Estimation of balneary-climatic potential in the central part of the Republic of Moldova

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ABSTRACT: Promotion of balneary-climatic tourism in the central part of the territory of the Republic of Moldova is extremely necessary due to the presence of a beneficial natural potential, expressed by favourable climatic conditions and curative waters. Current climate changes determine the degree of favourability of the balneary-climatic potential in the area under study. The digital maps elaborated in this paper highlight the favourable areas in the development of balneary-climatic tourism at different level. The obtained results can serve as a reference in the development of the spa tourism, taking into account the specific balneary-climatic potential of the region.

KEY WORDS: balneary-climatic potential, balneary-climatic tourism, regression analysis, cartographic models.

1. Introduction

The balneary-climatic tourism was practiced since antiquity and is at a point of great development during the last decades while economic and social development increases and so does the number of professional diseases caused by the stress of modern life in large urban settlements (Bistricean et al, 2017, Teodoreanu, Bunescu, 2007). Thus, people's preoccupations to capitalize on the therapeutic properties of natural factors that alleviate or heal various diseases have deep roots in the history of mankind, but is still present today. The purpose of this category of tourism is to make full use of the natural resources and health-improving natural factors that a country or a region has together with the availability of a specific material base with medical equipment, pavilions, spa clinics and the trained professional medical staff (Glăvan, 2005, Stoicescu, Munteanu, 1975).

We find that the central part of the country, although characterized by favourable climatic conditions and the presence of curative waters, is not perceived in general by the citizens of the European countries as a tourist destination; does not have a clear reputation as a reliable

destination for occasional tourists, this perception being due in part to: deficiencies in marketing and destination promotion, insufficient government support for tourism, low service standards, tourism infrastructure etc.

We believe that, at this stage, taking into account the environmental changes, including climate change, which at the present stage has an accelerated rate of manifestation, would make it possible to valorise the balneological climate potential in the region at its fair value.

Codru Spa Resort is located in the village of Hîrjauca in Călărași region, the first settlement of this type in Moldova, located in the central area of Codrii. The curative mineral water springs in the area are an important source of treatment, and the air quality in the village of Hîrjauca is recognized as having a therapeutic effect and is part of the complex of important balneotherapy resorts.

At the same time, the availability of climate-centered resources in the center of the country, the presence of mineral waters gives the Codru Spa Resort existing in this region a status of uniqueness in the country.

2. Initial materials and investigation methods

The process of creating of geoinformatics support initially requires the development of an informational database, necessary to be subjected to various concordance tests, followed by the general statistical calculation (of the basic statistical parameters), after which the deterministic and stochastic methods reveal the temporal laws characterizing the balneary-climatic potential of a territory.

The estimation of the balneary-climatic potential in the area under study was performed using some bioclimatic indices known in the literature (Bistricean et al. 2017).

The thermo-hygrometric index - THI (°C) or the thermal stress indicator is a computational variation of the Thom discomfort index. It is obtained based on relative air temperature and humidity, thus being avoided the use of wet-bulb temperature which is largely unavailable at meteorological stations.

The calculation formula **[1]** used in this paper for THI was proposed by Kyle in 1994:

$$THI = Tusc.-(0.55-0.0055*Ur)*(Tusc.-14.5), \quad \textbf{[1]}$$

where: T_{usc} - is the dry-bulb air temperature (°C) and Ur is the relative air humidity (%).

THI can be calculated for the entire year and is applicable to each month of the year. The drawback of this index is that for values higher than THI 30°C, it indicates only hot intervals, no matter how high air temperature and how variable air humidity are. THI thresholds correspond to different conditions, from excessively cold to very warm and torrid (Table 1).

Forestry Aridity Index (FAI), calculated for temperate forests (Führer E. et al., 2011), can also serve as a bioclimatic indicator in estimating the bioclimatic potential, based on the meteorological parameters that characterize it and the summer period of the year. As the values of this index will be less than 10, the climatic conditions will be more favourable for the development of balneary-climatic tourism. FAI is calculated according to formula **[2]**:

$$FAI = 100* ((T_{VII}+T_{VIII})/2)/ (P_V+P_{VI}+2*(P_{VII}+P_{VIII})) \quad \textbf{[2]}$$

where:

$T_{VII-VIII}$ — mean air temperature for July and August (°C),

P_{V-VIII}— sum of precipitation (mm) fallen between May and August.

Table 1 The THI threshold values (°C), bioclimatic conditions and the relationship with the thermal sensations felt by the human body.

