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ANALYSIS OF TOURISM CLIMATIC CONDITIONS IN HUNGARY CONSIDERING THE SUBJECTIVE THERMAL SENSATION CHARACTERISTICS OF THE SOUTH-HUNGARIAN RESIDENTS

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Summary: People living in different regions adapt physiologically and psychologically to the background climatic conditions of their place of origin. This may influence their decisions in the planning phase when travelling for holidays by determining their climatic preferences and the importance of individual climatic parameters. Due to the different levels of adaptation and acclimatization the subjective thermal assessments (e.g. the thermal perceptions) of the tourists in response to a thermal environment might be extremely varied, which should be considered in the climate potential studies. This paper analyses the tourism climatic potential of some Hungarian tourist destinations, assuming that people visiting these places have adapted to the climatic conditions prevailing in the Southern Great Hungarian Plain. We characterize the tourism climatic conditions using the Tourism Climatic Index (TCI) modified in a way which enables to include the real thermal perception characteristics of the people living in this region. To achieve this goal, we integrate a thermal sensation scale of the Physiologically Equivalent Temperature (PET) into the TCI which was modified to reflect the thermal sensation properties of the South-Hungarian citizens. Moreover, we compare the results with those referring to people living under the Western-Central-European climatic conditions by applying also the widely known conventional PET thermal sensation scale in the TCI. The preliminary results indicate that the most favourable tourism climatic conditions in terms of TCI occur in the shoulder seasons in each investigated area. The annual course of TCI is similar in the case of both methods with different PET scales, however the South-Hungarian residents seem to perceive the tourism climatic conditions less stressful throughout the year compared to the Europeans, which can be very unfavourable and dangerous in extreme warm conditions.

Key words: thermal adaptation, tourism climate potential, modified Tourism Climatic Index, Physiologically Equivalent Temperature, thermal sensation classes, Southern Great Hungarian Plain

1. INTRODUCTION

Climate and weather play a key role in the travel decisions of tourists by designating areas that offer suitable climatic conditions or by determining the best time to travel. However, visitors coming from different countries or even from distinct regions of a country may have differences in climatic preferences and in priorities for climate conditions, and thus in their choice of destination. For example, Morgan et al. (2000) found considerable differences in the preferences and the relative rankings of weather parameters between beach users of North and Mediterranean European origin using questionnaire data. Also, on the basis of questionnaire surveys conducted in Canada, New Zealand and Sweden Scott et al. (2008) pointed out that the background climatic conditions prevailing in the place of origin may explain some of the features of climatic preferences and the relative importance of the parameters, e.g. low mean summer temperatures experienced in the home country may create a desire for higher temperature when travelling for beach holidays.

These significant differences between the residents may be attributed to the various levels of physiological adaptation of the local residents to the special climatic background in their home country. Moreover, expectations, thermal experiences, as well as the different cultures and attitudes may influence their climatic preferences psychologically (Nikolopoulou and Steemers 2003, Knez and Thorsson 2006, Knez et al. 2009).

In the climate potential analyses of tourist areas it should be taken into account that travellers visiting these places have adapted both physiologically and psychologically to the thermal conditions of their place of origin and therefore their subjective evaluations might be different. This study aims to analyse and compare the annual variations of the tourism climatic potential of a few Hungarian popular tourist areas with a modified version of the Tourism Climatic Index (TCI), considering the thermal perception characteristics of the Western-Central-European people and the residents who live under the climatic conditions of the Southern Great Hungarian Plain.

2. METHODS AND MATERIALS

2.1. The original Tourism Climatic Index

In the climatic potential analysis the Tourism Climatic Index is applied which is a widely used metric for the suitability of climate for outdoor light activities (e.g. sightseeing, shopping) (Mieczkowski 1985). The TCI integrates monthly averages of seven climatic parameters relevant for tourism into five sub-indices which are then rated on different scales ranging from 'unfavourable' (0) to 'optimal' (5). After summing the weighted individual sub-indices the index takes on the following expression:

$$TCI = 2\cdot(4\cdot CId + CIa + 2\cdot R + 2\cdot S + W) \qquad (1)$$

where CId = daytime comfort index (consisting of the combination of daily maximum temperature and minimum relative humidity), CIa = daily comfort index (daily mean temperature and mean relative humidity), R = monthly amount of precipitation, S = daily sunshine duration, and W = daily mean wind speed. With an optimal rating of 5 for each sub-index, the maximum value of the TCI is 100. Mieczkowski (1985) proposed a classification of TCI scores, with values exceeding 40, 60 and 80 representing at least 'marginal', 'good' and 'excellent' conditions, respectively (Table 1).

