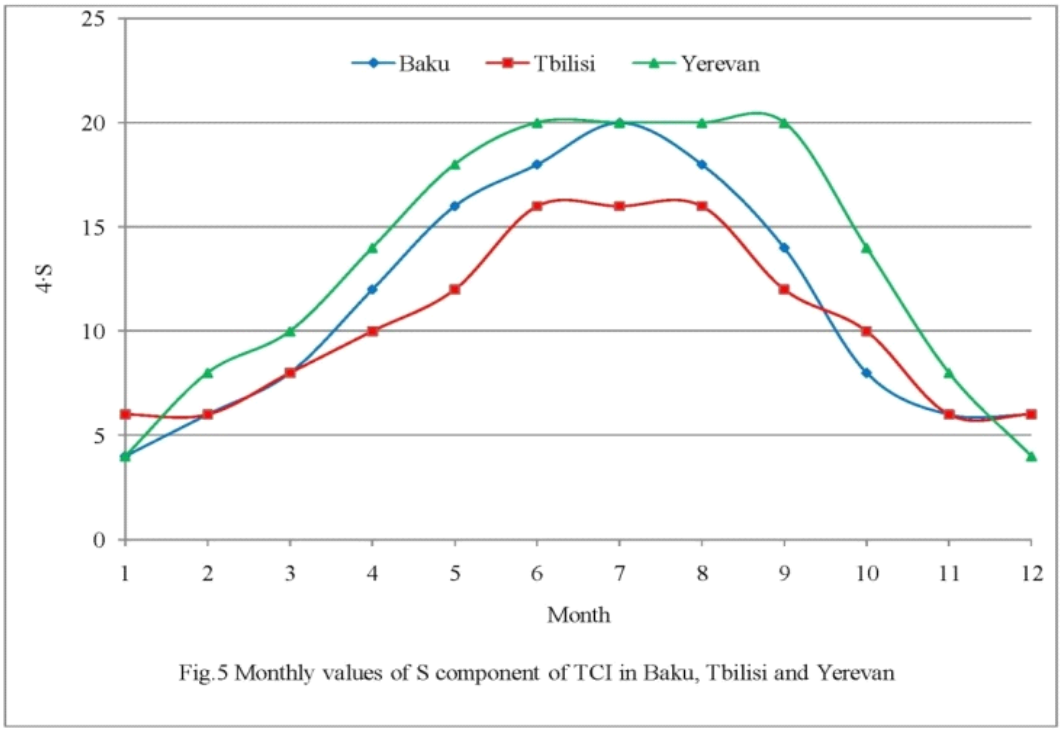

Fig.5 Monthly values of S component of TCI in Baku, Tbilisi and Yerevan

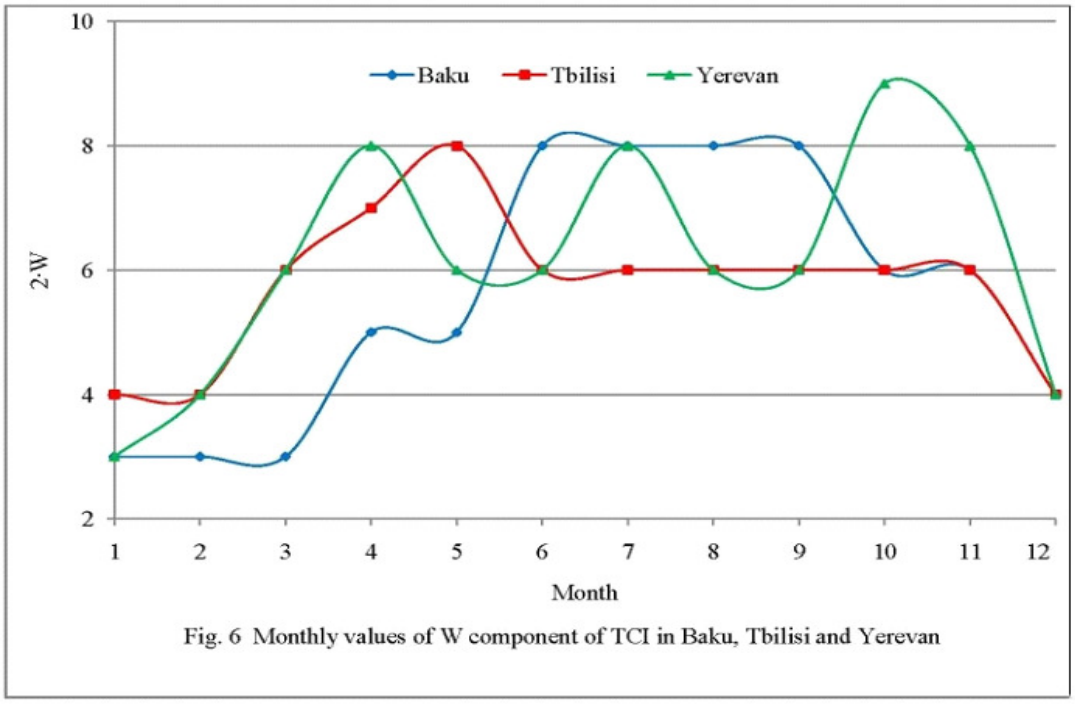

Fig. 6 Monthly values of W component of TCI in Baku, Tbilisi and Yerevan

The reason for the bimodal distribution of TCI (fig. 2) in the indicated cities is the bimodal nature of distribution of Cld (fig. 3), as basic component of TCI. The distribution of all remaining components is not bimodal (fig. 3 for Cla, fig. 4-6).

In fig. 7 the category of TCI in Baku, Tbilisi and Yerevan are presented. As follows from this figure, the climate of all three capitals is suitable for the year-round mass tourism. TCI categories changes from "Marginal" to "Excellent" in Tbilisi and "Marginal" to "Ideal" in Baku and Yerevan. The average annual category for each city is "Good".

In Baku, Tbilisi and Yerevan during January, February and December value of TCI are in corresponds to category "Marginal", during March and November - "Acceptable", during April – "Good".

In Baku during August and October TCI category are "Very Good", during May and July – "Excellent", during June and September - "Ideal". In Yerevan during July TCI category is "Very Good", during May, June, August and October – "Excellent", during September - "Ideal". In Tbilisi during May, July, August and October TCI category are "Very Good", and during June and September – "Excellent".

For the comparison let us give data about TCI for some cities of Iran [10, 12, 13]. In the northwest of Iran, the most suitable months for tourism activities in the TCI descriptive category "Excellent" were found in May, June, July, August and September. The