THI index (°C)	Bioclimatic conditions	Type of bioclimatic comfort/discomfort
-20 < THI <-10	Excessive cold	Bioclimatic discomfort due to overcooling
-10 < THI <-1.8	Very cold	
-1.8 < THI < +13	Cold	
+13 < THI < +15	Cool	
+15 < THI < +20	Comfortable	Bioclimatic comfort
+20 < THI < +26.5	Warm	Bioclimatic discomfort due to overheating
+26.5 < THI < +30	Very hot	
THI > 30	Torrid	

The extent of thermal discomfort and it's dangerous levels can be evaluated according to the Discomfort Index (DI) proposed by Giles et al., 1990.

To estimate the discomfort index (DI) in Celsius degrees, the following equation **[3]** by Giles et al. (1990) has been applied:

$$DI=Ta-0.55 (1-0.01 RH) (Ta-14.5) \quad \textbf{[3]}$$

Where:

Ta- is the hourly value of the average air temperature in Celsius degrees and

RH (%) is the corresponding hourly value of the relative humidity.

Discomfort increases as DI increases.

Statistical indexes calculation (Table 2) show us, that in the above-mentioned periods, the values of DI have exceeded 29, which means the appearance of the severe stress condition of the population.

Table 2 Classification of the DI values (Giles et al., 1990).

DI (°C)	Classification
DI <21	No discomfort
21<DI<24	Under 50% population feels discomfort
24<DI<27	More than 50% population feels discomfort
27<DI<29	Most of the population suffers from discomfort
29<DI<32	Everyone feels severe stress
DI>32	State of medical emergency

Spatial evaluations are supported by the various interpolation methods and specific geoinformational data layers (physical-geographic region, map of administrative districts, river basins, forests, etc.). Taking into account the specifics of the current climate manifestation (Nedealcov et al., 2017), we believe that only a complex assessment of meteorological processes and phenomena based on a large amount of data and combined research methods can provide reliable scientific results.

Therefore, Digital Elevation Model is used in the elaboration of the various cartographic models

and regression analysis of the climatic parameters that characterize the balneary-climatic potential and the physical-geographic factors was based on the initial data on the thermal and humidity regime collected for the period 1960-2017 from the meteorological stations from the Republic of Moldova. In the calculation of the temporal estimations of the balneary-climatic potential of "Codru" resort, with the same time period, the data of the Bravicea meteorological station were used. The necessary information on infrastructure and tourism activities in the region under study was selected from the National Bureau of Statistics. Taking into account the multitude of available data, various methods of interpolation have been used.

Taking into account the fact that in the context of spatial estimations, it is extremely important to "regionalize" the existing data, the cartographic models must be elaborated in dependence on the weight of each local physical-geographic factor that contributes to the redistribution of the climatic elements that characterize the balneary-climatic potential of a territory. The coefficient of determination (R2), the level of significance of each factor and of the model as a whole are the indicators of the quality of the model. Verification of the obtained results also takes place by comparing the interpolated data with those recorded at the meteorological stations in study. Such data interpolation, in areas where meteorological observations are not performed, allows for the production of quality digital maps, which are meant to highlight the favorable or vulnerable areas regarding the balneary-climatic potential of the territory (Nedealkov M., Nedealcov Z., 2012).

3. Obtained results analysis

In the Republic of Moldova (Figure 1), there is an increase in the number of tourist and agrotourist pensions, which is largely due to the increase in the offers to rest and recreate in a more friendly environment. Thus, their number increased 5 times in 2017 compared to 2005, thus creating favourable conditions for the development of rural tourism, including the spa tourism. The latter, within the limits of the country, is characterized by a more rural distribution, reminiscent of the balneary-climatic factors that characterize it.

Thus, bathing tourism is an economic area with development potential, especially in the central part of the country, thanks to the presence of healing waters and suitability of climate for tourism.

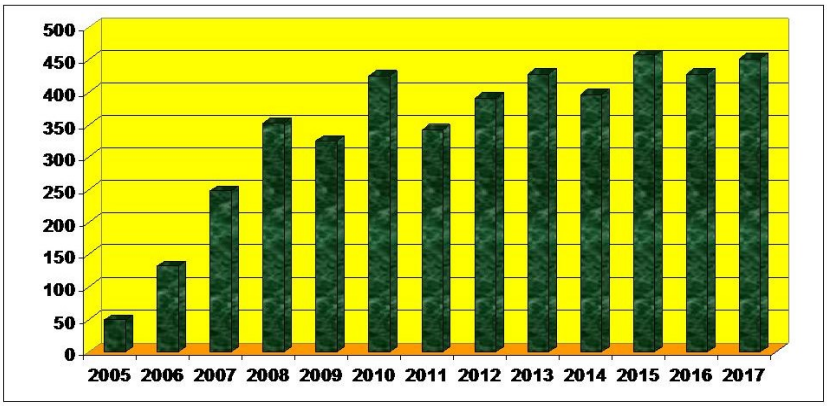

Figure 1 Dynamics of tourist and agrotouristic pensions in the Republic of Moldova.