Table 1 Rating categories of the Tourism Climatic Index (Mieczkowski 1985)

TCI scores	Categories
90–100	Ideal
80–89	Excellent
70–79	Very good
60–69	Good
50–59	Acceptable
40–49	Marginal
30–39	Unfavourable
20–29	Very unfavourable
10–19	Extremely unfavourable
<10	Impossible

A schematic framework of possible types of annual TCI distributions introduced by Scott and McBoyle (2001) is indicated in Fig. 1.

2.2. Applied modifications in the Tourism Climatic Index

In recent years a number of studies have revealed limitations in relation to the structure and applicability of the TCI. Some of them have suggested to update its daytime and daily comfort sub-indices (CId and CIa) to reflect a more current state of human bioclimatological knowledge (Scott et al. 2004, Amelung and Viner 2006, Perch-Nielsen et al. 2010); others have emphasized the coarse temporal scale of TCI (i.e. monthly averages) and suggested refinements (de Freitas et al. 2008, Yu et al. 2009, Perch-Nielsen et al. 2010).

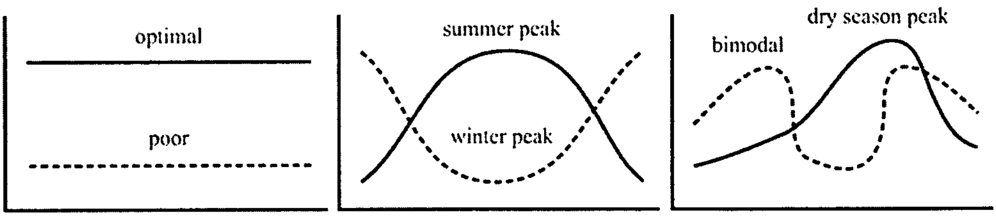

Fig. 1 Conceptual framework of annual TCI distribution (based on Scott and McBoyle 2001)

In this study we use a TCI modified in two steps. First, we used ten-day averages of each sub-index (CId, CIa, R, S as well as W) instead of monthly ones, which suits better to the tourists' interests. Ultimately, these ten-day averages were rated with scores in the TCI. Otherwise, the rating systems of wind speed, precipitation, sunshine duration, as well as the weightings of all sub-indices remained unchanged, holding the concept of Mieczkowski (1985).

Table 2 PET thermal sensation scale (°C) for the Western-Central-European residents (Matzarakis and Mayer 1996) and the modified thermal sensation class boundaries for people living in the Southern Great Hungarian Plain (Kovács et al. 2014)

Thermal sensation classes	European PET scale (°C)	South-Hungarian PET scale (°C)
Very hot	>41	–
Hot	35–41	>45.5
Warm	29–35	31.5–45.5
Slightly warm	23–29	21.9–31.5
Neutral	18–23	14.1–21.9
Slightly cool	13–18	7.4–14.1
Cool	8–13	1.3–7.4
Cold	4–8	<1.3
Very cold	<4	–

A further modification of TCI was to integrate the most widely applied thermal comfort index, namely the Physiologically Equivalent Temperature [PET (°C)] (Matzarakis and Mayer 1996, Höppe 1999) into the daytime (CId) and daily comfort (CIa) sub-indices. Notably, in the modified TCI the new CId and CIa sub-indices consist of the calculated daily maximum and daily average PET. However, for this integration process a rating system of both sub-indices has to be developed. Such a method was presented in Kovács and Unger (2014) based on the conventional relationship between the Predicted Mean Vote (PMV) and the Predicted Percentage of Dissatisfied (PPD). Since our aim is to reflect the real thermal perception characteristics of the residents in the Southern Great Hungarian Plain in the TCI, in this study we present a preliminary method in which their thermal sensation properties can be included. To achieve this goal, we have modified the thermal sensation boundaries of the PET classes recently (Kovács et al. 2014), which were derived originally for the Western-Central-European climatic conditions (Matzarakis and Mayer 1996). This new scale was developed on the basis of a quadratic regression function between the PET index derived from microclimate measurements as well as the mean thermal sensation votes of visitors (TSV) collected in simultaneous questionnaire surveys (Kovács et al. 2014). In the questionnaires the interviewees were asked to indicate their TSV on a semantic differential scale with 9 main thermal sensation classes ranging from very cold (-3) to very hot (+3). The measurements and the questionnaire surveys took place in a few outdoor public spaces in Szeged, the centre of the Southern Great Hungarian Plain Region. Table 2 illustrates the Western-Central-European PET scale (hereinafter referred to as European) and the modified thermal sensation class boundaries (hereinafter as South-Hungarian).