best region for tourism activities are cities such as Ardabil and Tabriz, which are classified as having "Very Good" climatic conditions. The cities Maku, Ahar, Ardabil, Takab, Khoy, Ourimeh and Sarab have a summer peak distribution. Each of these locations has at least 1 month with a TCI category "Excellent". The cities Maku, Ardabli and Takab have TCI above 90, an "Ideal" tourism climate for the summer months. Among these cities, Ardabil has the most favorable climatic conditions for tourist attractiveness in the summer [10].

Studying TCI for different months and cities of the Yazd province, it has been found that the best climatic condition with regard to physical health for tourists is in the months of October or November with TCI category "Excellent", and the worst month with TCI category "Acceptable" is evaluated for July [12]. In Chaloos city category of TCI during January, February, March, November, December are "Acceptable", during April, August, September - "Good", during October – "Very Good", during May, June, October - "Excellent" [13].

Thus, values of TCI in the indicated cities of Iran change in the range from category “Acceptable” to “Ideal”, in Baku and Yerevan from “Marginal” to “Ideal”, in Tbilisi from “Marginal” to “Excellent”.

It is interesting to note that wrote Vakhushti Bagrationi about the Tbilisi climate of approximately three centuries ago [31]. He wrote, that climate in Tbilisi is excellent and is pleasant. It is in summer hotly and intolerably, in winter coldly. Spring and autumn are excellent and cheerful. This description approximately coincides with the contemporary bioclimatic characteristics of Tbilisi.