At the level of Călăraşi district located in this region, the existing capacity of the collective tourist accommodation structures was significantly recorded in the years 2009-2014. In the last years (2015-2017), however, it is significantly decreasing, and the trend is also regional. The obtained

results reveal that, given the favourable conditions in the development of spa tourism, it is necessary to take into consideration the current situation, in order to use the local balneary-climatic potential adequately (Figure 2).

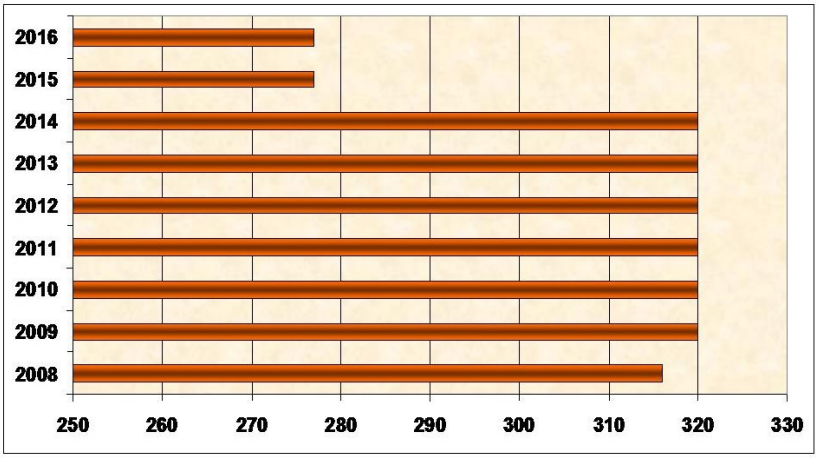

Figure 2 Capacity of the collective tourist accommodation structures.

We mention that Călăraşi district is located in the center area of the Republic of Moldova on an area of 753,5 km^2, it borders the Nisporeni district in South-West, Orhei - East, Ungheni - West, Teleneşti la Nord and Străşeni at South East. The district enjoys an advantageous position in several respects. First of all, the territory of the region is intersected by important access routes to Romania and Ukraine (railways and roads of national and international importance). The relief of the territory is complicated, intersected by slopes with different degrees of inclination and plateaus, and is located on the hill of the Republic of Moldova in the Codrii area, reaching a maximum height of 417 meters from the sea level. The lowest altitudes reach the 50 m elevation (Figure 3).

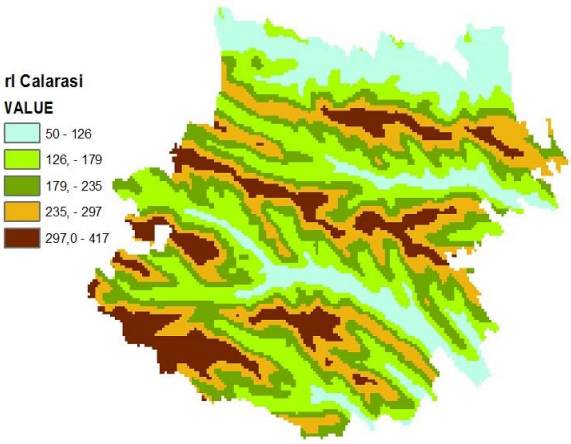

Figure 3 Altitude map (m) of Călărași Region.

The climate of Călărași district - an indisputable factor in estimating the balneary-climatic potential is less known. Therefore, a detailed assessment of the annual amount of atmospheric precipitation and of the thermal regime that characterizes this district was necessary.

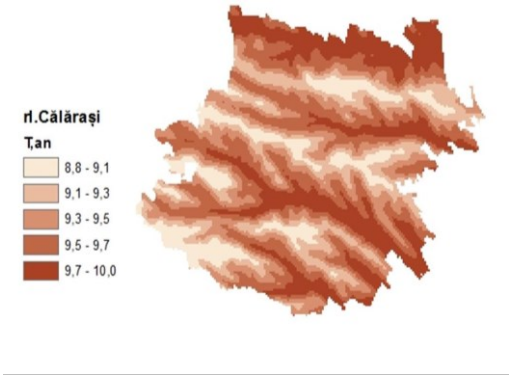

Figure 4 Average annual temperature (°C), r. Călăraşi (1960-2017).

