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EVALUATION OF THE TOURISM CLIMATE POTENTIAL BASED ON ORIGINAL AND IMPROVED METHODS ADAPTED TO HUNGARIAN POPULATION

Summary of PhD Thesis

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1. Introduction

There are a number of factors that affect the tourist attractiveness of a certain area, among which climate is the most significant component. The complex interactions of climate parameters may either enable or limit certain tourism activities and may also either strengthen or worsen the judgement formed of a certain area. One of the key factors of sustainable tourism development is that we should be aware how the climate conditions of a certain region are suitable for the different tourism activities. Knowing the tourism climate potential providers of the industry can work on their service offers in a more effective way. For the tourists themselves the knowledge of the climate circumstances might be an important aspect when choosing travel destinations, dates or activities. The variability of the climatic conditions affects tourists' sense of comfort and satisfaction in connection with the travel destination and thus influences tourism demand in a significant way.

Tourism – one of the most dynamically improving industrial sectors – is especially sensitive to climate change. Changes in the climatic circumstances influence each and every tourism destination and activity on a different level as well as affect other environmental resources in an indirect way. One of the biggest challenges of our time is to provide tourism industry with the necessary tools for coping with the inevitable effects of climate change. The development of the adaptation strategies can be facilitated by the analysis of the expected changes in the climate potential.

My doctoral dissertation deals with the area of tourism climatology which examines the relationship between tourism and climate conditions. A number of tools and methods have been worked out in recent decades in order to be able to quantify the extent to which the climate conditions of a certain area are suitable for different tourism activities. There are more simple tools which are more easily interpretable and aim at a wider public. At the same time they raise a few problems and deficiencies which mainly stem from the structure of these tools and it is also doubted whether they can give authentic answers for questions about complex tourism climate potential.

The problems often stem from the fact that the above mentioned methods mainly rely on objective parameters and these parameters are evaluated in the same way everywhere in the world without taking into consideration the subjective judgement of the residents and tourists of different regions. The perception and evaluation of the atmospheric environment is strongly subjective which means that different individuals or groups may evaluate the same conditions in a different way thus the need for adapting the evaluation tools to local residents and tourists of different climatic backgrounds emerges.

The exploration of the target group's subjective judgements and behavioural reactions is a very complex task which can be implemented mainly with the help of questionnaires. Subjective differences are usually studied along well defined market segments (e.g. age group, nationality, and certain tourism activities). At this point the close relationship between tourism climatology and human biometeorology becomes obvious. Human biometeorology examines the effects of the parameters of the atmospheric environment on the human body from physiological and nowadays also psychological perspectives. It is getting accepted to use more complex evaluation tools in order to reach trustworthy human biometeorological and tourism climatology assessments which make it possible to adapt the evaluation method to different tourist groups and tourism activities and also to take subjective characteristics into consideration.

The number of researches related to Hungary and based on tourism climatology indices is still very low and only a few initial steps have been made in the analysis of the impacts of climate change on tourism as well. In connection with these researches I attempted – for the first time in Hungary – to adapt the traditional evaluation tools to the Hungarian people taking into consideration their thermal reactions (manifested in the subjective thermal sensation).

The main targets of my dissertation were as follows:

I. Description of the role of climatic conditions in tourism and critical examination of the method developed for its evaluation.
II. Development of the method and its adaptation to the Hungarian population.
III. Complex evaluation of the climate potential of some highlighted (Hungarian and foreign) tourism destinations.

IV. Analysis of Hungary's future tourism climate potential.

The aim of my dissertation is to help forward the foundation and wider recognition of tourism climatology in Hungary with the help of the results of my study and also to contribute to the international knowledge base of this discipline.

2. Databases and research methods

My methodological development was based on the structural modification of the Tourism Climatic Index (TCI), one of the most widely known and used indices. During the process I modified the temporal resolution of the index and on the other hand improved its thermal components. As a result of the latter I managed to work out a new methodology which made it possible to integrate the Physiologically Equivalent Temperature (PET) into the TCI index and replace the current parameter of the thermal components with it.

The integration of the PET led to the need for a new rating score system for the thermal components. I defined the rating scores – contrary to the original method – based on the actual reactions of the Hungarian population on the thermal environment and not in an arbitrary way. I also adjusted the thermal components of the other widely known method, Climate-Tourism-Information-Scheme (CTIS) to the subjective assessments of the local residents.

The adaptation of the TCI and CTIS arose the need for the discovery of the subjective reactions given on the thermal environment, for which I used the data from an open-air human comfort measurement conducted in Szeged in 2011, 2012 and 2015, with my participation since the autumn of 2012. The researches were conducted in six busy public places of Szeged. The campaign was based on two series of surveys run parallel to each other. During the first one the parameters of the thermal environment were recorded during special micro-biometeorology measurements. The second measurement campaign consisted of the examination of the visitors' subjective reactions which were collected with the help of questionnaires. In my work I used the data on the visitors' actual thermal sensations.