Fig. 7 Tourism Climate Index in Baku, Tbilisi and Yerevan

Mean annual value of TCI in Tbilisi is 65 (category "Good"), the daytime and daily comfort indices (8·Cld + 2·Cla) is 34 (max = 50). In winter mean value of (8·Cld + 2·Cla) is 19. In July and August value of (8·Cld + 2·Cla) is 38, in April-June and September-October – 45 (it is close to the max comfort).

CONCLUSIONS

A picturesque nature, landscapes Great Caucasian Ridge, subtropical and subtropical semi-arid climate zones of the Black and Caspian Sea, rivers and waterfalls, cave towns, resorts and mineral springs, urbanized cities and settlements, and traditional Caucasus hospitality, etc. make Azerbaijan, Georgia and Armenia the countries of tourism.

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 to Baku, Tbilisi and Yerevan (the capitals of Azerbaijan, Georgia and Armenia) 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 these countries for the tourism (mapping the territory on TCI, study trends of TCI, determination of other climatic and bioclimatic indices for tourism - Physiologically Equivalent Temperature, Mean Radiant Temperature etc.).

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ტურიზმის კლიმატური ინდექსის შედარებითი მახასიათებლები სამხრეთ კავკასიის ქვეყნების დედაქალაქებში (ბაქო, თბილისი, ერევანი)

ა. ამირანაშვილი, ხ. ჩარგაზია, ა. მატზარაკის

რეზიუმე

ჩატარებულ იქნა შედარებითი ანალიზი ტურიზმის კლიმატური ინდექსის თვიური მნიშვნელობებისათვის სამხრეთ კავკასიის ქვეყნების დედაქალაქებში (ბაქო, თბილისი,ერევანი). შესწავლილია ტურიზმის კლიმატური იდექსის სტატისტიკური სტრუქტურა. მითითებულ ქალაქებში არსებობს მაღალი წრფივი კორელაცია ტურიზმის კლიმატური ინდექსის მნიშვნელობებს შორის, რომელიც აღწევს 1. ტურიზმის კლიმატური ინდექსის მნიშვნელობების შიდა წლიური განაწილება ყველა ქალაქისათვის ატარებს ბიმოდალურ ხასიათს ექსტრემუმებით ივნისსა და სექტემბერში და აღიწერება მეცხრე ხარისხის პოლინომით. ბაქოსთან და ერევანთან შედარებით თბილისში მაისიდან სექტემბრის ჩათვლით შეინიშნება ტურიზმის კლიმატური ინდექსის რამდენადმე დაბალი მნიშვნელობები, რაც განპირობებულია უფრო ჭარბი ნალექებით და მზის ნათების ნაკლები ხანგრძლივობით საქართველოს დედაქალაქში. საერთო ჯამში სამივე დედაქალაქის კლიმატი ვარგისია წლიური მასობრივი ტურიზმისათვის. (ტურიზმის კლიმატური ინდექსის კატეგორიები იცვლება „მისაღებიდან“ „შესანიშნავამდე“ თბილისში და „მისაღებიდან“ „იდეალურამდე“ ბაქოსა და ერევანში საშუალო წლიური კატეგორიით -„კარგი“ ამ ქალაქებისათვის.

Сравнительные характеристики климатического индекса туризма в столицах стран южного Кавказа (Баку, Тбилиси, Ереван)

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Резюме

Проведен сравнительный анализ месячных значений климатического индекса туризма (КИТ) в столицах стран южного Кавказа (Баку, Тбилиси, Ереван). Изучена статистическая структура КИТ. Между значениями КИТ в указанных городах имеется высокая линейная корреляция, достигающая 1. Внутригодовое распределение значений КИТ для всх городов имеет бимодальный характер с экстремумами в июне и сентябре и описывается полиномом девятой степени. В Тбилиси, по сравнению с Баку и Ереваном, с мая по сентябрь наблюдаются несколько заниженные значения КИТ, что обусловлено более обильными осадками и меньшей продолжительность солнечного сияния в столице Грузии. В целом, климат всех трех столиц пригоден для круглогодичного массового (категории КИТ меняются от " Приемлемый" до "Отличный" в Тбилиси и от " Приемлемый" до "Идеальный" в Баку и Ереване, при среднегодовой категории - "Хороший" - для этих городов).