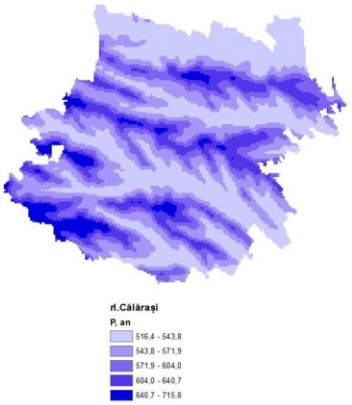

Figure 5 Annual precipitations sum (mm), r. Călăraşi (1960-2017).

Thus, the obtained data allows us to conclude that the limits of the air temperature variability are within the limits of the Călăraşi district constitutes 8.8 ... 10.0 ˚C, which means that spa resorts and pensions are characterized by very favourable climatic remedies and conditions from thermal point of view (Figure 4). Atmospheric precipitation with altitude increases in the limits of 640.7 and 715.8 mm (Figure 5), which is higher than the average in the country. We can conclude that Călăraşi Region has an established balneary-climatic potential which is favourable for the development of spa tourism.

Hîrjauca is a commune in Călărași Region in the center of the Republic of Moldova, about 60 km northeast of Chișinău, with springs and healing mineral waters in the area, which are an important source of treatment, and the air quality in the village of Hirjauca is recognized as having a therapeutic effect and is part of the complex of important balneotherapy resorts. The locality is situated in a hilly area in the heart of Basarabia's Codrii and is one of the main balneological resorts in the Republic of Moldova, being also a protected area within the category of the hydrological nature monuments.

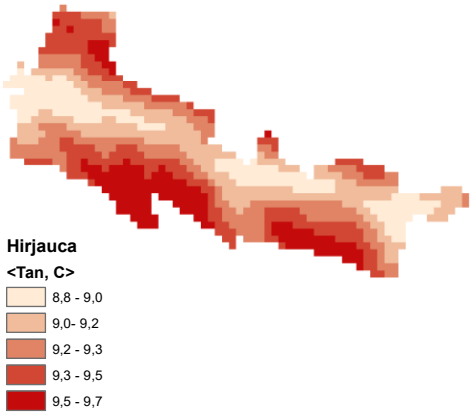

Figure 6 Average annual temperature, c. Hîrjauca (1960-2017).

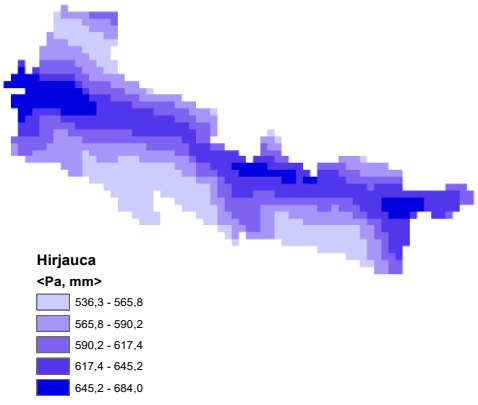

Figure 7 Annual precipitations sum, c. Hîrjauca (1960-2017).

The average annual temperature in the locality varies between 8.8 - 9.7°C, which is lower by 0.3 - 0.5˚C than in the rest of Călărași Region (Figure 6) and determines some of the most comfortable thermal conditions favourable for rest and treatment.

The annual amount of atmospheric precipitation, on the contrary, has higher values than those of the steppe area, exceeding values of 100-150 mm compared to some areas in the south and south-east of the country (Figure 7).

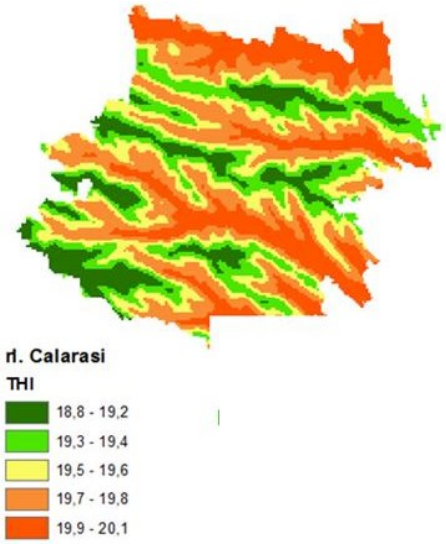

Figure 8 The balneary-climatic potential expressed in the Thermo-Hygrometric Index (°C), Călăraşi (1980-2017).