In the modified TCI the rating scores of the PET sub-indices were derived in two steps, with interposing the thermal sensation votes of the visitors (PET → TSV → rating scores). We gained scores for each PET value by applying at first the PET–TSV quadratic regression function mentioned above where the PET class boundaries were derived originally by substituting TSV=-2.5, -1.5 etc. values into the fitted quadratic equation (e.g. TSV between -2.5 and -1.5 designated the cool category 7.4–14.1°C) (Kovács et al. 2014). In fact, we gave rating scores not directly to the PET values but to the selected TSV thresholds (e.g. TSV=-2.5, -1.5, -0.5, 0.5 etc.), and then we fitted a function to these values, resulting in continuous scores (Fig. 2). According to this relationship, the neutral thermal sensation vote (TSV=0) gave the possible maximum score 5 and the scores then decrease continuously in line with the decline of the thermal sensation (Fig. 2).

Utilizing the TSV–rating score relationship we could already rate each PET value continuously considering the PET–TSV function. Since we derived scores continuously we could rate each PET value with different scores and not only the discrete class boundaries. Fig. 3a illustrates the derived PET–rating score relationship where we indicated the boundaries of the PET classes. The connections between the applied function relationships can be illustrated simply as follows:

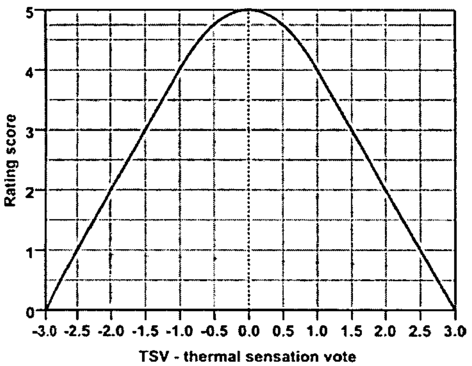

Fig. 2 Rating scores of the thermal sensation vote (TSV)

$$\text{score} = f(\text{TSV}) \rightarrow \text{TSV} = f(\text{PET}) \rightarrow \text{score} = f(\text{PET}) \qquad (2)$$

We can include also other thermal sensation classes in the method described above, by associating the same TSV value to the adequate class boundaries (with the example given above TSV between -2.5 and -1.5 designates the cool category boundaries). In this study we also derived scores for the conventional European PET scale (Matzarakis and Mayer 1996), by applying this new PET–TSV function as well as the original TSV–rating score relationship (Fig. 3b). Since the boundaries of the corresponding classes have always the same scores the shifts in the boundaries between the two scales are reflected in the resulting scores, and thus we have the possibility to compare the influence of the two methods with different scales on the overall TCI.

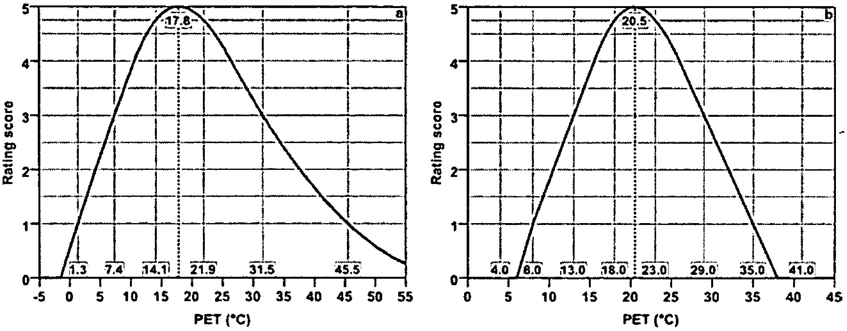

Fig. 3 Rating scores of the PET in the cases of the South-Hungarian (a) and the European scales (b). Vertical lines designate the boundaries of the PET classes, while dashed lines indicate the neutral temperatures (i.e. when TSV=0) which have the maximum score 5.

2.3. Study areas and applied data

By means of the modified TCI described above we analyse the annual variations of the tourism climatic conditions on the examples of Szeged (as our reference site) and other three popular Hungarian tourist areas (Budapest, Siófok, Pécs) which have slightly different climates (Table 3). For the calculation of PET and TCI hourly air temperature, relative humidity, wind speed and cloudiness data, as well as daily sunshine duration and precipitation data were used for the periods 1996–2010 (and 2000–2010 in the case of Pécs). We applied the measurement data of stations of the Hungarian Meteorological Service (Table 3). The selected stations are located on grass surface in the suburbs or outside the settlements and do not have considerable horizon limitation (the sky view factor is near to 1), therefore they can provide a good representation of climate on regional scale. The PET values were calculated with the bioclimate model RayMan (Matzarakis et al. 2007, 2010).