I linked the objective (measured) data to the questionnaire database and calculated PET-values from the linked data which can quantify the thermal load in an objective way. 5805 subjective thermal sensation – PET data pairs formed the base of my analysis. In the next step I attempted to explore the thermal sensation patterns peculiar to Hungarian people. I conducted regression analysis for the examination of the relation between the two quantities. In order to be able to examine the incidental seasonal differences, I conducted the regression analysis on every season (spring, summer, and autumn). With the regression method I defined the so-called neutral temperature for every season and also created new PET category boundaries which are in accordance with the thermal response of the local population. With the help of the regression curves, neutral temperatures and PET domains I evaluated the seasonal thermal perception characteristics of local residents.

With the application of the regression curves I assigned new rating scores to the PET-values, which formed the basis of the new thermal components of the modified TCI (mTCI). Based on the thermal perception category boundaries I marked out the neutral, warm and cold zones (PET-thresholds) as perceived by the Hungarian residents, which were necessary for the new thermal components of CTIS.

In the next step, I presented two examples for the utilization of the tools. During the first one I evaluated the actual climate potential of six national and four European tourism destinations based on the TCI, mTCI and CTIS. I used the measurements of the national meteorological services from the meteorological stations at the given areas. I used the daily maximum PET- and daily average PET-values as the new thermal components of the mTCI and I evaluated them with the season-dependent scores related to Hungarian residents. I used the TCI and mTCI in finer ten-day resolution compared to the original monthly. Moreover, I left out the data of the night hours because tourism activities are negligible during this part of the day. In case of the CTIS, I presented the evaluation of the thermal components using both the original PET-thresholds and those related to the Hungarian residents. I utilized the CTIS evaluation in a ten-day resolution as well with only the daytime data taken into consideration.

In the other example, I evaluated the future possible tendencies of the tourism climate potential from Hungary's point of view with the help of the

TCI and mTCI indices. At first the indices were calculated for the reference period of 1961–1990 with the help of the measurement database of the Hungarian Meteorological Service (HMS) (10 km horizontal resolution grid of extended CarpatClim data). The data concerning the future estimations were provided by a model run conducted by using the regional climate model ALADIN-Climate 4.5 at the HMS on 10 km horizontal resolution, prescribing anthropogenic activity according to A1B emission scenario. I used the model results for the period of 2021–2050 and 2071–2100 with the period of 1961–1990 being the model reference. I produced the results concerning the future with the so-called delta-method. I calculated the TCI and mTCI in monthly resolution for the 10 km horizontal resolution grid. The evaluation of the thermal components of the mTCI was done with the help of the season-dependent scores adapted to Hungarian residents this time as well. After I had all the appropriate TCI and mTCI data, I produced district averages from the grid data and visualized the spatial dispersion of the indices on maps.

I used SPSS Statistics 21–23, Microsoft Excel, ArcGIS 10.4., CorelDRAW X3, RayMan Pro 2.1 and CTIS 1.1b softwares and Fortran programming language for the production of the data, statistical examinations and the display of the results.

3. Results and conclusions

I. I identified problems and deficiencies in connection with the structure and credibility of TCI and CTIS indices based on my experience and the international literature of the discipline (*Kovács* and *Unger* 2014a, 2014b, *Kovács et al.* 2014, 2016, 2017).

1. During the critical examination of the methods I found that the current temporal resolution of the TCI index is insufficient, its thermal components (daytime and daily comfort index) seem to be outdated, moreover the rating score systems of the components and the weighing of the sub-indices are arbitrary. In connection with the CTIS I found that the generally used value ranges and thresholds do not reflect the subjective reactions of local residents.

2. Since the evaluation of the thermal environment is a highly subjective process, I emphasized the importance of the standardization of the evaluation methods (scale, rating score system and thresholds) based on the actual reactions of the local residents or tourists of a given region.

II. I improved the methodology of TCI and adapted the TCI and CTIS to the Hungarian residents' subjective evaluation on thermal conditions (*Kovács* and *Unger* 2014a, 2014b, *Kovács et al.* 2014, 2016, 2017, *Kántor et al.* 2016a).