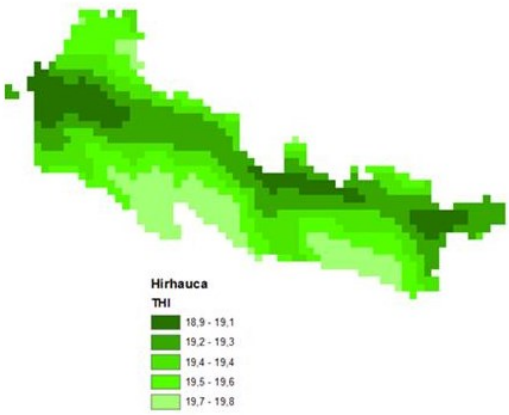

Figure 9 The balneary-climatic potential expressed in the Thermo-Hygrometric Index (°C), c. Hîrjauca (1980-2017).

The elaboration of cartographic models on the spatial distribution of the temperature-humidity index (THI) reveals that in the warmest month of the year (July), during the last decades (1980-2017), while most of republic's territory has THI values over 20.0 units, the bioclimatic potential is favourable in the development of the spa tourism both within the territory of Călăraşi and Hîrjauca (Figure 8, Figure 9).

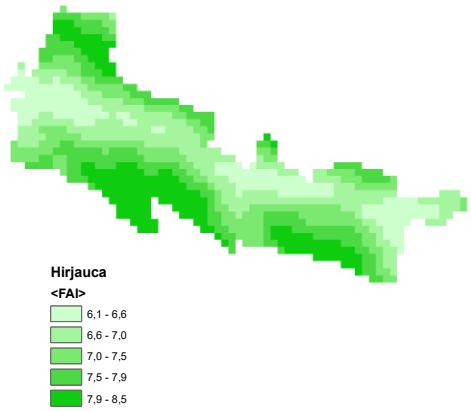

Figure 10 The balneary-climatic potential expressed in the Forest Aridity Index, s. Hîrjauca (1960-2017).

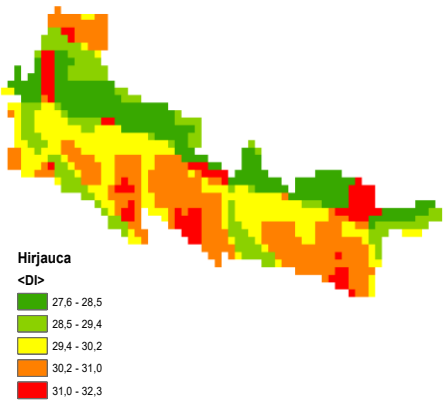

Figure 11 The balneary-climatic potential expressed in the Discomfort Index, s. Hîrjauca (1960-2017).

Harmonious combination of thermal and rainfall climatic parameters is confirmed by balneary-climatic conditions established on a good part of the summer season (June, July, August), expressed by the Forest Aridity index (FAI). It varies within the limits of 6.1 and 8.5 which characterizes climatic conditions as optimal in ensuring the bioclimatic potential in Hîrjauca commune (Figure 10). At the same time, besides the degree of climate favourability, it is also necessary to know the less favourable periods in the development of balneary-climatic tourism. This is conditioned by the fact that the country's climate is characterized by the predominance of dry and drought periods. The estimation of the heat Discomfort Index (DI) indicates that during the dry spells it has an island distribution, representing only about 20 % of the territory (Figure 11), which once again demonstrates the presence of favourable conditions (Codru spa resort) in the development of spa tourism within this locality.

4. Conclusion

In conclusion, we find that the Codru spa resort, located in the village of Hîrjauca, has a considerable balneary-climatic potential for the spa tourism, due to the unique healing properties of its mineral waters and the favourable climate. The list of therapeutic indications specific to the resort is one with which only a few resorts can compete in terms of diversity, and the list of natural factors is also generous. The marketing study has identified numerous competitive advantages of Codru spa resort, with the potential to attract both Moldavian and foreign tourists. The existence of complex natural resources and an attractive natural setting is of the primary importance. Taking into account the fact that the climatic changes attested in the last period of time do not have a major impact in the area under consideration, we consider that the "Codru" spa resort will become a strong center of health recovery adhering to all modern requirements in the near future.

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