Table 3 Meteorological stations included in the analyses with their names and geographical positions

Station	Latitude	Longitude	Altitude (m)
Szeged	46°15'N	20°05'E	82
Budapest-Pestszentlőrinc	47°25'N	19°10'E	139.1
Siófok	46°54'N	18°02'E	108.2
Pécs-Pogány	45°59'N	18°14'E	200.2

3. RESULTS

Using the modified TCI the annual courses of the ten-day rating scores using both methods with different PET scales are illustrated in Fig. 4. In all selected cities a bimodal type of distribution was obtained (see Fig. 1), i.e. the most pleasant climate in terms of sightseeing activities occurs in spring and autumn (TCI>70 and especially in the middle spring it is greater than 80), while in summer the climatic conditions are less favourable (mostly under 70). The most unpleasant conditions occur at the end of July and in early August with the most significant declines in TCI in Szeged and Budapest, though they reflect still good conditions (60<TCI<70). During the winter season there are unpleasant climatic conditions with TCI scores below 50 (Fig. 4).

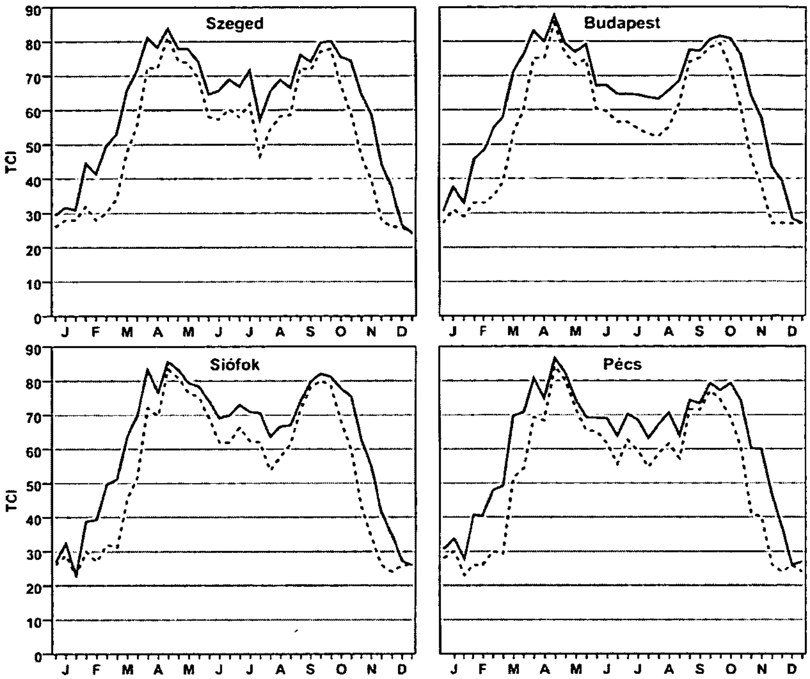

Fig. 4 Annual course of the ten-day TCI rating scores for the selected tourist areas. Solid and dashed lines indicate the results considering the South-Hungarian and European PET rating scales, respectively

The scores are almost always higher in all areas when the South-Hungarian rating scores are used, with the highest average annual difference in Budapest (9.0) and the smallest in Siófok (8.3) (Fig. 3a). The highest differences occur in February, March and November (nearly 20), as well as in the summer months (about 10), which indicate an improvement in the perceived tourism climatic conditions by 1–2 categories of TCI (Fig. 4). This can be explained by the fact that the South-Hungarian residents perceive the extreme conditions less stressful, which is reflected in the broader and less extreme PET classes and thus in the higher rating scores. For example, PET=36°C (corresponding to hot category in the original scale and only to the warm class in the South-Hungarian scale) gave more score (2.24) than in the former case (0.66), indicating rightly the perception characteristics of the South-Hungarian people (Table 2, Fig. 3).