3. I modified the structure of the TCI.
    a. I updated the thermal components of the TCI: I worked out a new methodology which makes it possible to integrate the PET index into the place of the original thermal components of the TCI.
    b. I modified the temporal resolution of the TCI: I proposed a ten-day system and in connection with this I modified the rating score system of the precipitation sub-index.
4. I specified the seasonal patterns of the subjective responses given by Hungarian residents on the thermal environment. I determined that people are more tolerant towards warmer thermal conditions in any seasons than towards colder ones. The seasonal trend of the neutral temperature given in PET (spring ~ autumn < summer) shows Hungarian residents' mid-year climatic adaptation processes. I discovered significant differences compared to the original PET value ranges, among which stands out Hungarian residents' higher tolerance towards warmer thermal conditions in the transition seasons.
5. I adjusted the thermal components of the TCI to Hungarian residents: I developed a new rating score system based on the actual, seasonally changing subjective responses of the Hungarian population.
6. I adjusted the thermal components of the CTIS to the local population: I designated seasonal PET value ranges according to their thermal sensation patterns and after this I integrated the zones per-

ceived as neutral, warm or cold by the Hungarian residents (PET-thresholds) into the CTIS as new thermal components.

III. I evaluated the climate potential of a few highlighted local and European tourist destinations based on the TCI, mTCI and CTIS (*Kovács* and *Unger* 2014a, 2014b, *Kovács et al.* 2016).

7. I marked out a considerable difference between the yearly distribution of the TCI and the mTCI. In case of the TCI, an intensive improvement can be observed during the spring months after the more disadvantageous winter conditions. The most favourable conditions can be detected from May to September in the local areas and from June to August in the northern regions. During the autumn conditions quickly decline. Yearly distribution thus takes on a structure of a "summer peak". Contrary to this, in case of the mTCI, the dispersion is "bimodal" meaning that whereas the most optimal climate is during some of the spring and autumn months (usually in April and September-October), conditions are more disadvantageous during the summer period. In case of the Southern-European regions, I got a mild "bimodal" structure based on the TCI dispersion and a strong one based on the mTCI.
8. With the division of the TCI and mTCI into sub-indices I managed to show that principally the daytime comfort index (*CId*/*mCId*) is responsible for the different yearly course of the two indices and the significant differences between the examined areas. The effects of the other sub-indices (*CIa*/*mCIa, R, S, W*) can contribute to this to a smaller extent.
9. The evaluations based on either mTCI and CTIS show that the transitional seasons are the most suitable periods for outdoor activities in all the examined regions. The distribution of the mTCI is strongly "bimodal" in all areas. As a result of the CTIS-based complex evaluation I can confirm that May and September seem to be the most favourable months in Hungary and the northern regions with relatively pleasant thermal conditions during summer as well in the latter territories. The transitional seasons – particularly April and October – can be recommended for outdoor activities in the Southern-European regions as well. I also proved that the above picture is

nuanced by precipitation because the probability of it is the highest in those periods which are considered to be the most favourable.

IV. I analyzed the possible future tourism climate potential of Hungary based on the TCI and mTCI (*Kovács et al.* 2017).

10. Based on the measurements reflecting the current climate I found that the yearly evolution of both TCI and mTCI reflects the tendencies observed during the evaluation made by the given indices on the tourist destinations. That is to say, according to the TCI evaluation, I received the most unfavourable conditions for winter whereas the period between May and September showed favourable conditions. The results here also prove that poor winter conditions show intensive improvement during spring, then the conditions remain stable between May and September just to show a great decline during the autumn period. In case of the mTCI – where I left out the winter months – the most unfavourable months are November and March. Spring brings a significant improvement here as well followed by a slight decline between June and September. After this another improvement and then a decline can be observed until the end of autumn.
11. I found that TCI and mTCI show equivalent tendencies for summer and similar for spring and autumn until the end of the 21^{st} century. According to both indices, an unfavourable change can be expected for the summer months which is particularly excessive in July and August (1–3 categories). According to the TCI, stable or slightly improving (by 1 category) conditions can be anticipated for spring. MTCI shows a significant improvement for March followed by a stable or slightly improving condition in April and – contrary to the TCI – a decline by 1 category for the majority of the country in May. Equal tendencies cannot be observed during the autumn months either. Based on the TCI, unchanged conditions can be anticipated for September, significantly improving ones for October and unchanged or at some areas improving by 1 category for November. MTCI shows a decline by 1 category for September such as for May, an improvement for October (similarly to TCI), and an improvement by 1 category for November almost everywhere.

Publications related to thesis

1. ***Kovács A***, *Németh Á*, *Unger J*, *Kántor N* (2017): Tourism climatic conditions of Hungary – present situation and assessment of future changes. *Időjárás 121*, in press (IF_{2015}: 0,810)

2. *Kántor N*, ***Kovács A***, *Takács Á* (2016a): Seasonal differences in the subjective assessment of outdoor thermal conditions and the impact of analysis techniques on the obtained results. *Int J Biometeorol 60*, 1615–1635 (IF_{2015}: 2,309)

3. ***Kovács A***, *Unger J*, *Gál CV*, *Kántor N* (2016): Adjustment of the thermal component of two tourism climatological assessment tools using thermal perception and preference surveys from Hungary. *Theor Appl Climatol 125*, 113–130 (IF_{2015}: 2,433)

4. ***Kovács A***, *Unger J* (2014a): Modification of the Tourism Climatic Index to Central European climatic conditions – examples. *Időjárás 118*, 147–166 (IF_{2014}: 0,5)

5. ***Kovács A***, *Unger J* (2014b): Analysis of tourism climatic conditions in Hungary considering the subjective thermal sensation characteristics of the south-Hungarian residents. *Acta Clim Chorol Univ Szegediensis 47–48*, 77–84

6. ***Kovács A***, *Kántor N*, *Égerházi LA* (2014): Assessment of thermal sensation of residents in the Southern Great Plain, Hungary. In: *Pandi G, Moldovan F* (szerk): Air and water components of the environment. Babeș-Bolyai University, Kolozsvár, 354–361

Additional relevant publications

1. *Kántor N*, ***Kovács A***, *Takács Á* (2016b): Small-scale human-biometeorological impacts of shading by a large tree. *Open Geosciences 8*, 231–245 (IF_{2015}: 0,726)

2. *Roshan G*, *Yousefi R*, ***Kovács A***, *Matzarakis A* (2016): A comprehensive analysis of physiologically equivalent temperature changes of Iranian selected stations for the last half century. *Theor Appl Climatol*. doi: 10.1007/s00704-016-1950-3 (IF_{2015}: 2,433)

3. *Takács Á*, ***Kovács A***, *Kiss M*, *Gulyás Á, Kántor N* (2016): Study on the transmissivity characteristics of urban trees in Szeged, Hungary. *Hung Geogr Bull 65*, *155–167*

4. *Kántor N*, ***Kovács A***, *Lin T-P* (2015): Looking for simple correction functions between the mean radiant temperature from the 'standard black globe' and the 'six-directional' techniques in Taiwan. *Theor Appl Climatol 121*, 99–111 (IF_{2015}: 2,433)

5. ***Kovács A***, *Unger J*, *Szépszó G* (2015): Adjustment of tourism climatological indicators for the Hungarian population in assessing exposure and vulnerability to climate change. In: *Demiroğlu OC*, *de Freitas CR*, *Scott D*, *Kurnaz ML*, *Ünalan D* (szerk): Proceed 4th Int Conf on Climate, Tourism and Recreation – CCTR2015. Istanbul Policy Center, Isztambul, 71–76

6. *Égerházi LA*, ***Kovács A***, *Takács Á*, *Égerházi L* (2014): Comparison of the results of two micrometeorological models and measurements. *Acta Clim Chorol Univ Szegediensis 47−48*, 33–42

7. ***Kovács A***, *Unger J* (2014c): A turizmus klíma index módosítási lehetősége a közép-európai klimatikus viszonyokhoz. *Légkör 59*, 78–85

8. *Égerházi LA*, ***Kovács A***, *Unger J* (2013a): Application of microclimate modelling and onsite survey in planning practice related to an urban micro environment. *Adv Meteorol 2013*, Article ID: 251586 (IF_{2013}: 1,348)

9. *Égerházi LA*, ***Kovács A***, *Kántor N*, *Unger J* (2013b): Examination of the simulated thermal conditions in a popular playground related to the human reactions and the judgment of the area design. In: *Pandi G*, *Moldovan F* (szerk): Air and water components of the environment. Babeș-Bolyai University, Kolozsvár, 277–284

10. ***Kovács A***, *Unger J* (2013): A turizmus klíma index első módosítása a közép-európai viszonyokhoz – példák. In: *Németh Á* (szerk.): Orvosmeteorológiai Konferencia – 2013 Konferenciakötet. MMT-MBE-MHT, Budapest, 36–50

11. ***Kovács A***, *Németh Á* (2012a): Tendencies and differences in human thermal comfort in distinct urban areas in Budapest, Hungary. *Acta Clim Chorol Univ Szegediensis 46*, 115–124

12. ***Kovács A***, *Németh Á* (2012b): Comparison of different urban areas with respect to thermal comfort conditions in Budapest (Hungary). In: *Mika J*, *Rázsi A*, *Wypych A* (szerk): International Mini-Conference The atmosphere as a risk and resource. Eger, 1–9

13. *Németh Á*, ***Kovács A***, *Unger J*, *Gulyás Á* (2012): Urban/rural thermal comfort changes over the past half-century in Budapest (Hungary). In: Proceed 8th Int Conf on Urban Climate. International Association for Urban Climate, Dublin, paper 406.