In order to analyse the differences between the two methods with distinct scales in details, it is worth examining the contribution of each sub-index to the overall value of TCI. The results are only presented for Szeged (Fig. 5), since the other areas have similar annual courses. It is clearly shown that the daytime comfort index (CId) is mainly responsible for the bimodal structure of the TCI, since the prevailing heat stress greatly reduces the rating scores in the afternoon hours of summer when usually the daily maximum PET occurs. Moreover, precipitation amount (R) which is the highest on average in summer also contributes to the significant TCI drops according to its rating system. However, the sunshine duration and the daily mean PET sub-indices compensate the declines in the summer months (Fig. 5).

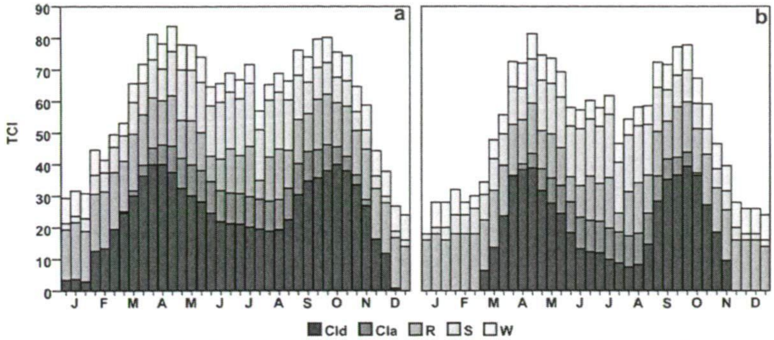

Fig. 5 Ten-day scores of the TCI sub-indices for Szeged considering the South-Hungarian (a) and the European PET scales (b). Note: the scores of R, S and W sub-indices are identical, since their rating systems remained unchanged. (CId = daily maximum PET, CIa = daily mean PET, R = monthly amount of precipitation, S = daily sunshine duration, W = daily mean wind speed sub-index)

Considering the differences in the two rating methods the CId sub-index does not correspond to the TCI value in winter in the case of the European scale (it is equal to zero, i.e. PET is below 6°C), and it has significantly less score from May to August compared to the other case, indicating the altered perceptions of the South-Hungarian residents (Fig. 5). Furthermore, it is obvious that the differences detected in the overall TCI values are due to the CId sub-index because of its high weight in TCI (Table 4). The TCI increases by the CIa sub-index from March to middle November according to the South-Hungarian scores and only from April to middle October in the case of the original scale (Fig. 5). The highest differences in CIa occur in spring and autumn, while in summer the scores are almost identical (Table 4).

Table 4 Mean monthly differences of CId and CIa sub-index scores for Szeged between the methods considering the South-Hungarian and the European PET scales. (CId = daily maximum PET, CIa = daily mean PET sub-index)

Sub-index	J	F	M	A	M	J	J	A	S	O	N	D
ΔCId	3.3	15.2	15.8	1.3	2.3	8.0	10.0	10.0	0.2	4.3	16.2	4.2
ΔCIa	0.0	0.0	1.8	4.4	1.8	-0.1	-0.3	-0.2	2.7	4.4	1.7	0.0

4. CONCLUSIONS

The study analysed the tourism climatic potential of a few Hungarian tourist destinations in terms of the Southern-Hungarian people using a modified Tourism Climatic Index. We integrated the most complex thermal comfort index PET into the TCI and provided a preliminary method to derive rating scores of PET values, which takes the thermal sensation characteristics of the Europeans as well as the residents in the Southern Hungarian Great Plain into account. We applied the conventional European PET thermal sensation classes (Matzarakis and Mayer 1996) as well as a recently developed new scale (Kovács et al. 2014) which reflects more properly the thermal perceptions of the South-Hungarian citizens outdoors. In the rating systems the shifts in the class boundaries of the two scales are reflected in the derived scores.

The results indicated a bimodal annual course of TCI in all cities with the most pleasant tourism climatic conditons for sightseeing tours occuring in the shoulder seasons.

The summer months are less applicable for outdoor activities, which can be attributed to the intense heat load in the afternoon hours (expressed by the daily maximum PET sub-index).

The course of the two TCI scores based on the different PET scales seem to be similar but the South-Hungarian people perceive the tourism climatic conditions better throughout the year. The differences often exceed 10–15 scores, denoting considerable changes. The differences can be attributed to the fact that the South-Hungarian citizens tend to perceive the extreme conditions less stressful, which is reflected in the broader and less extreme South-Hungarian PET classes and thus in the derived rating scores. It should be noted that the perception characteristics of the South-Hungarians can be very unfavourable and dangerous in extreme warm conditions, though the TCI differences are usually do not exceed 10 in summer. Much more significant differences can be found in early spring and late autumn (usually close to 20) which seems to be rather advantageous in those periods.

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